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Mathematics and Science in the Eighth Grade

Findings from the Third International Mathematics and Science Study

U.S. Department of Education
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Table of Contents

Chapter 4 Teachers and Teaching

Trevor Williams
Leslie Jocelyn
Patricia Butler
Camilla Heid
Jacqueline Haynes

List of Tables

Appendix A: Tables

List of Figures

List of Exhibits

Exhibit Page

Acknowledgements

The United States was one of more than 40 nations participating in the Third International Mathematics and Science Study (TIMSS), the latest in a series of international studies coordinated by the International Association for the Evaluation of Educational Achievement (IEA). The mathematics and science achievements of students, and hence of nations, is the primary focus of the study. In the spring of 1995, national samples of U.S. students in the early, middle, and final years of schooling were given the chance to demonstrate their knowledge of mathematics and science through performance on internationally designed, standardized assessments. Analyses of textbooks and curriculum guides and questionnaires to students, teachers, and schools provided the information necessary to address the concurrent focus of TIMSS—knowledge of the mathematics and science curricula and the forms of instruction to which these students were exposed.

Participation by the United States in TIMSS was funded and directly supported by the National Center for Education Statistics (NCES), the U.S. Department of Education, and the National Science Foundation (NSF). In addition, NCES also made a substantial contribution to the cost of international coordination of the study as a whole.

The core data collection activity of TIMSS for most nations was surveys of national samples of students, their teachers, and their schools. In the United States, two additional components were developed to provide complementary perspectives on the achievement of U.S. students. One of these involved case studies of education in the United States, Germany, and Japan to address, in the main, four questions: national educational standards; the provisions made for handling individual differences among students; the role of the school in adolescents' lives; and teachers' lives and working conditions. The second component was a videotaped observational study of teachers' instructional practices in samples of grade 8 mathematics classrooms in the same three nations. Since the present report is focused on the surveys alone, only a brief mention of these additional components is made. Detailed descriptions of these two studies can be found in Office of Educational Research and Improvement (OERI) (1998, 1999a, 1999b) and NCES (1999) reports.

Westat was responsible for the sample design, data collection, analysis, and reporting for the surveys of students, teachers, and schools that constitute the core U.S. contribution to TIMSS. General direction in these matters was provided by the National Project Coordinating Committee whose members included William Schmidt, Michigan State University; Eugene Owen, Director, International Studies Program, NCES; Lois Peak, NCES project officer; and Larry Suter, Directorate for Education and Human Services, NSF. Throughout the course of the project, Lois Peak assumed the bulk of the responsibility for the detailed coordination of the project itself and that of the various participating groups and individuals. During the course of the review process, much was gained from the detailed reading given to the draft report by Mary Frase, Lois Peak, and Eugene Owen at NCES, together with Sayuri Takahira, Patrick Gonzales, and Kitty Mak of the Education Statistics Services Institute (ESSI). We wish to acknowledge, in particular, the careful reading given to the report by Ellen Bradburn at ESSI with assistance from David Hurst and the constructive comments they provided. We wish to acknowledge as well the advice of those who contributed reviews as part of the adjudication process: Michael Cohen, Laura Lippman, Ghedam Bairu, Ralph Lee, and Patrick Gonzales from NCES; and, Eugene Gonzalez from Boston College.

We have benefited a great deal from the advice of those named and wish to acknowledge our debt in this respect. (The affiliations of the following persons have changed since this report was written: Lois Peak is now with the U.S. Department of Education's Policy and Evaluation Service; Mary Frase joined the National Science Foundation; Patrick Gonzales and Ellen Bradburn are now with NCES; Sayuri Takahira is now on the faculty of a Japanese university.)

Valuable advice was forthcoming as well from a review committee established to provide comment on the more substantive aspects of the project's focus—the teaching and learning of mathematics and science in the United States. We wish to acknowledge the contributions of the members of this committee: Glen Cutlip, National Education Association; John Dossey, Illinois State University; Wayne Martin, Council of Chief State School Officers; and Elizabeth Stage, New Standards Project, University of California.

The Educational Testing Service (ETS) and National Computer Systems (NCS) worked with Westat as subcontractors. Staff in both organizations provided valuable advice during the design and data collection stages. Nancy Mead from ETS provided especially helpful advice on questionnaire design early in the project. Christine O'Sullivan and Chan Jones provided helpful reviews of the applicability of the assessment items for U.S. students. We continue a rewarding collaboration with John Mazzeo, Clyde Reese, and their staff at ETS who, as subcontractors to Westat, were responsible for the development and production of several of the TIMSS reports. Mary Lynn Helscher and Connie Smith of NCS made an invaluable contribution through their work on the design and supervision of questionnaire coding and data entry. Albert Beaton and the staff of the International Study Center at Boston College, especially Eugene Gonzalez, were particularly helpful in providing early drafts of the international data tables, the basis of the analyses reported in Chapter 2 of this volume.

Within Westat, the project was under the general direction of Renee Slobasky, Senior Vice President and Director of the Survey Operations Group. Nancy Caldwell and Trevor Williams were co-directors of the project responsible for, respectively, data collection and analysis/reporting. The project's data collection activities owe much of their success to Nancy Caldwell's planning and oversight, to Dward Moore's very able direction of the field staff who conducted the assessment activities in schools, and to the dedication and professionalism of the Westat field staff. Lucy Gray contributed to various project activities. Much of the work entailed in creating the data presentations, both

graphic and tabular, was undertaken by Leslie Jocelyn. David Kastberg made an invaluable contribution during the final stages of manuscript preparation. Judy Brazil and Mark Waksberg played an important part in training the field staff. Lou Rizzo demonstrated his expertise in the design and selection of the U.S. sample and in the computation of the sampling weights. Keith Rust provided very valuable input and support throughout the project particularly in matters of sampling and statistical analyses. Seung Namkung provided most of the programming support for these tasks under the coordination of Bryan Davis and with the assistance of Carin Rauch. Shep Roey was responsible for the development of the data files to meet the international specifications, for the confidentiality analyses undertaken, and for oversight of the computing associated with analyses reported in this volume. Chi San, Doug Duncan, and Jack Hill undertook the computing that shaped raw data into statistics. Joan Murphy took on most of the responsibility for polishing the text and tables of the several authors into the present report. We are more than grateful for the efforts of all those named and for the contributions of many others who have been associated with the project from time to time.

As always in projects of this kind, we owe a substantial debt of gratitude to the districts, schools, teachers, and students without whose support and cooperation the United States would not have been part of TIMSS.

1. Mathematics and Science in the Eighth Grade

The United States participated in all of the various components of the Third International Mathematics and Science Study (TIMSS), assessing the mathematics and science achievement of national samples of students in grades 3 and 4 (population 1), grades 7 and 8 (population 2), and grade 12 (population 3) and collecting associated information from these same students, their teachers, and their schools. The bulk of the information collected centers on two matters: students achievement in mathematics and science and the instructional practices that teachers use in the teaching of mathematics and science.[1] International reports detailing the mathematics and science achievement of population 2 students in 41 nations have been published (Beaton et al., 1996a; 1996b).

The intent of the present report is to refocus the international comparisons of population 2 students' achievement with the view to highlighting the place of the United States among nations. A second component looks at the performance of sectors of the eighth-grade student population against the same kind of international benchmarks. A third component picks up TIMSS' emphasis on instructional practice by developing a description of the instructional practices of U.S. eighth-grade mathematics and science teachers.

The discussion that follows describes TIMSS as the source of the information for these analyses and the context in which the various comparisons are made. Chapter 2 provides an international perspective on the performance of U.S. seventh and eighth graders. Chapter 3 looks at the performance of sectors of the U.S. eighth-grade population in the same international context. Chapter 4 provides a description of the instructional practices of those who teach mathematics and science to these eighth-grade students. Chapter 5 provides observations on the findings as a whole.

I. Introduction

TIMSS is the latest, most ambitious, and most complex in the series of international studies of student achievement undertaken by the International Association for the Evaluation of Educational Achievement (IEA). The current study, under development since the late 1980s, is designed to measure the mathematics and science achievements of students in the early, middle, and final years of schooling and investigate differences in curriculum and instruction.

TIMSS coincides with the heightened interest in the United States about how American students compare internationally. In 1989, the National Education Summit, consisting of the President and the governors of all 50 states, adopted six goals for education, including one that specifically placed American education in a global context in stating that "U.S. students will be first in the world in mathematics and science achievement by the year 2000." Such a declaration, and the efforts to accom-

1 A detailed study of mathematics and science curriculum was undertaken as well, but as a separate exercise not linked to the surveys; see Schmidt et al. (1997a; 1997b).

plish the objective, highlight the need to monitor progress relative to other nations and to examine other education systems for exemplary practices that could have application in the United States.[2]

Using a variety of assessment methods, TIMSS seeks to understand differences in current performance in mathematics and science among participating nations through examination of a wide variety of associated variables, such as curriculum, student and teacher background, and social context. It encompasses three distinct populations of students—the two adjacent grades containing the most 9-year-old students; the two adjacent grades containing the most 13-year-old students; and students enrolled in the final year of secondary schooling, regardless of their program of study. TIMSS seeks to measure the home background of students in all three populations and the nature of the mathematics and science curricula intended for and presented to each population. It also seeks descriptions of the classroom, schools, and national contexts within which education takes place.

The United States is one of the more than 40 countries participating in TIMSS,[3] and this report is one in a series reporting results from U.S. TIMSS. The focus of this report is population 2, that is, those students enrolled in the two adjacent grades that contain the largest proportion of students age 13 at the time of testing. This group represents students who, in most countries, are still within the compulsory years of schooling. Population 2 also was established as the "core" of TIMSS. Thus, to participate in TIMSS, countries were required to conduct the assessment phase of the study among this group of students; the inclusion of populations 1 and 3, in contrast, was a country option, one that was exercised by the United States.

The procedures followed in collecting the data for population 2, of course, were essentially the same as for the other two populations; further, the conduct of TIMSS in the United States, for the most part, followed the standardized procedures and used the materials prepared by the International Study Center (ISC), as did all other countries participating in TIMSS. Detailed presentations of the history of TIMSS, its goals, planning and development phases, the international study design, and the U.S. study design can be found in the respective technical reports: the international report prepared by the ISC (Martin and Kelly, 1996); and the U.S. technical report prepared by Westat for the National Center for Education Statistics (NCES, in press). These reports serve as the most detailed sources of background and context for the population 2 discussion; however, very brief summaries of each of these topics are included for the convenience of the reader. Modifications from the international study, which were introduced into the survey design to meet the unique requirements of the United States, are described in some detail throughout the report.

2 Concerns that the campaign launched some 6 years ago to improve the nation's schools has made only slight progress to date led the nation's governors to reconvene the National Education Summit in March 1996. Subsequent meetings are planned.

3 The number of countries participating in TIMSS varies by population. At the time of preparing this report, the number of countries providing population 2 data was 41. They are as follows: Australia, Austria, Belgium (Flemish), Belgium (French), Bulgaria, Canada, Colombia, Cyprus, Czech Republic, Denmark, England, France, Germany, Greece, Hong Kong, Hungary, Iceland, Iran, Ireland, Israel, Japan, Korea, Kuwait, Latvia, Lithuania, Netherlands, New Zealand, Norway, Portugal, Romania, Russian Federation, Scotland, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, United States.

A Short History of TIMSS

A strong economic argument for improving education is based on the premise that failure to educate the future work force of a nation threatens a nation's ability to compete internationally in the global marketplace. Put simply, there is economic value in creating a strong education system.

With the 21st century looming close on the horizon, many countries realized that they required pertinent and timely information about how their students and their education systems compare to those in other countries. The assessment and explication of patterns of school learning around the world are precisely what IEA studies are designed to accomplish. Accordingly, through the offices of IEA, a number of countries initiated discussions toward accomplishing these goals by repeating earlier efforts. Initially, the effort was devoted toward conducting only a followup study to the Second International Mathematics Study.

Coincidentally, at the time this thinking was emerging, the U.S. government was establishing education policy to move the nation to the forefront in educational accomplishment in mathematics and science by the year 2000 and proposing and implementing initiatives to accomplish its goals. Recognizing that the proposed IEA study offered the appropriate vehicle for monitoring progress toward achieving its goals through comparisons of international assessment levels, the United States agreed to participate in the planned undertaking and proposed an expansion of the study to include science as well as mathematics. It also offered major funding support for the combined undertaking. As a result, TIMSS is one of the major international education surveys of the 1990s.

Previous international studies in the areas of mathematics and science have produced valuable insights into a number of aspects of the teaching and learning process. Further, they have provided a number of important lessons with respect to the design and conduct of large-scale international research projects in education. TIMSS' goals go beyond comparing the achievements of students in many different countries; they extend to explaining how countries differ in what they teach, the way they teach, and in how they overcome obstacles to student learning.

Participating countries also will benefit in several ways. Under the overall direction of IEA, the International Coordinating Center (ICC), and the ISC, countries have access to an international network of experts in curriculum and in research in an international context. The study also provides training opportunities for members of national research teams and assistance in the development of national research capacities in the area of education evaluation and assessment. The extensive variety of meetings necessitated by an undertaking of this scope and complexity provides an unparalleled opportunity for meeting and sharing experiences and for building networks for improved future education research and policy determination. For all these reasons, participation in TIMSS will yield substantial long-term benefits for each of the participating countries.

Goals

The fundamental goal of TIMSS is to contribute to the enhancement of the scientific knowledge about education and about the influence of a number of important variables on educational processes. To achieve this goal, a conceptual framework was developed in which the student outcomes in mathematics and science are placed in context. This context is in the form of a hierarchy: the local or school context, the more general contexts of mathematics and science education in a given country, and the overall societal context in which the study is conducted. Within the educational context, the Intended Curriculum, that which is formally stated in official documents, and the Implemented Curriculum, that which is actually taught, include all of the teaching and learning experiences that schools use to foster learning and growth in their students and are crucial determinants of the quantity and quality of students' educational experiences. Within the local context, student outcomes are not limited to narrowly conceived achievement objectives that can all be measured by multiple-choice items. Instead, they also include students' attitudes and opinions and higher-order thinking skills, as well as accomplishments and performance on more routine, knowledge-based tasks.

Needless to say, this hierarchy of contexts is both dependent and interrelated. The Implemented Curriculum is strongly influenced by the Intended Curriculum, but research has shown that the two are frequently not identical. Similarly, what students acquire as a result of experiencing the Implemented Curriculum in their local context is related to and dependent on the specific nature of the Implemented Curriculum, as well as on a wide variety of other locally important variables.

Given that TIMSS is a research project, unlike some other large-scale evaluation projects, the study was designed to contribute new knowledge about the content of mathematics and science curricula, about how mathematics and science are taught and by whom, and about the outcomes of that teaching, as reflected in students' achievement and attitudes. In pursuit of those objectives, new methodologies for conducting the curriculum analysis and for evaluating students' opportunities to learn the material assessed were developed and successfully implemented. TIMSS also was designed to serve the needs of countries desiring to use the results as part of their overall assessment and evaluation program at the national level or for a wide variety of within-country analyses they may wish to undertake.

The amount of data collected by TIMSS is unprecedented in the history of educational research and consists of 2 curriculum areas, more than 40 countries, and 4 grade levels, including curriculum data, achievement measures, and an extensive array of contextual information about educational systems' students, schools, teachers, and instruction. Realizing the full potential of the TIMSS data will require identifying all of the myriad research possibilities, establishing priorities, developing detailed analysis specifications, conducting the analyses, and reporting the results. One can only hope that educational researchers and research centers in many countries will have that interest. The more research carried out using TIMSS data and the more individuals involved, the better the chance to mine this very unique and comprehensive database about mathematics and science education and contribute to a better understanding of the education process.

II. International Studies of Student Achievement

The present study is the first to combine both mathematics and science in a single study; prior to TIMSS these international studies covered only a single subject area, either mathematics or science. In the late 1980s and early 1990s the Educational Testing Service (ETS) also carried out international combined studies of mathematics and science. These were identified as the International Assessment of Educational Progress (IAEP) (Lapointe et al., 1992a; 1992b). Medrich and Griffith (1992) provide a useful summary and evaluation of the findings of these projects. The findings from each of these studies are considered in the following chapter on student achievement.

The first IEA survey of student achievement was conducted in the early 1960s among 12 countries and was focused on mathematics achievement. Since that time, academics, educators, administrators, policymakers, and political representatives have looked, in increasing numbers and with increasing frequency, to the findings of such studies to provide a context within which to draw conclusions about the performance of their educational systems. Not surprisingly, given its importance in the school curriculum of virtually every country, given the universality of much of the content of the school mathematics curriculum, and given that mathematics is the basis for science education, mathematics is the subject area that has most frequently been selected to provide the substantive content of international comparative studies of education. More recent international studies of the teaching and learning of mathematics have focused much more directly and consciously on international variation in the content of the mathematics curriculum, on the ways in which mathematics is taught, and on broadly defined student outcomes. Similar interpretations have been made in the area of science.

Comparative international studies have ranged from major surveys involving fairly large numbers of countries to smaller studies involving students and teachers from as few as two countries, or even from within one city in each of two countries. They also have ranged across subject areas beyond mathematics and science as, for example, reading comprehension, word knowledge, literature, civic comprehension, and literacy. This discussion, however, is limited to the more major comparative international studies in mathematics and science, beginning with four IEA studies dating back to the mid-1960s, which represent the historic core of international surveys of student achievement in mathematics and science.

IEA is an independent international cooperative, funded through a variety of public and nonprofit sources with the participation of education research centers in nearly 50 developed and developing countries. Organized as a consortium of ministries of education, university education departments, and research institutes, projects are undertaken on a highly decentralized basis with modest institutional oversight. The agenda of IEA is to study systems of education from an international comparative perspective, focusing on five key issues:

- The curriculum and its effects on education outcomes;

- School and classroom organization and its effects on education outcomes;
- The relationship between achievement and attitudes;
- Educational attainment among special populations; and
- The relationship between changing demography and changing student achievement levels.

In addition, IEA provides technical assistance to developing countries attempting to improve their educational research capabilities.

As such, IEA holds a unique leadership role in the international testing community. IEA was the first entity to develop and administer student achievement tests in more than one country. These studies have attempted to explore almost every aspect of the elementary and secondary school curriculum. The surveys have led to important improvements in large-scale international sampling methodology, conceptual design, test administration, and data analysis. Because the surveys were developed as research projects typically without clear financial support, they were consistently underfunded and even completing the achievement testing process required extraordinary effort and commitment on the part of IEA researchers. The studies were originally designed to support comparative international research, and although there was an interest in linkages to policy, the work did not explicitly serve the diverse needs of policymakers. This situation changed dramatically in recent years as political systems began to focus on the effects of educational policy on the health of a nation in the competitive international arena.

First International Mathematics Study

The First International Study of Mathematics (FIMS) was initiated in 1960 as the founding study of IEA. FIMS was essentially a comparative investigation of the outcomes of schooling with a focus on mathematics achievement as the dependent variable. The 12 countries that participated in the data collection phase in 1964 were almost all located in Europe and were predominantly highly industrialized. FIMS examined national probability samples from two populations: 13-year-old students (population 1) and students in their last year of secondary school (population 2).

Almost all of the items developed for FIMS were multiple choice and constructed through a collaborative international effort. The items were designed to measure student performance on various mathematics content topics at five cognitive levels: knowledge and information, techniques and skill, translation of data into symbols or vice versa, comprehension, and inventiveness. In addition to the achievement items, five attitude scales were developed along with questionnaires for students, teachers, principals, and educational experts.

The instruments consisted of 10 versions of a 1-hour test. Each version included a subset of items from a pool of 174 mostly multiple-choice items, graded in difficulty. Supplemental questionnaires were developed to explore student views of teaching practice and instruction in mathematics (22 items) and effective outcomes (43 items). Separate questionnaires for teachers and school administrators examined characteristics of the teaching environment at each school surveyed and those of the general educational program.

FIMS produced numerous findings of interest to mathematics educators and contributed in a substantial manner to the development of a better understanding of the immense variability that exists across countries with respect to a number of variables with important implications for the teaching and learning of mathematics (Husen, 1967). This contribution laid the major groundwork for what would be a more intense study of the connections between what teachers do and what students learn. Nonetheless, the details of the sampling procedures used are sparse and response rates are unknown. Accordingly, FIMS scores and rankings must be read with caution because the field outcomes cannot be examined and the quality of the data cannot be assessed.

First International Science Study

Encouraged by the success of FIMS, the international education community, under the leadership of IEA, decided in 1966 to see if some of the FIMS results would also hold in other subject areas, including science. Following some years of developmental effort, the First International Science Study (FISS) was conducted in 19 countries in 1970. Data were collected from four populations: in population 1, the modal age was 10 years; in population 2, it was 14 years; population 4 was set as the terminal year of secondary education, with the modal age approximating 18; and population 3, which was described as between population 2 and 4, was included for national data collection and analysis only.

The aims of the research were to identify those factors accounting for differences between countries, between schools, and between students. The technique used was a cross-sectional survey at three different levels that described education as it was at the time of testing and not as it might be. The results were published in 1973 (Comber and Keeves, 1973).

Tests were developed to indicate knowledge of various fields (earth science, biology, chemistry, physics); to indicate general understanding of science; to measure practical (laboratory) skills; and to measure ability to use higher level cognitive skills (application, analysis, and synthesis) in relation to scientific subject matter. In addition, there were measures of interest in and attitudes toward science, and some description of the nature of science teaching also was obtained.

FISS offered a relatively complete description of field outcomes, which revealed that a majority of the countries, irrespective of the population level studied, reported response rates below what was considered an acceptable level (85%). FISS clearly demonstrated the need for complete documentation through the following efforts.

- It afforded a clearer picture of the sampling process and the difficulties encountered.
- It tried to establish common sampling practices across participating countries.
- It attempted to define a target population in a way that enables each country to design and execute comparable samples successfully.
- It tried to persuade schools to participate in this type of voluntary testing program.

Second International Mathematics Study

The Second International Mathematics Study (SIMS) was designed to provide an international portrait of mathematics education and allowed, at every stage, for significant input and guidance from a wide range of members of the mathematics community. The students in the study were selected from two populations: population A consisted of students in the grade containing the majority of those 13 years to 13 years and 11 months old by the middle of the school year; population B students were those in their last year of secondary school who were taking mathematics as a substantial part of an academic program.

Thirteen-year-olds were tested in five content areas: arithmetic, algebra, geometry, measurement, and statistics. Content areas for the last year secondary tests were sets and relations, number systems, algebra, geometry, functions and calculus, and probability and statistics. All 13-year-olds were administered the same 40-item core test and also one of four other tests consisting of some 34 items selected from the total pool of 176 items. Students in the last year of secondary education were administered two of eight sets of 17 items each (from a set of 136 items). In both samples, items from the available pool were randomly assigned within content areas of each version, and test versions were randomly assigned to students. Three other questionnaires were included in the cross-sectional survey to obtain information on student background, teacher data, and school data.

There were three main aims to SIMS: (1) to describe the mathematics curriculum in each system and also examine changes in the curriculum since 1960; (2) to measure achievement in mathematics in each system and examine the relative strength of different determinants; and (3) to measure growth in achievements over a 1-year period and assess the reasons for differential growth of students/classrooms in the participating systems.

In all, some 20 countries participated in SIMS in one of two ways during the 1981-82 school year. The full study was designed to provide longitudinal data comparing pretest (beginning of school year) data with posttest (end of school year) data. However, countries could opt to participate in only the posttest phase of the study. As in FIMS, items were developed according to a content-by-cognitive level grid. Content was divided into five strands for population A and nine strands for population B.

Once again, response rates for a majority of the participating countries fell well below an 85 percent response rate standard. For the 13-year-olds, 12 systems did not provide complete sampling information and 4 others were below the standard; among the sampled students in the last year of secondary school, 9 of 15 systems either reported response rates below the standard or did not supply data. Further, such documentation as did exist indicated some significant deviations from the definitions of the target populations in different countries, and the age of sample students also varied considerably across countries.

Nonetheless, SIMS produced a large number of useful and important findings (Travers and Westbury, 1989; Robitaille and Garden, 1989; and Burstein, 1992). Its emphasis on teaching practices, coupled with a closer examination of curricula across countries, generated findings that went substantially beyond those of its earlier counterpart. SIMS provided valuable information not only on the extent of growth in students' learning but also on a variety of relationships among teaching practices, curricula, and student growth. Such information is vital in reaching a greater understanding of how mathematics learning takes place and which factors contribute to the successful accomplishment of the goal.

Second International Science Study

The Second International Science Study (SISS) was initiated at an IEA General Assembly meeting in 1980. The aims of the study included the following:

- Examine the state of science study across the world;
- Identify factors that explain differences in achievement and other outcomes of science education, with particular attention to the role of the science curriculum as an explanatory factor; and
- Examine changes in the descriptive picture of science education and in the patterns of explanatory relationships since the early 1970s in the 10 SISS countries that also participated in the first study.

In all, 24 countries participated (including 10 of the 19 that had taken part in FISS). Data collection took place between 1983 and 1986. Three populations of students were included: children 10 years old (typically in grade 4 or 5); those 14 years old (typically in grade 8 or 9); and students in their final year of school (typically in grade 12).

Almost all of the items selected or constructed for SISS were multiple choice. Major emphasis was placed on the subdisciplines of biology, chemistry, and physics. Earth science topics were included but with less emphasis. Student questionnaires were used to collect background information, data on student effective outcomes, and student perceptions of classroom practices. Teachers also completed questionnaires that sought information about background and opportunity-to-learn variables. School administrators provided data on school administrative structure and on the general context of science education.

As in previous studies, SISS encountered difficulties in reaching acceptable response rate levels—for 10-year-olds, 7 of the 15 participating educational systems failed to achieve 85 percent response rates for students. Among the 14-year-olds, 6 of the 17 systems did not meet the standard. Response rates for the United States were 77 percent for the 10-year-old group and 69 percent for the 14-year-old sample.

Nonetheless, SISS provided a great deal of information about student achievement and attitudes and about the context within which achievement and attitude development takes place. The outcomes of the study essentially were linked to its cross-national nature. From a research viewpoint, it suggested generalizations about science education that seem to apply across a wide range of countries (IEA, 1988; Rosier and Keeves, 1991; Postlewaite and Wiley, 1991). In addition, the study enabled policymakers in individual countries to examine national performance in the context of the cross-national results, and it illuminated important national educational policy issues.

III. U.S. Participation in Previous International Studies

The changing world economic order, foreshadowing new demands on the labor force and workplace, highlights the larger international context within which American education, as all education, must be viewed. Over the past quarter century, there have been six major international studies of science and mathematics achievement at the elementary, middle, and secondary school levels. As reported earlier, four of these studies were undertaken under the auspices of IEA and the last two, known as the International Assessment of Educational Progress (IAEP), were carried out by a non-governmental research consortia organized by ETS, U.S., under contract to NCES. The United States has been involved in every one of these six studies.

Two additional studies of mathematics and science accomplishment were carried out at the initiative of the United States—the first in 1988 and the second in late 1990. The feature distinguishing these studies from those carried out by IEA, including TIMSS, is that the IAEP studies were based solely on age, whereas the other studies used a combined age-grade level criterion.

First IAEP Study

The initial study was related to another research program, the National Assessment of Education Progress (NAEP), which has been conducted in the United States periodically since 1969. It was administered in February 1988 and was designed to be exploratory in nature (although the results often are discussed as "definitive in nature"). IAEP had two objectives: to examine the feasibility of reducing the time and money spent on international comparative studies by capitalizing on design, materials, and procedures developed for the U.S. NAEP; and to permit interested countries to experiment with NAEP technologies to see if they were appropriate for local evaluation projects.

Six countries participated in the study. The target population was defined as all students born during the calendar year 1974; that is, students ranging in age from 13 years, 1 month to 14 years, 1 month at the time of testing. Tests were organized around the following topics:

Mathematics:

- Numbers and operations;
- Relations and functions;
- Geometry;
- Measurement;
- Data organization; and
- Logic and problem solving.

Science:

- Life science;
- Physics;
- Chemistry;
- Earth and space science; and
- Nature of science.

Test items were drawn from the 1986 NAEP. There were 63 mathematics questions selected from a pool of 281 questions and 60 science questions chosen from a pool of 188. All science questions were multiple choice and 14 of the mathematics questions were open ended. Ten of the 12 participating systems achieved an 85 percent response rate at each stage in both mathematics and science. The findings of the study are discussed in the following chapter.

Second IAEP Study

The second study, conducted in late 1990 and early 1991, was an international comparative study of the mathematics and science skills of samples of 9- and 13-year-old students from 20 countries. All 20 countries assessed the mathematics and science achievement of 13-year-old students, and 14 countries assessed 9-year-old students in these same subjects. Some of the participating countries assessed virtually all age-eligible children; in other cases, the samples were confined to certain geographic regions, language groups, or grade levels. In some countries, significant proportions of age-eligible children were not represented because they did not attend school. Further, in some counties low rates of school or student participation could have resulted in biased data. In addition to the regular assessment, a few countries administered performance tests to subsamples of students who had taken the written assessments.

The Second IAEP, as the first, used existing NAEP technology and procedures but expanded on the earlier experience. However, by drawing on NAEP, the time and money required to conduct such an international comparative study was reduced, thus allowing many interested countries to experiment with the innovative psychometric techniques incorporated into NAEP. The Second IAEP was designed to collect and report data on what students know and can do; on the educational and cultural factors associated with achievement; and on students' attitudes, backgrounds, and classroom experiences.

Typically, a random sample of 3,300 students from about 110 different schools was selected from each population at each age level; one-half were assessed in mathematics and one-half in science. The achievement tests lasted 1 hour. For 9-year-olds, the tests included 62 questions in mathematics and 60 questions in science. For 13-year-olds, the tests consisted of 76 questions in mathematics and 72 questions in science. Students at each age also spent about 10 minutes responding to questions about their backgrounds and home and school experiences. School administrators, in turn, completed a school questionnaire.

Each participating country was responsible for carrying out all aspects of the project, using standardized procedures, manuals, and training materials that were developed for the project. Several international training sessions were held for participants, at which each step of the process was explained in detail. One result of all this effort was that virtually every country or educational system exceeded the NCES threshold of 85 percent response rates; in fact, the overall response rates (combining both school and student participation) approached or exceeded 90 percent in 6 countries out of 10. Response rates for the United States were 71 percent for the age 13 group and 74 percent for those 9 years old.

IV. The TIMSS Design

It is important to realize that each of the efforts IEA sponsored, as well as the IAEP studies noted above, have significantly contributed to the development of TIMSS, which truly is the culmination of all the studies that have preceded it. Like these, TIMSS consisted of a series of data gathering efforts among a select group of student populations, teachers, and school administrators. The subject areas of concern were mathematics and science education; the three population levels were:

- Population 1 – students in the pair of adjacent grades that contained the most students who were 9 years old at the time of testing;
- Population 2 – students in the adjacent paired grades that contained the most students who were 13 years old at the time of testing; and
- Population 3 – students in their last year of secondary school.

Within each country, students were selected for testing through a sampling operation in which a sample of schools containing appropriate grades was selected from a master list of schools, a sample of mathematics and science classes was selected within the sampled schools and, in general, all students within these classes were tested. To the extent possible, teachers and schools were linked to the students, which permitted a very high degree of linkage among variables from all three components of the study. Some variations in this overall approach are noted in the technical description, as, for example, using random sampling in population 3. Performance assessments were given to a subsample of students in populations 1 and 2 in some of the nations.

TIMSS included a wide variety of instruments; the content reflected areas of present interest as well as drawing on past studies. In addition to the assessment items, questionnaires were developed to collect background information from students as well as important contextual information on the educational system from teachers and principals. Subsequent chapters deal in some detail with the development of the various instruments. This endeavor was a truly international undertaking, shared by people throughout the world who were experts in mathematics and science as well as educational training and evaluation. These individuals gave freely and often of their time and expertise to ensure that TIMSS would meet its manifold objectives in providing high quality, consistent data in virtually all participating countries and, thus, permit the much desired and sought international comparisons.

The International Study Center, assisted by numerous experts worldwide, was responsible for ensuring that, in so far as possible, every country in its application of the TIMSS study requirements was consistent in following the manuals and other materials. This included sampling, enrolling schools and students, administering tests and questionnaires, training staff, and editing and processing. Further, every effort, including repeated testing and review, was made to develop codes and psychometric scales that were unbiased and applicable to the range of results from the many countries involved in TIMSS. Finally, quality control measures were used throughout every aspect of the undertaking to produce valid and reliable information.

U.S. TIMSS Design, Population 2

U.S. TIMSS was funded and directly supported by two agencies of the government, NCES, the U.S. Department of Education, and the National Science Foundation (NSF). The actual data collection was performed under contract by Westat, a private survey research firm, with oversight from the National Project Coordinating Committee, which includes the U.S. National Research Coordinator and representatives from NCES and NSF. Policy direction for the study, however, resided with a steering committee established by NCES, consisting of education experts from the academic and non-governmental environment along with both NCES and NSF. Both committees, as well as NCES and NSF, sponsored, supported, and received frequent advice and counsel from numerous technical advisory committees on virtually every aspect of the study.

Of note, also, is the fact that NCES required that the overall sample size be somewhat larger than that required by the international specifications, which called for a minimum effective sample size of 150 schools and 400 students per population. The U.S. minimum effective sample consisted of 220 schools, with schools with large percentages of blacks and Hispanics oversampled by a factor of 2. The number of students in each population involved in the assessment phase exceeded 10,000. The response rate for schools, after allowance for substitution of noncooperating schools, was 85 percent; the cooperation rate for students reached 88 percent. Finally, the guideline called for at least 50 participating schools per population for the Performance Assessment[4] phase; the target in the United States was set at 100 schools per population. U.S. TIMSS met or exceeded the international guidelines.

In regard to population 2 specifically, a total of 220 schools throughout the United States were sampled. Of these 220 schools, 169 schools (77 percent), agreed to cooperate. Subsequent contacts with substitute schools led to an additional 14 schools participating. The final cooperation rate was 85 percent.[5] A total of 12,497 students were selected from these schools for testing, and 11,110, or 89 percent, actually took the tests. The activities involved in Performance Assessment for population 2 were accomplished by a sample of 731 students, some 98 percent of the selected sample, drawn from 83 schools.

Standards for participation rates were established by the International Study Center. Countries were expected to obtain a participation rate of at least 85 percent for both schools and students or a combined rate (the product of school and student participation rates) of at least 75 percent without using replacement schools. Countries that met or exceeded these standards are shown without annotation in the international reports. Countries that achieved these participation rates only after using replacement schools are placed among this group but are annotated to indicate that they failed to meet these participation standards. Countries demonstrating lower levels of participation and/or not satisfying other sampling guidelines are shown

4 Performance assessment refers to the use of integrated, practical tasks involving instruments and equipment as a means of assessing students' content and procedural knowledge as well as their ability to use that knowledge in reasoning and problem solving. In the U.S. a half-sample of schools from each of populations 1 and 2 was selected and within grade 4 and grade 8 classrooms participating students were selected randomly. See Harmon et al. (1997) for a description of the international results.

5 Both of these response rates are weighted rates; see Martin and Kelly (1997, p. 73).

separately. Since the combined participation rate for the United States was 71 percent at the upper grade (grade 8) and 72 percent at the lower grade (grade 7) before the use of replacement schools, but reached, respectively, 78 and 79 percent after replacement schools were included, the United States appears as one of the annotated countries in the international reports (Beaton et al., 1996, Appendix A).

Data were collected in the 1994-1995 school year; both test administration and completion of questionnaires began in late March 1995 and continued through mid-May 1995. The data collection staff consisted of approximately 60 supervisors and 325 data collectors. Review, editing, and data entry were performed by National Computer Systems under contract to Westat, after which the data followed the standard path of being sent to the International Data Processing Center in Hamburg for consistency checking and further review, and to Statistics Canada for the preparation of sampling weights, after which the data were returned to Westat for tabular presentation and analysis. The test assessment results underwent one additional step in that they were forwarded to the Australian Council for Educational Research (ACER) in order for the achievement test results to be scaled, using an Item Response Theory psychometric model. In turn, scaling of the U.S. assessment results was accomplished and entered into the data record, returned to Westat, and incorporated into the final data files.

A particularly innovative feature of U.S. TIMSS is the inclusion of two data collection methodologies that go well beyond the usual questionnaires and assessment instruments. At the initiative of the United States, Germany and Japan agreed to participate in a common study focused on a number of key elements of TIMSS. Case studies of the educational system in three countries and videotaping of eighth-grade mathematics classes in the same countries will greatly expand the information available from TIMSS and contribute to future improvements in assessment research. The results of these companion studies are reported elsewhere (OERI, 1998; 1999a; 1999b and NCES, 1999) and are not included in the present report. However, a brief overview of each of the studies is included in the interest of noting that complementary perspectives on U.S. mathematics and science education are available in companion volumes.

Videotape Classroom Observation Study

The Videotape Classroom Observation Study was designed to provide a rich source of information about practices of classroom mathematics instruction in three countries—Japan, Germany, and the United States—and also to provide contextual background information on the statistical indicators available from the main TIMSS study. This study was conducted among a subset of eighth-grade students included in the TIMSS assessment, with 109 U.S. schools selected for the original sample. After allowance for refusals and the selection of alternate, replacement schools, a total of 81 schools agreed to participate in this phase of TIMSS. Because the goal of the videotape study was to sample classes throughout the year, classes were videotaped from early November 1994 to mid-May 1995.

As the first large-scale study to collect videotaped records of classroom instruction in the mathematics classrooms of different countries, the successful accomplishment of the goal of organizing, coding, analyzing, and interpreting this large corpus of data opens a new frontier of cross-national educational research. It also leads toward developing new measures of instructional quality that can be monitored much as student achievement is monitored at present.

Case Studies in the United States, Germany, and Japan

The U.S. effort also included a case study module on four topics of great interest to policymakers in the United States: national standards; the working conditions of teachers; procedures for dealing with differences in ability; and the place of school in adolescents' lives. As such, these studies checked the information gained from official sources with information gained from teachers, students, and parents to ascertain the degree to which official policy reflects actual practice. The objective is to describe major policies and practices in the nations under study that are similar to, different from, or nonexistent in the United States.

The research plan called for each of the four topics to be studied in three locations in each country. The specific cities and schools were selected "purposively"; that is, while they are not a representative sample, they are geographically separated, contain different mixes of students, and have different teaching and learning environments. One location was designated as the primary site at which the greatest amount of time was spent and contained each of the three grade levels and levels of academic ability included in the assessment phase of TIMSS—one at the elementary level (grade 4), one at middle school (grade 8/population 2), and one at the high school level (grade 12). The other two locations were considered as secondary sites and were used to check the generality of the findings obtained from study at the primary site. As such, visits to secondary sites did not necessarily involve all three grade levels. Since these schools were not part of the TIMSS sample, where possible they were asked to administer the appropriate TIMSS tests to the students in the designated classrooms. Researchers in each of the countries used a variety of methods that rely on the interaction of experienced researchers with families and teachers in each of the countries, and on observation in schools. Information also was obtained from school authorities and governmental policy experts.

The resulting rich descriptive information obtained by the experienced interviewer and observers provides insight into and understanding of the organizational and cultural facts and on the practices, behaviors, and attitudes that contribute to the operation and outcomes of the educational system in each of the countries. Results from the Case Studies also served in isolating and clarifying many of the factors underlying cross-national differences in academic achievement and, especially so, when viewed in the overall context of the information collected in TIMSS.

2. Student Achievement

I. International Perspectives on U.S. Mathematics and Science Achievement

In 1983 the authors of *A Nation at Risk* observed that:

> *International comparisons of student achievement, completed a decade ago, reveal that on 19 academic tests American students were never first or second and, in comparison with other industrialized nations, were last seven times.*
> (National Commission on Excellence in Education, 1983, p.8)

From that time on, concern with where U.S. students stand vis-a-vis their peers in other nations, particularly those nations seen as competing with the United States in world markets, has grown. This concern, and the intent to remedy the situation, is reflected in the fifth of the eight National Education Goals: By the year 2000, United States students will be first in the world in mathematics and science achievement.

The discussion that follows looks at the mathematics and science achievement of U.S. middle school students, comparing the average level of performance of U.S. seventh and eighth graders with that of their peers in 40 other nations. Comparisons are made in terms of overall measures of mathematics and science achievement and with respect to the several content areas of mathematics and science. The discussion opens with a consideration of the performance of U.S. seventh and eighth graders relative to their peers in those nations that met TIMSS sampling specifications—27 and 25 nations, respectively, at these grade levels. It moves then to a focus on eighth graders alone, since this is the group of primary interest in population 2, and to the performance of these students relative to students in all 41 participating countries. In addition, some observations are made about changes, or the lack thereof, in the relative international standing of U.S. middle school students over the past 30 years.[1]

International Studies of Student Achievement

The source for the observation made in *A Nation at Risk* was the cross-national studies of student achievement carried out by the International Association for the Evaluation of Educational Achievement (IEA). These studies provide the only sustained source of information on this topic. Initiated in the 1960s by a group of prominent educational researchers from several countries and steered through their formative years by Torsten Husen, they continue to provide comparisons of the achievement levels of nations in a variety of subject-matter areas. While achievement comparisons are not the sole focus of IEA studies, they are the most visible component for at least the reason that matters of national pride and national productivity are considered to be at issue. Explanations of the between-nation differences in achievement highlighted in this way tend to be cast in terms of parallel differences in curriculum and/or instruction.

1 The analyses reported in this chapter have been published in a slightly different form in *Pursuing Excellence* (National Center for Education Statistics, 1996).

An International Perspective on the Achievement of U.S. Middle School Students

The factual basis for the discussion that follows is taken from three sources. The first of these is the international comparisons of mathematics and science achievement reported in the population 2 TIMSS reports (Beaton et al., 1996a; 1996b).[2] The second source, used to provide an historical perspective on the performance of U.S. students, is a synthesis of the findings of previous international studies conducted by IEA and reported in Medrich and Griffith (1992). The third source is reports of the International Assessment of Educational Progress (IAEP)—Lapointe et al. (1992a; 1992b)—which provide information of a kind similar to the IEA studies, information that is used to extend this "time series" of international comparisons.

Focusing on U.S. Performance

Unlike the international reports, which compare each nation with every other, the performance of the United States relative to other nations is the focus of the present analyses. To this end, the analyses are designed to identify nations whose average levels of achievement are significantly higher than, significantly lower than, and not significantly different from that of the United States. This focus is further sharpened by limiting the analyses to comparisons of achievement only, though expressed in several forms. Other information presented in the international reports—on such matters differences between lower- and upper-grade students, the achievement of 13-year-olds, and performance on specific test items—is considered outside the purview of the present analyses. In short, the following discussion is about the mathematics and science performance of U.S. middle school students, and in this discussion, most attention is directed to eighth graders.

2 The TIMSS International Study Center at Boston College, under the direction of Albert Beaton, kindly made available the tabular material from its population 2 international reports prior to publication to facilitate these analyses.

II. Where We Stand Among Nations

Two kinds of evidence are brought to bear on this matter. One relies on comparing the mathematics and science performances of the average student in each nation and the average student in all nations combined with that of the average U.S. eighth grader. The second form of evidence comes from similar comparisons but this time based on the proportion of students in each nation who meet an internationally defined cut-off score. Most of the findings are based on overall scores for mathematics and science. However, attention is also given to content-specific areas of mathematics and science by providing comparisons of national averages for each of these content areas.

Comparing Average Students

The measures of mathematics and science achievement available at the time the analyses were undertaken follow. National averages based on the total Item Response Theory (IRT) scale scores for mathematics and science provide the basis for the discussion. Comparisons of national averages for content-specific areas of mathematics and science are covered later.

MATHEMATICS

Total Score	IRT scale score[3]
Total Score	Percent Correct[4]
Content Area Scores	
Fractions and Number Sense	Percent Correct
Geometry	Percent Correct
Algebra	Percent Correct
Data Representation, Analysis and Probability	Percent Correct
Measurement	Percent Correct
Proportionality	Percent Correct

SCIENCE

Total Score	IRT scale score
Total Score	Percent Correct
Content Area Scores	
Earth Science	Percent Correct
Life Science	Percent Correct
Physics	Percent Correct
Chemistry	Percent Correct
Environmental Issues and the Nature of Science	Percent Correct

A Restricted Set of Comparisons

Figure 2-1 is adapted from the TIMSS international report on middle school mathematics achievement (Beaton et al., 1996a, tables 1-1 and 1-2). It displays the mean of the overall score separately for upper- and lower-grade students in each of the participating countries[5] —in the case of the United States, seventh and eighth graders. However, in this figure the number of nations being compared is restricted somewhat by quality control considerations. Concerns about the representativeness of samples have separated the countries into two groups: those that met the sampling criteria and those that did not.[6] The latter group is further subdivided according to the nature of the departure from sampling guidelines. The rationale for this distinction is that nations that failed to meet the sampling criteria may have unwittingly excluded certain subpopulations of students and, as a result, generated national achievement estimates biased to some (unknown) degree.[7]

3 Item Response Theory (IRT) is the name given to the statistical model used to scale the test items (see Hambleton et al., 1991, for an overview). The measures of total mathematics achievement and total science achievement available at this time were based on single plausible values. This IRT scale score for each of mathematics and science provides good estimates of national averages but not of individual student scores.

4 Scores for content area performance were cast in percent correct form, and these, too, allow estimates only for the country as a whole, not for students within countries. Percent correct is, as the name suggests, the percent of items answered correctly.

5 Note that only 39 of the 41 nations provided eligible data for the lower-grade.

6 These criteria are described in Foy et al. (1996).

7 Critics of cross-national achievement comparisons have voiced concerns of this kind often (Rotberg, 1990, for example), though mostly in connection with twelfth grade samples where between-country differences in school retention can lead to problems of comparability. At seventh and eighth grade this matter is less problematic, but the issue remains.

Mathematics. Figure 2-1 shows the nations separated into four or five groups—four for lower-grade students and five for upper-grade students. In the upper panel of the table are the nations meeting all the internationally established sampling criteria, listed in order of average achievement—27 nations in the case of the lower grade, and 25 for the upper grade. Even here, some nations, including the United States, are flagged in the international reports as not having met the strictest requirements regarding the use of replacement schools to substitute for nonresponding schools.[8] The second panel of the figure identifies nations that failed to meet the 85 percent response rate requirements for schools even after replacement. In the third panel are nations failing to meet age/grade requirements, and in the fourth and fifth panels are nations whose sampling procedures did not meet other sampling specifications. Only nations in the first panel are listed according to their average achievement.

Since an average score fails to take into account sampling error, means may differ as a function of sampling error alone. The extent of this sampling error is indicated in the standard error of each mean, shown in the column next to the mean. Taking this sampling error into account, tests of the statistical significance of the difference between the U.S. mean and the means of other nations allow the following three kinds of observations: a country's mean can be significantly higher than that of the United States; not significantly different from the U.S. mean; or, significantly lower than the U.S. mean.[9] Tests of the significance of the differences between the means of all 41 nations are provided in figure 1-1 of Beaton et al. (1996a).

In the case of lower-grade students, 12 of the 27 countries have significantly higher levels of mathematics achievement than the United States, 9 have levels not significantly different from the U.S. mean, and 5 show significantly lower levels of achievement (see Beaton et al., 1996a, table 1-2 and figure 1-2). The picture for upper-grade students is similar. The first 14 of the 25 nations listed in the upper panel have average levels of mathematics achievement that are significantly higher than that of the U.S. upper-grade students. This leaves six nations whose upper-grade students' average level of mathematics achievement is not significantly different from that of U.S. upper-grade students, and four where mathematics achievement levels are lower than those in the United States.

Comparisons with the international mean summarize these findings. In mathematics, the international mean for lower-grade students is 492, the mean of the 27 lower-grade students' country means. Its analogue for upper-grade students is based on 25 countries and comes to 527. In each instance the U.S. mean is significantly lower than the international mean. In short, the mathematics performance of U.S. middle school students is below this international average at both grade levels.[10]

8 In the case of the U.S. population 2 school sample, the cooperation rate without replacement was 77 percent. The use of replacement schools lifted this cooperation rate to 85 percent. For further details, see the discussion of this matter in Chapter 1.

9 Note that "not significantly different" need not mean scores are "not different." Since these means are based on sample data rather than population data, each is an estimate of the true mean for the nation. Differences between the estimated means may reflect real differences among the true means, sampling error, or both. Since we cannot be sure at the chosen level of certainty, we reserve judgment in this instance by saying "not significantly different."

10 Note that the results of statistical comparisons involving the international mean are indicated by symbols at the base of the appropriate figures.

Figure 2-1

Total mathematics score by country; lower and upper grades, population 2; selected nations, 1995

Nation	Mean Achievement	Standard Error	Grade	Mean Age	Nation	Mean Achievement	Standard Error	Grade	Mean Age
					UPPER GRADE				
Singapore	601	6.3	7	13.3	Singapore	643	4.9	8	14.5
Korea	577	2.5	7	13.2	Korea	607	2.4	8	14.2
Japan	571	1.9	7	13.4	Japan	605	1.9	8	14.4
Hong Kong	564	7.8	7	13.4	Hong Kong	588	6.5	8	14.2
Belgium (Fl)	558	3.5	7	13.0	Belgium (Fl)	565	5.7	8	14.1
Czech Republic	523	4.9	7	13.4	Czech Republic	564	4.9	8	14.4
Slovak Republic	508	3.4	7	13.1	Slovak Republic	547	3.3	8	14.3
Belgium (Fr)	507	3.5	7	13.3	Switzerland	545	2.8	7/8	14.2
Switzerland	506	2.3	6/7	13.2	France	538	2.9	8	14.3
Hungary	502	3.7	7	13.1	Hungary	537	3.2	8	14.3
Russian Federation	501	4.0	6/7	13.2	Russian Federation	535	5.3	7/8	14.0
Ireland	500	4.1	7	13.4	Ireland	527	5.1	8	14.4
Canada	494	2.2	7	12.9	Canada	527	2.4	8	14.1
France	492	3.1	7	13.0	Sweden	519	3.0	7	13.9
Sweden	477	2.5	6	13.1	New Zealand	508	4.5	8.5/9.5	14.0
England	476	3.7	8	12.9	England	506	2.6	9	14.0
UNITED STATES	476	5.5	7	13.0	Norway	503	2.2	7	13.9
New Zealand	472	3.8	7.5/8.5	13.2	UNITED STATES	500	4.6	8	14.2
Scotland	463	3.7	8	12.7	Latvia (LSS)	493	3.1	8	14.3
Latvia (LSS)	462	2.8	7	12.6	Spain	487	2.0	8	14.3
Norway	461	2.8	6	13.3	Iceland	487	4.5	8	13.6
Iceland	459	2.6	7	13.2	Lithuania	477	3.5	8	14.3
Spain	448	2.2	7	13.6	Cyprus	474	1.9	8	13.7
Cyprus	446	1.9	7	13.3	Portugal	454	2.5	8	14.5
Lithuania	428	3.2	7	13.4	Iran, Islamic Republic	428	2.2	8	14.6
Portugal	423	2.2	7	12.8					
Iran, Islamic Republic	401	2.0	7	13.4					
	▼					▼			

Australia	498	3.8	7/8	13.2	Australia	530	4.0	8/9	14.2
Austria	509	3.0	7	13.3	Austria	539	3.0	8	14.3
Bulgaria	514	7.5	7	13.1	Belgium (Fr)	526	3.4	8	14.3
Netherlands	516	4.1	7	13.2	Bulgaria	540	6.3	8	14.0
					Netherlands	541	6.7	8	14.3
					Scotland	498	5.5	9	13.7

Colombia	369	2.7	7	14.5	Colombia	385	3.4	8	15.7
Germany	484	4.1	7	13.8	Germany	509	4.5	8	14.8
Romania	454	3.4	7	13.7	Romania	482	4.0	8	14.6
Slovenia	498	3.0	7	13.8	Slovenia	541	3.1	8	14.8
					Denmark	502	2.8	7	13.9
					Greece	484	3.1	8	13.6
					Thailand	522	5.7	8	14.3

Denmark	465	2.1	6	12.9	Israel	522	6.2	8	14.1
Greece	440	2.8	7	12.6	Kuwait	392	2.5	9	15.3
South Africa	348	3.8	7	13.9	South Africa	354	4.4	8	15.4
Thailand	495	4.8	7	13.5					

					Israel	522	6.2	8	14.1
					Kuwait	392	2.5	9	15.3
					South Africa	354	4.4	8	15.4

Key:

- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- (light shading) Country mean significantly higher than U.S. mean
- (no shading) Country mean not significantly different from U.S. mean
- (dark shading) Country mean significantly lower than U.S. mean

NOTE:

The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.

Latvia (LSS) indicates only the Latvian-speaking schools were sampled.

SOURCE:

Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Tables 1.1 and 1.2) Chestnut Hill, MA: Boston College.

Science. Figure 2-2 is adapted from the international report on middle school science achievement (Beaton et al., 1996b, tables 1-1 and 1-2) and is the analogue of figure 2-1 presented earlier. In lower-grade science, five of these countries have significantly higher levels of achievement than the United States, six have levels that are not significantly different, and 15 show lower levels of achievement (see Beaton et al., 1996b, table 1-2 and figure 1-2). Where upper-grade students are concerned, five nations have average levels of science achievement that are significantly higher than that of the United States, 11 nations have achievement levels not significantly different from that of the United States, and 8 show average achievement levels that are significantly lower.

Relative to the international mean, mean science achievement for U.S. lower-grade students is significantly higher, and that for upper-grade students is not significantly different. U.S. standing in science, then, differs by grade. The performance of lower-grade students is somewhat above the international average. However, the performance of U.S. upper-grade students does not differ from the international mean.

Extending Comparisons to Forty-one Nations

Since their beginnings, and especially in the earlier years, IEA studies have come in for some criticism with respect to sampling. Most of this has been directed at the sampling of students in the final year of secondary school where differences in student attrition between nations have created noncomparable final-year student populations. Sampling of student populations still within the years of compulsory schooling has been less problematic but probably not as precise as it might have been, largely as a result of resources and the limited authority of IEA over its relatively autonomous members. The introduction of more explicit sampling designs and quality control procedures, first in the Reading Literacy Study (Wolf, 1995), and subsequently with increased vigor in TIMSS, has gone a long way toward remedying the situation.

This increased attention to quality control in sampling has had the effect of disqualifying about one-third of the TIMSS nations from explicit achievement comparisons of the kind made earlier. In the international publications, the countries in question are shown separately and are not ranked, though they are included in other tables and in the figures providing multiple comparisons of country means (figure 1-1 in each of Beaton et al., 1996a; 1996b). The effect of this is to trade off coverage of nations for increased precision in the international achievement comparisons. While this emphasis on strict comparability is almost a requirement for the international reports, it is possible to adopt a less restrictive approach in the U.S. national report by placing the United States among all 41 nations and qualifying the comparisons as appropriate. This has the advantage of setting the United States among a broader range of nations and providing for comparisons with most of those nations that are economic competitors of the United States. It allows as well for international comparisons over time with the first and second IEA studies of mathematics and science achievement.

Figure 2-2

Total science score by country; lower and upper grades, population 2; selected nations, 1995

LOWER GRADE					UPPER GRADE				
Nation	Mean Achievement	Standard Error	Grade	Mean Age	Nation	Mean Achievement	Standard Error	Grade	Mean Age
Singapore	545	6.6	7	13.3	Singapore	607	5.5	8	14.5
Korea	535	2.1	7	13.2	Czech Republic	574	4.3	8	14.4
Czech Republic	533	3.3	7	13.4	Japan	571	1.6	8	14.4
Japan	531	1.9	7	13.4	Korea	565	1.9	8	14.2
Belgium (Fl)	529	2.6	7	13.0	Hungary	554	2.8	8	14.3
Hungary	518	3.2	7	13.4	England	552	3.3	9	14.0
England	512	3.5	8	13.1	Belgium (Fl)	550	4.2	8	14.1
Slovak Republic	510	3.0	7	13.3	Slovak Republic	544	3.2	8	14.3
UNITED STATES	508	5.5	7	13.2	Russian Federation	538	4.0	7/8	14.0
Canada	499	2.3	7	13.1	Ireland	538	4.5	8	14.4
Hong Kong	495	5.5	7	13.2	Sweden	535	3.0	7	13.9
Ireland	495	3.5	7	13.4	UNITED STATES	534	4.7	8	14.2
Sweden	488	2.6	6	12.9	Canada	531	2.6	8	14.1
Russian Federation	484	4.2	6/7	13.0	Norway	527	1.9	7	13.9
Switzerland	484	2.5	6/7	13.1	New Zealand	525	4.4	8.5/9.5	14.0
Norway	483	2.9	6	12.9	Hong Kong	522	4.7	8	14.2
New Zealand	481	3.4	7.5/8.5	13.0	Switzerland	522	2.5	7/8	14.2
Spain	477	2.1	7	13.2	Spain	517	1.7	8	14.3
Scotland	468	3.8	8	12.7	France	498	2.5	8	14.3
Iceland	462	2.8	7	12.6	Iceland	494	4.0	8	13.6
France	451	2.6	7	13.3	Latvia (LSS)	485	2.7	8	14.3
Belgium (Fr)	442	3.0	7	13.2	Portugal	480	2.3	8	14.5
Iran, Islamic Republic	436	2.6	7	13.6	Lithuania	476	3.4	8	14.3
Latvia (LSS)	435	2.7	7	13.3	Iran, Islamic Republic	470	2.4	8	14.6
Portugal	428	2.1	7	13.4	Cyprus	463	1.9	8	13.7
Cyprus	420	1.8	7	12.8					
Lithuania	403	3.4	7	13.4					
International Mean	483					527			
U.S. mean	▲					■			
Countries not satisfying guidelines for sample participation rates									
Australia	504	3.6	7/8	13.2	Australia	545	3.9	8/9	14.2
Austria	519	3.1	7	13.3	Austria	558	3.7	8	14.3
Bulgaria	531	5.4	7	13.1	Belgium (Fr)	471	2.8	8	14.3
Netherlands	517	3.6	7	13.2	Bulgaria	565	5.3	8	14.0
					Netherlands	560	5.0	8	14.3
					Scotland	517	5.1	9	13.7
Countries not meeting age/grade specifications (high percentage of older students)									
Colombia	387	3.2	7	14.5	Colombia	411	4.1	8	15.7
Germany	499	4.1	7	13.8	Germany	531	4.8	8	14.8
Romania	452	4.4	7	13.7	Romania	486	4.7	8	14.6
Slovenia	530	2.4	7	13.8	Slovenia	560	2.5	8	14.8
					Denmark	478	3.1	7	13.9
					Greece	497	2.2	8	13.6
					Thailand	525	3.7	8	14.3
Countries with unapproved sampling procedures at classroom level									
Denmark	439	2.1	6	12.9	Israel	524	5.7	8	14.1
Greece	449	2.6	7	12.6	Kuwait	430	3.7	9	15.3
South Africa	317	5.3	7	13.9	South Africa	326	6.6	8	15.4
Thailand	493	3.0	7	13.5					
Unapproved sampling procedures at classroom level and not meeting other guidelines									
					Israel	524	5.7	8	14.1
					Kuwait	430	3.7	9	15.3
					South Africa	326	6.6	8	15.4

Key:

▲ Significantly higher than international mean

▼ Significantly lower than international mean

■ Not significantly different from international mean

Country mean significantly higher than U.S. mean

Country mean not significantly different from U.S. mean

Country mean significantly lower than U.S. mean

NOTE:
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.

SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Tables 1.1 and 1.2) Chestnut Hill, MA: Boston College.

In the interests of providing for a relatively simple presentation from this point on, the focus of the analyses shifts to U.S. eighth graders, the middle school grade of primary interest. No further reference is made to the performance of U.S. seventh graders, though parallel information to that presented in this report can be extracted from the two international reports.

Mathematics and science. Figure 2-3 presents information on the mathematics and science achievement of upper-grade students in each of the 41 participating nations and offers comparisons with the achievement of U.S. eighth graders. The presentation differs from that in Beaton et al. (1996a, 1996b) in that countries are listed in one list according to their average score. Countries not meeting TIMSS sampling guidelines are identified by italics. Figure 2-3 provides the following information:

- National means for mathematics and science based on upper-grade students;
- Identification of nations that meet and do not meet TIMSS sampling specifications;
- Identification of countries whose mean achievement is significantly greater than, less than, and not different from, that of the United States; and
- The average of all 41 national means, identified as the "international mean."[11]

Focusing for the moment just on performance in mathematics, figure 2-3 makes it clear that there is a considerable spread among the nations. Singapore leads with an average of 643, and South Africa brings up the rear with a score of 354.[12] With a mean of 500, the United States turns in a performance that is below average by international standards; that is, the U.S. mean is significantly lower than the international mean of 513.

Countries whose means are significantly higher than, lower than, and indistinguishable from the U.S. mean are indicated in figure 2-3. With an average of 500 U.S. eighth graders score below 20 nations,[13] do better than 7 countries,[14] and show a level of performance indistinguishable from that of 13 others.[15]

The rightmost column of figure 2-3 presents analogous information on the science achievement of U.S. eighth graders. As with mathematics, the range of scores among nations is substantial. Again, Singapore leads with an average of 607, and South Africa trails with a 326. With a mean score of 534, the United States does relatively well with an average that is significantly higher than the international mean of 516.

U.S. eighth graders do significantly better than their peers in 15 nations,[16] though students in 9 countries[17] appear to know more science, on average. The remaining 16 nations[18] have mean scores not significantly different from that of the United States. Relatively speaking then, the world standing of the United States is better in science than in mathematics.

11 While it is not a world mean in the strict sense, this international mean includes the scores of a sizeable proportion of the world's nations.

12 These scores have no concrete meaning of the kind given by, for example, percent-correct scores.

13 Singapore, Korea, Japan, Hong Kong, Flemish-speaking Belgium, Czech Republic, Slovak Republic, Switzerland, Netherlands, Slovenia, Bulgaria, Austria, France, Hungary, Russian Federation, Australia, Ireland, Canada, French-speaking Belgium, and Sweden.

14 Lithuania, Cyprus, Portugal, Iran, Kuwait, Colombia, and South Africa.

15 Thailand, Israel, Germany, New Zealand, England, Norway, Denmark, Scotland, Latvia, Spain, Iceland, Greece, and Romania.

16 Spain, France, Greece, Iceland, Romania, Latvia, Portugal, Denmark, Lithuania, French-speaking Belgium, Iran, Cyprus, Kuwait, Colombia and South Africa.

17 Singapore, Czech Republic, Japan, Korea, Bulgaria, Netherlands, Slovenia, Austria, and Hungary.

18 England, Flemish-speaking Belgium, Australia, Slovak Republic, Russian Federation, Ireland, Sweden, Germany, Canada, Norway, New Zealand, Thailand, Israel, Hong Kong, Switzerland, and Scotland.

Figure 2-3
Mathematics and science total scores by country; upper grade, population 2; all nations, 1995

MATHEMATICS

Total Score

Nation	Mean
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium (Fl)	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	540
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium (Fr)	526
Thailand	522
Israel	522
Sweden	519
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
UNITED STATES	500
Scotland	498
Latvia (LSS)	493
Spain	487
Iceland	487
Greece	484
Romania	482
Lithuania	477
Cyprus	474
Portugal	454
Iran, Islamic Republic	428
Kuwait	392
Colombia	385
South Africa	354
International Mean	513
U.S. mean	▼

SCIENCE

Total Score

Nation	Mean
Singapore	607
Czech Republic	574
Japan	571
Korea	565
Bulgaria	565
Netherlands	560
Slovenia	560
Austria	558
Hungary	554
England	552
Belgium (Fl)	550
Australia	545
Slovak Republic	544
Russian Federation	538
Ireland	538
Sweden	535
UNITED STATES	534
Germany	531
Canada	531
Norway	527
New Zealand	525
Thailand	525
Israel	524
Hong Kong	522
Switzerland	522
Scotland	517
Spain	517
France	498
Greece	497
Iceland	494
Romania	486
Latvia (LSS)	485
Portugal	480
Denmark	478
Lithuania	476
Belgium (Fr)	471
Iran, Islamic Republic	470
Cyprus	463
Kuwait	430
Colombia	411
South Africa	326
International Mean	516
U.S. mean	▲

Key:

- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- Country mean significantly higher than U.S. mean
- Country mean not significantly different from U.S. mean
- Country mean significantly lower than U.S. mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.
The placement of Sweden may appear out of place; however, statistically its placement is correct.

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

The Distribution of Achievement

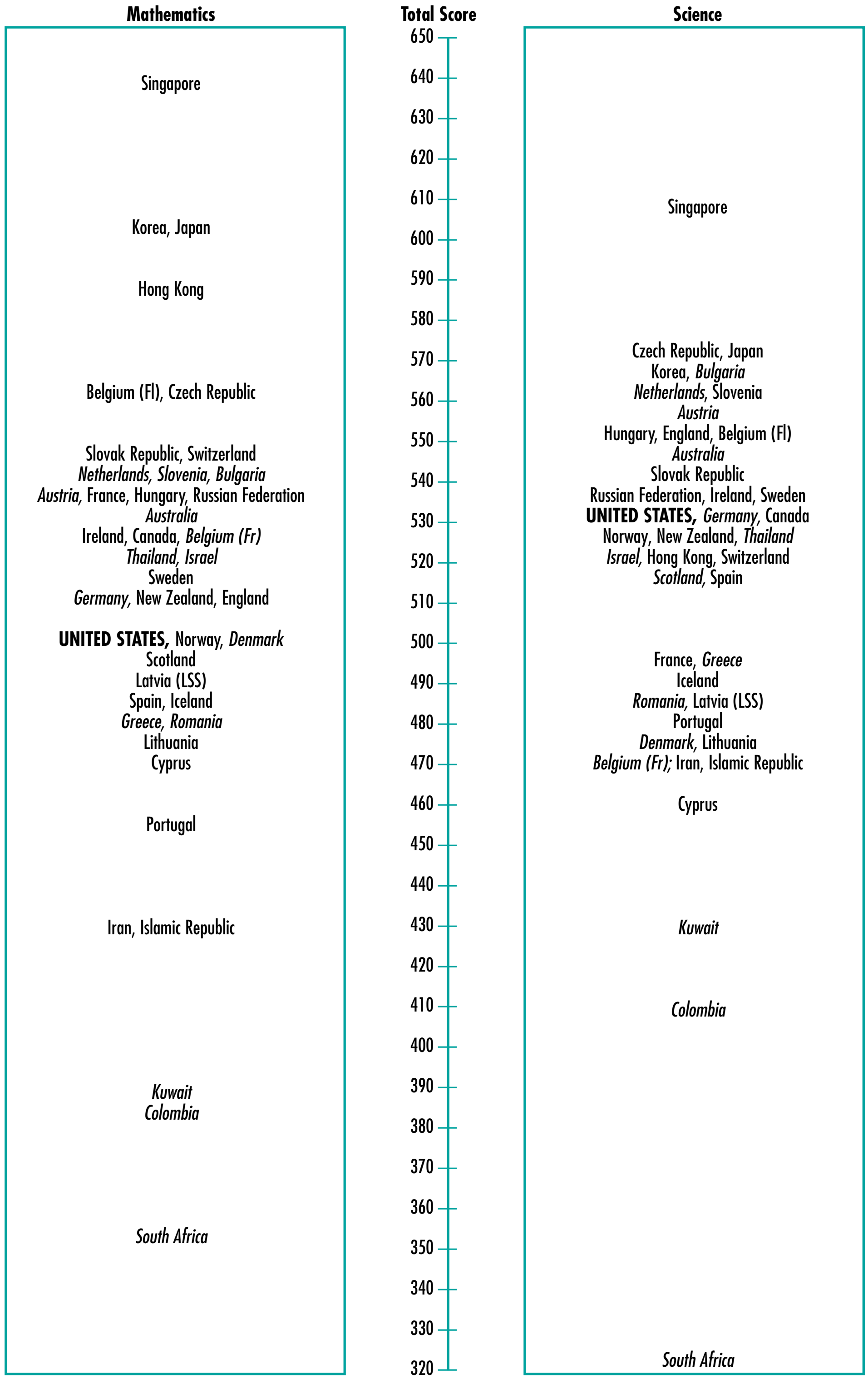
Listing the nations according to their average scores indicated in figures 2-1 through 2-3 obscures the fact that the distance between nations' average scores varies. For example, although figure 2-3 shows Singapore adjacent to Korea and Japan in the listing, it is easy to overlook the fact that the national averages for Korea and Japan are only 2 points apart, while the gap between Singapore and Korea is 36 points. In picturing the performance of nations and the place of the United States among these nations, it is helpful to have this additional perspective on the distribution of mathematics and science achievement across the TIMSS nations. Figure 2-4 provides this perspective by taking into account the distance between national averages. Note, however, that the position of nations in the figure is indicative rather than exact and meant only to provide an indication of the spread among national scores.[19]

Comparing the Best Students

The following discussion shifts focus a little—from the relative performance of the "average" student to that of the "best" student. Best in this instance is defined as being among the "international best"—for example, being among the top 10 percent of all upper-grade students regardless of nation. What this amounts to is establishing an international benchmark and then looking at the percentage of students from each nation that equal or better this cutoff. Three such benchmarks were defined internationally and marked by scores that identified, respectively, the top 10, 25, and 50 percent of students from the pool of all students from all 41 nations.[20]

19 Since the mathematics and science total scores were scaled independently of each other, direct comparisons of mathematics/science performance are not legitimate.
20 Differences in sample size were adjusted so that all nations contributed to this pool in proportion to the size of their eighth grade population.

Figure 2-4
Distribution of mathematics and science total scores; upper grade, population 2; all nations, 1995



NOTE:
Nations not meeting international sampling guidelines shown in italics.
Nations' total scores are grouped by 5 points. Placement of countries is approximate.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.

Mathematics. Figure 2-5 provides this benchmark performance information for eighth graders' mathematics achievement. The form of presentation is similar to that used in previous figures. The difference here is that instead of being ordered by means, countries are listed by the estimated proportion of their students in the top 10, 25, and 50 percent respectively of all students. For example, in the first column of figure 2-5, that referring to the top 10 percent benchmark, the data presented indicate that 45 percent of eighth-grade students in Singapore are in the top 10 percent of all students. In the case of the United States, the comparable figure is 5 percent. Nations vary a great deal in the percentage of their students that achieve this level of performance. More than one-fourth of students from each of the four top-ranked Asian nations do well enough to be in the top 10 percent of all students. At the other end of the distribution, none of the sampled students in Portugal, Colombia, Iran, Kuwait, or South Africa exceed the cutoff.

Figure 2-5 also indicates which nations are significantly different in this respect from the United States and those that are not. Sixteen nations have significantly greater proportions of their students in the top 10 percent of all students. Among these are the four Asian nations (Singapore, Korea, Japan, Hong Kong), six Eastern European countries (Czech Republic, Bulgaria, Slovak Republic, Hungary, Slovenia, Russian Federation), five Western European nations (Flemish-speaking Belgium, Austria, Switzerland, Netherlands, Ireland), and Australia. Fifteen nations are not significantly different from the United States in terms of the proportion of their students meeting this benchmark; and nine others have lower proportions of their students in the top 10 percent than the United States. By the criterion applied here, only one-half of the U.S. top 10 percent get into the world top 10 percent.

With regard to the two less stringent benchmarks—the 25 and 50 percent cutoffs—18 percent of U.S. eighth graders make it into the top 25 percent of all students, and 45 percent are counted among the top 50 percent of students from all 41 participating countries. In each instance, the United States is not among the top half of the countries with regard to the proportions of students who represent either the top 25 percent or the top 50 percent.

Figure 2-5

Percentage of students in top 10, 25, and 50 percent of all students; mathematics total score; upper grade, population 2; all nations, 1995

Percent of students in international top 10 percent

Nation	%
Singapore	45
Korea	34
Japan	32
Hong Kong	27
Czech Republic	18
Belgium (Fl)	17
Bulgaria	16
Slovak Republic	12
Austria	11
Hungary	11
Slovenia	11
Australia	11
Switzerland	11
Netherlands	10
Russian Federation	10
Ireland	9
Canada	7
Thailand	7
France	7
England	7
Israel	6
New Zealand	6
Germany	6
Belgium (Fr)	6
Sweden	5
Scotland	5
UNITED STATES	5
Norway	4
Denmark	4
Greece	3
Romania	3
Latvia (LSS)	3
Cyprus	2
Spain	2
Iceland	1
Lithuania	1
Portugal	0
Colombia	0
Iran, Islamic Republic	0
Kuwait	0
South Africa	0

Percent of students in international top 25 percent

Nation	%
Singapore	74
Japan	58
Korea	58
Hong Kong	53
Belgium (Fl)	41
Czech Republic	39
Switzerland	33
Slovak Republic	33
Bulgaria	33
Austria	31
Slovenia	31
Netherlands	30
Russian Federation	29
Hungary	29
Australia	29
Ireland	27
France	26
Belgium (Fr)	25
Canada	25
Israel	24
Thailand	23
Sweden	22
Germany	20
England	20
New Zealand	20
UNITED STATES	18
Denmark	17
Scotland	17
Norway	17
Latvia (LSS)	14
Romania	13
Greece	13
Cyprus	11
Iceland	10
Spain	10
Lithuania	10
Portugal	2
Colombia	1
Iran, Islamic Republic	0
Kuwait	0
South Africa	0

Percent of students in international top 50 percent

Nation	%
Singapore	94
Japan	83
Korea	82
Hong Kong	80
Belgium (Fl)	73
Czech Republic	70
Switzerland	65
Slovak Republic	64
France	63
Netherlands	63
Slovenia	61
Austria	61
Russian Federation	60
Hungary	60
Belgium (Fr)	58
Canada	58
Australia	57
Ireland	57
Bulgaria	57
Israel	56
Thailand	54
Sweden	53
Germany	49
New Zealand	48
England	48
Denmark	47
Norway	46
UNITED STATES	45
Scotland	44
Latvia (LSS)	40
Iceland	37
Greece	37
Romania	36
Spain	36
Lithuania	34
Cyprus	34
Portugal	19
Iran, Islamic Republic	9
Colombia	4
Kuwait	3
South Africa	2

Key:

- Country percent significantly higher than U.S. mean
- Country percent not significantly different from U.S. mean
- Country percent significantly lower than U.S. mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.

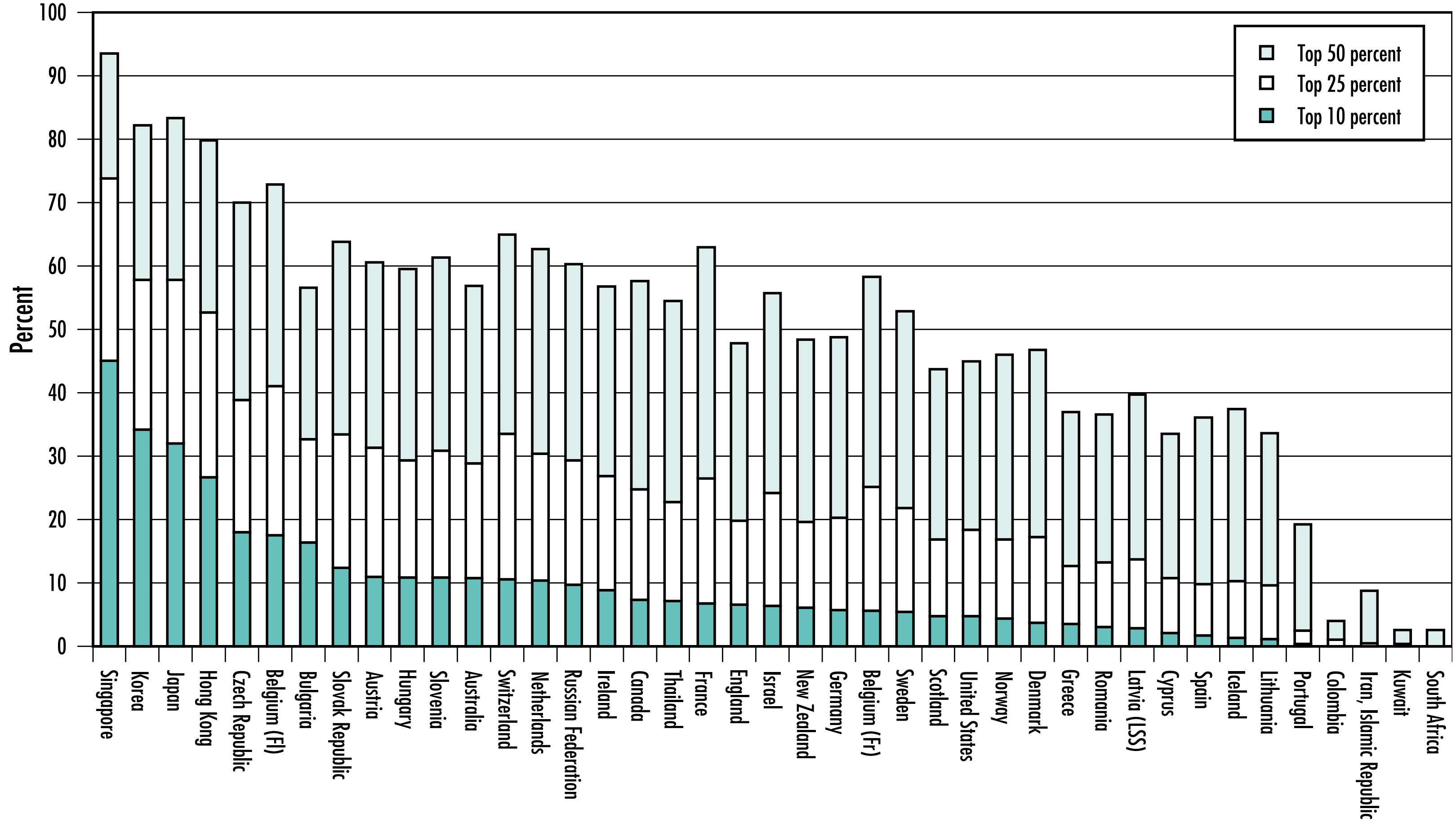
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.4) Chestnut Hill, MA: Boston College.

It is possible to take a more consolidated view of these comparisons, one that highlights visually the differences between nations with regard to proportions of students reaching each cutoff point and the cumulation of these proportions across these three benchmarks. Figure 2-6 presents this view of the findings with regard to mathematics. The figure adopts a stacked-bar format in which the bar for each nation has three parts: the sector nearest the axis indicates the proportion of students reaching the 10 percent cutoff; the adjoining sector represents the proportion of students making the 25 percent benchmark over and above those who make the 10 percent mark; and the final sector shows the additional proportion of students who make the 50 percent cutoff over and above those making the 25 percent cutoff. The nations in question are ordered by the proportion of students in the international top 10 percent.

In this way the three sectors of each bar are cumulative. The height of the first sector represents the proportion of students in the top 10 percent internationally. The height of the first two sectors combined shows the proportion of students in the top 25 percent internationally, and the height of all three sectors indicates the proportion of students in the top 50 percent of all students. Thus, Singapore can be seen to have 45 percent of students in the top 10 percent group, 74 percent of students in the top 25 percent of all students, and 94 percent in the top 50 percent of all students.

Figure 2-6

International benchmarks in mathematics: top 10, 25, and 50 percent of all students; total score; upper grade, population 2; 1995



NOTE:
Nations are ordered according to their standing at the 10 percent benchmark.
The French-speaking (Belgium-Fr) and the FLemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.4) Chestnut Hill, MA: Boston College.

Science. Figure 2-7 provides analogous information on the science performance of U.S. eighth graders' relative to international benchmarks. With an estimated 13 percent of U.S. eighth graders meeting the top 10 percent benchmark, U.S. students are overrepresented among the top 10 percent of students from all nations. Some nations did better, of course, but not many. Among the six that did, Singapore has 31 percent of its students in the international top 10 percent, Japan and Korea have 18 percent each, Bulgaria and the Czech Republic have 21 and 19 percent respectively, and the remaining country in the group—England—has 17 percent. At the other extreme, none of the sampled students in Colombia or Kuwait make it into the international top 10 percent.

The picture is similar where the top 25 percent benchmark is concerned, but the relative position of the United States among nations slips a little where the comparison is with the top 50 percent of all students. In this case, although the United States has more than 50 percent of its eighth graders in the top 50 percent of all students, 8 nations have significantly more, and the United States does better than 15 nations. However, overall, the United States has more eighth graders above each of the international benchmarks than would be expected if performance was distributed equally among all nations. These results let us say with some assurance that the best of U.S. eighth graders in science, if not exactly first in the world, are over-represented among the best in the world.

Figure 2-7

Percentage of students in top 10, 25, and 50 percent of all students; science total score; upper grade, population 2; all nations, 1995

Percent of students in international top 10 percent

Nation	%
Singapore	31
Bulgaria	21
Czech Republic	19
Japan	18
Korea	18
England	17
Austria	16
Australia	16
Hungary	14
Slovenia	14
UNITED STATES	13
Netherlands	12
Slovak Republic	12
Ireland	12
Germany	11
Russian Federation	11
Israel	11
New Zealand	11
Belgium (Fl)	10
Sweden	9
Canada	9
Scotland	9
Norway	7
Switzerland	7
Hong Kong	7
Romania	5
Spain	4
Greece	4
Thailand	4
Denmark	2
Iceland	2
Latvia (LSS)	2
Lithuania	1
France	1
Cyprus	1
Belgium (Fr)	1
Portugal	1
South Africa	1
Iran, Islamic Republic	1
Colombia	0
Kuwait	0

Percent of students in international top 25 percent

Nation	%
Singapore	56
Japan	41
Czech Republic	41
Bulgaria	40
Korea	39
Austria	35
Netherlands	35
Slovenia	34
England	34
Hungary	34
Australia	33
Belgium (Fl)	31
UNITED STATES	30
Slovak Republic	30
Ireland	29
Russian Federation	29
Germany	29
Sweden	27
New Zealand	26
Canada	25
Israel	25
Norway	24
Switzerland	23
Scotland	23
Hong Kong	22
Thailand	19
Spain	18
Romania	16
Greece	14
France	11
Latvia (LSS)	10
Iceland	10
Denmark	9
Lithuania	8
Belgium (Fr)	8
Cyprus	7
Portugal	7
Iran, Islamic Republic	5
Kuwait	2
South Africa	1
Colombia	1

Percent of students in international top 50 percent

Nation	%
Singapore	82
Czech Republic	72
Japan	71
Korea	68
Netherlands	67
Slovenia	65
Austria	64
Belgium (Fl)	64
Bulgaria	64
Hungary	63
England	60
Slovak Republic	59
Australia	59
Ireland	57
Sweden	56
Russian Federation	56
UNITED STATES	55
Germany	54
Canada	54
Norway	52
Thailand	51
Israel	51
Hong Kong	51
New Zealand	51
Switzerland	51
Scotland	48
Spain	47
Greece	38
France	37
Iceland	36
Romania	36
Latvia (LSS)	33
Denmark	32
Lithuania	29
Belgium (Fr)	29
Portugal	28
Cyprus	26
Iran, Islamic Republic	24
Kuwait	11
Colombia	8
South Africa	5

Key:

- Country percent significantly higher than U.S. mean
- Country percent not significantly different from U.S. mean
- Country percent significantly lower than U.S. mean

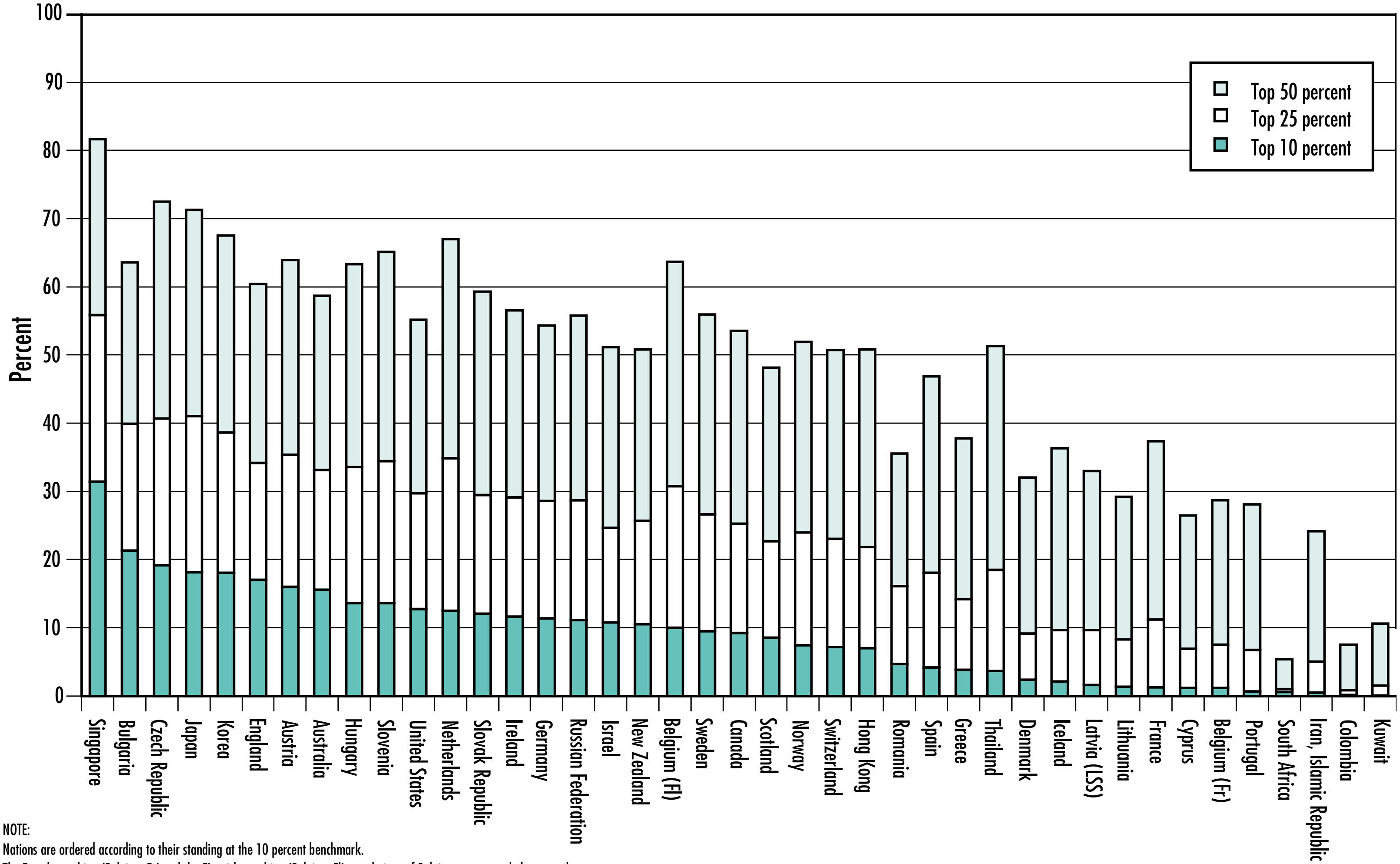
NOTE:
Nations not meeting international sampling guidelines shown in italics.
Canada, Switzerland and Hungary may appear out of place; however, statistically their placement is correct.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.

SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.4) Chestnut Hill, MA: Boston College.

Figure 2-8 is the analogue of figure 2-6; that is, it adopts a cumulative stacked-bar format to display these same data on proportions of students meeting each of the three international benchmarks. Taking the United States as an example, 13 percent of students are included in the top 10 percent of all students, an additional 17 percent are included among the top 25 percent group for a total of 30 percent, and a further 25 percent take the proportion of U.S. eighth graders in the top 50 percent internationally to 55 percent.

Figure 2-8

International benchmarks in science: top 10, 25, and 50 percent of all students; total score; upper grade, population 2; 1995



NOTE:
Nations are ordered according to their standing at the 10 percent benchmark.
The French-speaking (Belgium-Fr) and the FLemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.4) Chestnut Hill, MA: Boston College.

III. U.S. International Standing in Content-specific Areas of Mathematics and Science

Representing student achievement in mathematics and/or science as a total score is a useful summary device but one that conceals a good deal of information about the content structure of mathematics and science. In fact, many would object to the use of a single score to represent achievement, pointing out that both subject areas have well-defined subordinate content structures whose parts are conceptually distinct; have differing levels of complexity; enter the curriculum at different times; and may well be taught differently, sometimes by different teachers. As a result, one might not necessarily expect performance to be highly correlated across content areas. It follows that the use of a total score alone has the potential to obscure substantively interesting variation between content areas. It would be possible, for example, to be first in the world in one content area, last in the world on another, and at the world average in terms of a total score.

Mathematics Content Areas. The mathematics content areas reflected in the TIMSS mathematics test are described in detail in the publication that outlines the curriculum framework on which the test was based (Robitaille et al., 1993). Though there are slight differences between the framework and the assessments developed, the majority of the proposed content areas are covered. They are as follows:

- Fractions and number sense;
- Geometry;
- Algebra;
- Data representation, analysis and probability;
- Measurement; and
- Proportionality.

At the time these analyses were undertaken, scores were available for nations in each of these content areas but not for individual students. These scores take the form of estimates of the average percentage of items answered correctly by the upper-grade students. Figure 2-9 provides a display of these data in a configuration similar to the figures previously presented. In each of the six content areas nations are listed in order of the percentage of items correct; countries not meeting the sampling criteria are shown in italics; countries whose scores are significantly different from that of the United States, and those whose scores are not, are identified; and, the average percentage correct score for all nations is indicated as an "international mean."

The rationale for using content area scores over a total test score finds some support in these data. The performance of U.S. students vis-a-vis the students of other nations varies across the six content areas, in two instances, substantially. While the performance of U.S. students is not at the top in any of these content areas, it is relatively poorer in *geometry, measurement* and *proportionality*.[21] In each of these content

Figure 2-9
Average percent correct scores by country; mathematics content areas; upper grade, population 2; all nations, 1995

Fractions & Number Sense		Geometry		Algebra		Data Representation Analysis & Probability		Measurement		Proportionality	
Nation	%	Nation	%	Nation	%	Nation	%	Nation	%	Nation	%
Singapore	84	Japan	80	Singapore	76	Singapore	79	Singapore	77	Singapore	75
Japan	75	Singapore	76	Japan	72	Korea	78	Japan	67	Hong Kong	62
Korea	74	Korea	75	Hong Kong	70	Japan	78	Korea	66	Korea	62
Hong Kong	72	Hong Kong	73	Korea	69	Belgium (Fl)	73	Hong Kong	65	Japan	61
Belgium (Fl)	71	Czech Republic	66	Czech Republic	65	Switzerland	72	Czech Republic	62	Belgium (Fl)	53
Czech Republic	69	France	66	Hungary	63	*Netherlands*	72	*Austria*	62	Switzerland	52
Switzerland	67	Bulgaria	65	Russian Federation	63	Hong Kong	72	Switzerland	61	Czech Republic	52
Slovak Republic	66	Belgium (Fl)	64	Belgium (Fl)	63	France	71	Slovak Republic	60	*Netherlands*	51
Austria	66	Russian Federation	63	Slovak Republic	62	Sweden	70	Belgium (Fl)	60	*Thailand*	51
Ireland	65	Slovak Republic	63	*Bulgaria*	62	Ireland	69	*Slovenia*	59	Ireland	51
Hungary	65	*Thailand*	62	*Slovenia*	61	Canada	69	Netherlands	57	*Slovenia*	49
France	64	*Slovenia*	60	*Israel*	61	*Austria*	69	France	57	Slovak Republic	49
Canada	64	Hungary	60	*Austria*	59	Czech Republic	68	Hungary	56	*Austria*	49
Slovenia	63	Switzerland	60	*Australia*	55	*Belgium (Fr)*	68	Russian Federation	56	France	49
Sweden	62	*Netherlands*	60	Spain	54	*Australia*	68	Sweden	56	Russian Federation	48
Belgium (Fr)	62	*Belgium (Fr)*	58	France	54	*Denmark*	67	*Belgium (Fr)*	56	Canada	48
Russian Federation	62	Canada	58	Canada	54	Norway	66	*Bulgaria*	54	*Belgium (Fr)*	48
Netherlands	62	*Australia*	57	Ireland	53	New Zealand	66	*Australia*	54	Bulgaria	48
Australia	61	*Israel*	57	*Belgium (Fr)*	53	*Slovenia*	66	Ireland	53	Australia	47
Israel	60	*Austria*	57	*Thailand*	53	England	66	Norway	51	Hungary	47
Bulgaria	60	Latvia (LSS)	57	Switzerland	53	Hungary	66	Canada	51	Sweden	44
Thailand	60	New Zealand	55	*Netherlands*	53	UNITED STATES	65	*Germany*	51	*Israel*	43
UNITED STATES	59	England	54	*Romania*	52	*Scotland*	65	*Thailand*	51	New Zealand	42
Germany	58	*Denmark*	54	UNITED STATES	51	*Germany*	64	England	50	UNITED STATES	42
Norway	58	Lithuania	53	Latvia (LSS)	51	*Israel*	63	*Denmark*	49	*Germany*	42
New Zealand	57	*Romania*	52	New Zealand	49	Iceland	63	New Zealand	48	*Romania*	42
Iceland	54	*Scotland*	52	England	49	*Thailand*	63	*Israel*	48	England	41
England	54	Ireland	51	*Germany*	48	*Bulgaria*	62	*Scotland*	48	*Denmark*	41
Scotland	53	*Germany*	51	Cyprus	48	Slovak Republic	62	*Romania*	48	Norway	40
Denmark	53	Iceland	51	Lithuania	47	Russian Federation	60	Latvia (LSS)	47	Spain	40
Greece	53	Norway	51	*Scotland*	46	Spain	60	Iceland	45	*Scotland*	40
Latvia (LSS)	53	*Greece*	51	*Greece*	46	*Greece*	56	Spain	44	Cyprus	40
Spain	52	Spain	49	Norway	45	Latvia (LSS)	56	Cyprus	44	*Greece*	39
Lithuania	51	Sweden	48	*Denmark*	45	Portugal	54	*Greece*	43	Latvia (LSS)	39
Cyprus	50	UNITED STATES	48	Sweden	44	Cyprus	53	Lithuania	43	Iceland	38
Romania	48	Cyprus	47	Iceland	40	Lithuania	52	UNITED STATES	40	Iran, Islamic Republic	36
Portugal	44	Portugal	44	Portugal	40	*Romania*	49	Portugal	39	Lithuania	35
Iran, Islamic Republic	39	Iran, Islamic Republic	43	Iran, Islamic Republic	37	Iran, Islamic Republic	41	Iran, Islamic Republic	29	Portugal	32
Colombia	31	*Kuwait*	38	*Kuwait*	30	*Kuwait*	39	*Colombia*	25	*Colombia*	23
Kuwait	28	*Colombia*	29	*Colombia*	28	*Colombia*	37	*Kuwait*	24	*South Africa*	21
South Africa	26	*South Africa*	24	*South Africa*	23	*South Africa*	26	*South Africa*	18	*Kuwait*	21
International Mean	58		56		52		62		51		45
U.S. Mean	■		▼		■		▲		▼		▼

Key:
▲ Significantly higher than international percent
▼ Significantly lower than international mean
■ Not significantly different from international mean
Country percent significantly higher than U.S. percent
Country percent not significantly different from U.S. percent
Country percent significantly lower than U.S. percent

NOTE:
Nations not meeting international sampling guidelines shown in italics.
The placement of Hungary may appear out of place; however, statistically its placement is correct.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 2.1) Chestnut Hill, MA: Boston College.

areas U.S. students turn in levels of performance significantly lower than the international mean. In the case of *geometry*, the upper-grade students in 24 of the 41 countries do significantly better than their U.S. peers, whose performance exceeds those of students from Iran, Kuwait, Colombia, and South Africa. The situation is similar for *measurement*, perhaps a little worse; students in 30 of the 41 nations do significantly better than U.S. students. With regard to *proportionality*, 18 nations do better, and U.S. students' performance exceeds that of upper-grade students in 6 countries.

In the other three domains of mathematics, the performance of U.S. students relative to the international mean is varied. In the case of *fractions and number sense* and *algebra* the U.S. mean and the international mean are not significantly different. In one content area, that identified as *data representation, analysis and probability*, the U.S. score is significantly higher than the international mean. For *fractions and number sense*, *algebra*, and *data representation, analysis and probability*, 13, 13, and 9 nations have scores significantly higher than the United States, and U.S. eighth graders exceed the performance of 14, 10, and 11 nations respectively.

This examination of mathematics content area scores makes clear that mathematics performance varies across these areas. In three content areas, our performance is below the international average; U.S. eighth graders know less, on average, about *geometry, measurement* and *proportionality* than their peers in this group of nations. In the case of *fractions and number sense*, U.S. performance is about average by international standards, and in the case of *data representation, analysis and probability*, U.S. eighth graders exceed the international average.

Science Content Areas. Detail on the science content areas reflected in the TIMSS test can be found in the same curriculum framework publication noted earlier (Robitaille et al., 1993). Here, too, there are slight differences between what was intended in the way of content areas and the form of the actual assessment, though the test taps most of the content areas proposed. In the following discussion student performance in each of the following five areas is examined:

- Earth science;
- Life science;
- Physics;
- Chemistry; and
- Environmental issues and the nature of science.

The content area scores available for science at the time of these analyses are also for nations, not individual students. As with the mathematics scores, these scores are estimates of the average percentage of items answered correctly by the upper-grade students. Figure 2-10 displays the performance of nations by science content area in a form analogous to that used in figure 2-9: nations are ranked in order of the percentage of items correct; countries not meeting the sampling criteria are italicized;

21 Content area names are italicized in the text to make clear that the discussion is about a test score rather than the content area as a whole.

Figure 2-10

Average percent correct scores by country; science content areas; upper grade, population 2; all nations, 1995

Earth Science		Life Science		Physics		Chemistry		Environmental Issues & the Nature of Science	
Nation	%	Nation	%	Nation	%	Nation	%	Nation	%
Singapore	65	Singapore	72	Singapore	69	Singapore	69	Singapore	74
Slovenia	64	Japan	71	Japan	67	*Bulgaria*	65	*Netherlands*	65
Czech Republic	63	Korea	70	Korea	65	Korea	63	England	65
Korea	63	Czech Republic	69	Czech Republic	64	Japan	61	Korea	64
Belgium (Fl)	62	*Netherlands*	67	*Netherlands*	63	Czech Republic	60	*Australia*	62
Austria	62	*Thailand*	66	*Austria*	62	Hungary	60	*Thailand*	62
Sweden	62	Hungary	65	England	62	*Austria*	58	UNITED STATES	61
Norway	61	*Austria*	65	Slovak Republic	61	Slovak Republic	57	Canada	61
Ireland	61	*Slovenia*	65	*Slovenia*	61	Russian Federation	57	Ireland	60
Netherlands	61	*Bulgaria*	64	Belgium (Fl)	61	*Slovenia*	56	Japan	60
Japan	61	England	64	*Bulgaria*	60	Sweden	56	*Bulgaria*	59
Slovak Republic	60	Belgium (Fl)	64	*Australia*	60	England	55	Czech Republic	59
Hungary	60	*Australia*	63	Hungary	60	Hong Kong	55	New Zealand	59
England	59	*Germany*	63	Canada	59	*Germany*	54	*Slovenia*	59
Russian Federation	58	UNITED STATES	63	Hong Kong	58	Ireland	54	Belgium (Fl)	58
Bulgaria	58	Sweden	63	New Zealand	58	*Australia*	54	*Scotland*	57
UNITED STATES	58	Russian Federation	62	Switzerland	58	*Israel*	53	Norway	55
Switzerland	58	Canada	62	Russian Federation	57	UNITED STATES	53	Hong Kong	55
Canada	58	Hong Kong	61	*Germany*	57	New Zealand	53	*Austria*	55
Australia	57	Norway	61	Sweden	57	*Netherlands*	52	Slovak Republic	53
Germany	57	*Israel*	61	*Israel*	57	Iran, Islamic Republic	52	Hungary	53
Spain	57	New Zealand	60	*Scotland*	57	Canada	52	France	53
Thailand	56	Slovak Republic	60	Norway	57	Spain	51	Spain	53
New Zealand	56	Ireland	60	Ireland	56	*Greece*	51	*Israel*	52
Israel	55	Switzerland	59	UNITED STATES	56	Belgium (Fl)	51	Sweden	52
France	55	Spain	58	Spain	55	*Scotland*	51	*Germany*	51
Hong Kong	54	Iceland	58	France	54	Portugal	50	Switzerland	51
Scotland	52	*Scotland*	57	*Thailand*	54	Switzerland	50	*Greece*	51
Portugal	50	France	56	Iceland	53	Norway	49	Russian Federation	50
Belgium (Fr)	50	*Denmark*	56	*Greece*	53	Latvia (LSS)	48	Iceland	49
Iceland	50	*Romania*	55	*Denmark*	53	Lithuania	48	*Denmark*	47
Romania	49	*Belgium (Fr)*	55	*Belgium (Fr)*	51	France	47	Latvia (LSS)	47
Greece	49	*Greece*	54	Latvia (LSS)	51	*Romania*	46	Cyprus	46
Denmark	49	Portugal	53	Lithuania	51	Cyprus	45	*Belgium (Fr)*	46
Latvia (LSS)	48	Latvia (LSS)	53	*Romania*	49	*Thailand*	43	Portugal	45
Lithuania	46	Lithuania	52	Portugal	48	Iceland	42	*Romania*	42
Cyprus	46	Iran, Islamic Republic	49	Iran, Islamic Republic	48	*Belgium (Fr)*	41	*Colombia*	40
Iran, Islamic Republic	45	Cyprus	49	Cyprus	46	*Denmark*	41	Lithuania	40
Kuwait	43	*Kuwait*	45	*Kuwait*	43	*Kuwait*	40	*Kuwait*	39
Colombia	37	*Colombia*	44	*Colombia*	37	*Colombia*	32	Iran, Islamic Republic	39
South Africa	26	*South Africa*	27	*South Africa*	27	*South Africa*	26	*South Africa*	26
International Mean	55		59		55		51		53
U.S. Mean	▲		▲		■		■		▲

Key:
- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- Country percent significantly higher than U.S. percent
- Country percent not significantly different from U.S. percent
- Country percent significantly lower than U.S. percent

NOTE:
Nations not meeting international sampling guidelines shown in italics.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 2.1) Chestnut Hill, MA: Boston College.

countries whose scores are significantly different from that of the United States, and those whose scores are not, are identified; and, the average percentage correct score for all nations is indicated as the "international mean."

Relative to mathematics the picture presented for science achievement is much more encouraging. In three of the five content areas the mean score for U.S. eighth graders exceeds the international average, and in the remaining two it is not significantly different from this international benchmark. U.S. students do better than the international average in *earth science, life science* and *environmental issues and the nature of science*. In fact, in the latter content area only Singapore's upper-grade students know significantly more on average than U.S. eighth graders, and the achievement of U.S. students exceeds that of 25 of the 41 participating nations. Similarly, four countries do significantly better than the United States in *earth science* and *life science*. Where the U.S. does least well is in *physics* and *chemistry*. Even here, seven nations show performance levels higher than that of the U.S. in *chemistry*. However, in the case of *physics*, 13 nations have significantly higher mean scores, and U.S. performance exceeds that of 10 countries.

As seen earlier in connection with the total scores, relatively speaking, U.S. students do better in science than in mathematics by these international standards. With regard to the "softer science" content areas relating to earth, life and environmental sciences, a handful of countries do better. Even in the case of the "harder sciences," U.S. eighth graders' performance is consistent with international standards. While not different from the international average in *chemistry*, seven nations have higher levels of student performance than the United States. In *physics*, U.S. performance is comparable to the international average though 13 nations show significantly higher levels of performance in this area.

IV. Comparisons Across Three Decades

Discussions of the current standing of U.S. students raise the question of whether this is an improvement on past performance. It is possible to throw some (qualified) light on this question by reference to previous international studies of mathematics and science achievement. Most of these are IEA studies: for mathematics, the First International Mathematics Study (FIMS) and the Second International Mathematics Study (SIMS); and, for science, the First International Science Study (FISS) and the Second International Science Study (SISS). Data on FIMS, SIMS, FISS, and SISS were extracted from Medrich and Griffith (1992), Appendix B. Also included are data from the second of the two surveys known as the International Assessment of Educational Progress (Lapointe et al., 1992a; 1992b). Sometimes referred to as "international NAEP," these are studies modeled after the IEA studies but using the NAEP subject-matter frameworks as the foundation for test development.

Strict comparisons of the relative achievement of U.S. students over the more than 30 years separating the first mathematics study from TIMSS, or over the 25 years that separates the first science study from TIMSS, are not possible. The number and identity of the countries participating in the surveys changed—FIMS had 12 including the United States, SIMS has 20, IAEP had 20,[22] and TIMSS has 41. Only 5 of these countries are comparable across all three IEA mathematics studies—Japan, Israel, the Netherlands, France, and Sweden. Six countries appear comparable across the three science studies—Japan, Hungary, Australia, Sweden, England, and the Netherlands. Even here one cannot be sure because sampling designs and sampling quality varied between the three studies. The age of the students sampled varied as well though by no more than a year. Further, aspects of test design were not the same across the studies, and one cannot be certain that the three studies were measuring comparable forms of mathematics and science achievement in each instance. The matter is complicated a little further by the fact that SIMS did not produce a total mathematics score, only subtest scores. However, to the extent that one can make sense out of the relative position of U.S. students among participating countries, then the following observations may be of some value.

22 To varying degrees nine of these "countries" failed to sample a national population. This is true as well in SIMS and SISS where "Canada" is represented by two separate provinces, or by English-speaking Canada.

Mathematics

Figure 2-11 displays the nations according to the average levels of mathematics achievement, as reported in FIMS, SIMS,[23] IAEP and TIMSS. The data are displayed in the same manner as in the figures already discussed, with the exception that all nations in each of the studies are assumed to have met the criteria for adequate samples of comparable student populations. Countries are ranked in order of the percentage of items correct, except in the case of TIMSS, which used scale scores. Countries whose scores are significantly different from that of the United States, and those whose scores are not, are identified, and the average of the scores of all nations is indicated as the "international mean."

Clearly, the relative performance of U.S. students in the first of the international mathematics studies was significantly lower than the average level of performance of this group of nations, essentially Organization for Economic Cooperation and Development (OECD) nations. The data from the second IEA study conducted in the 1970s shows the expected variation in performance by content area. U.S. students did best in statistics—their mean level of achievement lies significantly above the international mean of 55, placing the United States below 2 nations, above 5, and not significantly different from the remaining 12 countries. In the worst case—measurement—the U.S. mean is significantly lower than the mean of almost all nations, placing the United States ahead of Swaziland and Nigeria but no one else. Over the range of content areas, which are roughly comparable between SIMS and TIMSS,—arithmetic, algebra, geometry and measurement—the proportion of participating nations whose performance exceeds that of the United States is roughly equivalent: in SIMS arithmetic, 26 percent versus 33 percent in TIMSS fractions and number sense; for algebra, 37 percent in SIMS and 33 percent in TIMSS; for geometry, 58 percent in SIMS and 60 percent in TIMSS; for SIMS measurement, 89 percent and for TIMSS measurement, 75 percent. At the time of the early 1990s the IAEP study shows the relative performance of U.S. students still below the international average for the countries in question, below the means of 11 of these nations, and significantly better than only 2.[24]

If it is possible to draw any conclusions from such comparisons, they must be tentative ones. However, considering that U.S. performance has been significantly lower than the international average in FIMS, in two of the five SIMS subtests, in IAEP and in TIMSS, and has only exceeded this average once (the statistics subtest of SIMS), the weight of the evidence points to the proposition that U.S. middle school students probably have not improved in mathematics relative to other nations over the past three decades.

23 Note that five subtest scores are reported for SIMS rather than a total score.
24 In the IAEP study the countries shown are not necessarily countries in the strict sense. In some cases they are regions/states/provinces; see Lapointe et al. (1992) for details.

Figure 2-11

Comparisons of national mean scores from international studies of mathematics achievement

First International Mathematics Study — FIMS (1965) — mathematics

Nation	%
Israel	32
Japan	32
Belgium	30
Finland	26
Germany (FRG)	25
England	24
Scotland	22
Netherlands	21
France	21
Australia	19
UNITED STATES	18
Sweden	15
International Mean	24
U.S. Mean	▼

Second International Mathematics Study — SIMS (1982)

arithmetic Nation	%	algebra Nation	%	geometry Nation	%	measurement Nation	%	statistics Nation	%
Japan	60	Japan	60	Japan	58	Japan	69	Japan	71
Netherlands	59	France	55	Hungary	53	Hungary	62	Netherlands	66
Canada (BC)	58	Belgium (Fl)	53	Netherlands	52	Netherlands	62	Canada (BC)	61
Belgium (Fl)	58	Netherlands	51	Scotland	46	France	60	Hungary	60
France	58	Hungary	50	England & Wales	45	Belgium (Fl)	58	England & Wales	60
Belgium (Fr)	57	Belgium (Fr)	49	New Zealand	45	Belgium (Fr)	57	Scotland	59
Hungary	57	Canada (BC)	48	Canada (Ont)	43	Hong Kong	53	Belgium (Fl)	58
Hong Kong	55	Israel	44	Finland	43	Canada (BC)	52	UNITED STATES	58
Canada (Ont)	55	Finland	44	Belgium (Fl)	43	Finland	51	Finland	58
UNITED STATES	51	Hong Kong	43	Hong Kong	43	Canada (Ont)	51	France	57
Scotland	50	Scotland	43	Belgium (Fr)	43	Luxembourg	50	New Zealand	57
Israel	50	UNITED STATES	42	Canada (BC)	42	Sweden	49	Canada (Ont)	57
England & Wales	48	Canada (Ont)	42	Sweden	39	England & Wales	49	Sweden	56
New Zealand	46	England & Wales	40	Thailand	39	Scotland	48	Hong Kong	56
Finland	46	New Zealand	39	France	38	Thailand	48	Belgium (Fr)	52
Luxembourg	45	Thailand	38	UNITED STATES	38	Israel	46	Israel	52
Thailand	43	Nigeria	32	Israel	36	New Zealand	45	Thailand	45
Sweden	41	Sweden	32	Swaziland	31	UNITED STATES	41	Luxembourg	37
Nigeria	41	Luxembourg	31	Nigeria	26	Swaziland	35	Nigeria	37
Swaziland	32	Swaziland	25	Luxembourg	25	Nigeria	31	Swaziland	36
International Mean	50		43		41		51		55
U.S. Mean	■		■		▼		▼		▲

International Assessment of Educational Progress — IAEP (1991) — mathematics

Nation	%
Korea	73
Taiwan	73
Switzerland	71
Soviet Union	70
Hungary	68
France	64
Italy	64
Israel	63
Canada	62
Scotland	61
Ireland	61
England	61
Slovenia	57
Spain	55
UNITED STATES	55
Portugal	48
Jordan	40
International Mean	62
U.S. Mean	▼

Third International Mathematics & Science Study — TIMSS (1995) — mathematics

Nation	Mean
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium (Fl)	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	540
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium (Fr)	526
Thailand	522
Israel	522
Sweden	519
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
UNITED STATES	500
Scotland	498
Latvia (LSS)	493
Spain	487
Iceland	487
Greece	484
Romania	482
Cyprus	474
Portugal	454
Iran, Islamic Republic	428
Kuwait	392
Columbia	385
South Africa	354
International Mean	513
U.S. Mean	▼

Key:

- ▲ Significantly higher than international mean/percent
- ▼ Significantly lower than international mean/percent
- ■ Not significantly different from international mean/percent
- Light shading: Country mean significantly higher than U.S. mean/percent
- No shading: Country mean not significantly different from U.S. mean/percent
- Dark shading: Country mean significantly lower than U.S. mean/percent

NOTE:
For FIMS and SIMS information on the quality of the samples is not available.
In the case of IAEP, seven of the 17 nations listed failed to sample national populations and/or had low participation rates.
With regard to TIMSS, nations not meeting international sampling guidelines are indicated in figure 2-1.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Belgium (Fl) and Sweden may appear out of place; however, statistically the placement is correct.

SOURCE:
Medrich, E. and Griffith, J. (1992). *International mathematics and science assessments: what have we learned?* (Appendix B) Washington, D.C.: National Center for Education Statistics.
Lapointe, A., Mead N. and Askew, J. (1992). *Learning mathematics.* (Figure 1.1) Princeton, N.J.: Educational Testing Service.
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.

Science

Figure 2-12 provides the basis for comparisons between the three IEA science studies carried out over the past 20 years (FISS, SISS, and TIMSS) and the IAEP science study conducted in the early 1990s. In this case, the available data allow comparisons of total scores in each case. In making comparisons of science achievement across the two decades in question, all the same qualifications apply here as they did to the mathematics comparisons.

In the early 1970s, 14 countries participated in FISS, and 5 of these had achievement means that exceeded the U.S. mean, as did the mean of all nations.[25] In the mid-1980s, the time of SISS, 17 countries tested their 14-year-old students in science, and the results show a relatively poorer performance on the part of U.S. students. The U.S. mean is significantly below the international mean, and this places the United States behind 10 of the nations in question and ahead of only one—the Philippines. The IAEP offers a similar view: The U.S. mean is significantly below the mean of all nations; four nations have higher means; nine are not significantly different; and three have lower levels of performance. By the time of TIMSS, the U.S. average was significantly higher than the international average, though one-fourth of the 41 participating nations had means significantly higher than the United States and about one-third had means that were significantly lower. The countries in question are not identical, of course, so the meaning of these comparisons is uncertain. However, in the 25-country comparisons made in figure 2-2, the U.S. mean was not significantly different from that international mean. In short, comparisons with the 25 most precisely estimated country means show the United States about average. Where there is greater coverage of nations, at the cost of some precision, the U.S. science mean is significantly higher than the 41-nation international mean.

Given all of this uncertainty, it is not possible to put forward a definitive statement about changes in the science achievement of U.S. students, relative to other nations, over the past decade. However, the evidence available suggests that the performance of U.S. students has never been outstanding in comparison to that of various collections of other nations and in all except TIMSS has been lower than the international average. In TIMSS though, U.S. eighth graders could probably be seen as doing a little better in science than they have in the past.

25 In figure 2-12 the U.S. mean and the international mean appear to be the same. This is due to rounding. The U.S. mean is 21.6 and the international mean 22.3. While small, this difference is statistically significant.

Figure 2-12
Comparisons of national mean scores from international studies of science achievement

First International Science Study

FISS (1970)

Nation	%
Japan	31
Hungary	29
Australia	25
New Zealand	24
Germany (FRG)	24
Sweden	22
UNITED STATES	22
Scotland	21
England	21
Belgium (Fl)	21
Finland	21
Italy	19
Netherlands	18
Belgium (Fr)	15
International Mean	22
U.S. Percent	▼

Second International Science Study

SISS (1986)

Nation	%
Hungary	22
Japan	20
Netherlands	20
Canada (Eng.)	19
Finland	19
Sweden	18
Korea	18
Poland	18
Norway	18
Australia	18
England	17
Italy	17
Singapore	17
UNITED STATES	17
Thailand	17
Hong Kong	16
Philippines	12
International Mean	18
U.S. Percent	▼

International Assessment of Educational Progress

IAEP (1991)

Nation	%
Korea	78
Taiwan	76
Switzerland	74
Hungary	73
Soviet Union	71
Slovenia	70
Italy	70
Israel	70
Canada	69
France	69
England	69
Scotland	68
Spain	68
UNITED STATES	67
Ireland	63
Portugal	63
Jordan	57
International Mean	69
U.S. Percent	▼

Third International Mathematics & Science Study

TIMSS (1995)

Nation	Mean
Singapore	607
Czech Republic	574
Japan	571
Korea	565
Bulgaria	565
Netherlands	560
Slovenia	560
Austria	558
Hungary	554
England	552
Belgium (Fl)	550
Australia	545
Slovak Republic	544
Russian Federation	538
Ireland	538
Sweden	535
UNITED STATES	534
Germany	531
Canada	531
Norway	527
New Zealand	525
Thailand	525
Israel	524
Hong Kong	522
Switzerland	522
Scotland	517
Spain	517
France	498
Greece	497
Iceland	494
Romania	486
Latvia (LSS)	485
Portugal	480
Denmark	478
Lithuania	476
Belgium (Fr)	471
Iran, Islamic Republic	470
Cyprus	463
Kuwait	430
Colombia	411
South Africa	326
International Mean	516
U.S. Mean	▲

Key:

▲ Significantly higher than international mean/percent

▼ Significantly lower than international mean/percent

■ Not significantly different from international mean/percent

Country mean significantly higher than U.S. mean/percent

Country mean not significantly different from U.S. mean/percent

Country mean significantly lower than U.S. mean/percent

NOTE:
For FIMS and SIMS information on the quality of the samples is not available.
In the case of IAEP, seven of the 17 nations listed failed to sample national populations and/or had low participation rates.
With regard to TIMSS, nations not meeting international sampling guidelines are indicated in figure 2-1.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only the Latvian-speaking schools were sampled.

SOURCE:
Medrich, E. and Griffith, J. (1992). *International mathematics and science assessments: what have we learned?* (Appendix B) Washington, D.C.: National Center for Education Statistics.
Lapointe, A., Askew, J. and Mead, N. (1992). *Learning science.* (Figure 1.1) Princeton, N.J.: Educational Testing Service.
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.

V. Explanations?

Explanations are few, and they are not definitive. Most attribute these between-nation performance differences to differences in the opportunity to learn the material tested, differences that arise mainly out of national differences in curriculum and/or instruction—in IEA nomenclature, the Intended and Implemented Curricula of schools. Explanations for the relatively poor performance of U.S. students in mathematics tend to be seen in curricular terms; the best known exposition of this view is found in *The Underachieving Curriculum* (McKnight et al., 1987). More recently, Schmidt et al. (1996a; 1996b) have made a similar argument.

Instructional differences between nations are also invoked as an explanation, sometimes tied to the nature of the curriculum or more broadly to cultural differences in educational policies between nations, especially differences between Asian and Western nations (e.g., Stevenson and Stigler, 1992). Cultural differences in attitudes toward education and learning and in more fundamental beliefs about the foundations of success in learning are also invoked at times (Stevenson, 1992).

Intriguing though they may be, existing explanations for between-nation differences in achievement probably should be seen more as propositions than firmly established facts. Statistical support for these explanations is consistent with these propositions but not definitive by any means. Theories of comparative education are not well developed and thorny statistical problems relating to the international comparability of measures remain to be resolved to everybody's satisfaction. Nevertheless, when differences between nations in curriculum, instruction, family involvement and community support, and in the material and human resources available to schooling, parallel differences in national achievement levels, they do provide input into policy debate about how and what one nation may learn from another in this respect.

3. The Distribution of Student Achievement

In this chapter attention shifts somewhat, from comparisons of the performance of the U.S. eighth graders as a whole against international benchmarks to comparisons of the performance of different sectors of the eighth-grade population. The population sectors in question are defined by basic demographic criteria, such as gender and race/ethnicity, and the population groups defined in this way are treated like separate countries in these comparisons. Their average level of performance in mathematics and science is compared with the international average, and with the average performance of each of the 41 nations that participated in the Third International Mathematics and Science Study (TIMSS). Comparisons of the population groups, one with the other, are provided as well. By way of example, consider the two population groups defined by gender. The analyses provide for a comparison of the performance of males with that of females; a comparison of the achievement of each population group with the international average; and comparisons of the performance of U.S. eighth-grade males and females to that of the 41 TIMSS nations such that nations with average scores significantly higher, lower, or not different from these population groups are identified.

I. Population Groups

Population groups are sectors of the population defined by demographic attributes, such as gender, race/ethnicity, language, and so on. With the exception of race-ethnicity and gender, these defining characteristics are attributes of the students' families that become the (ascribed) attributes of the students themselves. Interest in the comparative performance of population groups reflects a concern that between-group differences in educational outcomes may reflect inequities of various kinds, notably inequalities in the educational opportunities offered to different sectors of the population.

Comparisons of U.S. population group performance are common in the literature on student achievement, especially comparisons by gender and race/ethnicity.[1] Publications such as *The Condition of Education* (NCES, 1996b), the *Digest of Education Statistics* (NCES, 1996e), and the various reports associated with each National Assessment of Educational Progress (NAEP) routinely provide comparisons of the achievement levels of selected population groups. The comparisons displayed here offer similar information on the mathematics and science achievement of eighth graders. They offer as well a unique international perspective on the performance of U.S. population groups in the form of international benchmarks of two kinds. First, the performance of U.S. population groups is reflected against the international average of the 41 TIMSS nations, allowing observations about where these groups stand relative to this international standard. Second, an international standing of each defined U.S. population group is provided to indicate where the performance level of the group falls relative to particular nations. Anchoring these comparisons to a "world

1 The TIMSS data were collected in 1995. At that time students were not provided with the opportunity to indicate membership in more than one racial-ethnic group. As a consequence, racial-ethnic categories are limited to: White; Black; Hispanic; Asian or Pacific Islander; American Indian or Alaskan Native.

standard" in this way provides a benchmark that aids interpretation of the differences seen. To know, for example, that U.S. eighth graders with college-educated parents do better, on average, than peers from families with lower levels of parental education is one thing. If it also turns out that the most educationally advantaged group performs at levels similar to students in the top performing nations, and/or that all but one of the several population groups in question are above the international average, then the population group differences observed gain additional meaning.

Defining Population Groups

The delineation of population groups is somewhat flexible and, to some extent, determined by the issue under investigation. For the most part, however, such groups are defined in terms of attributes ascribed at birth and/or by one's family of origin, especially when the issue at hand is possible inequities in the social system such as those brought on by inequality of opportunity. In the analyses reported here, population groups characterized by the following attributes are defined as follows: gender; race/ethnicity; language; national origins; parental education; family wealth;[2] and, family configuration. These are not exhaustive of the universe of possible population groups, of course, but they do cover most of the major social-structural dimensions of the eighth-grade population. As a result, one might reasonably expect performance to vary across these groups.

Gender and race/ethnicity define the population groups that tend to be given attention as a matter of course, and these groups are identified in the analyses reported here. The two gender groups were established from reports made by the test administrator. Five race/ethnicity groups were identified from students' self-reports of race/ethnicity in the student questionnaire (SQ2b);[3] the categories are white, black, Hispanic, Asian/Pacific Islander, and other.

Population groups defined in terms of language and national origin were also identified. Two language groups were established: students reporting that they always or mostly speak English at home; and those who indicate that they speak English "sometimes or never" (SQ4). Four national origin groups were identified. Student responses to questions about the birthplace of their parents (SQ10a, SQ10b) allowed the definition of groups in which both parents were born in the United States; mother born in the United States/father not; father born in the United States/mother not; and both parents born outside the United States.

Three measures of the social/educational/economic status of students' families were used to establish population groups. Student reports of the highest educational level attained by their mothers and fathers (SQ9) identified four groups in each instance—"less than high school," "high school graduate," "further education, not college," and "college." The economic dimension of social origins was tapped by a composite score based on student responses to 16 questions concerning family possessions (SQ12). For the purposes of this presentation, the variable is categorized as quartiles.

2 A fairly crude and indirect measure of family wealth is used in this instance. It is an index based on possession of consumer durables. See NCES (1994) and NCES (1996a).

3 The questionnaires are reproduced in Appendix H of the technical report (NCES, 2000). Here, and subsequently, questionnaire items are identified by questionnaire type and item number; SQ indicates the student questionnaire, TQM the mathematics teacher questionnaire, TQS the science teacher questionnaire, and SC the school questionnaire. Item numbers are indicated as "2a," "2b," and so on.

The final perspective taken is one based on family configuration, something that has come to represent an important dimension of this country's social structure. Three main patterns now describe the configuration of the families in which children grow up: traditional two-parent families in which the parents are the biological[4] parents of the child; two-parent families in which one of the parents is not a biological parent,[5] and single-parent families in which, for the most part, the single parent is the biological mother. Population groups defined in these terms were established from the students' responses to a question about who lived in their home with them (SQ7). This information allowed the identification of four categories of family configuration: "2-parent-biological" (both biological parents present); "2-parent-blended" (two parents present, one a biological parent); "one-parent-mother" (one parent present, the biological mother); and "other."

4 Since these data come from student reports, biological parent should be interpreted broadly to mean an adult that the student considers as a parent. In the majority of cases this parent will be the student's biological parent. In other instances it could be an adoptive parent or some other person whom the student regards as a parent rather than a step-parent, guardian, and the like.

5 Often identified as "blended" families.

II. Between-group Comparisons

Table 3-1 shows the results of statistical comparisons of U.S. eighth graders' performance in mathematics and science across the categories of the population groups noted earlier. Each panel in the table refers to population groups defined by a single characteristic, and within each of the panels means and their standard errors are shown for eighth-grade students in each population group category. The results of testing the statistical significance of the difference between group means[6] are shown in the adjacent matrix, with the results for mathematics above the diagonal and those for science below the diagonal.

Gender

While it is commonly held that there are gender differences in mathematics and science performance and that these differences favor boys, support for this view is somewhat variable. Gender differences in average levels of mathematics performance on tests administered in 1996 as part of NAEP can be demonstrated for fourth graders but not for eighth and twelfth graders (Reese et al., 1997, p. iii). In the case of science, gender differences in performance are not evident among fourth graders but are apparent among eighth and twelfth grade students (Campbell et al., 1996). In the latest NAEP science assessment these gender differences persist for twelfth graders but were not apparent among students in the fourth and eighth grades (O'Sullivan et al., 1997).

The evidence from TIMSS is that there are no significant differences in the performance of males and females in either mathematics or science at the eighth-grade level. Consider the first panel of the table where information on population groups defined by gender is presented. Females score, on average, 497 in mathematics and 528 in science in comparison with males who average, respectively, 502 and 540.[7] Neither gender difference in mean scores is statistically significant.

Race/Ethnicity

In a similar way, NAEP documents differences in performance across racial/ethnic groups. These differences are often reported and favor whites and Asians as a whole over the two largest minority groups, namely, blacks and Hispanics. Reese et al. (1997) show these population group differences in the latest mathematics assessment, and O'Sullivan et al. (1997) report parallel findings from the most recent science assessment. Racial/ethnic group differences in performance on NAEP assessments have a documented history stretching back more than two decades (Campbell et al., 1996). There is a substantial literature offering explanations for these between-group differences in performance. Much of the explanation revolves around the notion of parallel differences in social and economic advantage/disadvantage and in the differences in quality of social and educational environments that follow (see for example Jencks et al., 1972). Arguments suggesting various forms of inequality of opportunity brought on by direct and indirect discriminatory practices are also common (Wilson, 1987, 1996a, 1996b).

6 Alpha is set at .05 and adjustments are made for multiple comparisons.

7 Note that there is sometimes a small discrepancy between some of these values and their counterparts reported in Beaton et al. (1996a; 1996b). In the present analyses the estimates of category means were based on all five plausible values. The international reports noted above used a single plausible value to generate their estimates.

Table 3-1
Between-group Comparisons

1. Gender

Are you a boy or a girl?	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
f=female	496.8	4.4	527.7	5.2
m=male	501.7	5.1	539.6	4.9

Mathematics

	x
x	

Science

2. Race/Ethnicity

Which best describes you?	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
w=White	520.6	3.6	560.8	3.4
b=Black	436.9	4.4	458.0	5.3
h=Hispanic	450.9	4.2	474.0	4.4
a=Asian	520.4	12.6	529.2	10.8
o=Other	479.2	14.8	514.3	18.4

Mathematics

	w>b	w>h	x
b<w		x	b<a
h<w	x		h<a
a<w	a>b	a>h	

Science

3. Language at Home

How often do you speak English at home?	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
a=always or almost always	504.7	4.2	541.6	4.2
s=sometimes or never	464.2	8.0	473.9	8.6

Mathematics

	a>s
a>s	

Science

4. National Origin

Was your mother/father born in the United States?	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
MF=both parents born in U.S.	503.5	4.3	541.3	4.4
Mf=mother only born in U.S.	491.3	10.1	522.5	10.9
mF=father only born in U.S.	487.6	11.9	518.8	11.6
mf=both parents born out of U.S.	481.6	7.4	492.2	7.0

Mathematics

	x	x	MF>mf
x		x	x
x	x		x
mf<MF	x	x	

Science

5. Mother's Education

How far in school did your mother go?	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
h-=less than high school	463.0	4.5	494.5	5.7
h=high school	493.9	3.7	530.6	4.2
h+=more than high school	505.4	5.0	541.5	5.8
c=college	527.6	6.0	561.7	6.0
dk=don't know	491.7	7.5	514.0	7.0

Mathematics

	h-<h	h-<h+	h-<c
h>h-		x	h<c
h+>h-	x		h+<c
c>h-	c>h	x	

Science

6. Father's Education

How far in school did your father go?	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
h-=less than high school	462.7	4.8	493.2	5.2
h=high school	489.3	4.2	528.1	4.4
h+=more than high school	504.0	4.8	541.5	4.7
c=college	535.4	5.4	567.7	5.3
dk=don't know	493.2	7.2	519.5	6.6

Mathematics

	h-<h	h-<h+	h-<c
h>h-		x	h<c
h+>h-	x		h+<c
c>h-	c>h	c>h+	

Science

7. Family Wealth

	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
Q1= First quartile	462.0	5.0	491.5	6.3
Q2= Second quirtile	496.7	4.9	531.9	4.6
Q3= Third quartile	512.6	4.4	548.9	5.0
Q4= Fourth quirtile	519.5	5.2	555.0	5.2

Mathematics

	Q1<Q2	Q1<Q3	Q1<Q4
Q2>Q1		x	Q2<Q4
Q3>Q1	Q3>Q2		x
Q4>Q1	Q4>Q2	x	

Science

8. Family Configuration

	Mathematics Mean	Mathematics s.e.	Science Mean	Science s.e.
bi=2 biological parents	511.3	4.7	545.0	4.7
sm=single mother	474.7	5.1	505.2	6.5
bl=blend - 1 biological parent, 1 step-parent	488.1	4.7	528.9	5.9
4=other	472.8	6.9	507.5	10.6

Mathematics

	bi>sm	bi>bl
sm<bi		x
x	bl>sm	

Science

NOTE:
Significance test results are indicated in the matrix to the right of the display of means and standard errors.
The results for mathematics are above the diagonal and those for science are below the diagonal.
Significant differences between population group means are indicated by inequality relationships.
Non-significant differences are indicated by an 'x'.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Student Questionnaire, 1995.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study. Unpublished Tabulations, 1995.

The second panel of table 3-1 displays the average performance levels of eighth graders in mathematics and science across the five racial/ethnic groups identified. In general the pattern is similar to that observed in other national surveys. Ignoring the "other" group, the basic picture is that, for mathematics, the performance levels of whites and Asians are indistinguishable, and both of these population groups turn in significantly higher levels of performance than do blacks or Hispanics. Differences in achievement between the latter two groups are not statistically significant. In the case of science achievement, the situation is similar, though with one exception; the performance of whites exceeds that of Asians by a statistically significant margin. Such findings are consistent with what is already known about the racial\ethnic group differences in school achievement. Such differences usually diminish substantially after between-group differences in social and economic status, and related factors, are taken into account (NCES, 1996a).

Language

One factor that may be associated with performance on tests taken in English is whether English is a student's primary language. Over the past decade the number of speakers of languages other than English among U.S. 5- to 17-year-olds grew from 3.8 million to 5.2 million—from 8 percent to 12 percent of all school-age children (McArthur, 1993). Over this same period, the Hispanic students in the nation's schools, as a proportion of all students, increased from 6.4 percent to 10 percent. During this time, Asian and Pacific Islander students increased by more than 116 percent[8] (NCES, 1991). Approximately 75 percent of these students reside in eight states.[9] Lehmann (1996) shows that many Hispanic and Asian students use a language other than English in the home.

Panel 3 of table 3-1 (on page 53) displays the performance levels of two population groups distinguished by whether they speak English at home "always or almost always" or "sometimes or never." The group speaking English "always/almost always" turns in significantly higher levels of performance in both mathematics and science than does the "sometime/never" group.

National Origins

At the beginning of this century close to 14 percent of the population was foreign born. By 1980 this proportion declined to a low of 6 percent, rising again to around 8 percent in 1990 (U.S. Census Bureau, 1993). As of 1997, 25.7 million members of the U.S. population were classified as foreign born (U.S. Census Bureau, 1998). Some of these were students who participated in the TIMSS assessments. Among those whose first language was not English, English-language proficiency will vary at least in part because of the amount of time they have spent learning to speak, read, and write in English. Other achievement-related attributes of students and their families may vary as well along this same dimension (Lehmann, 1996). Following this line of argument, population groups are defined on the basis of parental birthplace.

8 An increase from 535,000 to 1,158,000.
9 Arizona, California, Colorado, Florida, New Jersey, New Mexico, New York, and Texas.

The fourth panel of table 3-1 (on page 53) shows the performance levels of eighth-grade population groups defined by birthplace of parents. Since the birthplace measure was a simple dichotomy of United States versus other, considering the birthplaces of both parents simultaneously produced four population groups: "both parents born in the United States;" "mother born in the United States/father elsewhere;" "father born in the United States/mother elsewhere;" and "both parents born outside the United States." In both mathematics and science the only significant between-group difference in performance occurred in the comparison between students with both parents born in the United States and those for whom neither parent was born in the United States. Differences in language proficiency and/or in other achievement-related attributes for which national origins may act as a proxy may be involved.

Parental Educational Attainments

Traditionally, this variable has been difficult to measure in student reports in questionnaires, especially the reports of children or adolescents (NCES, 1997b). The evidence at hand suggests that TIMSS was no exception, and two cautions follow. First, students may not be able to report on the specified levels very accurately. Thus, "college" need not mean that the parent has a college degree. This response may simply indicate that the parent has a high level of education. In the same way, "less than high school" may be interpreted as "low level of education." Second, students may not report accurately on differences in educational levels between parents. That is, the reports on mother's and father's education may not be independent of each other and, instead, represent some kind of a composite view of parental educational attainments. Nevertheless, parental educational attainments as reported by students are consistent with other results. With the appropriate cautions about literal interpretation of the categories, the following observations hold.

The relationship between parental educational attainments and the educational achievements/attainments of offspring is well documented (Featherman, 1981; Sewell and Hauser 1975; Sewell, Hauser and Wolf, 1976; Bielby, 1981). It is seen as one of the critical links by which the social and economic attainments of one generation are passed on to the next. The usual explanations invoked in this context involve differences in resources to support education, differences in the educational models provided within the family, and differences in the value placed on education within the family (Sewell and Hauser, 1976).

As panels 5 and 6 of table 3-1 (on page 53) indicate, the findings with respect to mother's and father's education are almost identical and so allow the simplification of describing them in terms of parental educational attainments. Of the four population groups the "less than high school" groups demonstrated levels of performance in both mathematics and science that were significantly lower than each of the other parental education groups. At the other extreme, students with college-educated parents show higher performance levels than each of the other groups in both subject areas.[10] Overall then, parental education is clearly associated with student performance in mathematics and science.

10 With one exception: for "mother's education," the contrast between "college" and "more than high school" is not statistically significant.

Family Economic Circumstance

Questions about the effects of family economic circumstance on the educational opportunities of children figure large in discussions about social inequalities and social disadvantage. Evidence of the relationship between family economic status and school-related behaviors is abundant and shows, for example, that children from low-income families are less likely to enroll in pre-kindergarten programs; are more likely to drop out of school before high school graduation; and so on (NCES, 1992; NCES, 1993). The economic resources that families have at their disposal may influence educational opportunities directly, and indirectly through their effects on parental behaviors.

As with parents' educational attainment, eighth graders may not always be able to report parental income accurately. There is also the further consideration about whether income adequately taps family economic resources. In the face of this problem studies based on surveys of students, TIMSS among them, measure family economic circumstance, if at all, through student reports on housing characteristics and/or family possessions. Such measures behave similarly to other measures of family wealth.

In TIMSS, family economic circumstance is tapped by a composite "possessions" measure.[11] The measure itself is a composite of student responses to 16 items and, as such, is a continuous measure but one without any concrete metric. For the purposes of the analyses reported here, the measure is categorized as quartiles and defines four population groups—ranging from the first quartile, which indicates 'low' levels of economic resources, to the fourth quartile, which is indicative of families with high levels of such resources. The intermediate second and third quartiles are taken to represent intermediate levels of resources and are not named.

The findings shown in panel 7 of table 3-1 (on page 53) show a clear pattern of relationships for this economic circumstance variable consistent with other evidence. Students from the least well-off group (quartile 1) show lower levels of performance in both mathematics and science than students in the other three groups. Students in quartile 2 turn in levels of performance not significantly different from those in quartile 3 but significantly lower than eighth graders in the highest quartile. Performance differences between students from quartiles 3 and 4 are not significantly different from each other. Apparently, being at the lower end of the "economic circumstance" distribution is associated with lower performance in mathematics and science. Whether this disadvantage is due to economic circumstance *per se*, to family attributes related to economic circumstance, or both, is unclear at this point.

Family Configuration

Over the past 50 years, the configuration of American families has changed markedly, transformed by increasing divorce rates, greater numbers of children born out of wedlock, the growth in participation of women in the work force, and the more gen-

11 A factor score based on the first principal component.

eral transformation of traditional female roles (Lippman, et al. 1996). Between 1965 and 1989 annual divorce rates increased by 120 percent, involving about 1 million children each year (Snyder, 1991). Over this same period birth rates overall declined, but the number of births to unmarried women has increased. Similarly, the labor force participation of women with children under 18 years of age doubled between 1970 and 1992 (U.S. Census Bureau, 1996).

Some research suggests that nontraditional forms of family configurations are associated with lower levels of achievement, but overall the research is inconclusive (Ganong and Coleman, 1984) for at least the reason that most studies fail to control for other factors associated with achievement that are linked to nontraditional family configurations.

Measures of family configuration developed in the present analyses allow the identification of three population groups based on the three most common family configurations: two-parent (biological); two-parent (blended); and, one-parent (mother).[12] In each designation, the parent configuration is identified first with the modifier enclosed in parentheses. To indicate that these are compound names and to provide for easy identification, these designations have been italicized in the text.

Panel 8 of table 3-1 (on page 53) shows the levels of performance in mathematics and science across these population groups and indicates the statistical significance of between-group differences. Overall, students from *two-parent (biological)* families turn in levels of performance in mathematics significantly higher than students from either *two-parent (blended)* or *one-parent (mother)* families. In the comparison involving the latter two population groups the performance difference fails to reach statistical significance. In the case of science achievement, students from *two-parent* families of either variety turn in similar levels of performance, and each is significantly higher than the achievement of students from *one-parent (mother)* families. In short, these data are consistent with an association of nontraditional families with lower achievement, but no attempt has been made to control for confounding influences.

12 An "other" group was identified as well, but its definition allows no clear interpretation so it is ignored for these purposes.

III. International Comparisons

The intent of this section is to consider again the performance levels of these same U.S. eighth-grade population groups but this time against an international background—the achievement levels of the upper-grade students in the 41 TIMSS nations. In so doing the analyses offer the same kind of international perspective on U.S. population group performance among eighth graders as was provided for the performance of the eighth-grade population as a whole.

The international benchmarking itself is developed in two ways. First, comparisons of population group means are made to the average performance of all nations—the international average. Second, the average performance level of each population group is displayed relative to the 41 TIMSS nations ordered, in the usual way, by their average level of achievement. This allows the same kind of observations as were made in the preceding chapter in connection with the Unites States as a whole. In that instance nations were identified as showing performance levels significantly higher than, lower than, or not different from the Unites States. In the discussion that follows, the same kinds of observations will be made relative to the performance levels of U.S. population groups.[13] The presentation of the findings on achievement levels of population groups defined by race/ethnicity develops these considerations in some detail to provide a guide to the interpretation of subsequent findings relating to population groups defined in other ways.

Race/Ethnicity

Figure 3-1 displays the 41 TIMSS nations according to average level of mathematics performance; nations are identified in column 1, and national averages are shown in column 2. The four columns adjacent to these define, in this case, racial/ethnic population groups—white, black, Hispanic, Asian.[14] Within each of these columns three areas are identified by, respectively, light shading, no shading, and darker shading. Projecting these areas across to the country names in column 1 identifies, respectively, countries with higher performance levels than the population group in question, countries whose performance levels are not significantly different, and countries with lower levels of performance. The average score for each population group and the results of statistical comparisons with the international average are shown at the base of the graph.

More concretely, 12 of the 14 nations listed in order from Singapore down to Hungary show higher levels of mathematics performance than U.S. white eighth graders. Two nations in this list—Netherlands and Bulgaria—have performance levels not significantly different from that of whites, as do the 10 nations indicated by the remaining unshaded part of the list, those listed from the Russian Federation down to New Zealand. Finally, U.S. white eighth graders do better than the average eighth grader in the 17 remaining nations—England through South Africa (including the United States as a whole). Relative to the other international benchmark, the international

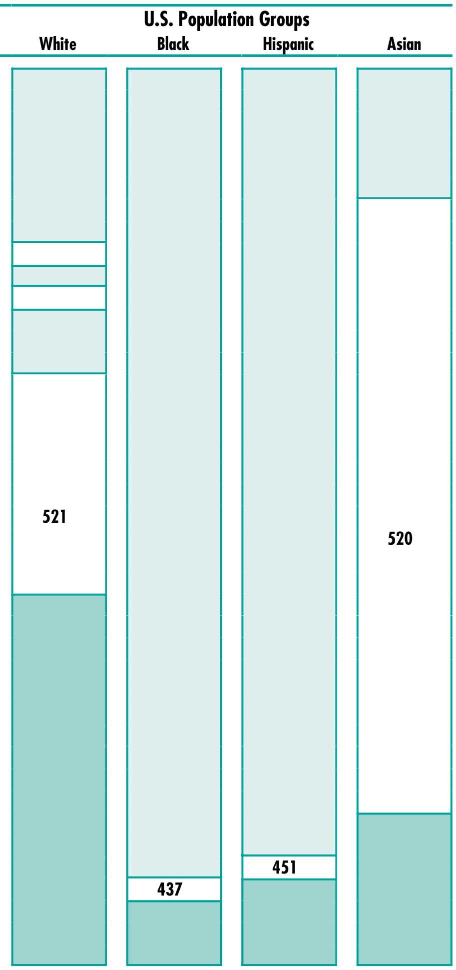
13 Since the U.S. average is part of the international average these comparisons are slightly confounded. However, it seems to make sense to proceed in this way since the international average has taken on the status of a benchmark. Whether to count the United States among the nations designated as higher, lower, or not different from population groups is less clear. The decision made here is that comparisons of parts to the whole are useful.

14 The group labeled "other" has been omitted since it allows only limited interpretations without any substantive meaning.

Figure 3-1
Race/ethnicity and mathematics achievement: mathematics total scores; upper grade, population 2; 1995

National Averages	
Nation	**Mean**
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium (Fl)	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	540
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium (Fr)	526
Thailand	522
Israel	522
Sweden	519
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
UNITED STATES	500
Scotland	498
Latvia (LSS)	493
Spain	487
Iceland	487
Greece	484
Romania	482
Lithuania	477
Cyprus	474
Portugal	454
Iran, Islamic Republic	428
Kuwait	392
Colombia	385
South Africa	354

U.S. Population Groups



	White	Black	Hispanic	Asian
Population Group Mean	521	437	451	520
Comparison to international mean of 513:	■	▼	▼	■

Key:

▲ Significantly higher than international mean

▼ Significantly lower than international mean

■ Not significantly different from international mean

Country mean significantly higher than U.S. population group mean

Country mean not significantly different from U.S. population group mean

Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Netherlands and Bulgaria may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996) *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

average, U.S. white eighth graders show a mean score of 521, which is not significantly different from the international average of 513.[15]

Carrying these kinds of interpretations through to the remaining racial/ethnic population groups allows the following observations. At 437, the average level of mathematics achievement of black eighth graders in the United States is lower than that of 37 of the 41 TIMSS nations and is significantly lower than the international average. A similar situation applies for U.S. eighth graders of Hispanic origin. Their average—451—falls below the national averages of 36 of the TIMSS nations, and it too is significantly lower than the international average.[16]

Figure 3-2 provides parallel information but with respect to science achievement. The pattern of performance across population groups is similar to that seen in the case of mathematics. U.S. white eighth graders are outperformed[17] by only one other nation—Singapore. In contrast, 34 of the TIMSS nations show achievement levels significantly higher on average than that of U.S. black students, and 30 nations do better than the average U.S. Hispanic student. Relative to the international mean for science, U.S. white eighth graders do significantly better, U.S. black and Hispanic eighth graders do significantly worse, and U.S. Asian students show no significant difference.

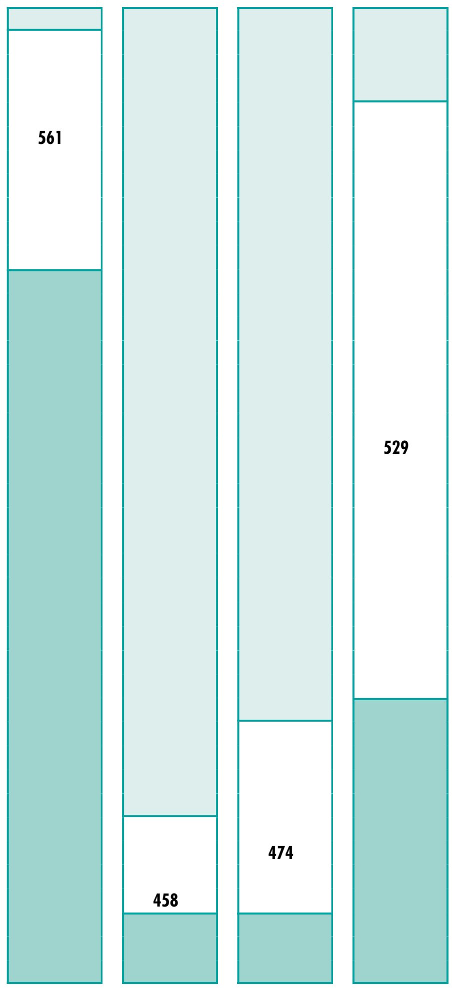
15 The population group means are also shown in their approximate position within the columns of the graph itself.

16 Black and Hispanic students were oversampled with the result that the standard errors of their mean scores approximate those of whites (see table 3-1). The Asian/Pacific Islander group was not oversampled and hence shows a larger standard error. As a result, only large differences between Asian and other groups are likely to achieve statistical significance. Note, too, that the confidence intervals for the black and Hispanic student means appear smaller than that for white students. This is not the case, as table 3-1 indicates, but is simply a function of the unequal intervals between country means in different parts of the list of nations.

17 That is, bettered with 95 percent certainty; other nations may do better, but the difference does not achieve this level of certainty in this instance.

Figure 3-2
Race/ethnicity and science achievement: science total scores; upper grade, population 2; 1995

National Averages		U.S. Population Groups			
Nation	**Mean**	**White**	**Black**	**Hispanic**	**Asian**
Singapore	607				
Czech Republic	574				
Japan	571				
Korea	565				
Bulgaria	565				
Netherlands	560				
Slovenia	560				
Austria	558				
Hungary	554				
England	552				
Belgium (Fl)	550				
Australia	545				
Slovak Republic	544				
Russian Federation	538				
Ireland	538				
Sweden	535				
UNITED STATES	534				
Germany	531				
Canada	531				
Norway	527				
New Zealand	525				
Thailand	525				
Israel	524				
Hong Kong	522				
Switzerland	522				
Scotland	517				
Spain	517				
France	498				
Greece	497				
Iceland	494				
Romania	486				
Latvia (LSS)	485				
Portugal	480				
Denmark	478				
Lithuania	476				
Belgium (Fr)	471				
Iran, Islamic Republic	470				
Cyprus	463				
Kuwait	430				
Colombia	411				
South Africa	326				
Population Group Mean		561	458	474	529
Comparison to international mean of 516:		▲	▼	▼	■



Key:
- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- (light shading) Country mean significantly higher than U.S. population group mean
- (unshaded) Country mean not significantly different from U.S. population group mean
- (dark shading) Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

Gender

Figure 3-3 provides a parallel presentation of the findings regarding population groups defined by gender. The data relating to both mathematics and science are shown side by side in this figure. Note, however, that direct comparisons between mathematics and science scores are not legitimate as the scales for mathematics and science were derived independently of each other.

With regard to mathematics performance it is clear that male eighth graders in the United States are about "average" from an international perspective. Their level of performance is lower than that of about one-half the TIMSS nations (19), not significantly different from that of 14 more, better than the average level of achievement of their peers in the 8 remaining nations, and not significantly different from the international average. The scores of females are not as high, their average being lower than those of 22 nations, not different from those of 12 others, and higher than the remaining 7 nations, but significantly lower than the international average of 513.

In the case of science, the pattern is similar, but the relative international performance a little better. The performance of males places them below 6 nations in these terms (Singapore through Bulgaria, plus Slovenia), not distinguishable from 18 others, and above the remaining 17 countries. This level of achievement places the performance of U.S. eighth-grade boys above the international average. Girls' performance is not significantly different from the international average, is lower than those of 11 countries (Singapore through Flemish-Belgium in the list), not significantly different from those of 16 nations, and above those of their peers in the remaining 14 nations.

Figure 3-3
Gender and mathematics and science achievement: mathematics and science total scores; upper grade, population 2; 1995

MATHEMATICS

National Averages		U.S. Population Groups	
Nation	**Mean**	**Male**	**Female**
Singapore	643		
Korea	607		
Japan	605		
Hong Kong	588		
Belgium (Fl)	565		
Czech Republic	564		
Slovak Republic	547		
Switzerland	545		
Netherlands	541		
Slovenia	541		
Bulgaria	540		
Austria	539		
France	538		
Hungary	537		
Russian Federation	535		
Australia	530		
Ireland	527		
Canada	527		
Belgium (Fr)	526		
Thailand	522		
Israel	522		
Sweden	519		
Germany	509		
New Zealand	508		
England	506		
Norway	503		
Denmark	502	**502**	
UNITED STATES	500		
Scotland	498		**497**
Latvia (LSS)	493		
Spain	487		
Iceland	487		
Greece	484		
Romania	482		
Lithuania	477		
Cyprus	474		
Portugal	454		
Iran, Islamic Republic	428		
Kuwait	392		
Colombia	385		
South Africa	354		
Population Group Mean		502	497
Comparison to international mean of 513:		■	▼

SCIENCE

National Averages		U.S. Population Groups	
Nation	**Mean**	**Male**	**Female**
Singapore	607		
Czech Republic	574		
Japan	571		
Korea	565		
Bulgaria	565		
Netherlands	560		
Slovenia	560		
Austria	558		
Hungary	554		
England	552		
Belgium (Fl)	550		
Australia	545		
Slovak Republic	544		
Russian Federation	538	**540**	
Ireland	538		
Sweden	535		
UNITED STATES	534		
Germany	531		
Canada	531		
Norway	527		**528**
New Zealand	525		
Thailand	525		
Israel	524		
Hong Kong	522		
Switzerland	522		
Scotland	517		
Spain	517		
France	498		
Greece	497		
Iceland	494		
Romania	486		
Latvia (LSS)	485		
Portugal	480		
Denmark	478		
Lithuania	476		
Belgium (Fr)	471		
Iran, Islamic Republic	470		
Cyprus	463		
Kuwait	430		
Colombia	411		
South Africa	326		
Population Group Mean		540	528
Comparison to international mean of 516:		▲	■

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Slovenia may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

Key:
▲ Significantly higher than international mean
▼ Significantly lower than international mean
■ Not significantly different from international mean
Light shading: Country mean significantly higher than U.S. population group mean
Unshaded: Country mean not significantly different from U.S. population group mean
Dark shading: Country mean significantly lower than U.S. population group mean

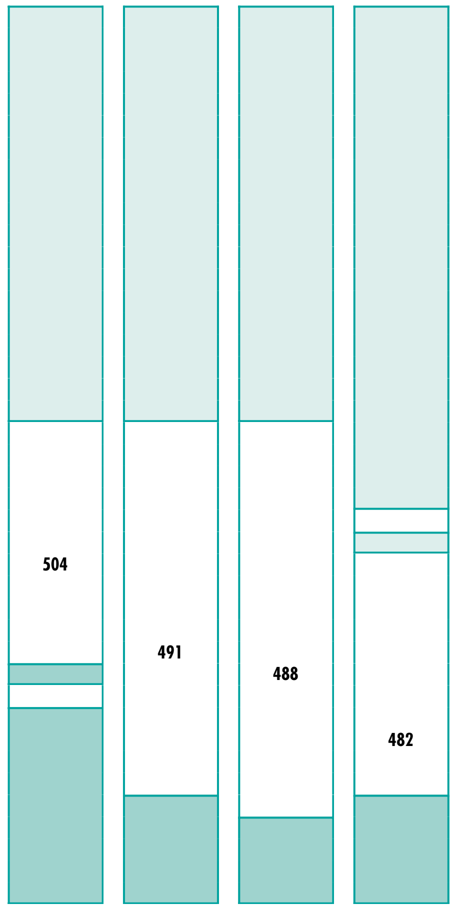
National Origins

As noted earlier, national origins refers to the national origins of the students' parents, defined simply as "born in the United States" or "born elsewhere." Taking into account the birthplace of both parents provides for four combinations, and these are represented in figure 3-4, which displays the findings for mathematics achievement.

Families in which both parents were born outside the country show the lowest mean score of all four groups, a score that is significantly lower than the international average. In the other three population groups, where one or both parents were born in the United States, the group means do not differ significantly from the international average, or from each other, for that matter. All 3 of these groups show levels of performance that place them below almost one-half (19) of the TIMSS nations. In the case of the population group defined by having both parents born outside the United States, 24 of the 41 TIMSS nations turn in performances that are significantly higher.

Figure 3-4
National origins and mathematics achievement: mathematics total scores; upper grade, population 2; 1995

National Averages		U.S. Population Groups*			
Nation	**Mean**	**M/F**	**M/f**	**m/F**	**m/f**
Singapore	643				
Korea	607				
Japan	605				
Hong Kong	588				
Belgium (Fl)	565				
Czech Republic	564				
Slovak Republic	547				
Switzerland	545				
Netherlands	541				
Slovenia	541				
Bulgaria	540				
Austria	539				
France	538				
Hungary	537				
Russian Federation	535				
Australia	530				
Ireland	527				
Canada	527				
Belgium (Fr)	526				
Thailand	522				
Israel	522				
Sweden	519				
Germany	509				
New Zealand	508				
England	506				
Norway	503				
Denmark	502				
UNITED STATES	500				
Scotland	498				
Latvia (LSS)	493				
Spain	487				
Iceland	487				
Greece	484				
Romania	482				
Lithuania	477				
Cyprus	474				
Portugal	454				
Iran, Islamic Republic	428				
Kuwait	392				
Colombia	385				
South Africa	354				
Population Group Mean		504	491	488	482
Comparison to international mean of 513:		■	■	■	▼



Key:

▲ Significantly higher than international mean

▼ Significantly lower than international mean

■ Not significantly different from international mean

Country mean significantly higher than U.S. population group mean (light shading)

Country mean not significantly different from U.S. population group mean (unshaded)

Country mean significantly lower than U.S. population group mean (dark shading)

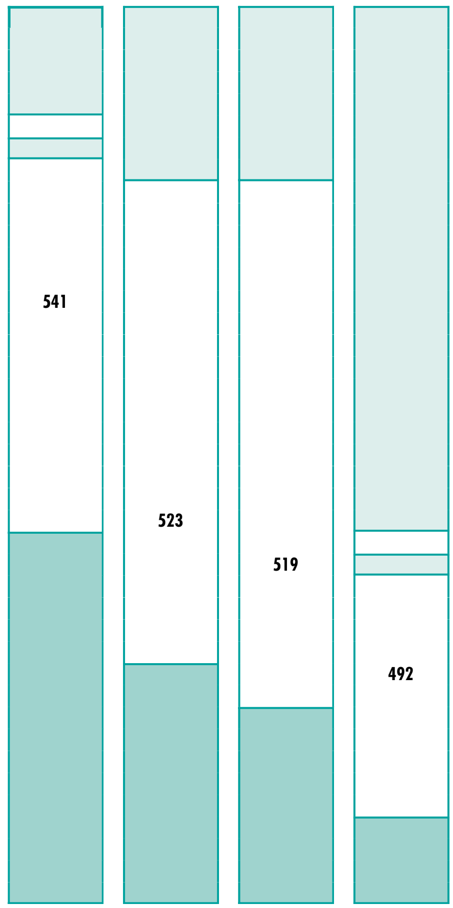
***Population Group Identification:** M=mother born in U.S.; F= father born in U.S.; m=mother born elsewhere; f=father born elsewhere.

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Spain and England may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

With regard to performance in science, the more parents born in the United States that one has, the better the level of science achievement. The findings displayed in figure 3-5 indicate that students with both parents born in the United States turn in an average level of performance that is significantly higher than the international average. Students with neither parent born in the United States show average performance levels that are lower than the international average. Students with one parent born in the United States and one born elsewhere exhibit levels of achievement not significantly different from the international average. With regard to standing vis-a-vis other nations, some 6 to 8 nations do better than the groups defined by having at least one parent born in the United States. In the case of students with both parents born outside the United States, their average performance is exceeded by 26 of the 41 nations.

Figure 3-5
National origins and science achievement: science total scores; upper grade, population 2; 1995

National Averages		U.S. Population Groups*			
Nation	**Mean**	**M/F**	**M/f**	**m/F**	**m/f**
Singapore	607				
Czech Republic	574				
Japan	571				
Korea	565				
Bulgaria	565				
Netherlands	560				
Slovenia	560				
Austria	558				
Hungary	554				
England	552				
Belgium (Fl)	550				
Australia	545				
Slovak Republic	544				
Russian Federation	538				
Ireland	538				
Sweden	535				
UNITED STATES	534				
Germany	531				
Canada	531				
Norway	527				
New Zealand	525				
Thailand	525				
Israel	524				
Hong Kong	522				
Switzerland	522				
Scotland	517				
Spain	517				
France	498				
Greece	497				
Iceland	494				
Romania	486				
Latvia (LSS)	485				
Portugal	480				
Denmark	478				
Lithuania	476				
Belgium (Fr)	471				
Iran, Islamic Republic	470				
Cyprus	463				
Kuwait	430				
Colombia	411				
South Africa	326				
Population Group Mean		541	523	519	492
Comparison to international mean of 516:		▲	■	■	▼



***Population Group Identification:** M=mother born in U.S.; F= father born in U.S.; m= mother born elsewhere; f= father born elsewhere

Key:
- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- (light shading) Country mean significantly higher than U.S. population group mean
- (unshaded) Country mean not significantly different from U.S. population group mean
- (dark shading) Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Slovenia and Scotland may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

Language

It may be that some of the association of achievement with non-U.S. national origins is linked to language. A large proportion of immigrant families speaks a language other than English in the home, which may present a challenge for students taking a test in English (NCES, 1998). It is possible to examine the relationship between language and achievement in mathematics and science by defining two population groups in terms of language spoken at home: students who always spoke English at home; and those who spoke it sometimes or never. The findings in this respect are displayed in figure 3-6, which adopts a combined format in which the findings pertaining to both mathematics and science are displayed in the one graph.

The relationship of language to achievement is apparent in these data. For mathematics, students from English-speaking backgrounds show performance levels that, on average, are not significantly different from the international mean. Students from non-English-speaking backgrounds score significantly lower than the international average. These differences are reflected as well in the position of these population groups among the 41 TIMSS nations. Students in 19 nations do better than U.S. eighth graders from English-speaking backgrounds. Students in 30 nations outperform U.S. eighth graders from non-English-speaking backgrounds.

Consistent with the higher language content of science, the difference between the two language groups in science achievement is more pronounced, relative to the international average. Students from English-speaking backgrounds show levels of performance significantly higher than the international average while those from non-English-speaking backgrounds score significantly below the international average. From the perspective of the place of these population groups among nations, students in 6 nations do better than the former group, but 27 nations turn in performances that exceed that of the non-English-speaking group.

The data then are consistent with the notion that speaking English as a second language may be associated with lower performance when test-taking in English. Eighth graders whose families converse in languages other than English either do not know or cannot demonstrate that they know as much mathematics and science as students from English-speaking families. This relationship may also be confounded with other factors associated with both achievement and language spoken at home.

Figure 3-6
Language and mathematics and science achievement: mathematics and science total scores; upper grade, population 2; 1995

MATHEMATICS

Nation	Mean
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium (Fl)	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	540
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium (Fr)	526
Thailand	522
Israel	522
Sweden	519
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
UNITED STATES	500
Scotland	498
Latvia (LSS)	493
Spain	487
Iceland	487
Greece	484
Romania	482
Lithuania	477
Cyprus	474
Portugal	454
Iran, Islamic Republic	428
Kuwait	392
Colombia	385
South Africa	354

U.S. Population Groups*	English	Other
Population Group Mean	505	464
Comparison to international mean of 513:	■	▼

SCIENCE

Nation	Mean
Singapore	607
Czech Republic	574
Japan	571
Korea	565
Bulgaria	565
Netherlands	560
Slovenia	560
Austria	558
Hungary	554
England	552
Belgium (Fl)	550
Australia	545
Slovak Republic	544
Russian Federation	538
Ireland	538
Sweden	535
UNITED STATES	534
Germany	531
Canada	531
Norway	527
New Zealand	525
Thailand	525
Israel	524
Hong Kong	522
Switzerland	522
Scotland	517
Spain	517
France	498
Greece	497
Iceland	494
Romania	486
Latvia (LSS)	485
Portugal	480
Denmark	478
Lithuania	476
Belgium (Fr)	471
Iran, Islamic Republic	470
Cyprus	463
Kuwait	430
Colombia	411
South Africa	326

U.S. Population Groups*	English	Other
Population Group Mean	542	474
Comparison to international mean of 516:	▲	▼

***Population Group Identification:** English=English is always or almost always spoken at home; Other=English is sometimes or never spoken at home.

Key:
- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- Light shading: Country mean significantly higher than U.S. population group mean
- Unshaded: Country mean not significantly different from U.S. population group mean
- Dark shading: Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Spain, Norway and Slovenia may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.

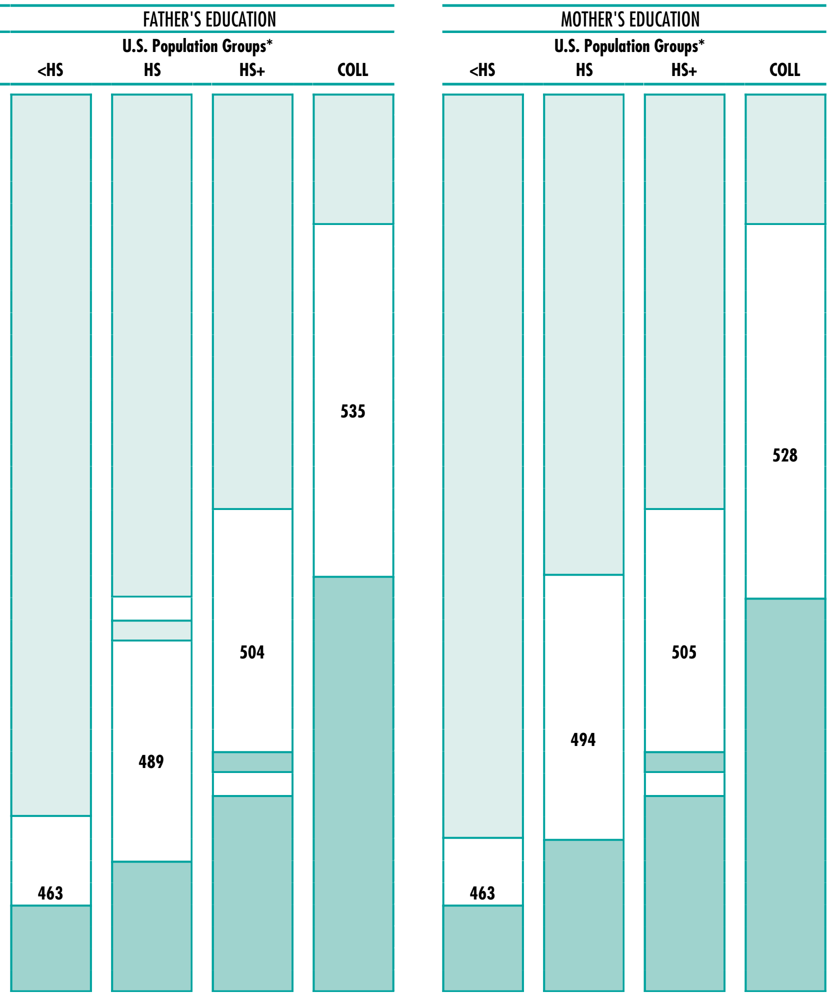
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

Father's and Mother's Education

Figure 3-7 displays the findings pertaining to the mathematics performance of population groups defined by father's and mother's education. The data demonstrate clearly that as parental education level increases, so too does mathematics performance. Benchmarking these group averages against the international mean shows the two lowest educational groups significantly below the international mean, the next highest group not different from this mean, and, for father's education at least, the college-educated group significantly above the international mean. In the case of mother's education the college-educated group, though having a higher mean score, does not differ significantly from the international mean. A similar pattern holds when the groups are placed among the 41 TIMSS nations. The number of nations with performance levels above those of the population groups in question ranges from some 34 in the case of the lowest education group to 6 for the "college-educated" group.

Figure 3-7
Father's and mother's education and mathematics achievement: mathematics total scores; upper grade, population 2; 1995

National Averages	
Nation	**Mean**
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium (Fl)	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	540
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium (Fr)	526
Thailand	522
Israel	522
Sweden	519
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
UNITED STATES	500
Scotland	498
Latvia (LSS)	493
Spain	487
Iceland	487
Greece	484
Romania	482
Lithuania	477
Cyprus	474
Portugal	454
Iran, Islamic Reublic	428
Kuwait	392
Colombia	385
South Africa	354



	Father's <HS	Father's HS	Father's HS+	Father's COLL	Mother's <HS	Mother's HS	Mother's HS+	Mother's COLL
Population Group Mean	463	489	504	535	463	494	505	528
Comparison to international mean of 513:	▼	▼	■	▲	▼	▼	■	■

***Population Group Identification:** <HS=not high school graduate; HS=high school graduate; HS+=more than high school; COLL=College

Key:
- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- (light shading) Country mean significantly higher than U.S. population group mean
- (unshaded) Country mean not significantly different from U.S. population group mean
- (dark shading) Country mean significantly lower than U.S. population group mean

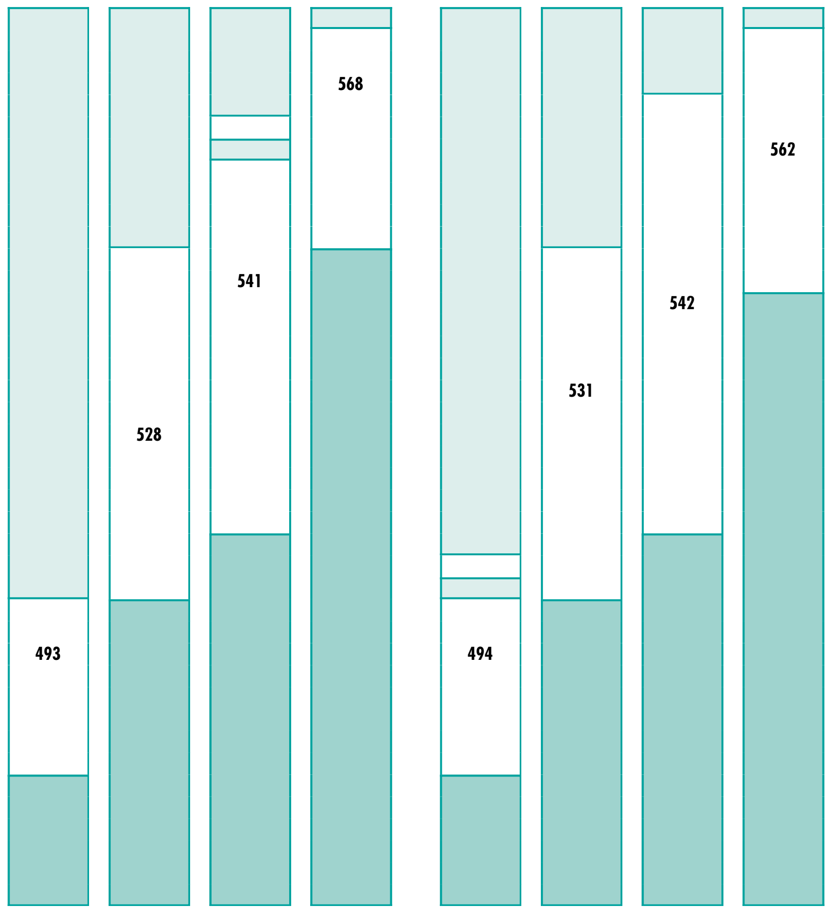
NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of England and Spain may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

A similar pattern holds in respect to the findings for science achievement, as indicated in figure 3-8. The pattern with regard to the international mean is the same for the four groups defined by both mother's and father's education. In each case, the lowest education group shows performance levels significantly lower than the international average, and all other groups have mean scores that exceed the international average. Similarly, the trend seen in figure 3-7 with respect to the ordering of groups among the TIMSS countries is seen again here. As the reported level of parental education increases, so too does the mean level of performance of students. Almost two-thirds of the 41 nations have scores that exceed the performance level of the lowest education group. Only one nation (Singapore) turns in a performance significantly above that of the highest group, the college-educated group. Clearly, the educational attainments of parents are important for the educational achievements of children.

Figure 3-8
Father's and Mother's education and science achievement: science total scores; upper grade, population 2; 1995

National Averages		FATHER'S EDUCATION (U.S. Population Groups*)				MOTHER'S EDUCATION (U.S. Population Groups*)			
Nation	Mean	<HS	HS	HS+	COLL	<HS	HS	HS+	COLL

Nation	Mean
Singapore	607
Czech Republic	574
Japan	571
Korea	565
Bulgaria	565
Netherlands	560
Slovenia	560
Austria	558
Hungary	554
England	552
Belgium (Fl)	550
Australia	545
Slovak Republic	544
Russian Federation	538
Ireland	538
Sweden	535
UNITED STATES	534
Germany	531
Canada	531
Norway	527
New Zealand	525
Thailand	525
Israel	524
Hong Kong	522
Switzerland	522
Scotland	517
Spain	517
France	498
Greece	497
Iceland	494
Romania	486
Latvia (LSS)	485
Portugal	480
Denmark	478
Lithuania	476
Belgium (Fr)	471
Iran, Islamic Republic	470
Cyprus	463
Kuwait	430
Colombia	411
South Africa	326



	Father <HS	Father HS	Father HS+	Father COLL	Mother <HS	Mother HS	Mother HS+	Mother COLL
Population Group Mean	493	528	541	568	494	531	542	562
Comparison to international mean of 516:	▼	▲	▲	▲	▼	▲	▲	▲

***Population Group Identification:** <HS=not high school graduate; HS=high school graduate; HS+=more than high school COLL=College

Key:
- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- (light shading) Country mean significantly higher than U.S. population group mean
- (unshaded) Country mean not significantly different from U.S. population group mean
- (dark shading) Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Slovenia and Spain may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

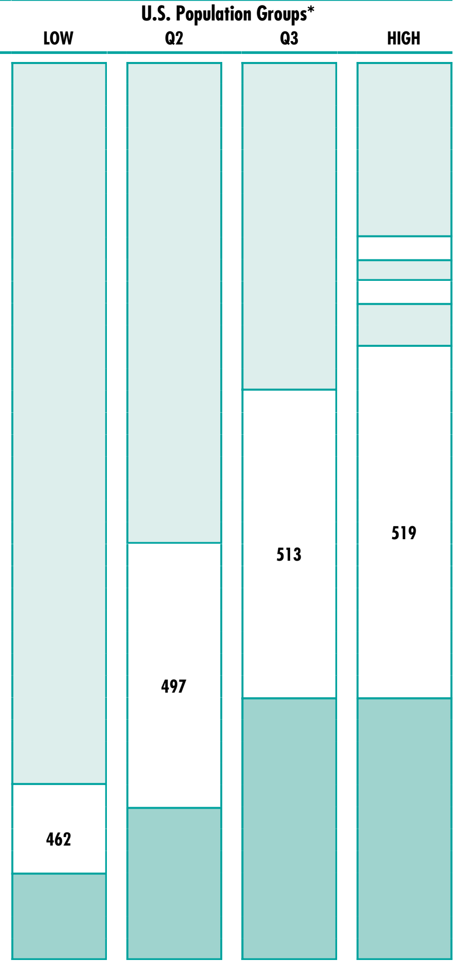
Family Economic Circumstance

Figure 3-9 displays findings relating to the mathematics performance of population groups defined by family economic circumstance. Relative to the international mean, the lower two quartiles show significantly lower levels of performance, and both of the groups with higher levels of economic resources show performance levels not significantly different from this international standard. In terms of the relative standing of these population groups among the TIMSS nations a similar pattern holds: In the case of the group assumed to have the lowest levels of resources, 33 countries exhibit higher levels of performance; 22 countries do better than the population group defined by the second quartile of this economic resource measure; and about the same number of nations—15 and 11 respectively—show performance levels higher than the two highest resource groups.

Figure 3-9
Family wealth and mathematics achievement: mathematics total scores; upper grade, population 2

National Averages / U.S. Population Groups*

Nation	Mean
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium (Fl)	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	540
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium (Fr)	526
Thailand	522
Israel	522
Sweden	519
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
UNITED STATES	500
Scotland	498
Latvia (LSS)	493
Spain	487
Iceland	487
Greece	484
Romania	482
Lithuania	477
Cyprus	474
Portugal	454
Iran, Islamic Republic	428
Kuwait	392
Colombia	385
South Africa	354



	LOW	Q2	Q3	HIGH
Population Group Mean	462	497	513	519
Comparison to international mean of 513:	▼	▼	■	■

***Population Group Identification:** LOW=1st quartile; Q2= 2nd quartile; Q3= 3rd quartile; HIGH= 4th quartile

Key:

- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- Country mean significantly higher than U.S. population group mean
- Country mean not significantly different from U.S. population group mean
- Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Netherlands and Bulgaria may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.

SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

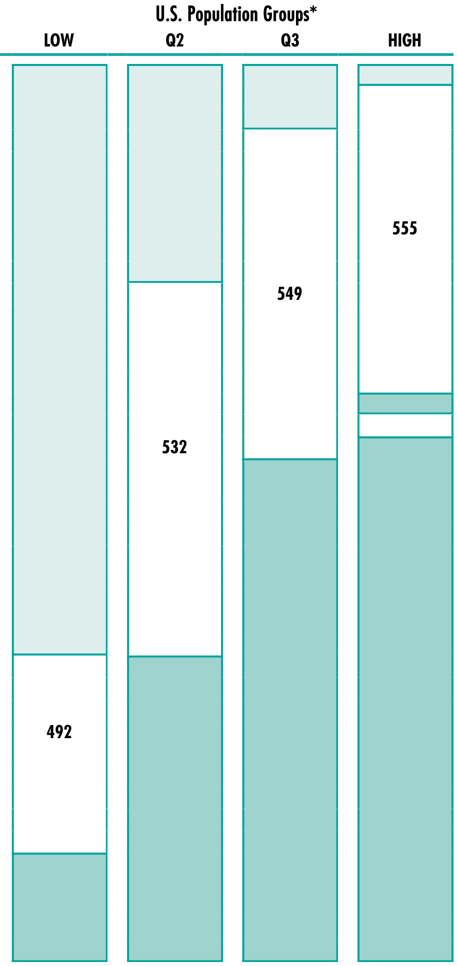
The findings displayed in figure 3-10 refer to science achievement and parallel those for mathematics. Relative to the international mean, the lowest resource group does significantly worse than the international mean, but students in each of the other three groups show average levels of science achievement significantly higher than the international mean. This basic pattern is repeated when the relative standing of these population groups among the TIMSS nations is examined. Students in 27 nations turn in levels of performance significantly greater than that of the average student in the low resource group. This number drops to 10 nations for the group defined by the second quartile, to 3 nations for the second highest resource group, and to a single country (Singapore) for the highest group. On the surface then, the data are consistent with the view that the economic circumstances of families make a difference to the academic achievement of their children.

However, the very fact that constructs like socioeconomic status exist implies that social and economic attributes of families go together. Thus, it is conceivable that some part of this observed achievement disadvantage lies with the social disadvantages that accompany economic disadvantage rather than economic disadvantage as such.

Figure 3-10
Family wealth and science achievement: science total scores; upper grade, population 2; 1995

National Averages	
Nation	**Mean**
Singapore	607
Czech Republic	574
Japan	571
Korea	565
Bulgaria	565
Netherlands	560
Slovenia	560
Austria	558
Hungary	554
England	552
Belgium (Fl)	550
Australia	545
Slovak Republic	544
Russian Federation	538
Ireland	538
Sweden	535
UNITED STATES	534
Germany	531
Canada	531
Norway	527
New Zealand	525
Thailand	525
Israel	524
Hong Kong	522
Switzerland	522
Scotland	517
Spain	517
France	498
Greece	497
Iceland	494
Romania	486
Latvia (LSS)	485
Portugal	480
Denmark	478
Lithuania	476
Belgium (Fr)	471
Iran, Islamic Republic	470
Cyprus	463
Kuwait	430
Colombia	411
South Africa	326

U.S. Population Groups*



	LOW	Q2	Q3	HIGH
Population Group Mean	492	532	549	555
Comparison to international mean of 516:	▼	▲	▲	▲

***Population Group Identification:** LOW=1st quartile; Q2= 2nd quartile; Q3= 3rd quartile; HIGH= 4th quartile

Key:

- ▲ Significantly higher than international mean
- ▼ Significantly lower than international mean
- ■ Not significantly different from international mean
- (light shading) Country mean significantly higher than U.S. population group mean
- (unshaded) Country mean not significantly different from U.S. population group mean
- (dark shading) Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Sweden may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

Family Configuration

Students' reports of persons present in their household were used to identify the three population groups based on family configuration: two-parent families in which both parents are the biological parents of the child; two-parent families in which one parent is a biological parent and the other is not;[18] and one-parent families in which the parent is the biological mother. Other configurations reported by students are small in number and are grouped as "other." Since this group is not homogeneous and offers no clear interpretation it is ignored for the purposes of this presentation. Figure 3-11 refers to mathematics achievement and shows the performance levels of these three family configuration groups reflected against the performance levels of the 41 TIMSS nations.

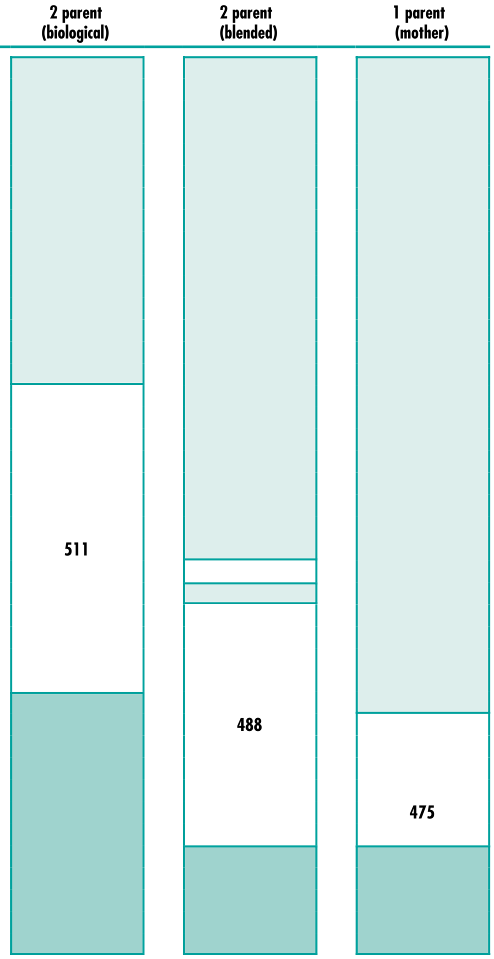
When the benchmark is the international average, the traditional family configuration is associated with higher achievement. Students from *two-parent (biological)* families show average levels of performance not significantly different from the international average. Students from nontraditional families, on average, show significantly lower levels of mathematics achievement relative to the average of all students from the 41 TIMSS nations. Thus, the distinction, it seems, is between the traditional configuration and the two nontraditional configurations; the performance levels of the *two-parent (blended)* and the *one-parent (mother)* groups are not significantly different from each other, but both are significantly lower than that of the *two-parent (biological)* group. These observations find further support from the relative standing of these population groups among the TIMSS nations. Where 15 nations exhibit significantly higher levels of performance than the *two-parent (biological)* group, this number increases to 24 for the *two-parent (blended)* group, and to 30 for students living with their mother as sole parent.

18 In subsequent discussion these family configurations are identified as, respectively: two-parent (biological); two-parent (blended); and, one-parent (mother). In each designation the parent configuration is identified first with the modifier enclosed in parentheses. To indicate that these are compound names, and to provide for easy identification, these designations have been italicized in the text.

Figure 3-11
Family configuration and mathematics achievement: mathematics total scores; upper grade, population 2; 1995

National Averages

Nation	Mean
Singapore	643
Korea	607
Japan	605
Hong Kong	588
Belgium (Fl)	565
Czech Republic	564
Slovak Republic	547
Switzerland	545
Netherlands	541
Slovenia	541
Bulgaria	540
Austria	539
France	538
Hungary	537
Russian Federation	535
Australia	530
Ireland	527
Canada	527
Belgium (Fr)	526
Thailand	522
Israel	522
Sweden	519
Germany	509
New Zealand	508
England	506
Norway	503
Denmark	502
UNITED STATES	500
Scotland	498
Latvia (LSS)	493
Spain	487
Iceland	487
Greece	484
Romania	482
Lithuania	477
Cyprus	474
Portugal	454
Iran, Islamic Republic	428
Kuwait	392
Colombia	385
South Africa	354



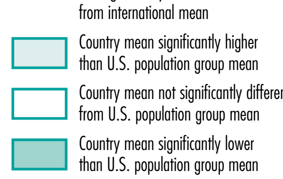
	2 parent (biological)	2 parent (blended)	1 parent (mother)
Population Group Mean	511	488	475
Comparison to international mean of 513:	■	▼	▼

Key:

▲ Significantly higher than international mean

▼ Significantly lower than international mean

■ Not significantly different from international mean



NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of England may appear out of place; however, statistically the placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.

SOURCE:
Beaton et al. (1996a). *Mathematics achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

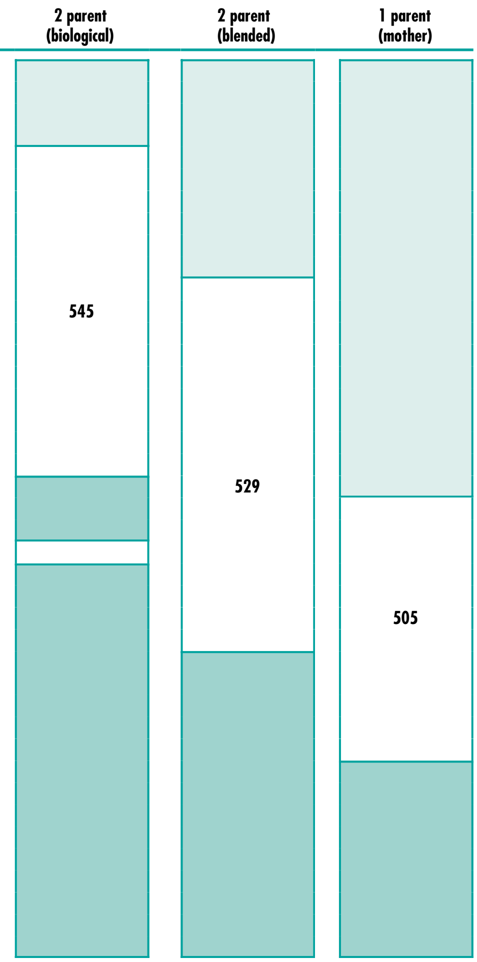
A similar pattern holds for achievement in science, as indicated in figure 3-12. Comparisons with the international mean show that the same relativities hold; however, eighth graders overall show higher levels of performance in science. That is, students from *two-parent (biological)* families, on average, do significantly better than the international mean. Students from the other two population groups show average levels of performance not significantly different from the average of all 41 TIMSS nations. Four nations turn in higher levels of performance than the average students with two biological parents. This number increases to 10 for U.S. eighth graders from *two-parent (blended)* families and further increases to 20 for students from *one-parent (mother)* families.

As with most of the family attributes noted, other explanations are possible and cannot be dismissed on the basis of the analyses reported here. For example, there are economic consequences to family disruption that predispose nontraditional families to a variety of social and economic disadvantages, and these could well explain the apparent between-group differences in achievement (Bleckman, 1982; Longfellow, 1979; Wallerstein and Kelly, 1980).

Figure 3-12
Family configuration and science achievement: science total scores; upper grade, population 2; 1995

National Averages

Nation	Mean
Singapore	607
Czech Republic	574
Japan	571
Korea	565
Bulgaria	565
Netherlands	560
Slovenia	560
Austria	558
Hungary	554
England	552
Belgium (Fl)	550
Australia	545
Slovak Republic	544
Russian Federation	538
Ireland	538
Sweden	535
UNITED STATES	534
Germany	531
Canada	531
Norway	527
New Zealand	525
Thailand	525
Israel	524
Hong Kong	522
Switzerland	522
Scotland	517
Spain	517
France	498
Greece	497
Iceland	494
Romania	486
Latvia (LSS)	485
Portugal	480
Denmark	478
Lithuania	476
Belgium (Fr)	471
Iran, Islamic Republic	470
Cyprus	463
Kuwait	430
Colombia	411
South Africa	326



	2 parent (biological)	2 parent (blended)	1 parent (mother)
Population Group Mean	545	529	505
Comparison to international mean of 516:	▲	■	■

Key:

▲ Significantly higher than international mean

▼ Significantly lower than international mean

■ Not significantly different from international mean

Country mean significantly higher than U.S. population group mean

Country mean not significantly different from U.S. population group mean

Country mean significantly lower than U.S. population group mean

NOTE:
Nations not meeting international sampling guidelines shown in italics.
Unshaded areas indicate 95 percent confidence interval of population group mean.
Population group mean scores are shown in unshaded area in approximate position.
The French-speaking (Belgium-Fr) and the Flemish-speaking (Belgium-Fl) populations of Belgium were sampled separately.
The placement of Israel may appear out of place; however, statistically its placement is correct.
Latvia (LSS) indicates only Latvian-speaking schools were sampled.
SOURCE:
Beaton et al. (1996b). *Science achievement in the middle school years.* (Table 1.1) Chestnut Hill, MA: Boston College.
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, 1995.

IV. Benchmarking American Subpopulation Groups Against an International Average

The demonstration of achievement differences between nations and differences between population groups within nations is a relatively simple exercise once the data are in hand. Assigning meaning to these differences, in the sense of developing explanations for these phenomena, is less straightforward. For the most part between-nation differences in performance seem to be associated with between-nation differences in the (official) content and/or organization of curriculum and instruction (Schmidt et al., 1997a; 1997b) and, occasionally, to national differences in the motivation and/or application to learn (Stevenson, 1992). Achievement differences between population groups within nations tend to be attributed to similar but more subtle differences in the provision of opportunities to learn or to an association of group characteristics with other factors also related to achievement.

Beginning in the 1960s with the landmark *Equality of Educational Opportunity* (Coleman et al., 1966), long-standing concerns about population group differences in educational opportunities were shown to have a basis in fact. In subsequent years other large-scale research confirmed this general proposition and extended it in scope to a broader range of population groups, and in time, to show the enduring effects of such inequities on adult status attainments (Blau and Duncan, 1967; Jencks et al., 1972; for example).

Given this, the findings presented above provide a *prima facie* case that the opportunity to learn mathematics and science and/or the demonstration of knowledge on achievement tests varies among U.S. eighth-grade population groups. Racial/ethnic minorities, students whose parents have low levels of education, those who are less well-off economically, students from immigrant families, those from non-English-speaking backgrounds, and students from nontraditional families all score lower on average. The extent of the apparent difference is highlighted in the differences between the groups in question. These comparisons are underscored when reflected against the scores of other nations. This allows one to see that U.S. population group performance spans the range of country performance. Some U.S. population groups do as well as the best among the 41 TIMSS nations, and others are the equal of those nations showing the lowest levels of mathematics and science knowledge.

Note, however, that this apparent demonstration of population group difference is indicative only. Many of the variables identified above are confounded: Immigrants are less well-off economically and are more likely to speak languages other than English at home; racial/ethnic minority groups tend to be economically disadvantaged as well; and so on. Thus, it may not be legitimate to attribute the differences observed, in whole or in part, to population group membership alone. For example, other studies have shown that apparent differences between population groups disappear when such confounding factors are taken into account. The apparent disadvantage of *one-parent (mother)* family configurations is one case in point. Analyses undertaken in a related study of U.S. reading performance show that differences by family configuration are negligible when related socioeconomic and racial/ethnic characteristics are taken into account (Williams, 1994; NCES, 1996a). This study also reports similar analyses applied to other forms of population group differences and these show varying reductions in the amount of difference that can be attributed to particular population group membership.

In short, the analyses reported here have shown that population groups differ, on average, in achievement in mathematics and science. Some groups of U.S. eighth graders are literally among the best in the world. Other groups of U.S. eighth graders perform so poorly in mathematics and science that they stand among the lowest scoring of the TIMSS nations. What has not been established is whether population group membership *per se* is responsible. It is not necessarily the case, for example, that students from poor families do less well because they are poor, or that students from single-parent families achieve at lower levels because they have only one parent. Evidence bearing on such matters awaits further more complicated analyses of the TIMSS data.

4. Teachers and Teaching

I. Introduction

Most of the public attention directed at studies conducted by the International Association for the Evaluation of Educational Achievement (IEA) is generated by comparisons of the achievement of nations. However, the simple demonstration of between-nation differences in student achievement has never been the sole motivating force behind these international studies. Rather, the underlying rationale is that one might look for correlates of achievement differences between nations in national curricula and learning contexts. While a great deal of work goes into the design of the achievement measures, and students spend several hours demonstrating their subject-matter knowledge by taking these paper-and-pencil tests, the students, teachers, and schools who take part in IEA studies devote an equal or greater effort to describing both the methods and content of instruction. The measurement of curriculum and instruction dominates the content of student, teacher, and school questionnaires in IEA studies.[1] The Third International Mathematics and Science Study (TIMSS) follows this same general pattern. The discussion that follows focuses on the mathematics and science instruction given to U.S. eighth graders and is based on the information provided by teachers during the course of TIMSS.

Describing Instruction in Mathematics and Science

Three considerations shaped the form and content of the analyses developed. First, their content focus is one of the major themes of TIMSS—the instructional practices of mathematics and science teachers. Curriculum has been dealt with elsewhere (Schmidt et al., 1997a; 1997b); the present analyses take up the description of instruction in mathematics and science. Second, this is the one content area shared by all three components of U.S. TIMSS, which had two components additional to the surveys of students, teachers, and schools. One consisted of ethnographic case studies of education systems in the United States, Germany, and Japan. The second involved videotape observational studies of eighth-grade mathematics classrooms in the same three countries. Together these provided the opportunity to bring all three perspectives to bear on matters held in common. The one matter common to all three components was the instructional practices of eighth-grade teachers. The third consideration shapes both the form of the analyses and the nature of their presentation. The charter for these analyses was that they provide a simple statistical description of the mathematics and science instruction of eighth graders in United States schools and, to a lesser extent, of the mathematics and science instructors of eighth graders. Since the teaching of mathematics and science is described with simple descriptive statistics alone, it makes particular sense to embed these statistical descriptions in the literature on teaching mathematics and science. By so doing, such interpretations as are possible gain strength from their consistency, or lack thereof, with what is already known.

1 This information is supplemented by questions about the attributes of students, teachers, and schools, which, while of interest in their own right, are designed to serve mainly as covariates of the measures of curriculum and instruction.

The information in question comes principally from the questionnaires administered to the mathematics and science teachers of the students sampled. In separate questionnaires, mathematics and science teachers were asked essentially parallel sets of questions and in considerable number; some 500 responses were allowed for in each of these questionnaires. Since the questionnaires asked more about teaching than about teachers, most of this chapter is devoted to describing the way in which mathematics is taught to eighth graders in the United States.

The substantive issues addressed by these questionnaires, and hence the issues to be described in these analyses, reflect traditional concerns about teachers and teaching—basically, the identification of effective teachers and effective teaching. These issues have generated a research tradition of long standing known more generically as process-product research. Its focus is the effectiveness of various classroom processes in producing student learning (achievement). Early studies concentrated on teachers' education and training; on personal attributes such as age, race and gender; and on personality characteristics such as warmth and enthusiasm. Later research shifted attention to generic teaching behaviors such as clarity of presentation, pacing of instruction, feedback and monitoring, and predictability of classroom routines. Duncan and Biddle (1974) collected and integrated the various conceptual components of this research tradition into a model for the study of classroom teaching. Reviews of the effective teaching literature can be found in Medley (1979), and Brophy and Good (1986).

More recent approaches focus more on teachers' knowledge and beliefs and how these are translated into effective practice. These constructivist perspectives are well articulated in papers on teaching in general (Shulman, 1986; 1987), the teaching of mathematics (Peterson, 1988a; Putnam et al., 1990; Ball, 1991), and the teaching of science (Carlsen, 1991; Smith and Neale, 1991; Tobin, 1991; Gallagher, 1993).

In TIMSS, much of what is asked of teachers about themselves and about their instructional practices appears to relate closely to the process-product tradition since it tends to focus on the link between instructional practice and achievement. In fact, the broader substantive emphases implied by the content of the questionnaire items map to the conceptual groups shown in the Duncan and Biddle model. This coincidence is helpful in the present circumstances as it provides a structure for the organization of the questionnaire items and a framework within which to write about the issues that these items address.[2] In the first instance, more than 20 categories of items to do with teachers and their instructional practices were identified. Subsequently these were grouped into five broader sections. This structure is shown in Exhibit 4-1.

2 While the bulk of the information comes from the teacher questionnaires, at times reference is made to student and school questionnaires where these offer additional information or another perspective on instructional practices in U.S. classrooms.

Exhibit 4-1
Content categories of TIMSS teacher questionnaires

I. Eighth-grade mathematics and science teachers

Demographic characteristics

Education and training

Experience

Curriculum and content knowledge

Beliefs about mathematics/science

II. Teachers' working conditions

Workload: teaching; nonteaching; out-of-hours

The teaching profession: autonomy; collegiality

Contextual constraints: class size; student ability; instructional context

III. Instructional resources

Technology in the schools: calculators and computers;

student attitudes to technology

Remedial and enrichment programs

Instructional time

IV. Instructional practices

Lesson planning

Introducing new topics

Organizing and interacting with students

Instructional activities

Promotion of higher order cognitive processes

Responding to students' errors

Homework: amount; content; followup

Assessment: types; uses

V. The last lesson

Topics covered

Instructional activities

Summary

These emergent themes are consistent with the general emphases of the literature noted above. Category I contains what Duncan and Biddle call "presage variables." Categories II and III contain "context variables," and Category IV groups the items of primary interest, the "process variables." More specifically, TIMSS provides for an examination of some personal attributes of the teachers themselves; aspects of the school and classroom environments in which they teach; instructional resources they can draw on to support instruction; and the instructional practices they use to generate the product—student learning. The instructional practice emphasis receives a second and more specific treatment in the questionnaires in the section labeled "the last lesson." Here, teachers are asked to respond about the content and nature of instruction with reference to a particular lesson.

The teachers and teaching of eighth-grade mathematics and science is described below in these terms, with the first four categories providing a description in general terms, and the "last lesson" something of a summary of the specifics of mathematics and science teaching in lessons taught during the spring 1995, the time of the TIMSS data collection.

Description and Explanation

Since the teaching of mathematics and science is described with simple descriptive statistics alone, it makes particular sense to organize this description according to an explicit conceptual framework and, within this framework, to embed these statistical descriptions in the literature on teaching mathematics and science. By so doing, such interpretations as are possible gain strength from their consistency, or lack thereof, with the extant literature on this subject. In the present chapter these interpretations are enriched in particular by references to the following four large-scale studies that provide comparable information on teachers' lives and work.

- National Assessment of Educational Progress (NAEP); Mathematics 1992 (Dossey et al., 1994; Lindquist et al., 1995)
- NAEP; Science 1990 (Jones et al., 1991)
- National Survey of Science and Mathematics Education (NSSME) (Weiss et al., 1994)
- Schools and Staffing Survey by State: 1990-91; 1993-94 (National Center for Education Statistics [NCES], 1993a; 1993b; 1996c)

Within this general context, the strategy adopted is to display the findings for mathematics and science teachers in a comparative fashion. The intent is to demonstrate in the first instance such parallels between mathematics and science instruction as there may be and, secondarily, to highlight where instruction differs between mathematics and science.

The text proper provides graphic presentations to display the findings with regard to each of the variables examined. The statistics in question are either percentages (the majority) or means and these are shown on the figures themselves. Pairwise tests of the statistical significance were applied to differences between mathematics and science teachers in these percentages or means. Where differences are statistically significant this is indicated in the figures by bolding the percentage or mean in the pair with the highest value. In the case where the difference between mathematics and science teachers is not statistically significant neither of the statistics in question are bolded.

These graphics are supported by detailed tabular presentations in an appendix to the chapter, Appendix A. Notes accompany the tables providing questionnaire item references and, where appropriate, a description of the way in which a variable was constructed and/or a statistic derived. In most cases these tabulations portray the form of the variable as it is represented in the questionnaires.[3] Where categories are collapsed for the graphic presentations, the appropriate statistics for the collapsed categories are included as a supplement to the tables.

Presentations based on simple univariate statistics pose something of a problem when the number of attributes being described is large, as it is in this case. The teachers and teaching of eighth-grade mathematics and science are described with 40 tables and 38 figures. Describing each of the elements of these tables and figures in detail would make the text unreadable, in the sense that few readers would persist with it. In an attempt to overcome this problem, approximations to the actual numbers are used to simplify the text in some cases; and, at times, broad patterns apparent in the data are highlighted rather than each individual element of the pattern. The detail is always available, of course, in the tables provided in Appendix A.

A Note on Sampling and Interpretation

The TIMSS samples were developed as samples of schools in the first instance and then samples of mathematics classes within schools—two grade 8 mathematics classes and one grade 7 mathematics class. Teachers as such were not explicitly sampled. The teachers selected for participation in TIMSS were those teaching mathematics to the sampled classes and science to these same students. Since students in the United States tend to have only one mathematics teacher, this meant the involvement of one, two, or three mathematics teachers per school (one teacher for each of the sampled classes, a single teacher teaching all three classes, or one teacher teaching two classes and another teaching only one). The number of science teachers linked to these students could vary quite a lot according to how many science classes the school had and how widely the students from each mathematics class were dispersed among these science classes.

Issues to do with response burden sharply curtailed the actual number of teachers completing questionnaires. The basic rules applied were that a teacher should not fill out more than one questionnaire or, if linked to less than five of the sampled students, should not fill out a questionnaire at all. The latter rule affected science teachers. If a teacher taught two or more of the mathematics classes sampled, he/she completed

3 The questionnaires themselves are reproduced in the technical report (NCES, 2000).

a questionnaire for only one class. If a teacher taught both mathematics and science classes, the mathematics class was chosen as the subject of the questionnaire. In the case of science, where the students sampled in the mathematics class could spread to multiple science classes, only those science teachers teaching five or more of the sampled students completed questionnaires.

"Administrative losses" of this kind resulted in some 18 percent of students being without a link to a mathematics teacher. The situation for science was worse in that the analogous figure was 42 percent of students without a link to a science teacher. Teacher nonresponse added to these losses for a total of 73 percent of students linked to a mathematics teacher but only 49 percent linked to a science teacher. Adjustments for this "administrative nonresponse" have been made to the sampling weights. The procedures used to do this are complicated and require considerable statistical sophistication. They are described in detail in Rizzo (2000). However, the principle behind the methods used is the one behind most methods of nonresponse adjustment in sample surveys—poststratification and reweighting. The achieved sample is stratified into cells, and the cells are reweighted to the designed sample proportions.

Irrespective of this issue, the eighth-grade mathematics and science teachers selected by these procedures, and whose instructional practices are described below, are not strictly a sample of the population of eighth-grade mathematics and science teachers. These are the teachers of a sample of eighth-grade students. Generalizations, then, are to the population of students, not the population of teachers.

This fact adds a degree of complexity to the description of instructional practices in eighth-grade mathematics/science classrooms and ideally, one avoided in the interests of simplicity and readability. Since U.S. eighth graders appear to have only one mathematics teacher and only one science teacher, one way around the problem of awkward interpretations is to weight each teacher's responses with the sum of the student weights for all students linked to that teacher. By so doing, each teacher is represented in estimates of teacher characteristics/behaviors in proportion to the number of students linked to that teacher. Thus, the estimate in question is linked back to the student population, as is appropriate. One further complication stems from the fact that weighting teachers with the sum of student weights results in an apparent total population size equal to the number of students. The result is to make it appear that, as far as the teacher variables are concerned, there is more information available than there really is. To deal with this matter, we have chosen to scale the sum of the student weights associated with each teacher so that their total is equal to the number of teachers rather than the number of students. The relativity of the weights is maintained but the total is now the number of teachers rather than the number of students.

Teachers, Teaching, and Achievement

Ideally one would like to link the attributes of teachers and teachers' instructional practices to the demonstrated achievement of the students they teach and, in this way, identify effective teachers and effective teaching practice. Such a linking is possible within the TIMSS data, but cross-sectional designs of the kind that characterize TIMSS (and IEA studies in general) are not well-suited to this purpose. Students enter eighth grade with knowledge, beliefs, and orientations accumulated over 7 years of schooling and some 13 to 14 years of family life. What teachers do within the space of a school year is unlikely to radically alter the achievement level of the class as a whole and so create a sizable correlation between teacher instructional practices and student achievement at the classroom level. The best hope to demonstrate the relationship between teachers' instructional practices and student achievement is to look at the relationship to growth in achievement over the year, rather than absolute levels of achievement. Recognizing this, the original design of TIMSS was one that required a pre- and posttest to measure this growth. Unfortunately, most of the participating nations were unable to support both a pre- and a posttest, so the study reverted to a simple cross-sectional single testing design.

As a result, the present analyses and those which look at influences besides instruction (curriculum, for example), can offer no more than circumstantial evidence of the context for learning mathematics and science and, hence, of what might move U.S. students toward the realization of the goal of being first in the world.

II. Eighth-grade Mathematics and Science Teachers

This section of the report looks first at the demographic attributes of teachers (age, gender, and race/ethnicity), followed by their education, training, and experience, and finally, their beliefs about mathematics/science as disciplines and the nature of teaching within these disciplines.

Demographic Characteristics

The typical mathematics or science teacher in secondary public schools and in middle schools is a white, college-educated, teacher-trained female in her 40s (Blank et al., 1994; Weiss et al., 1994). Eighth-grade teachers in TIMSS fit this profile quite well, as indicated in appendix table 4-1 (on page A-1). Mathematics teachers are predominantly white (89 percent) and female (64 percent). Science teachers are also white (90 percent), but about one-half are female. Black teachers account for 8 percent or less, and Hispanic teachers about 2 percent of eighth-grade mathematics and science teachers. On average, teachers in both subject areas are in their early 40s (a mean of 41 years), with 45 percent of the mathematics teachers and 29 percent of the science teachers between 40 and 49 years of age. In both subject areas, teachers under 30 and over 50 each constitute 17 to 24 percent of the teachers.

Education and Training

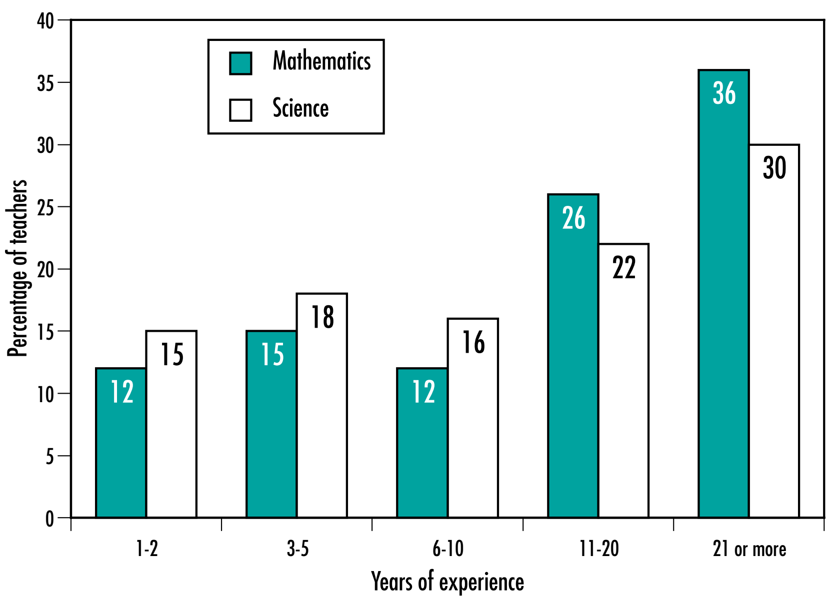
TIMSS provides a limited amount of information on teachers' preparation, and none of this refers to subject-matter preparation for the teaching of mathematics and/or science. The measures of education and training available are restricted to formal education (degree/higher degree) and specific teacher training (presence/absence) combinations. Panel 4-2a of appendix table 4-2 (on page A-2) shows that about 54 percent of eighth-grade mathematics and science teachers have bachelor's degrees and teacher training, and approximately 44 percent of eighth-grade mathematics teachers and 39 percent of eighth-grade science teachers have a master's or doctoral degree and teacher training. Two percent of mathematics teachers and 8 percent of science teachers have no teacher training background. These patterns are consistent with the Schools and Staffing Survey for 1993-94 (NCES, 1996c). However, we cannot determine whether the substantive focus of their formal education was in the area in which they now teach.

New standards in mathematics and science call for a better balance in teacher preparation between coursework in the academic disciplines and in education (Mathematical Association of America, 1991; National Council of Teachers of Mathematics [NCTM], 1991a; National Research Council, 1996; Interstate New Teacher Assessment and Support Consortium, 1991; National Board for Professional Teaching Standards, 1991). The NCTM standards, for example, recommend that middle school teachers take courses to develop their knowledge of mathematics and mathematical pedagogy as well as courses to develop their understanding of students as learners of mathematics. NCTM recommends that middle/junior high school level mathematics teachers have college coursework in abstract algebra, geometry, calculus, probability and statistics, and applications of mathematics/problem solving. In the case of science teachers, National Science Teachers Association (NSTA) recommends that middle/junior high school level science teachers take at least two courses in biological sciences, physical sciences, and earth sciences as well as coursework in science education. On a national level, many teachers fall short of the recommended coursework. Seven percent of grades 5-8 mathematics teachers meet the NCTM criteria, and 34 percent of the grades 5-8 teachers have taken none of the recommended courses; 42 percent of grades 5-8 science teachers and 57 percent of grades 7-9 science teachers meet the NSTA criteria (Weiss et al., 1994). Sixty percent of secondary mathematics teachers (grades 7-12) majored in mathematics or mathematics education while 69 percent of secondary science teachers majored in science or science education (NCES, 1993b).

Experience

Traditionally, education and experience are considered together as the fundamentals of occupational productivity. The TIMSS teacher questionnaires tap both the extent and the breadth of teaching experience—respectively, years of teaching and grade levels taught over the past 5 years. Data on years of experience are presented in panel 4-2b of appendix table 4-2 (on page A-2) and in figure 4-1. On average, teachers of TIMSS eighth-grade students are an experienced group having taught an average of 14 to 15 years. Approximately 62 percent of eighth-grade mathematics teachers and 52 percent of eighth-grade science teachers have been in the profession for 11 years

Figure 4-1
Years of teaching experience; eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

or more. Around 30 percent in each subject have been teaching for 5 years or less. These data parallel findings from the most recent Schools and Staffing Survey (NCES, 1996c) and the National Survey of Science and Mathematics Education (Weiss et al., 1994), which also paint a picture of an experienced teaching force.

Information on the breadth of experience of eighth-grade mathematics and science teachers is presented in panel 4-2c of appendix table 4-2 (on page A-2). Responses to the question, "At which of these grade levels have you taught in the past 5 years?" were used to construct an index of teaching experience at each of the three levels of schooling commonly defined in statements about educational standards: elementary (grades K-4), middle (grades 5-8), and high school (grades 9-12). This index shows that approximately two-thirds of eighth-grade mathematics teachers and three-fourths of science teachers taught only at the middle school level during the previous 5 years. An additional 28 percent and 18 percent, respectively, taught both middle and high school classes, with 10 percent or less of the teachers in both fields having a combination of middle and elementary grade experience. Two percent or less had experience at all three levels of schooling in the prior 5 years. In short, eighth-grade mathematics and science teachers are experienced mostly at the level they now teach—the middle school. This pattern may be a reflection of the licensing and credentialing structures in most states, which differ by grade level.

Knowledge

While there is virtually no consensus on what constitutes the knowledge essential to teach in general, or to teach mathematics or science in particular, several related viewpoints exist. A common thread to all of these is that subject-matter knowledge alone is not sufficient for high-quality classroom instruction. Shulman (1986) proposed a general framework with elements of subject-matter knowledge, pedagogical content knowledge, and curricular knowledge. Peterson (1988b) identified three categories: how students think in specific content areas, how to facilitate growth in students' thinking, and self-awareness of teachers' own cognitive processes. Along similar lines Fennema and Franke (1992) developed a more specific model of mathematics teachers' knowledge with elements of knowledge of mathematics, pedagogical knowledge, knowledge of learners' cognitions in mathematics, and teacher beliefs.

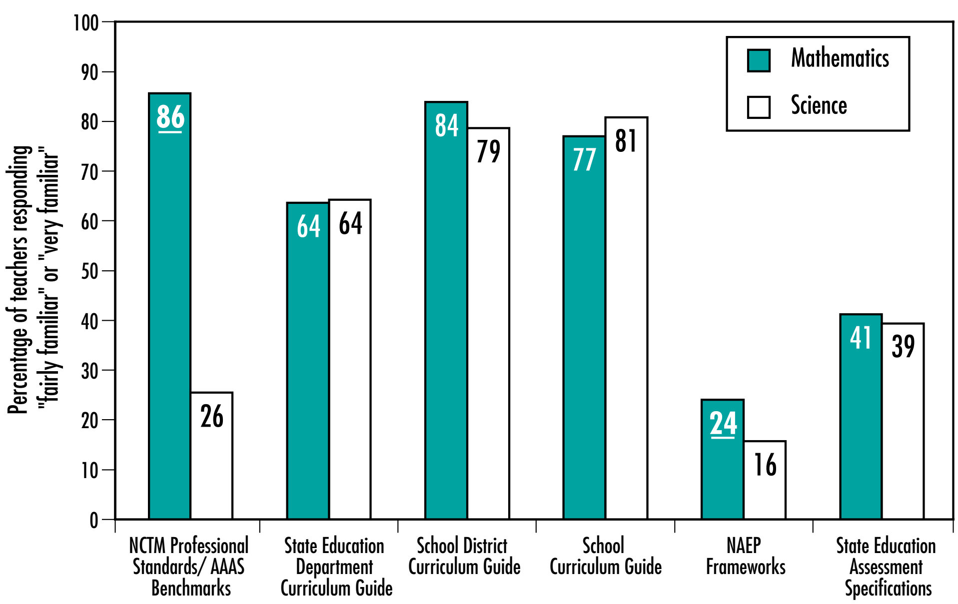
The TIMSS teacher questionnaires provide some information relating to two of these dimensions of teacher knowledge: curricular knowledge and pedagogical content knowledge. These measures are limited to teachers' reported familiarity with national, state, and local subject standards and curriculum guides; and to science teachers' reports of their preparedness to teach in particular topic areas.

Curriculum knowledge. Curriculum knowledge is intimately linked to the most recent plans for the reform of mathematics and science curricula and teaching as exemplified in statements of standards for curriculum content and the teaching process—most notably, the NCTM-produced Curriculum and Evaluation Standards for School Mathematics Teaching (NCTM, 1989) and Professional Standards for Teaching

Mathematics (NCTM, 1991a). The counterparts of these standards for science were those developed by the American Association for the Advancement of Science (AAAS) and reported in Benchmarks for Science Literacy (AAAS, 1993) and, more recently, the National Science Education Standards (National Research Council, 1996). But many states, school jurisdictions, and even individual schools also operate under mathematics and science guidelines developed closer to home. The TIMSS questionnaires covered both sources of curriculum knowledge by asking teachers to rate their knowledge of subject standards and curriculum and assessment guidelines at the local, state, and national levels, specifically, the NCTM Professional Standards for Teaching Mathematics/AAAS Benchmarks for Science Literacy; State Education Department Curriculum Guide; School District Curriculum Guide; School Curriculum Guide; NAEP Assessment Frameworks/Specifications; and State Education Department Assessment Specifications.

Figure 4-2 and appendix table 4-3 (on page A-3) illustrate the proportion of eighth-grade mathematics and science teachers reporting that they are "very familiar" or "fairly familiar" with specific subject standards and curriculum guides. In general, the responses were similar for mathematics and science teachers with the exception of the professional standards documents and NAEP frameworks. Eighty-six percent of mathematics teachers reported being "very" or "fairly familiar" with the NCTM Professional

Figure 4-2
Familiarity with curriculum documents; eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Standards, similar to Weiss et al. (1994) who reported 88 percent of grades 5-8 teachers are well informed about the NCTM Standards for the grade they teach. This stands in contrast to the case for TIMSS science teachers, where 26 percent report this same level of familiarity with the AAAS Benchmarks. In good part the explanation for this difference is that these publications have been out in the field for different lengths of time, the AAAS Benchmarks being a more recent publication than the NCTM Standards. Acceptance could be an issue as well; science teachers may see the NSTA as their national reference group more so than the AAAS.

About one-third of mathematics and science teachers report no familiarity with the assessment specifications used by their State Education Departments (SEAs). Even larger numbers (three-fourths or more) are unfamiliar with NAEP specifications in mathematics and science. Teachers do, however, tend to be better acquainted with curriculum guidelines. Seventy-seven percent or more of mathematics and science teachers reported they were "very" or "fairly familiar" with district- and school-level curriculum guides. About 16 percent of the mathematics teachers and 13 percent of the science teachers report that their schools have no specific curriculum guides.

Content knowledge. Weiss et al. (1994) reported that for grades 5-8, 49 percent of mathematics teachers teaching mathematics and approximately 40 percent of science teachers teaching life or earth sciences felt well qualified to teach those subjects. While TIMSS does not provide information on how well teachers are prepared to teach by virtue of their subject-matter training, it does offer some evidence in this respect from the point of view of the teachers themselves. The information is available only for eighth-grade science teachers and consists of their reports on how well prepared they feel to teach in each of nine science topic areas.[4] Figure 4-3 and appendix table 4-4 (on page A-4) illustrate their responses. Significantly more than one-half of the teachers report being sufficiently prepared to teach *earth's features, energy, human reproduction, measurement* and *data preparation/interpretation.* In the case of the other topics noted—*light, human tissues/organs, human metabolism,* and *human genetics*—the proportions shown are not significantly different from 50 percent. In short, one in every two teachers feels sufficiently prepared to teach this aspect of physical science, and these several aspects of biological sciences. Seen from another angle, about half of all science teachers surveyed report not being sufficiently prepared to teach in these content areas.

Teachers' Beliefs

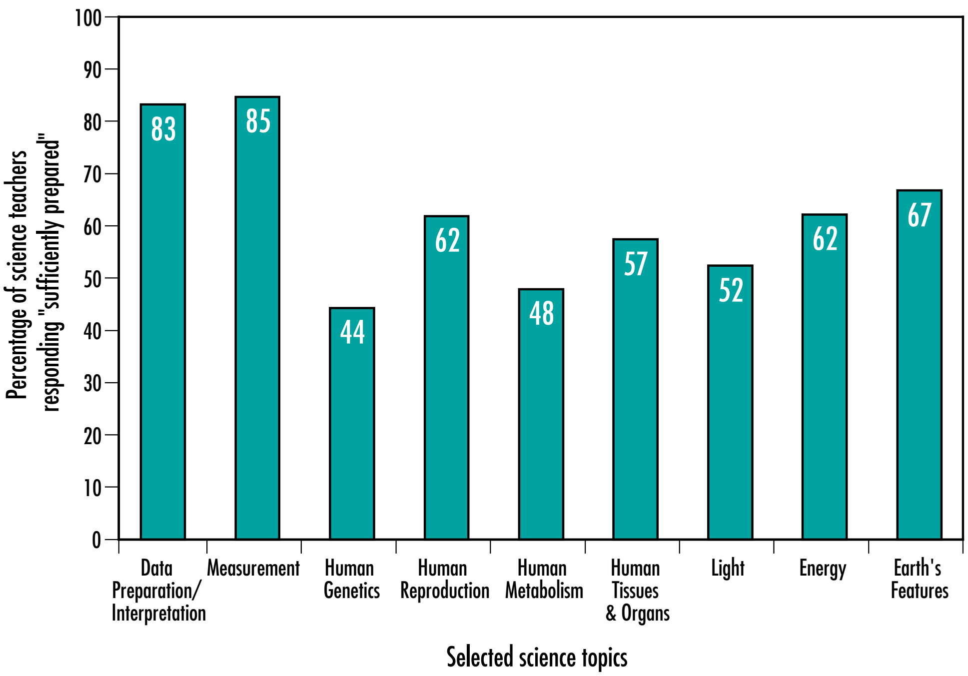
Teachers' knowledge of subject matter, curriculum, and pedagogy goes hand-in-hand with sets of beliefs about, in this case, the nature of mathematics and science as disciplines and the way in which mathematics and science is most effectively taught. The TIMSS questions tap aspects of more general discussions of subject matter and pedagogical belief systems that appear in the literature. In the case of subject-matter beliefs, different views of mathematics and science as disciplines can be placed on a continuum. According to this particular view of instruction, at one end of the con-

4 There was no parallel question for mathematics teachers in the TIMSS teacher questionnaires.

tinuum are viewpoints commonly characterized as "external," "abstract," and "formal." In these frameworks, mathematics and science are seen as codified bodies of knowledge. At the opposite end are the so-called "internal views," which place great significance on the processes of building individual knowledge and establishing accepted knowledge in the discipline. Constructivism falls in this latter camp (Wheatley, 1991). As noted earlier, the past decade has seen an increasing focus on learning as an active process of constructing knowledge, rather than as a passive process of acquiring it (Wittrock, 1979; Weinstein and Mayer, 1986; Brophy, 1989; Fennema et al., 1989). Modern learning theorists hold that learning occurs by students' active engagement in a process of exploration, discovery, and synthesis, rather than by serial accumulation of factual information dispensed by teachers and textbooks, and that expert teachers are adept at teaching using this paradigm (Brophy, 1989; Sternberg and Horvath, 1995; Jonassen, 1992).

Within the constructivist context, particular attention has focused on the translation of teacher beliefs into practices affecting the content and methods of instruction. Findings have shown a great deal of consistency between the two (Thompson, 1992). For example, science teachers who subscribe to a static or "facts" view of their discipline tend to favor didactic approaches in which presentations, practice, and memorization are the critical teaching and learning events. Those who see science as resting

Figure 4-3
Level of topic preparation; eighth-grade science teachers



SOURCE: U.S.Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

ultimately on empirical discovery more often promote hands-on learning and favor open-ended environments (Smith and Neale, 1991). Much the same is true in mathematics. Teachers who view mathematics as an immutable product or commodity stress formalisms in their teaching and approach content in a very structured fashion. Those who see mathematics in more constructivist terms, as a dynamic field of human endeavor, are more inclined to take an active, problem-solving approach to instruction (Dossey, 1992; Thompson, 1992).

The TIMSS teacher questionnaires focus on two aspects of teachers' beliefs: beliefs about the nature of mathematics/science as disciplines; and a related set of beliefs to do with the forms of pedagogy appropriate for teaching these disciplines. Some of the latter involve beliefs about students and the ways in which they learn.

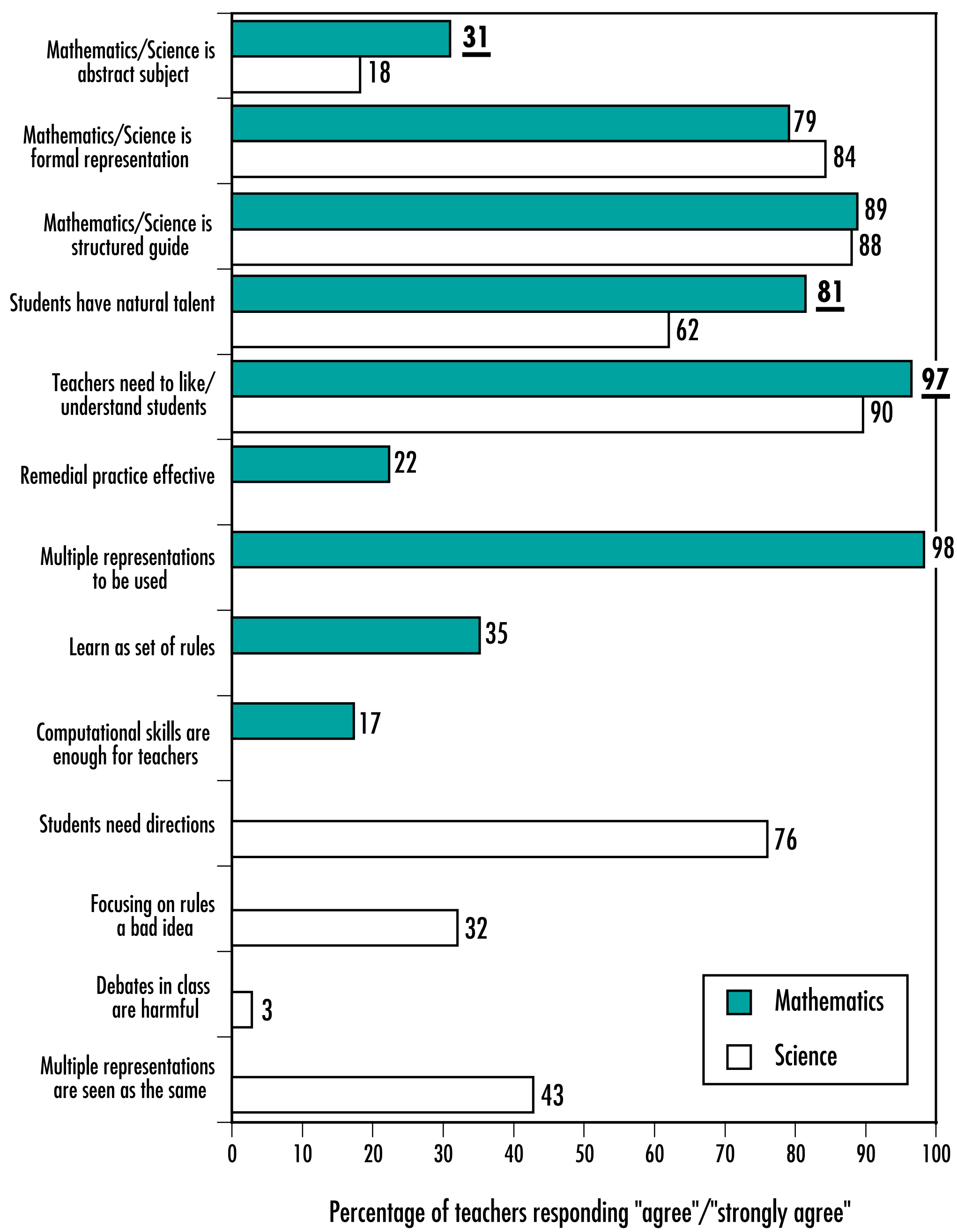
The nature of mathematics/science. Teachers reported their views on these matters by registering their level of agreement with nine statements, five of which are parallel in the two versions of the questionnaire. Appendix table 4-5 (on page A-5) displays the teachers' responses in full, and figure 4-4 pictures the combined proportion of teachers who either agree or strongly agree with the statements.

The items that most directly tap beliefs about the disciplines themselves are the first three shown in appendix table 4-5 (on page A-5), and these refer to the relative abstract/concrete nature of the subjects in question. Overall, teachers appear to take a fairly practical view of both mathematics and science, seeing these disciplines as ways of modeling the real world rather than abstract conceptual systems. More than three-fourths of teachers see their respective disciplines as a "formal way of representing the real world" and "a structured guide for addressing real situations." Thirty-one percent of mathematics teachers and 18 percent of science teachers "strongly agree" or "agree" that mathematics and science, respectively, are primarily abstract subjects.

There was high agreement from mathematics teachers that, "A liking for and understanding of students are essential for teaching mathematics," and that "More than one representation should be used in teaching a mathematics topic." About one-third of mathematics teachers support the notion that mathematics should be learned as a set of algorithms or rules. About 70 percent of science teachers reject the statement that "focusing on rules is a bad idea." Three-fourths of all science teachers agree that "it is important for teachers to give students prescriptive and sequential directions for science experiments."

Cognitive demands. This emphasis on rule learning rather than rule inference may have something to do with teachers' views of the cognitive demands that mathematics and science make on students and their views about the capabilities of students in this respect. From the perspective of student capabilities, appendix table 4-5 (on page A-5) indicates that significantly more mathematics teachers (81 percent) than science teachers (62 percent) report that some students have a natural talent for mathematics (science) and others do not.

Figure 4-4
Attitudes to mathematics and science; eighth-grade mathematics and science teachers

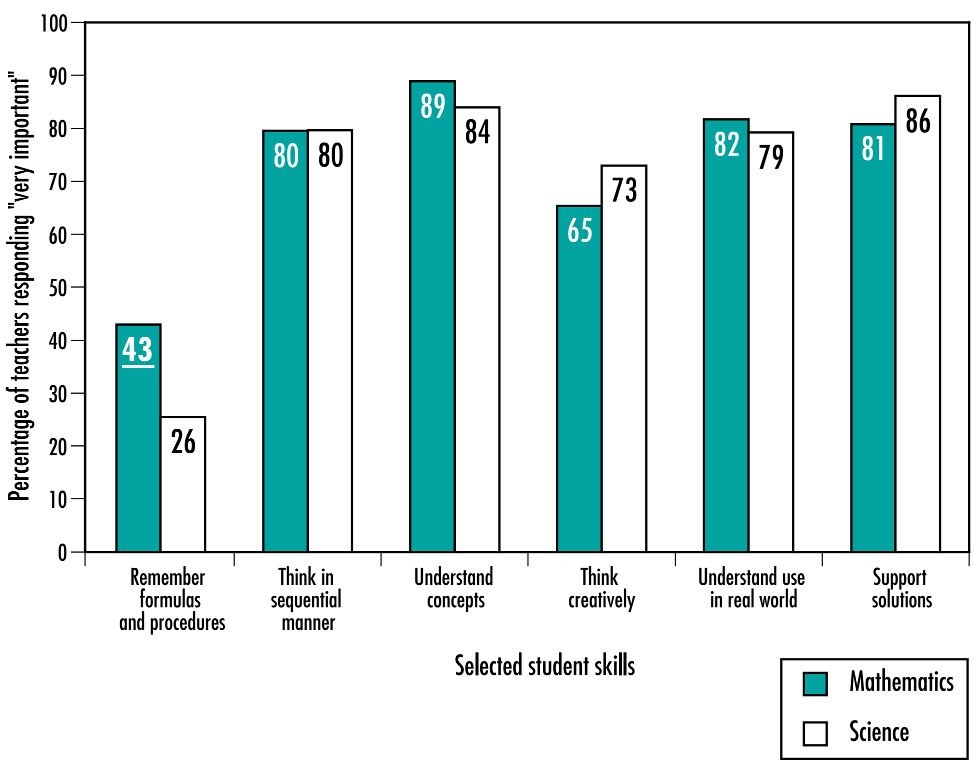


NOTE:
Some questions were asked to both mathematics and science teachers; some questions were asked only to mathematics or science teachers.
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

On the matter of the cognitive demands made on students, the teacher questionnaires contain a set of items that tap teachers' beliefs about the cognitive demands of their respective disciplines. The items are parallel across the two questionnaires, and in each case, teachers were asked to rate the importance of particular kinds of skills for success in the discipline. The skills in question have elements ranging from remembering through understanding to thinking creatively.

Teacher responses to this item are displayed in appendix table 4-6 (on page A-6) and figure 4-5. In all, most teachers identify higher level cognitive skills as being "very important"—sequential thinking, understanding concepts, and creative thinking, and less emphasis on rote learning. This pattern of responses may reflect teachers' views about student aptitudes and the need to tailor instruction appropriately. It may also reflect a tension arising out of the conflict between teaching the practical skills that are tested and helping students sharpen their higher order thinking skills (Orton and Lawrenze, 1990). However, significantly more mathematics teachers (43 percent) than science teachers (26 percent) consider it "very important" to remember formulas and procedures.

Figure 4-5
Student skills required for success; eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Eighth-grade Mathematics and Science Teachers

Close to 40 percent of U.S. eighth-grade mathematics and science teachers report that they hold graduate degrees. Virtually all have some teacher training, and the majority have been in the profession for 14 to 15 years. Ethnic minorities, however, are underrepresented in the teaching force. Estimates put the percentage of minority teachers at 10-13 percent nationally (Lindquist et al., 1995; Blank et al., 1994; NCES, 1995; Weiss et al. 1994). In this context, Lindquist et al. (1995) observe that it is critical to find ways of encouraging more ethnic minorities to enter the profession.

A sizable proportion of all teachers in U.S. schools, mathematics and science teachers among them, are approaching their 50s. Reformers point out that most of these teachers were prepared for the profession at a time when very different views of teaching and learning prevailed. They emphasize a need for providing appropriate in-service experiences and support to these teachers (Lindquist et al., 1995; Weiss, et al., 1994).

Most of the science teachers feel they are adequately prepared for the subjects they teach and knowledgeable about the curriculum guidelines under which their schools, school districts, and states operate. Further, most teachers also agree with the broader principles of current reform movements though considerable numbers of them, particularly science teachers, are unfamiliar with the professional standards in their fields. In addition, many teachers hold beliefs that may be at variance with constructivist directions and more consistent with traditional paradigms.

III. Teachers' Working Conditions

The working conditions of teachers figure prominently in public discussions of teaching. Class size, staffing configurations, physical facilities, and scheduling of time are some of the more widely recognized elements of teachers' working conditions (NCES, 1993a; 1993b). Questions about the size of classes, teaching and preparation time, the adequacy of the teaching environment, salaries, and safety enter the public and political arena regularly because of their cost implications, and teachers' unions/associations focus a sizable portion of their time on the maintenance and/or improvement of these conditions. Many believe that working conditions are the key to attracting and retaining good teachers (Holmes Group, 1986), shaping their effectiveness, fostering effective teaching, and determining students' instructional activities and learning experiences.

The TIMSS teacher questionnaires collected information on several aspects of teachers' working conditions, employment status, time allocations to teaching, selected nonteaching duties and school-related duties outside the regular school day, professional responsibilities, and the contextual constraints that place limits on instruction. The discussion that follows focuses on these aspects of teachers' working conditions considered respectively as teachers' work, professional responsibilities, and contextual constraints.

Teachers' Work

Most of the nearly 3 million teachers in the nation's schools are employed on a full-time basis. In this capacity they provide for the instruction of some 47 million students. Close to 90 percent of these teachers teach in public schools and close to 90 percent of these public school teachers hold full-time assignments. Further, the majority of public school teachers hold full-time appointments throughout their teaching career. Among teachers employed in private schools, full-time employment rates are somewhat lower, closer to 80 percent (NCES, 1993b). Full-time employment among the mathematics and science teachers of TIMSS' eighth graders is almost universal—99 percent for science teachers and 97 percent for mathematics teachers.

While the precise responsibilities of teachers are not well defined (Scriven, 1994), it is clear that teachers' work is not limited to the instruction of students. Scriven identifies the major categories of teachers' responsibilities as knowledge of subject matter, instructional competence, assessment competence, professionalism, and other duties to the school and community. However, although the fundamental work of teachers is classroom instruction, almost without exception, teachers have other nonteaching, school-related responsibilities both during and outside the regular school day—administrative tasks, parent meetings, lesson preparation, student appraisal/counseling, student monitoring, class-related clerical tasks such as collecting money, and the ever-present responsibility of reading, grading, and commenting on student work (Popkewitz and Myrdal, 1991).

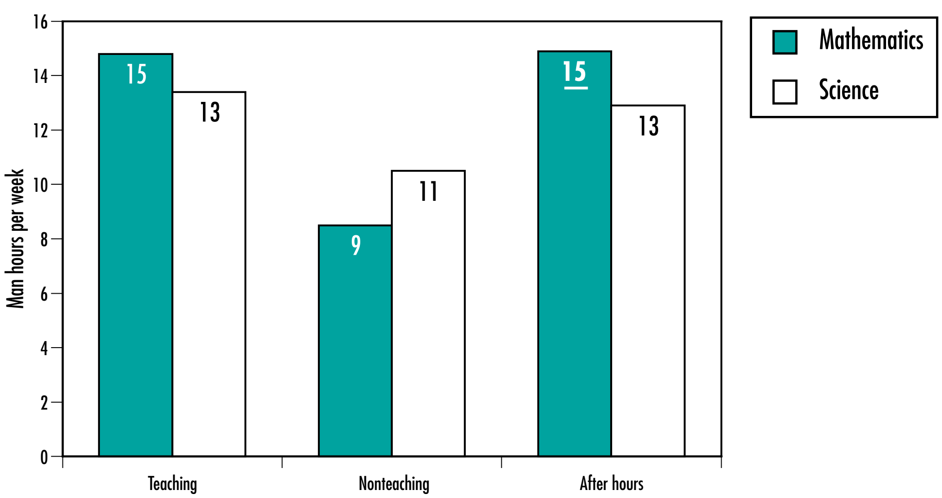
Teacher Workload

The National Education Commission on Time and Learning (1994, p.36) described the daily working life of most teachers as "one of unrelieved time pressure and isolation; they work largely alone, in a classroom of 25-30 children or adolescents for hours every day." The commission remarked that educators have insufficient time to perform their job properly and that academic time has been lost to nonacademic activities.

Snapshots of the typical work week for teachers are available from national reports (NCES, 1993a; 1993b; 1994a; Nelson, 1994). In TIMSS, teachers were asked to report the number of periods per week for which they were formally scheduled to teach mathematics, science and "other" subjects, the number of periods per week for which they were formally scheduled for six specific nonteaching tasks such as administrative duties and curriculum planning,[5] and the number of hours per week spent on eight selected school-related activities outside the regular school day (reading or grading assignments, preparing lessons, etc.). Unfortunately, the response categories for the latter two aspects of workload are not exhaustive of all activities. Unlike the case of scheduled teaching time, these cannot be totaled to give a measure of total time spent in nonteaching activities within school, or teaching-related out-of-school activities. As a consequence, it is not possible to estimate the total workload of teachers as the sum of all three categories.

Appendix table 4-7 (on page A-7) provides detail on time allocations to each of the activities listed and on the totals for each of the three categories. These same totals are displayed in figure 4-6.

Figure 4-6
Total hours per week spent on teaching and selected nonteaching tasks; eighth-grade mathematics and science teachers



NOTE:
Nonteaching tasks include student supervision, student counseling, administration, curriculum planning and non-student contact.
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

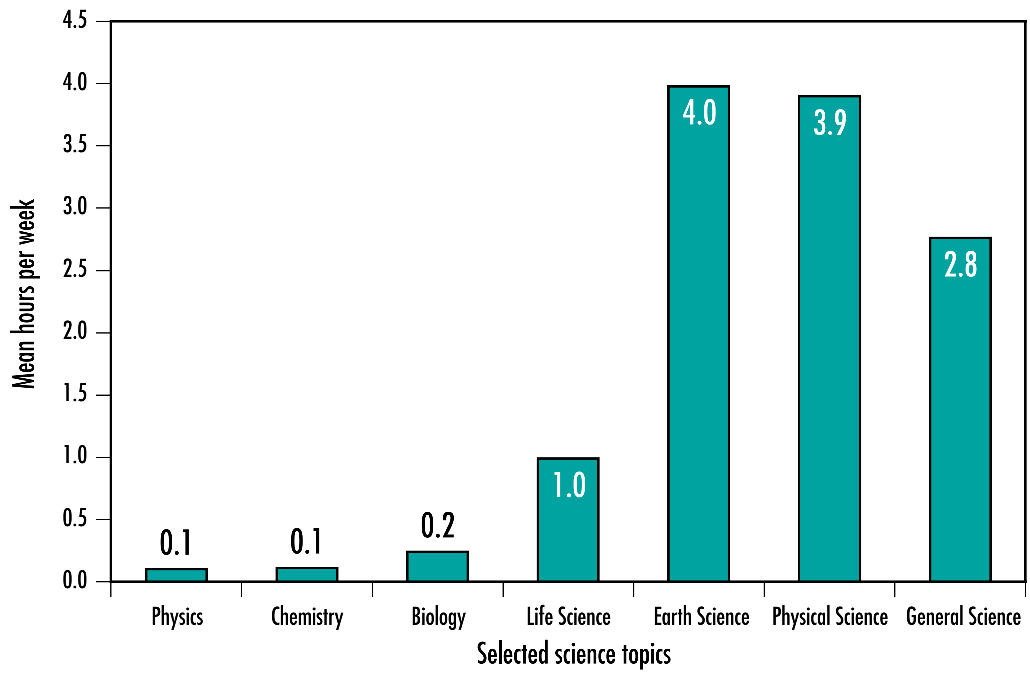
5 To simplify comparisons and to render them more meaningful, data reported in periods were converted to hours using the principal's report of the average length of a class period.

On average each week eighth-grade mathematics teachers spend 14.8 hours at teaching, 8.5 hours doing the specified nonteaching tasks at school, and 14.9 hours outside the regular school day at school-related activities noted. Science teachers report spending roughly comparable amounts of time on the first two sets of activities—13.4 hours for teaching, and 10.5 hours for the listed nonteaching tasks—though, at 12.9 hours on average, significantly less time for these school-related activities conducted out of school hours.

Teaching Responsibilities

Questions about scheduled teaching responsibilities allow a more fine-grained look at the allocation of teachers' teaching time along two dimensions: subject specialization and grade specialization, each of which has implications for the workload of teachers. Each eighth-grade mathematics and science teacher was asked to report how many single periods per week he or she was formally scheduled to teach mathematics, general/integrated science, physical science, earth science, life science, biology, chemistry, physics, or other subjects. Panel 4-7b of appendix table 4-7 (on page A-7) illustrates the time allocated to teaching mathematics, science, and other subjects for both mathematics and science teachers. Converting periods to hours, mathematics teachers report that they are scheduled for an average of 14.8 hours of teaching. Of this 12.7 hours is allocated to the teaching of mathematics. The comparable figure for

Figure 4-7
Hours per week spent teaching science topics; eighth-grade science teachers



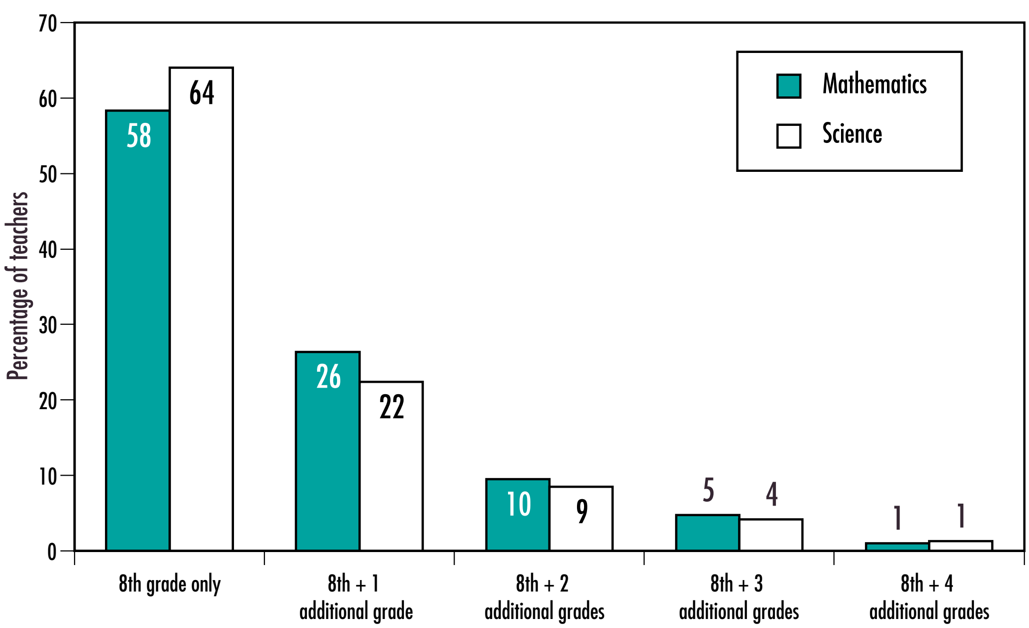
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

science teachers is 13.4 hours in total with an average of 12.1 hours spent teaching science. Assuming that full-time teachers work something like a 40-plus hour week, it seems that they spend about one-third of this time in face-to-face teaching. For the most part these teachers are specialists; mathematics teachers spend most of their time teaching mathematics classes, and science teachers spend most of their time teaching science classes.

The TIMSS questionnaire allows a more detailed look at science instruction from the point of view of subjects taught. Figure 4-7 and panel 4-7b of appendix table 4-7 (on page A-7) show the mean number of hours scheduled per week for selected science subjects. Clearly, eighth-grade science instruction is concentrated in general science, physical science, and earth science, courses that, in addition to life sciences, are those most often offered in grades 7 and 8 (Weiss et al., 1994).

The eighth-grade mathematics and science teachers were also asked to report the grade levels they teach. Figure 4-8 and appendix table 4-8 (on page A-8) show the distribution of eighth-grade mathematics and science teachers by the number of grade levels taught. Although the majority of the teachers in the sample teach only at the eighth-grade level, 42 percent of mathematics teachers and 36 percent of science teachers teach one or more additional grades. Teaching across grades, as with teaching across subject areas, carries with it increased preparation time and a concomitant increase in teacher workload.

Figure 4-8
Grade levels taught; eighth-grade mathematics and science teachers



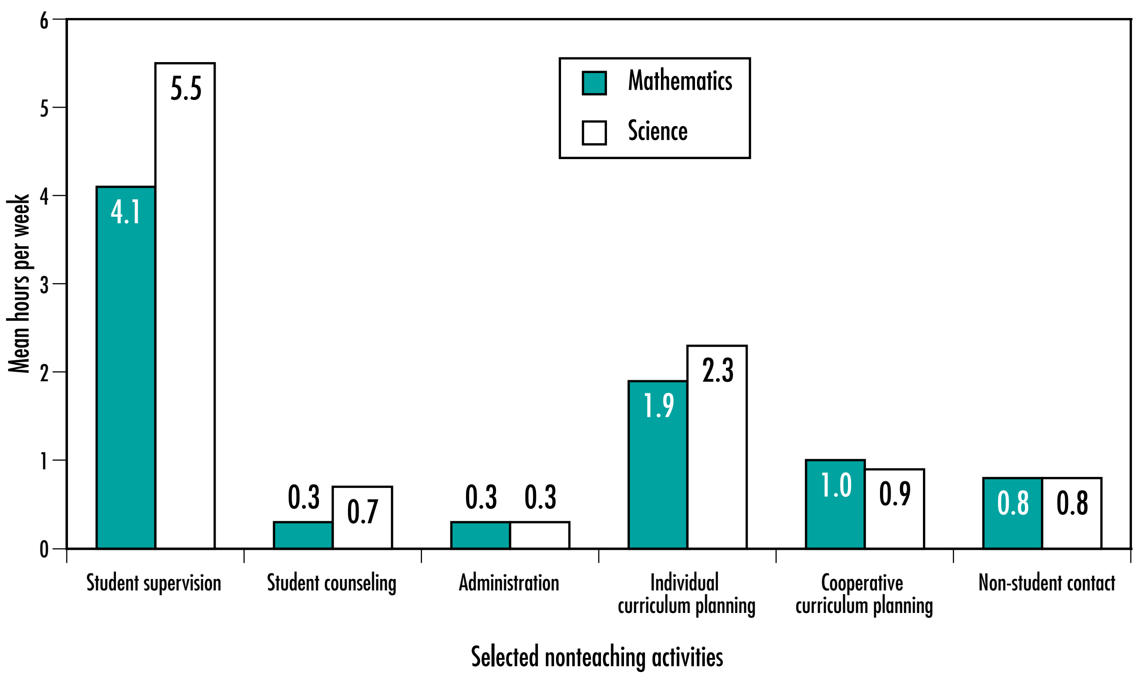
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Nonteaching Responsibilities

There are two dimensions to this aspect of teachers' work: nonteaching responsibilities during the school day and nonteaching responsibilities outside the regular school day. The TIMSS questionnaires allow an examination of the issue of nonteaching responsibilities through two questions. The first addressed formally scheduled nonteaching responsibilities during school hours: student supervision; student counseling/appraisal; administrative duties; individual curriculum planning; cooperative curriculum planning; and other nonstudent contact time. The second looked at nonteaching responsibilities undertaken outside the regular school day: preparing or grading student tests or exams; reading and grading other student work; planning lessons alone; meetings with students outside of classroom time, such as for tutoring or guidance; meeting with parents; professional reading and development activities such as seminars or conferences; keeping students' records up to date; and administrative tasks such as staff meetings, photocopying, and displaying students' work.[6]

Scheduled nonteaching responsibilities. Teachers were asked to report the number of periods[7] per week for which they were formally scheduled for specific nonteaching tasks. Mathematics teachers reported an average of 8.4 hours per week scheduled for these six nonteaching tasks and science teachers reported 10.5 hours per week.

Figure 4-9
Hours per week spent on in-school nonteaching activities; eighth-grade mathematics and science teachers



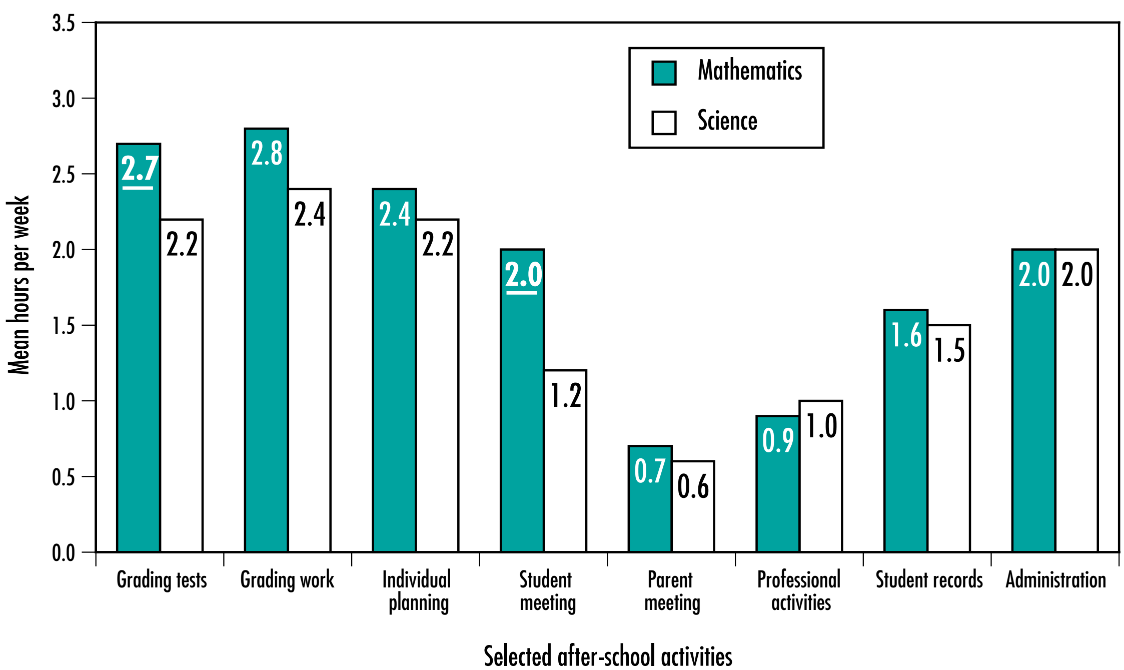
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

6 As noted earlier, the questionnaires did not allow an exhaustive accounting of hours spent outside the school day.
7 Since the length of a period is not standard, the reported periods were converted to hours using the principal's report of the length of an average period.

Eighth-grade mathematics and science teachers spend more time on student supervision than on the other tasks. Mathematics teachers reported an average of 4.1 hours per week scheduled for student supervision, and science teachers reported an average of 5.5 hours per week on this task. These data are presented in panel 4-7c of appendix table 4-7 (on page A-7). Figure 4-9 illustrates the distribution of the average number of hours reported for each of the selected nonteaching tasks.

School-related activities outside the regular school day. Teachers were also asked to report the number of hours per week spent on selected school-related activities outside the regular school day. The activities selected are listed in panel 4-7d of appendix table 4-7 (pn page A-7), which displays the relevant data. Figure 4-10 illustrates the distribution of the teachers' mean responses for the selected school-related activities. Mathematics teachers reported an average of 14.9 hours, and science teachers 12.9 hours, spent on such activities each week. For the most part, grading tests, grading other work, and individual lesson planning in general, take more time than each of the other tasks noted. On average, teachers spend more than 2 hours per week on each. In addition, mathematics teachers report spending significantly more time (2 more hours, on average) per week on the total of these activities than science teachers.

Figure 4-10
Hours per week spent on school-related activities after school hours; eighth-grade mathematics and science teachers



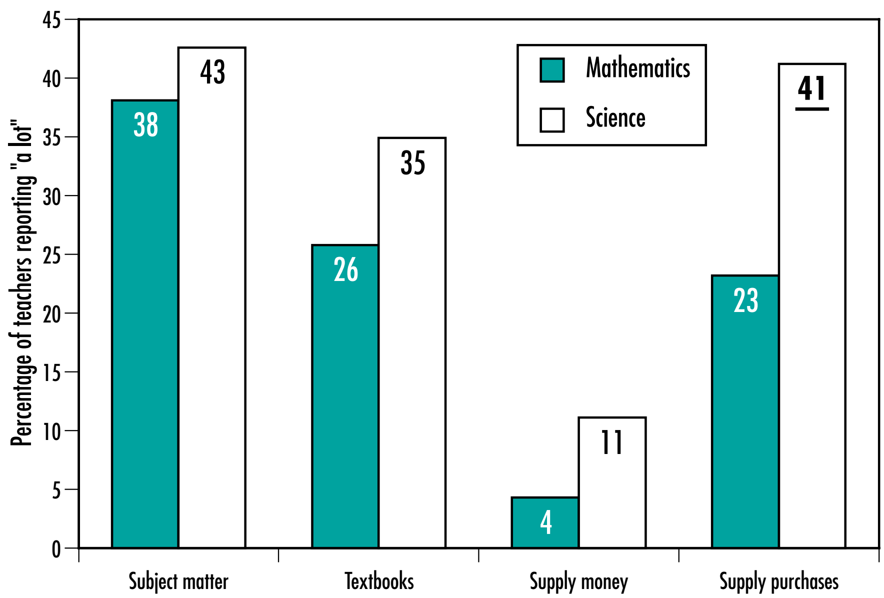
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

The Profession of Teaching

Several characteristics typically define an occupation as a "profession": control over selection and regulation; specialized knowledge; norms of altruism and service; privilege and status hierarchies; and collegiality and autonomy (Noddings, 1992). Teachers have little control over selection and regulation; there is no clear agreement on the specialized knowledge characteristics of teaching; and, while their social status is high relatively speaking, it is not close to that of the traditional professions. Teachers do, however, subscribe to the norms of service and client welfare, have varying degrees of autonomy over their work, and express their collegiality in various ways. In short, teaching takes on some of the attributes of a profession and, as a result, is sometimes called a "semi-profession" (Etzioni, 1969).

Questions asked of eighth-grade mathematics and science teachers during the course of TIMSS provide a limited perspective on two of these professional attributes—autonomy and collegiality. These questions focus on the teachers' level of influence on selected activities and their level of interaction with other teachers on curriculum planning and teacher observation.

Figure 4-11
Level of influence on certain school matters; eighth-grade mathematics and science teachers

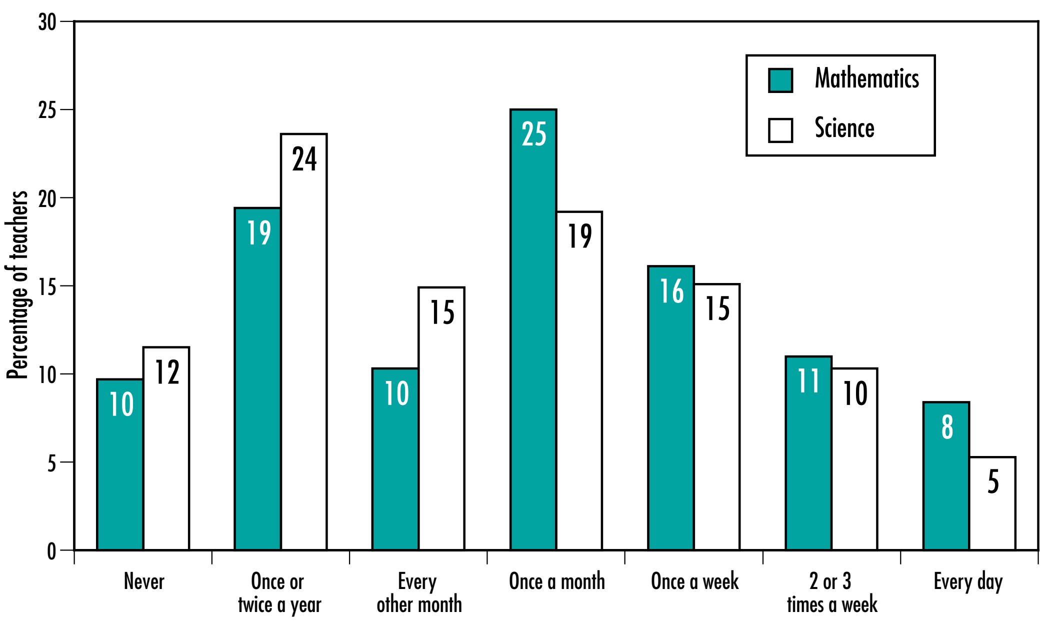


NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Autonomy. Matters of professional autonomy are tapped with a question about teachers' influence on decisions about curriculum and materials. Teachers have reported considerable autonomy in areas such as selecting materials; teaching content, topics, and skills; teaching techniques; and amount of homework (NCES, 1993a). Sizable, but smaller, proportions of teachers have also reported an influence on the establishment of curriculum (NCES, 1993b; Weiss et al., 1994). Autonomy flourishes most among teachers who have a strong national reference group, who are involved in decision making with competent departmental colleagues, and who have control over classroom events (Conference Board of the Mathematical Sciences, 1984).

The measures of autonomy are based on teachers' reports of the influence they have on the subject matter to be taught, specific textbooks to be used, the amount of money spent on supplies, and the nature of the supplies purchased. Figure 4-11 and appendix table 4-9 (on page A-9) illustrate that, for the most part, the majority of teachers report not having a great deal of autonomy in these areas. About 40 percent report having a lot of influence over the subject matter they teach, and between one-fourth and one-third say they determine which textbooks they use. Control of money for supplies does not lie with eighth-grade teachers, which is consistent with what is known about the structure of education and the professional autonomy of teachers.

Figure 4-12
Frequency of cooperative curriculum planning; eighth-grade mathematics and science teachers



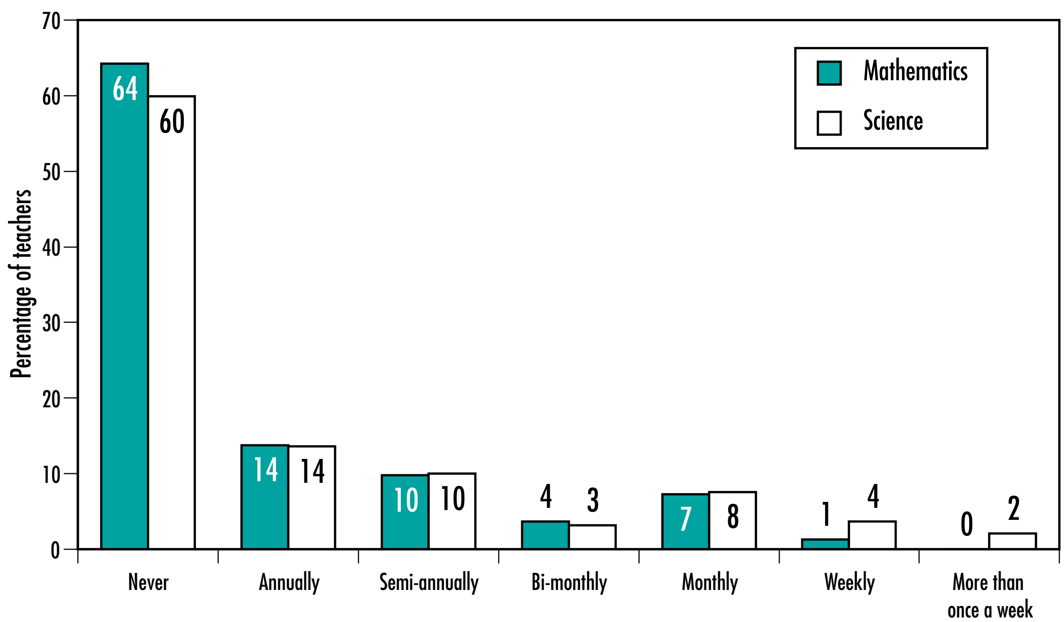
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Collegiality. The workload of U.S. teachers, the cellular organization of the school (Lortie, 1975), and a perceived lack of institutional commitment to collegiality (Nelson and O'Brien, 1993) all tend to inhibit the development of this trait among teachers. However, collegiality does appear to flourish in schools with positive school climates and general overall effectiveness (Little, 1982) and in those where the sharing of ideas about curriculum and teaching with other teachers is common and encouraged (NCES, 1993a; Weiss et al., 1994). In other words, collegiality is greatest in environments that support active collaboration among teachers.

In TIMSS, eighth-grade mathematics and science teachers were asked three questions bearing on collegiality: "How often do you meet with other teachers in your subject area to discuss and plan curriculum or teaching approaches?"; "Excluding any team teaching partners, how often do you visit another teacher's classroom to observe their teaching?"; and "Excluding any team teaching partners, how often does another teacher visit your classroom to observe your teaching?" Teachers' responses are summarized in appendix table 4-10 (on page A-10) and in figures 4-12, 4-13, and 4-14.

As figure 4-12 (on page 109) shows, about one-third of these eighth-grade teachers meet weekly or more frequently to engage in cooperative curriculum planning. Cooperative instructional planning, in the sense of demonstrating and observing instruction, is typically even less frequent. About three-fifths of mathematics teach-

Figure 4-13
Frequency of other teaching observed; eighth-grade mathematics and science teachers



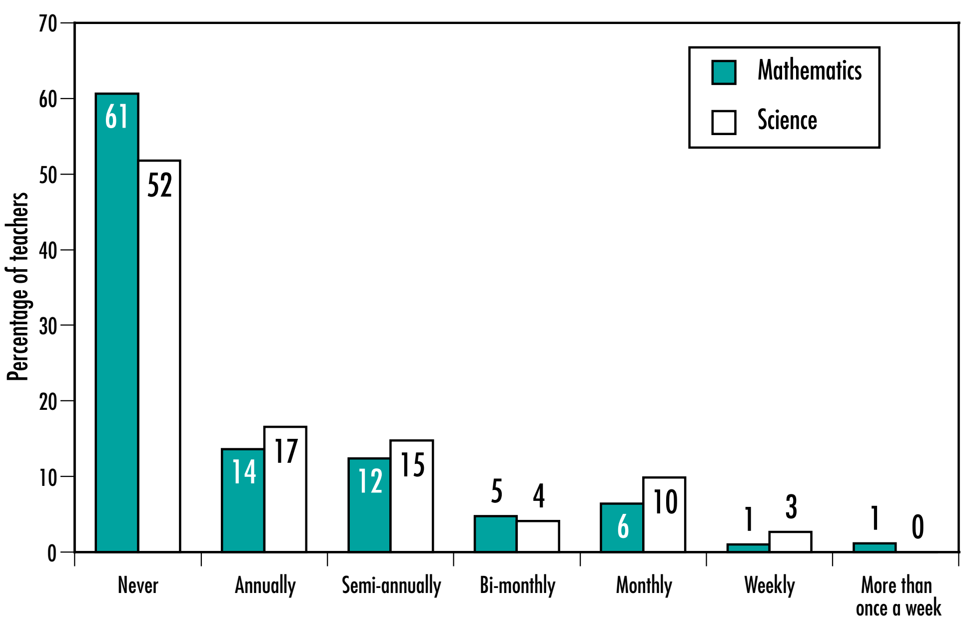
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

ers are never observed in their own teaching and do not observe the teaching of others. In the case of science teachers, some 52 percent report not observing other teachers at work. Such collegiality as was assessed in this group appears to revolve around the planning of instructional content and not the instructional process.

Contextual Constraints

The working environment of teachers may have grown more complex and demanding over the years. To the matters of long-standing concern to teachers—how to teach large classes and classes with a wide range of academic abilities—have been added responsibilities previously assumed by others outside of the school. These range from the needs of children from homes plagued by poverty, drugs, violence, and abuse to uninterested students (NCES, 1998). Nonteaching responsibilities such as these place on schools a variety of problems that constrain teachers and teaching in and out of the classroom. As part of their professional life, teachers may come to deal with student absenteeism, tardiness and class cutting, fighting and other forms of violence, student pregnancy, drug and alcohol use, physical and verbal abuse directed at them, dropouts, apathy on the part of both students and parents, racial/ethnic tensions, and more (NCES, 1998). All of these act to constrain the way teachers teach. TIMSS offers some evidence of the impact of these constraints on teachers and teaching.

Figure 4-14
Frequency of own teaching observed; eighth-grade mathematics and science teachers

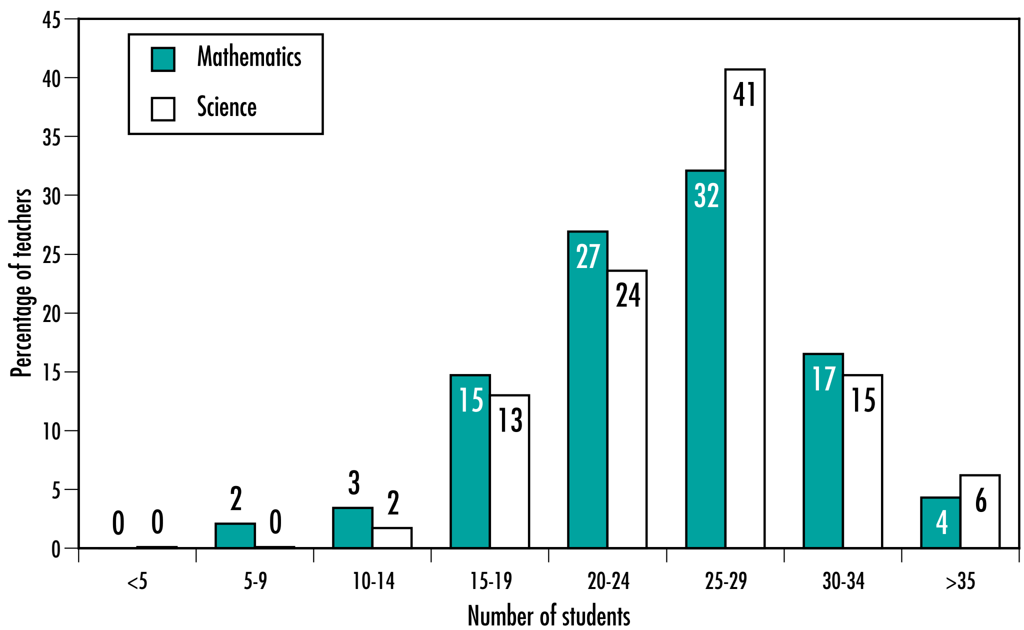


NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Class size. The question of class size has an extended history and remains an ongoing education issue. While there is evidence that only very dramatic class size reductions support important gains in student achievement (Glass and Smith, 1978; Nye, 1992; Word, 1990), reduced class size does seem to have a positive effect on teacher attitudes and behaviors (Smith and Glass, 1980; Odden, 1990). The average class size in U.S. schools as reported by various groups lies somewhere between 20 and 30 students (Carnegie Foundation for the Advancement of Teaching, 1988; NCES,1996c). In the 1990-91 school year, the national average was 23 students for high school science classes and 21 students for mathematics classes (Blank and Gruebel, 1995).

The measures of class size available in TIMSS are based on separate reports by the school principal, teacher and the test administrator. In the present analyses that report on the size of the mathematics and science classes, the class size reported by the teachers was used.[8] More than one-half of the eighth-grade mathematics and science teachers reported having 20-29 students in their classes selected for TIMSS, with an average class size of about 25 students. Figure 4-15 and appendix table 4-11 (on page A-11) illustrate the distribution of responses for class size as reported by the eighth-grade mathematics and science teachers.

Figure 4-15
Average class size; eighth-grade mathematics and science teachers



NOTE:
Percentages less than .5 have been rounded to 0.
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

8 The data show some confusion on the part of teachers and some of the responses are clearly out of range. The class size reported here was calculated after "outlier" responses were eliminated.

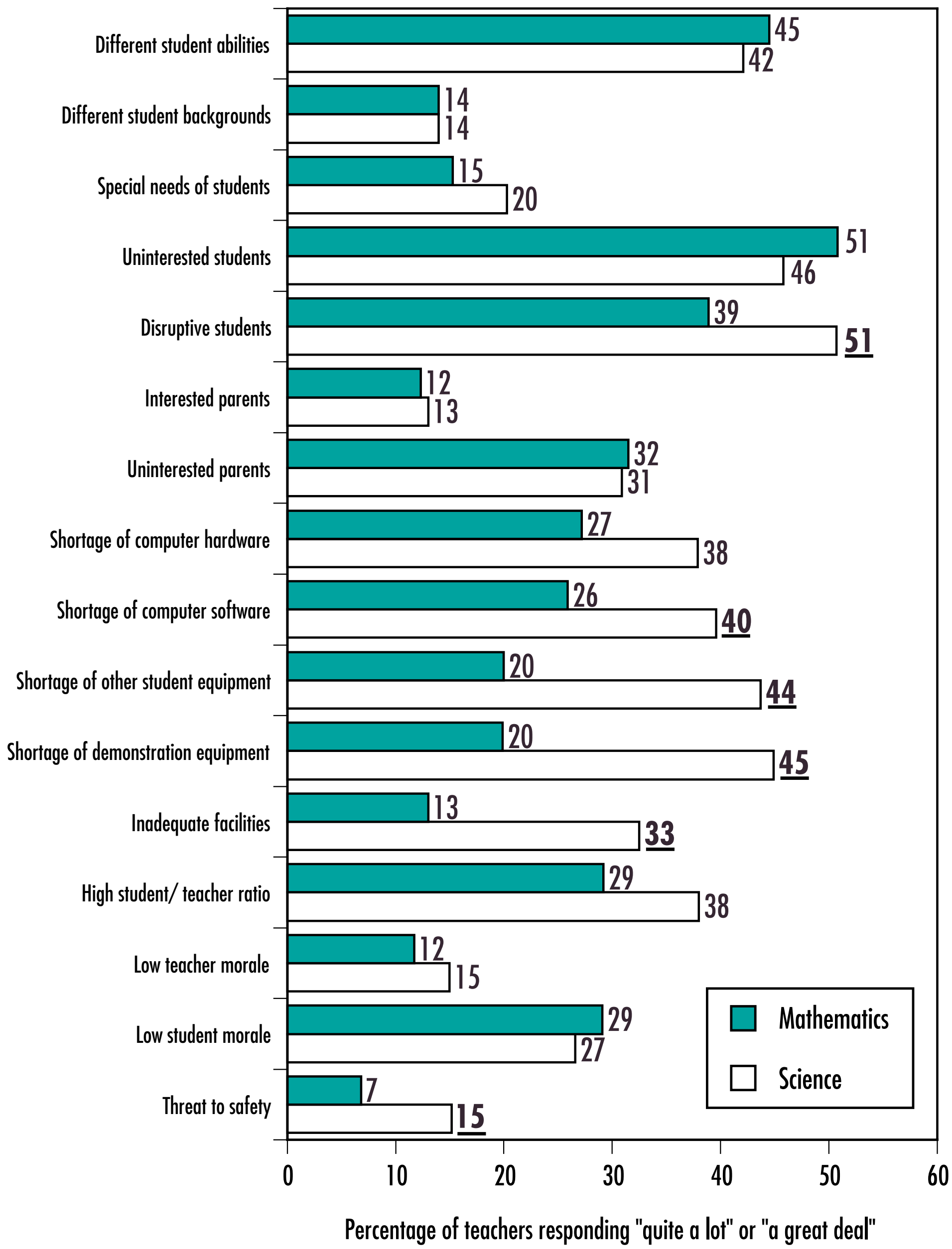
Student ability. For whatever the reason, it is a fact that students vary in their ability to handle much of what is taught in schools. Schools and teachers face this issue each day and, in the United States, the most widely adopted approach is one of narrowing the range of abilities within classrooms by grouping (tracking) for instructional purposes (Gamoran et al., 1995). While groups formed in this way are expected to cover much the same course content, the pacing and depth of the content is adjusted to match the abilities of the students. About one in every two mathematics and science classes are heterogeneous in terms of ability (Weiss et al., 1994). Evidence of the effectiveness of tracking (or, ability grouping) is mixed. High-ability students may be better served in such settings, but middle- and low-ability students seem to do better in mixed-ability groupings (Dreeben and Gamoran, 1986; Gamoran, 1986; 1987).

The TIMSS data offer two perspectives on tracking, one indirect and one direct. Teachers were asked to report on the academic ability of the students in their class in the form of the percentage of students in their class that have high achievement levels, middle achievement levels, and low achievement levels relative to other students in the United States at this grade level. Classes with more than 50 percent at any of the three levels were identified as being at that level, and the remaining classes are described as mixed. Appendix table 4-12 (on page A-12) shows the results of this distribution, which places 37 percent of mathematics classes and 46 percent of science classes in the middle achievement level. Approximately 16 percent of mathematics classes and 9 percent of science classes were classified as high achievement, a significant difference which probably reflects greater tracking between mathematics classes. The comparable figures for low achievement were 14 percent or less in each case. About one-third of the eighth-grade mathematics and science teachers reported mixed achievement-level classes.

Perhaps the most direct evidence on the extent of tracking comes from the principals of the sampled schools. Asked whether all eighth-grade mathematics/science students take the same course of study, their responses indicate that about 80 percent of mathematics classes are tracked. By contrast, about 80 percent of eighth-grade science classes are not tracked (see appendix table 4-19 (on page A-19)).

Problems and constraints on teaching. In addition to the commonly reported deficiencies in the resources available to support teaching, teachers can face student behavior problems. Student absenteeism, tardiness, alcohol use, cutting classes, physical conflicts, vandalism, student pregnancy, drug abuse, verbal abuse, student disrespect, dropping out, student apathy, lack of academic challenge, lack of parent involvement, parental alcoholism and/or drug abuse, poverty, and racial/ethnic tensions are reported (NCES, 1993a; 1993b). The TIMSS teacher questionnaires list a total of 16 such situations. Teachers were asked to indicate the extent to which each limited their teaching of mathematics or science. The factors tapped are indicated in appendix table 4-13 (on page A-13), which shows the distribution of responses separately for mathematics and science teachers. Figure 4-16 (on page 114) displays the

Figure 4-16
Possible constraints on teaching; eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

summed proportions of teachers responding "quite a lot" or "a great deal" to the items in question.

We label these attributes of teachers' work as constraints when many teachers report that it limits their teaching "quite a lot" or "a great deal." Given this definition of constraint, then some 40 to 50 percent of both mathematics and science teachers feel constrained by the range of student abilities they must deal with, students' lack of interest in the subject and disruptive students, the latter significantly more so in the case of science teachers. Relative to mathematics teachers, science teachers also report significantly more effects of equipment shortages—computer software, student equipment, equipment for demonstrations, and facilities generally, as factors that limit how they teach.[9]

The Work of Teaching

Teaching mathematics and science to eighth graders is work that is carried out in relative isolation from colleagues and in a context made less than ideal by the need to accommodate a variety of problems that students bring to school. Full-time teachers spend in excess of 40 hours a week on the job, about one-third of this time in face-to-face teaching and the remaining two-thirds in nonteaching but teaching-related activities—student supervision, individual curriculum planning, grading student work and tests, and the like. Many see their teaching affected by classes with a range of student abilities, by uninterested and disruptive students, and by a shortage of equipment. Their autonomy appears to be limited to decisions about content and teaching methods, and collaboration is centered around curriculum planning; teaching itself remains an act conducted in the privacy of one's own classroom. There is little question that these aspects of teachers' working conditions, and others as well, affect the quality of teachers' working lives.

9 Some of these responses appear to reflect the special needs of science teachers to provide students with hands-on activities as an integral part of their work, with the difficulties attendant to the supervision of such activities.

IV. Instructional Resources

School resources in general, particularly resource differences between schools, have always attracted a great deal of interest especially from those interested in education production functions (see, for example, Greenwald et al., 1996) and those concerned with the inequalities of opportunity that attend resource differences between schools (Coleman et al., 1966). Prominent among these resources are those available to teachers to facilitate instruction. These instructional resources are the focus of the discussion that follows, though this discussion is somewhat limited by the fact that TIMSS did not take a special interest in resources as such. Instructional practice, covered in the following section, was the main focus. Four categories of instructional resources are discussed: the use of technology in classrooms; the availability of remedial and enrichment provisions; the use of remedial and enrichment provisions; and instructional time. All of these are seen as resources on which teachers can draw to support their mainline instructional activities.

Technology

It is something of a truism to say that technology in general has changed rapidly—from calculators and computers to robotics, microtechnologies, artificial intelligence, and electronic global education. Yet, the use of technology in the classroom as an aid to instruction and/or a replacement for it is widely and hotly debated. Views about the use of technology in classrooms range from providing calculators as a way of relieving computational burdens, to using computers in both structured and unstructured learning situations (Kaput, 1992). However, much more is claimed than is demonstrated with respect to the effectiveness of existing technology to promote learning. While advances in technology proceed, the focus in schools remains essentially on the use of calculators and, to a lesser extent, computers. Classroom calculators tend to be used for computation, problem solving, and concept development, while classroom computers are used, to the extent that they are used at all, for drill and practice, tutorial, simulation, and problem solving (Beaton et al., 1996a).

In the TIMSS questionnaires, information on resources is available from teachers, students, and principals. Eighth-grade mathematics and science teachers were asked to report on student access to calculators; the availability of hardware, software, and other instructional equipment; and the use of calculators and computers during instruction. Students were asked questions about attitudes toward computer use in mathematics and science classes; the frequency of use of calculators and computers in mathematics and science classes; and the availability of a calculator, computer, or laptop or notebook computer at home. School principals were asked to report on the availability of calculators and computer hardware and software for mathematics and science instruction.

Calculators and computers in classrooms. The NCTM Standards state that all middle grade students should have a calculator and every middle school classroom should have at least one computer available at all times "to free students from tedious computations and allow them to concentrate on problem solving and other important content (NCTM, 1989, p. 67)." This standard, consistent with the "constructivist" paradigm, is not uniformly implemented. Most schools have calculators, but the classroom set is the standard rather than a calculator for every student (Hembree and Dessart, 1992), and the four-function calculator is the typical model. While schools vary widely in how often calculators are used in mathematics classes, eighth-grade students tend to use calculators at least every week (Blank and Gruebel, 1995), and there is evidence that the use of calculators fosters the development of desired mathematical concepts, skills, and attitudes (Hembree and Dessart, 1986; Wheatley, 1980; Szetela, 1982; Wheatley and Wheatley, 1982).

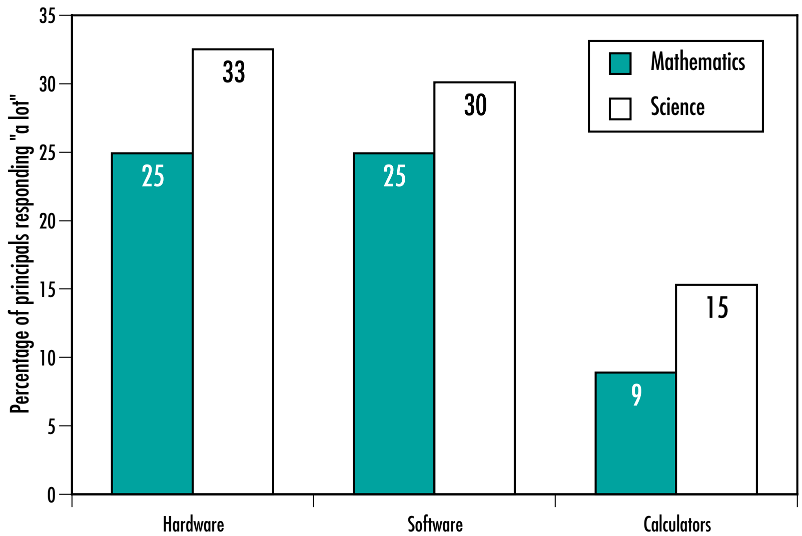
With respect to computers, 99 percent of the elementary and secondary schools in the United States had installed computers by 1992, and 92 percent of the students reported using them during the school year. The United States was the world leader in this respect, with the typical middle school having one computer for every 14 students (Anderson, 1993). At grade 8, about 7 percent of mathematics students and 2 percent of science students use computers heavily in instruction (Lundmark, 1993). While there is evidence that computer-assisted instruction has advantages over traditional instructional methods, saving learning time and increasing learning (Roblyer et al., 1988; Bangert-Drowns et al., 1985; Niemiec et al., 1987), not a lot is known about the effects of more routine use of computers in classrooms. In part, this lack of knowledge comes about because routine use of computers in classrooms is a relatively rare event. Lack of computer hardware and software poses serious problems for mathematics and science teachers (Office of Technology Assessment, 1988; Becker, 1990; Anderson, 1993; Weiss et al., 1994), though equipment shortages are probably not the only reason, or even the main reason, for the lack of integration of technology into instruction.

However, a number of TIMSS' school principals report that their schools face shortages of computer hardware and software. Some 25 to 33 percent viewed these shortages as having "a lot" of impact, as figure 4-17 (on page 118) illustrates. Calculator shortages were less often reported as affecting instruction. Appendix table 4-14 (on page A-14) shows the distribution of responses from principals.

Using calculators. In mathematics, at least, teachers view calculators as important; 80 percent of grade 5-8 mathematics teachers see calculators as an important part of mathematics instruction (Weiss et al., 1994). Their availability, then, is an issue. TIMSS mathematics and science teachers report that calculators are generally available to students, especially in mathematics classes. Appendix table 4-15 (on page A-15) shows the distributions of responses for mathematics and science classes separately. Close to 80 percent of mathematics teachers and 40 percent of science teachers reported that "almost all" students have access to calculators during class.

TIMSS teachers were also asked how often students use calculators for checking answers, tests and exams, performing routine computation, solving complex problems,

Figure 4-17
Shortages of computer hardware, software, and calculators; population 2 schools



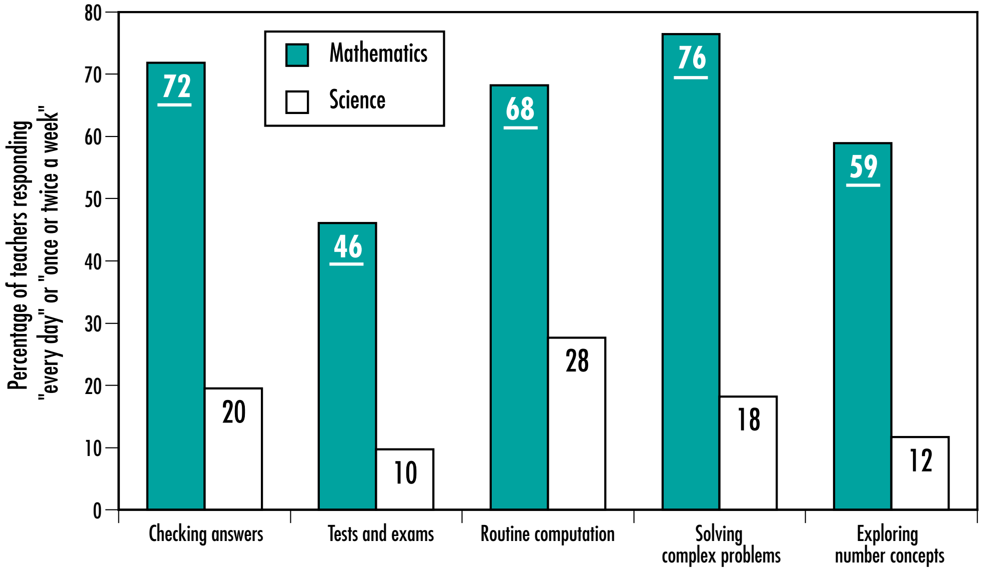
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 School Questionnaire, 1995.

and exploring number concepts. Since most of the computational aspects of science are found in later grades, mathematics teachers report more frequent use of calculators for all activities relative to science teachers. Appendix table 4-16 (on page A-16) shows the distribution of responses for mathematics and science teachers, and figure 4-18 illustrates the percentage of eighth-grade mathematics and science teachers whose classes use calculators "once or twice a week" or more frequently. Eighth-grade mathematics teachers report using calculators in their classes significantly more often than eighth-grade science teachers for all the listed activities.

The perspective of students in this matter was obtained as well. Students were asked to report how often they use calculators in mathematics and science classes. As with teachers, students report using calculators more often in mathematics classes than in science classes; 44 percent of the students reported they "almost always" use calculators in mathematics class, while 7 percent of the students reported they "almost always" use calculators in science class. Appendix table 4-17 (on page A-17) and figure 4-19 (on page 120) show the distribution of student responses.

Using computers. In the TIMSS questionnaires, eighth-grade mathematics and science teachers were asked to report how often they have students use computers to solve exercises or problems. The responses were similar for mathematics and science teachers within each category: about three-fourths of the teachers reported they "never or almost never" ask students to use computers to solve exercises or problems.

Figure 4-18
Teacher reported frequency of calculator use in the classroom; eighth-grade mathematics and science teachers

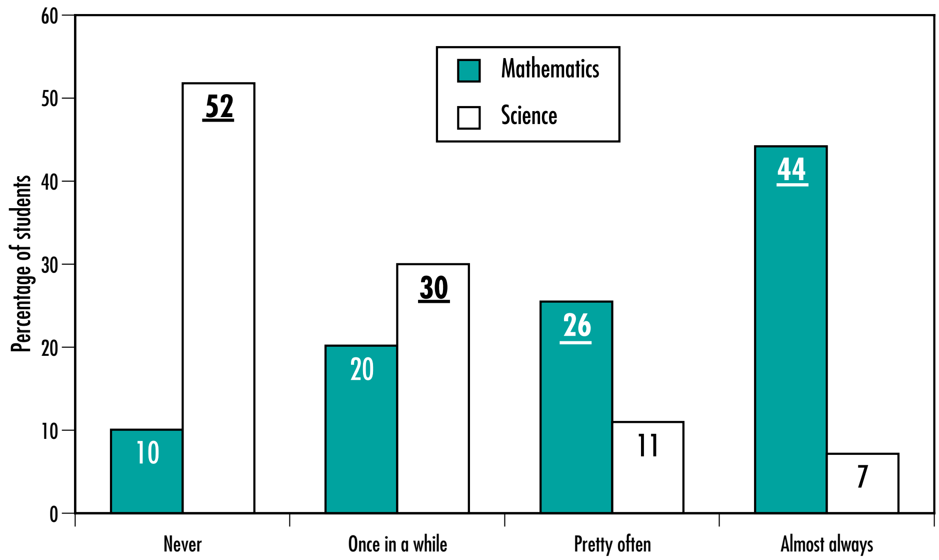


NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Students also were asked how often they used computers in mathematics and science classes and reported a similar level of non-use; at least 65 percent of the students reported they "never" use computers in mathematics or science class. Panels a and b of appendix table 4-18 (on page A-18) provide the distributions of responses for both teachers and students. For whatever reason, it is clear that computers do not figure prominently in the eighth-grade mathematics and science curriculum.

Liking computers. While two-thirds of the eighth graders do not use computers in their mathematics or science classes, those students who do have access to computers in class report they like to use them. However, this is less than one-half of all students; see panel 4-18c of appendix table 4-18 (on page A-18). Of course, access to computers is not limited to the classroom. The Current Population Survey suggests that about one-third of all first- to eighth-grade students have computers at home (U.S. Census Bureau, 1995). In the case of TIMSS students, some 98 percent of students have calculators at home, 58 percent have computers, and 22 percent have laptops or notebook computers at home (see Beaton et al., 1996a). Since computer experience and having a computer at home are related to positive attitudes toward computers and computing (Lockheed et al., 1985; Miura, 1984), these students—whose families may be more able to afford or more likely to want a computer in the home—may also be likely to respond affirmatively to this question.

Figure 4-19
Student reported frequency of calculator use in the classroom; eighth-grade students



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Student Questionnaire, 1995.

Course Differentiation: Tracking, Remediation, and Enrichment

Dealing with variation in students' levels of achievement and aptitude is seen as a persistent problem in the nation's classrooms (NCES, 1996d). The efficacy of the most widely used solution—tracking students in order to tailor instruction to aptitude/interest—is subject to question largely because of its side effects (Gamoran et al., 1995). As noted earlier the TIMSS school questionnaires asked schools whether all students take the same course of study in mathematics and science and the percentage of students taking the most and least advanced courses offered. While it is not clear from the data how the content of the most and least advanced courses differs from other courses, it is possible to highlight the extent to which tracking is used in eighth-grade mathematics and science classes to accommodate differences in students' abilities and/or interests. In this sense, program differentiation provides one means of giving students remedial or enrichment opportunities.

Schools' responses to the question of course differentiation in eighth-grade mathematics and science show opposite patterns. Mathematics courses appear to be highly differentiated, with 20 percent of schools reporting that all students take the same course of study. Science courses, on the other hand, are largely undifferentiated by student ability. More than 80 percent of schools report that all students take the same course of study in eighth-grade science—appendix table 4-19 (on page A-19) provides the distribution of responses. In part, this difference may reflect the higher priority that many schools place on mathematics; many districts and states, for instance, have minimum competency requirements for mathematics that require schools to offer remedial programs to students who perform poorly on achievement tests. There are fewer requirements related to science achievement (Madaus et al., 1992).

A related accommodation adopted by schools is to provide programs for students at both ends of the performance spectrum: remedial programs for students who, for one reason or another, cannot keep up with the majority of students; and enrichment programs for students who excel in mathematics and/or science and who may not be challenged by regular classwork. These initiatives may be identified specifically as programs for remediation or enrichment, or they may be incorporated into the school's normal offerings, such that within-class instruction is differentiated for the most or least advanced students in mathematics or science. In this sense, one can see remedial and enrichment programs of either type as an instructional resource made available by schools to assist teachers in the teaching of mathematics and science.

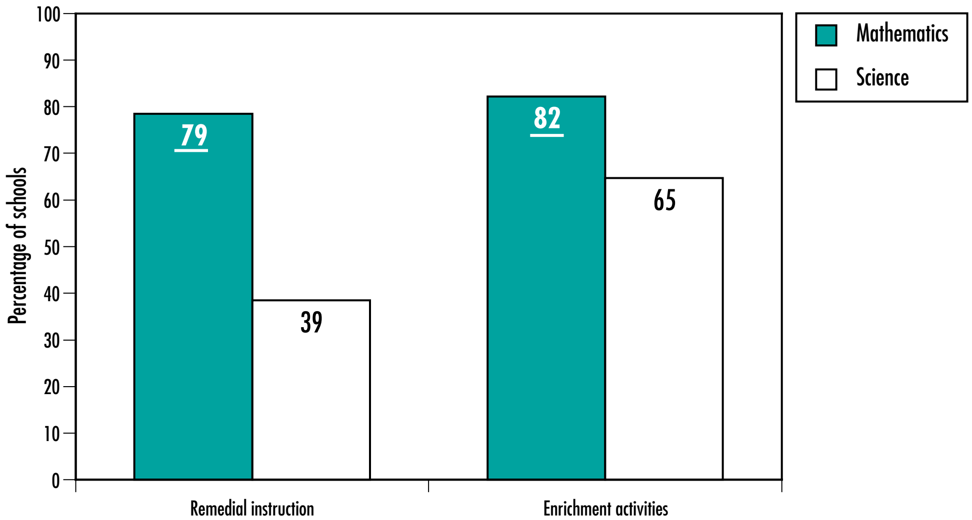
In TIMSS, the provision of these was addressed through four general questions in the school questionnaire. In each case, schools were asked whether remedial and enrichment programs were offered in mathematics and science and how the programs were organized—groups formed within a regular class, students removed from regular class, students receiving extra instruction, or other methods. Since the questions inquire only about the structural arrangements made, a description of the content of these programs, the criteria by which students are selected, or the instructional methods used cannot be offered.

Appendix table 4-20 (on page A-20) provides a detailed description of the reported remedial and enrichment programs for mathematics and science in the schools sampled. Remedial teaching is more prevalent in eighth-grade mathematics classes (79 percent) than eighth-grade science classes (39 percent). Although about two-thirds of schools offer enrichment activities in science (65 percent), schools are more likely to provide these activities in mathematics (82 percent). Figure 4-20 (on page 122) displays these differences in program offerings by subject area.

Remedial programs. Remedial education is a form of compensatory education. Nationally, approximately 20 percent of public school students in grades pre-K to 6 and 6 percent in grades 7 to 12 participate in Chapter 1 programs, which provide remedial programs for socioeconomically disadvantaged students (NCES, 1995). These federally funded programs are not the only programs schools use to provide remedial instruction to students, nor are they necessarily targeted at remediation in science and/or mathematics instruction.

Little data exist concerning the effects of different remedial instruction activities in the middle school grades on student achievement outcomes. However, the practice of

Figure 4-20
Provision of remedial and enrichment programs; population 2 schools



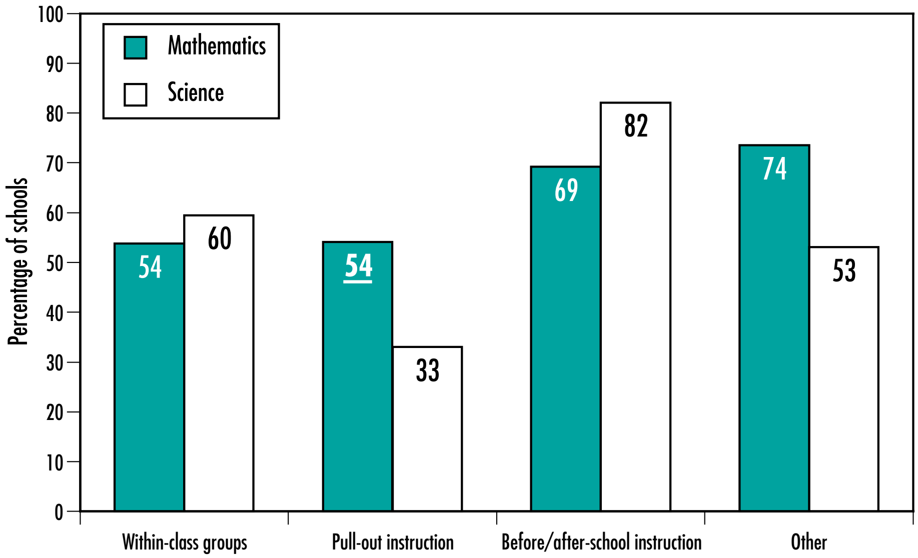
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 School Questionnaire, 1995.

providing extra periods for selected subjects during the school day in place of elective or exploratory courses offers some promise (MacIver, 1991). Other potentially effective approaches include the use of adult tutors (Cooledge and Wurster, 1985; Wilkes and Clarke, 1988; Wasik and Slavin, 1990), peer tutors (Devin-Sheehan et al., 1976; Palincsar et al., 1987), Saturday classes (MacIver, 1991), and summer classes, though the effects of these are not well established. Computer-assisted instruction offers some promise as well.

Panel b of appendix table 4-20 (on page A-20) provides data on the use of the three dominant approaches to remediation described above: within-class grouping, pull-out programs, and before/after school programs. It also gives data for "other" approaches. Note that the percentages in question are based on the 79 percent of schools that offered remediation in mathematics and the 39 percent of schools that offer this for science. These are not mutually exclusive approaches so schools may use one or more concurrently and/or sequentially. Figure 4-21 shows these same data graphically.

TIMSS' principals report that remediation in science is offered most often through before/after school instruction (82 percent) and least often through pull-out arrangements (33 percent). Remedial instruction in mathematics is most often provided through arrangements other than the those listed in the survey (reported by more than 70 percent of the schools). Included among "other arrangements" may be any or all of the following: independent study; special classes such as computer-assisted

Figure 4-21
Organization of remedial instruction; population 2 schools



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 School Questionnaire, 1995.

instruction; peer or cross-age tutoring; cooperative learning; individualized instruction; mainstreaming; resource teachers in the regular classroom; or home/parental involvement (Dillon and Franks, 1973; Passow, 1980).

Within-class grouping and pull-out remedial instruction in mathematics are used by close to one-half of the schools. Pull-out programs have been one of the more common forms of remedial instruction (Schultz, 1991), even though most teachers believe that children requiring remedial assistance should be instructed in the regular classroom. Despite this view, teachers do not seem to provide differentiated instruction in their classrooms tailored to student needs (Schumm and Vaughn, 1992; Vaughn and Schumm, 1994). Further, MacIver (1991) reports that mathematics pull-out programs have little impact on students' scores, probably because students in such programs receive less exposure to the material presented in class while they are out receiving special instruction targeted at basic or lower level skills.

Enrichment programs. Magnet schools or Governors' schools, often featuring an enriched curriculum in science, mathematics, and/or technology, provide one option for talented students. As another option, some parents influence their school's administration to have their gifted children skip a grade, thereby providing a more advanced curriculum, even if there is not a special program offered (Kirkpatrick, 1991).

Community colleges located throughout the United States also provide enrichment programs for early adolescents, and this has been effective in encouraging women and minorities into scientific fields (Quimbita, 1991). The community college system has been especially prominent in providing summer enrichment programs for youth, and many gifted youth use this option to gain enrichment experiences (Jensen and McMullen, 1994).

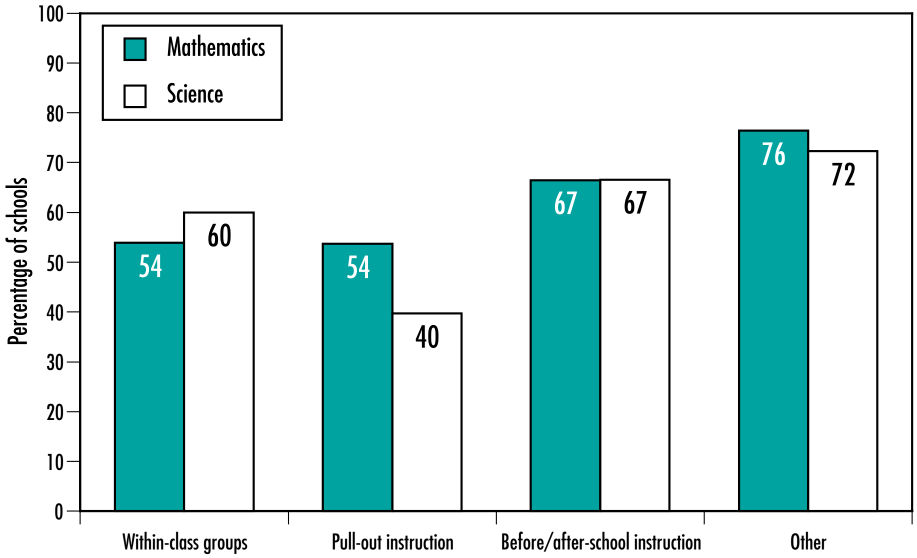
The focus of the questions asked of schools in the TIMSS school questionnaire is the structural arrangements schools make in providing enrichment experiences for students. As with remedial programs, the options explored cover the following four common forms of instructional differentiation:

- "Within-class" enrichment, where more advanced students are "grouped" within the regular class and provided with enriched instructional content and activities;
- "Pull-out" enrichment programs in which students are removed from the regular class to receive special instruction elsewhere; and
- Before- and/or after-school enrichment programs.
- Special within-school programs of study identified as "gifted and talented" or "enrichment" programs.

In the within-class approach to enrichment, students may work in groups or independently on more advanced tasks, or they may pace themselves on content to be covered by the class and then spend time as peer tutors helping less-advanced students. Current reform efforts regarding middle school education have emphasized "within-class approaches" and de-emphasized "pull-out" options for students needing enrichment experiences, for fear that the less academically capable students will feel stigmatized and that better educational opportunities are being denied to them as a result. Before- and after-school specialized enrichment programs are alternatives, and these include secondary enrichment programs located at specialized centers, such as a center for arts, sciences, technology, and the like. In many schools, mathematics and science classes use a combination of pull-out enrichment activities and "in-class" activities because there is evidence that students who are singled out for special programming maintain higher levels of self-esteem (Hoge and Renzulli, 1993).

Appendix table 4-20d (on page A-20) provides data on the use of these three approaches, plus an undefined "other" approach, in enriching the mathematics and science curriculum of eighth-grade students. Note that the percentages in question are based on only those schools indicating that an enrichment program was in place. Note also that, as with remedial programs, these are not mutually exclusive approaches, so schools may use more than one of these arrangements. Figure 4-22 shows these same data graphically.

Figure 4-22
Organization of enrichment activities; population 2 schools



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 School Questionnaire, 1995.

Schools are likely to provide mathematics enrichment through arrangements other than the three specified in the TIMSS questionnaire; about three-fourths of schools report using some other form of organization for enrichment programs. Within-class grouping is used for mathematics and science enrichment to roughly the same degree; 54 percent of schools use this for mathematics enrichment relative to 60 percent for science enrichment. Before- and after-school instruction arrangements are in place for each subject in about two-thirds of schools. Pull-out arrangements are used by 54 percent of schools for mathematics enrichment and 40 percent for science enrichment.

Instructional Time

For more than 100 years, time and its relationship to instruction have been part of the national education agenda in the United States, and since the Beginning Teacher Evaluation Study of the 1980s, instructional time has come to be seen as a critical element of schooling with a pronounced effect on educational outcomes (Fisher et al., 1978). The prevailing view is that more learning time must be provided in order for systemic change to take place in American schools (National Education Commission on Time and Learning, 1994; Slattery, 1995).

It is unusual for one topic in instruction to generate such broad consensus. Part of the reason may be that this is a commonsense proposition; the more time one spends learning, the more one learns. Time is a policy variable as well, and one amenable to policy action—increases in the school day, the school year, and so on are reasonably easy to implement given sufficient funding. There is evidence that more time spent in school may mean more learning, but only if this time is time that students spend engaged in learning activities. At least one model of school learning has made time its central element (Carroll, 1963), and this kind of thinking has given rise to three general notions as to how learning time might be increased. The first is to provide more exposure to schooling, directly, by increasing the length of the school year, school day, class period, the number of periods per day, or indirectly, through increases in course requirements—graduation requirements, for example. A second suggested approach is to decrease the amount of time used for administrative functions, nonacademic activities, or classroom management. A third approach advocates the use of instructional methods that promote increased learning time, to the end that students' on-task learning behaviors and engagement are increased.

The TIMSS school questionnaire asks principals to report on various aspects of instructional time for their school as a whole and for eighth-grade mathematics and science classes. The responses are shown in panel a of appendix table 4-21 (on page A-21) in terms of mean hours for each of the categories. Overall, the schools sampled spend an average of 179 days on instruction each year—about one-half of the total days each year. This average reflects two patterns: 15 percent of schools provide for 175 instructional days each year, and 51 percent provide 180 days of instruction. In each of these days, the average school provides 5 to 6 hours of instructional time (an average of 26 hours per week, with a mode of 30 capturing 21 percent of schools).

In panels b and c of appendix table 4-21 (on page A-21), instructional time is displayed separately for mathematics and science courses and, within these, for both tracked and nontracked classes at the highest and lowest levels. These data on hours of instructional time make one thing clear: Tracked and untracked classes in mathematics receive the same amount of instructional time, on average. In science, tracked classes at the highest levels receive a greater amount of instructional time (151 hours on average) than untracked classes (138 hours). When classes are not tracked, mathematics class time exceeds that of science classes (146 vs. 138 hours). In the case of tracked classes differences in the mean hours of allocated instructional time across mathematics and science courses are not statistically significant.

Instructional resources in mathematics and science classrooms. While virtually all schools report access to computers, in 1995, at the time of the TIMSS data collection, computers did not appear to be an integral part of the eighth-grade mathematics and science curriculum. Less than 50 percent of students report using computers as part of their mathematics and/or science classes. This situation may have changed since that time and, one would guess, will change at an increasing rate from this point on.

With all of its problems, differences in students' abilities, interests and motivations will probably continue to drive course differentiation in classrooms as a way of dealing with individual differences. The growth of information technology could well be important in this respect, providing remediation or enrichment at an individual level via software rather than through pull-out and within-class programs during school time, or through programs available before and/or after school. Course differentiation in the future may well occur at the level of the individual student with the teacher acting as a resource rather than the source of knowledge. For whatever reason mathematics is likely to remain a difficult subject in the eyes of many students and so one could expect in the future, as now, that the demand for remedial teaching in mathematics will continue.

V. Instructional Practices

Models of teaching present different pictures of effective instruction and also describe existing practice from quite different perspectives. Current thinking suggests that notions of what constitutes effective instruction have been shaped by studies conducted within the "process-product" paradigm.[10] Instructional models that promote "active teaching," "mastery teaching," and "direct instruction" are grounded in this tradition. In these models of teaching the teacher is the expert on the subject matter and controls the flow of knowledge and information. Such models focus on generic teacher behaviors, with particular emphasis on how teachers organize students, time, and resources to promote learning and achievement. The student is expected to learn the information and demonstrate mastery by reproducing the information in the same form that it was taught.

Critiques of direct-instruction models and their underlying research framework take content, classroom activities, and learners as their starting points (Shulman, 1987). Models reflecting this constructivist orientation place greater emphasis on the content of instruction and on the intellectual work required of students (Shulman, 1986). Basic to these critiques of process-product research is the notion that the study of teaching cannot be separated from what is taught or what is worth knowing (Putnam et al., 1990; Yager et al., 1988). Typically, such models treat subject matter as fundamental; view deep understanding of content as the goal of instruction; see learning as an active, sense-making process; and see the teacher's role as structuring tasks and the classroom environment in ways that promote active engagement in the subject matter. In this view, students develop understanding as they attempt to integrate new concepts and ideas with what they already know and as they test and flesh out new ideas through discussion and applications (Gallagher, 1993; Wheatley, 1991). Instructional models framed within this perspective include "teaching for understanding," "teaching for conceptual change," and "constructivist" teaching. In the "constructivist" paradigm, the student has a more central role. Instruction, activities, and discussion are designed so that the students will manipulate the information and materials to construct the underlying concept that is being taught.

Two other lines of inquiry also shape current views of teachers and teaching. Studies of teachers' expertise are clarifying the knowledge base that underlies effective teaching (Ball, 1991; Carlsen, 1991; Peterson, 1988a; 1988b; Smith and Neale, 1991; Shulman, 1986; 1987). Studies of teaching as a profession are helping to clarify how issues such as autonomy, responsibility, and collegiality enter into teaching decisions (Little, 1982; Noddings, 1992). Other studies draw attention to how working conditions facilitate or impede good classroom practice (Nelson and O'Brien, 1993). Views of instruction informed by constructivist principles and these newer lines of research form the core of emerging standards for mathematics and science education.

In mathematics, the blueprint for standards was laid out by the Mathematical Sciences Education Board (MSEB) of the National Academy of Sciences in Everybody Counts:

10 For reviews of this work, see Brophy and Good (1986), Medley (1979), and Rosenshine and Stevens (1986).

A Report to the Nation on the Future of Mathematics Education (MSEB, 1989). This was followed immediately by two publications from the NCTM[11] that identified the concrete changes required to reform mathematics education along the lines laid out by MSEB. These two reports—Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) and Professional Standards for Teaching Mathematics (NCTM, 1991a)—are considered landmarks for the standards-based reform movement as a whole. In one respect, the experience of NCTM served as a model for reform in other areas of education. It demonstrated participation in standards development as open to all interested parties, especially the teachers responsible for interpreting and translating the standards into daily practice.

Standards for science teaching and learning followed several years later. The National Science Education Standards were released by the National Research Council (NRC) of the National Academy of Sciences in early 1996 (NRC, 1996). Although quite recently published, many elements of the standards are familiar to science educators since they reflect consensus positions that were articulated in earlier reports such as the American Association for the Advancement of Science (AAAS) publications, Science for All Americans (1989) and Benchmarks for Science Literacy (1993) and the NSTA publication Scope, Sequence, and Coordination of Secondary School Science (1992).

The published standards for mathematics and science education share many of the tenets of the constructivist philosophy.[12] In both areas the standards promote development of an in-depth understanding of the core concepts of the discipline rather than the encyclopedic knowledge of procedures, facts, and terminology. The standards also embrace the proposition that what students learn is fundamentally connected to how they learn and so emphasize both hands-on and "minds-on" explorations of content. Both sets of standards emphasize the importance of thinking, talking, and writing as keys to understanding the discipline well. In each case the standards set high expectations for all students and view teachers as the critical agents in meeting this challenge.

While the TIMSS questionnaires appear not to have been explicitly designed to address instruction in these terms, they contain information that offers a portrait—albeit, a partial one—of mathematics and science teaching in the mid-90s and viewed through lenses that reflect both traditional and newer reform-oriented perspectives on instruction. The teacher questionnaires offer a broad look at instructional practices by examining factors representing both views. Included are questions on the following aspects of teachers' practice: (1) planning for instruction; (2) introducing new topics; (3) organizing and interacting with students; (4) orchestrating instruction through classroom activities; (5) promoting high-level cognitive processes; (6) responding to student errors; (7) weaving homework into the instructional process; and (8) assessing student learning. The discussion that follows examines the instructional practices of eighth-grade mathematics and science teachers in these terms.

11 NCTM is the leading professional association for mathematics educators.
12 See Weiss et al. (1994) for a more complete analysis of shared perspectives in the two sets of standards.

Lesson Planning

Lesson plans and lesson planning are generally thought of as central elements of teachers' work since they define the structure and content of lessons. Lesson planning receives a good deal of emphasis in teacher education programs and novice teachers, at least, spend time developing formal lesson plans to support their teaching and satisfy administrative requirements. Formal planning and plans are less common among experienced teachers but most teachers engage in some kind of planning even if it consists of simple mental rehearsals of lessons.

The personal and institutional resources that teachers draw on in planning what to teach and how to teach it are of particular interest to those advocating reform in mathematics and science education. The National Survey of Science and Mathematics Education (NSSME) report of 1994 (Weiss et al., 1994) indicates that middle school teachers' content decisions are influenced most by their understanding of what motivates students and by their own background in the subject matter. Curriculum frameworks and the availability of facilities and equipment rank next in influence. Professional standards and external examinations, which some see as driving much of instruction,[13] play a less critical role in teachers' views (Weiss et al., 1994).

The TIMSS survey posed two questions about lesson planning that both overlap and extend the coverage of NSSME: (1) how often teachers rely on seven common sources of information in planning lessons; and (2) which particular published resources are used in deciding on different aspects of a lesson. Appendix table 4-22 (on page A-22) presents responses to the first question. Teachers report using most of the sources about which the survey inquired in at least some lessons; however, in order to focus on teachers' customary planning practices, attention is directed to the resources they "always" use. Some 25 to 37 percent of teachers always use previous lesson plans, teacher or student versions of the text, and in the case of science teachers, other resource books. In contrast, about 10 percent of mathematics teachers rely on outside books in planning, a significantly smaller proportion than for science teachers. Written school plans, collaborative planning with other teachers in their departments, and the content of standardized tests do not figure as prominently in this planning process. These are always used as resources by 10 percent or fewer of the teachers in each case.

Appendix table 4-23 (on page A-23) and figure 4-23 present teachers' reports of the major written resources used in particular areas of instructional decision making. As the response patterns indicate, teachers relied on different resources for different purposes. About 40 percent of the teachers base topic selections on district curriculum guides and about one-fourth use school curriculum guides as their main source of written information. In deciding how to present the selected content, about one-half of teachers rely on teacher guides/editions of the textbook. An additional 28 percent rely on other resource books for this purpose. Close to 50 percent of mathematics and science teachers rely on teacher versions of the text to provide exercises for classwork

13 See the discussion in the reports of the National Commission on Testing and Public Policy (1990).

Figure 4-23a-d Resources used for instructional decisions; eighth-grade mathematics and science teachers

Figure 4-23a

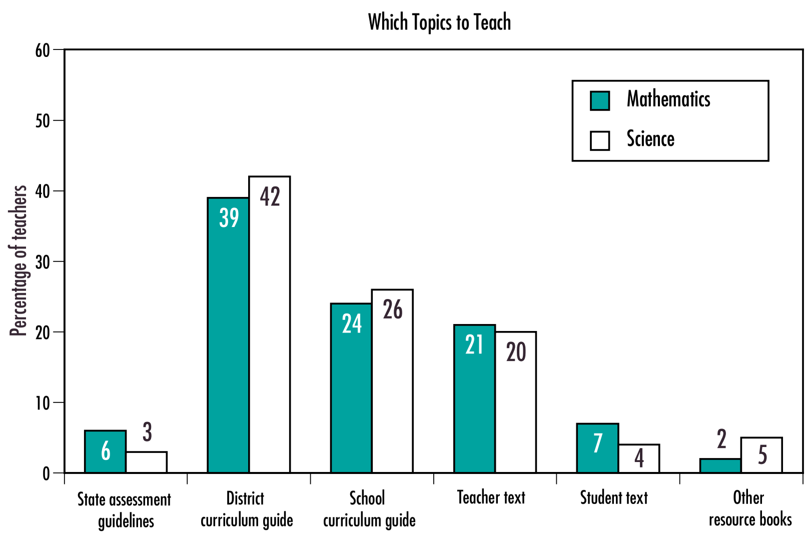


Figure 4-23b

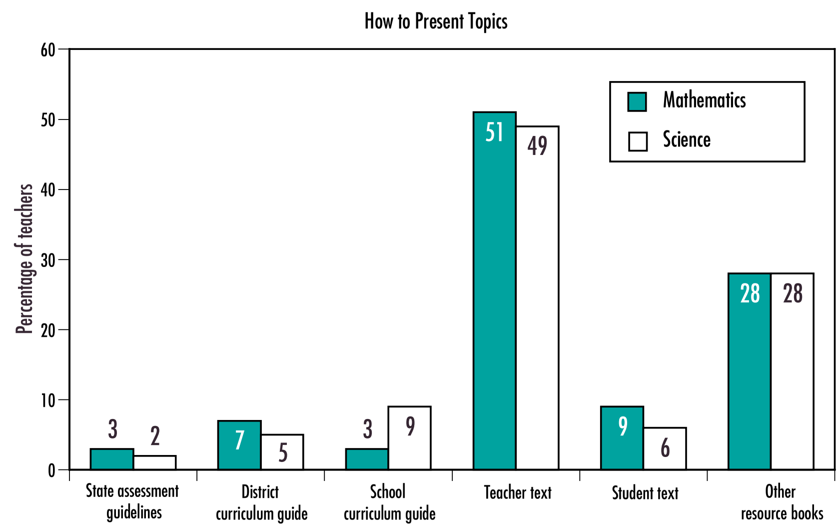


Figure 4-23c

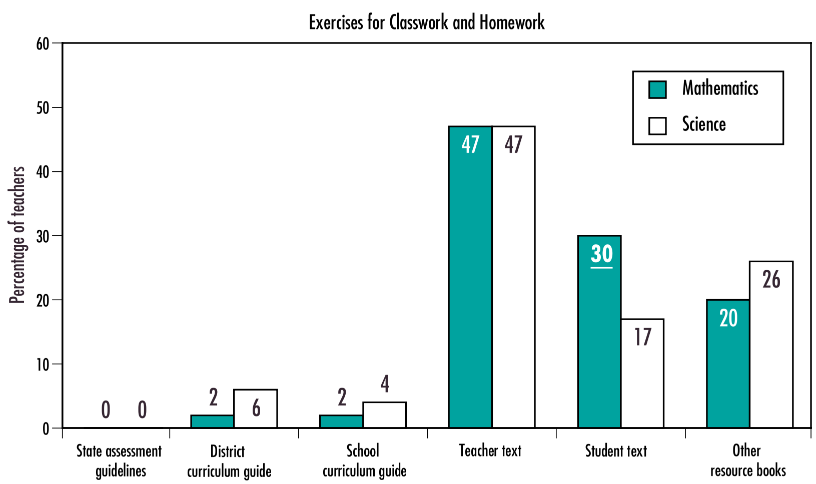
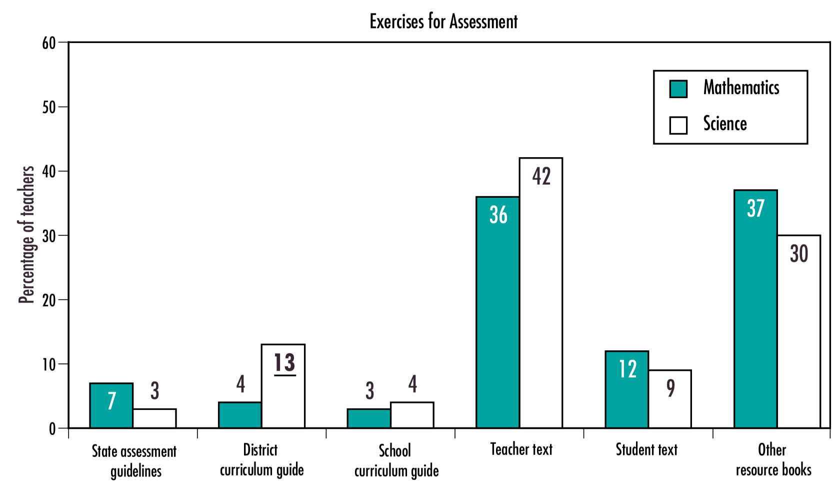


Figure 4-23d



NOTE:
Where pairwise comparisons indicate signifigant differences, the higher number of the pair is shown in bold and underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

and homework. Teacher texts, along with other resource books, are the primary sources of assessment exercises for close to 70 percent of teachers in each of the subject areas. Responses of teachers in the two content areas differed significantly in two respects: more mathematics teachers use student textbooks as a source of homework and classwork exercises; and more science teachers use district curriculum guides in choosing assessment exercises.

These findings are consistent with the results of other surveys in several respects. Like other aspects of teaching, lesson planning is largely a solitary task for most TIMSS teachers. Just as Weiss and her colleagues found that teachers rarely have time for genuine collaboration with one another (Weiss et al., 1994), the TIMSS data show that teachers do not often consult one another when planning lessons and do not often use lesson plans developed by colleagues within their schools or departments. Instead, teachers take their cues on what to teach at the topic level from (local) curriculum guidelines. When it comes to defining the more detailed content, student and teacher texts are the source of choice, an indication that textbooks remain a major influence on teaching, as documented in other recent surveys (Lindquist et al., 1995; Dossey et al., 1994; Weiss et al., 1994).

Introducing New Topics

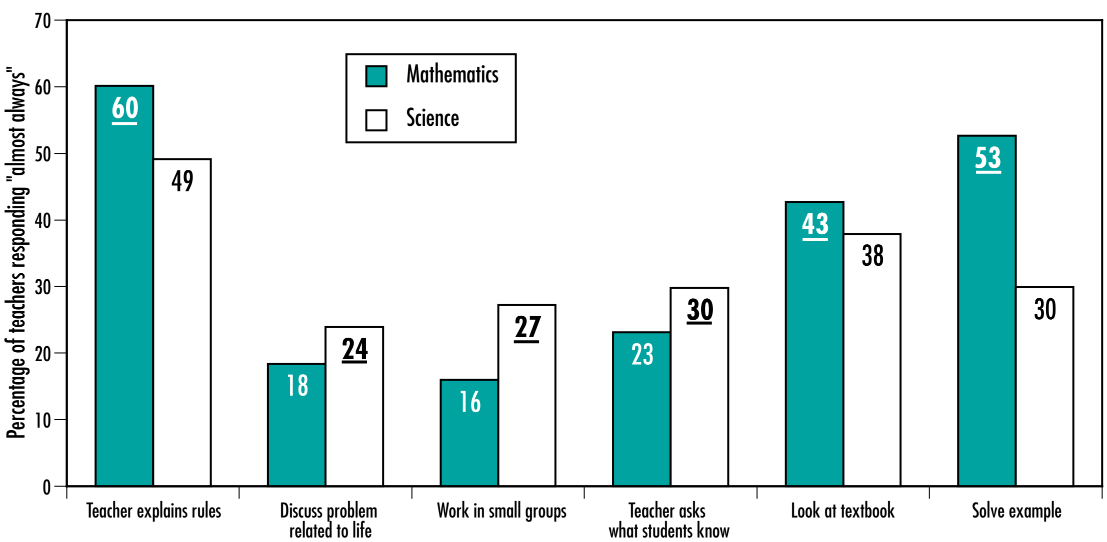
Virtually all teaching models recognize the importance of prerequisite knowledge to the development of new understandings. They recognize, as well, the importance of helping students connect new knowledge and ideas to what they already know and believe about the subject matter. Although not all models differentiate between the introduction of new topics and their subsequent development, those based on different visions of teaching often stress different aspects of the process.

Direct instruction models typically focus on teachers' lectures, demonstrations, and other forms of presentation. They generally offer guidelines on concrete actions to be taken by the teacher in presenting information, such as starting off with a statement of goals and main points and following up with step-by-step procedures (Brophy and Good, 1986; Rosenshine and Stevens, 1986). Models based on constructivist principles more often focus on learner activities designed to foster deep understanding. These models promote tasks like concept mapping to help students visualize connections between ideas, or small group work and real-life problems to serve as springboards for learning new material (Gallagher, 1993; Loucks-Horsley et al., 1990; Jakubowski, 1993; National Center for Improving Science Education, 1991; Wheatley, 1991).

Information on the ways in which TIMSS teachers introduce new topics in mathematics and science to eighth graders was obtained from the student's perspective. Students were asked how often each of several approaches is used. Some of the approaches in the questionnaire focused on the kinds of active teaching behavior described by direct instruction models—lecturing, explaining, and the like. Others focused on the kinds of tasks that promote active student engagement, reflecting the constructivist assertion that understanding builds from experience with particular problems, cases, or examples.

The responses of these students are summarized in appendix table 4-24 (on page A-24) and pictured graphically in figure 4-24, where the "almost always" responses are displayed. Sixty percent of students report that new mathematics topics are almost always introduced through explanation of rules and definitions. In the case of science topics the comparable figure is about 50 percent. Another approach reported by about 40 percent of students with respect to both mathematics and science is to have students follow along in the textbook while the teacher talks. In addition, students report that about one-half of their mathematics lessons and about 3 in 10 of their science lessons began with their teachers solving examples related to the new topic. Since the approaches mentioned are not mutually exclusive, it seems likely that they are used in combination. This form of presentation exemplifies elements of the general strategy of direct instruction—presentation, demonstration, guided practice (see Rosenshine and Stevens, 1986). Around one-fourth of mathematics and science teachers typically start new topics by determining what students already know. Fewer lessons introduce new topics through group problem solving or by using problems from everyday life, but more of them do so in science than in mathematics classrooms. While science teachers appear to be somewhat more catholic in their approach to introducing new topics, learning rules from the teacher and the textbook remain favored approaches in both subjects.

Figure 4-24
Strategies for introduction of new topics; eighth-grade mathematics and science teachers



NOTE:
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SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Organizing and Interacting with Students

Academic performance has been shown to differ depending on how students are organized for instruction. In whole-class instruction, teachers make presentations, conduct discussions, or demonstrate procedures and applications to all students simultaneously. In independent practice or seatwork, students work alone, with or without supervision by the teacher. Both whole-class instruction and independent work are standard features of traditional classrooms. Small-group instruction, where two or more students work together on a task, occurs less frequently, though it is endorsed by many teachers and educational reformers alike (NCTM, 1991a; National Research Council, 1996). In principle, there are advantages to small-group work, as each student has a greater opportunity to present and test out ideas than when working alone or in whole-class instruction (Gallagher, 1993; Tobin et al., 1994; Webb and Farivar, 1994). In practice, however, group tasks often do not facilitate either extended exploration of ideas or collective effort; instead, it is often the case that each student works alone on the task assigned to the group (Gerelman, 1987).

Research suggests that whole-class instruction usually results in higher student achievement (Brophy and Good, 1986; Evertson et al., 1990). It allows teachers to spend more time developing concepts and less time on management functions. It also provides the quality of supervision needed for students to stay on task (Fisher et al., 1978; Rosenshine, 1980). Independent practice has been associated with lower achievement levels when more than 50 percent of instructional time is spent in this way (Rosenshine and Stevens, 1986). Evidence on the effectiveness of group instruction is mixed (Good et al., 1992a; 1992b; Linn and Burbules, 1993). The outcomes vary depending on group structure, the kinds of tasks presented, the nature of interactions among students, and the characteristics of the students involved (Gamoran et al., 1995; Gerelman, 1987; King, 1994; Webb, 1989; 1991; Webb and Farivar, 1994).

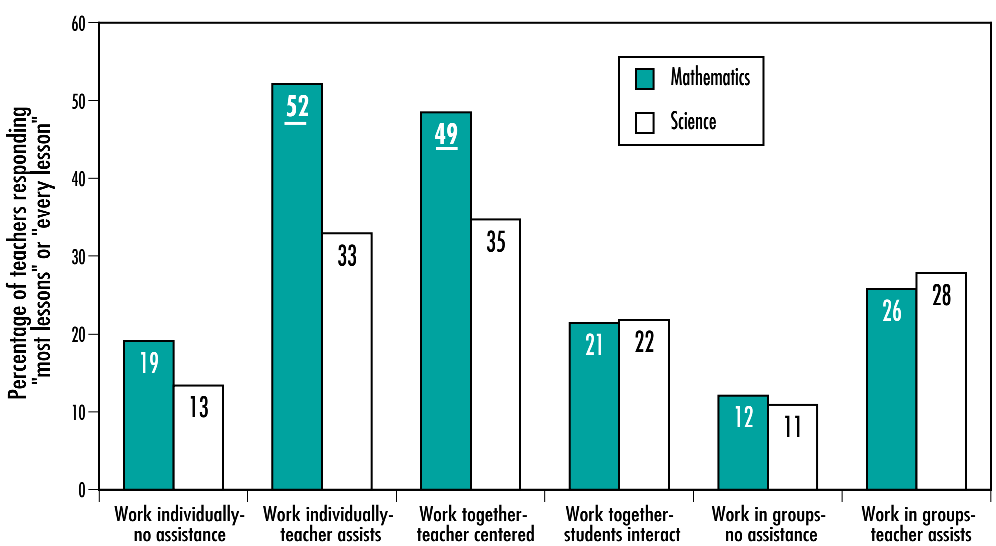
Achievement also seems to depend on the manner of teachers' involvement as students work in each mode. For example, both individual and small-group activities are most productive when the teacher monitors students as they work—asking questions, providing clues and answers, and offering feedback and explanations (Fisher, et al. 1978; Rosenshine, 1980). Similarly, class discussions are most productive when the teacher actively focuses and guides the conversation, drawing out, contrasting, and challenging student ideas (Ball, 1991; Hollon et al., 1991).

Classrooms differ in terms of how much time is given to each of these strategies for organizing students and monitoring instruction. On average, students in middle school mathematics and science courses spend almost 40 percent of class time on whole-class lecture and discussion; 20-25 percent on independent seatwork; and less than 10 percent in small groups (Weiss et al., 1994). In most cases, teachers provide little direct assistance to students during independent practice. In contrast, most teachers play an active role in class discussions, often too active by some accounts (see the authors cited below). Rather than guiding and supporting the process, many teachers originate and respond to almost all statements, leaving students to comment or supply answers primarily when called on to do so (Brophy and Good, 1986; Klinzing and Klinzing-Eurich, 1988; Smith and Neale, 1991).

The TIMSS survey addressed each of these aspects of classroom organization and interaction by considering the intersection of the teacher assistance dimension with the whole-class/group/individual instruction dimension. Thus, teachers were asked how frequently students work as a whole, in pairs or small groups, or individually, and whether they provide active assistance or direction to students during each kind of activity. Appendix table 4-25 (on page A-25) presents a summary of responses, and figure 4-25 below displays the aggregation of the "most" and "every" responses.

Strategies for organizing student-student and student-teacher interaction tended to follow a similar pattern in both mathematics and science classrooms. A simple rank ordering of the responses suggests that teachers tend to maintain a central role in classroom activities. The two most common activities were teacher-centered: the teacher teaching the whole class, and students engaged in individual seatwork with the teacher providing assistance.[14] About one-half of all mathematics teachers report that these occur in most or every lesson. Approximately one-third of science teachers respond in the same way, a proportion significantly less than that of mathematics teachers. Close to one-fourth of all teachers report that group work with teacher assistance occurs in most or every lesson. Ten to 20 percent of teachers indicate that they provide for unassisted group or individual work by students this frequently. Again, the overall pattern is consistent with the direct instruction framework.

Figure 4-25
Frequency of types of teacher-student interaction; eighth-grade mathematics and science classes



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

14 Among science teachers, these two approaches were not significantly more common than working in groups with teacher assistance or working together with student interaction.

Classroom Activities

Educational standards in both mathematics and science call for more active learning in classrooms: use of hands-on activities, manipulatives, and laboratories; work on small investigations and longer-term projects; and work with tools and models (AAAS, 1993; Mathematical Sciences Education Board, 1989; NCTM, 1989, 1991a; National Research Council, 1996). While there is movement in these directions, many classrooms still fit the picture painted by the pioneering case studies conducted in the late 1970s by Stake and Easley (1978). Instruction appears to be still largely organized around routine tasks. At the middle school level, lectures, note taking, and exercises from textbooks and worksheets are the norm. Hands-on activities—staples in elementary school classrooms—are encountered much less often in higher grades. By the time students reach grade 8 they spend little time working productively in small groups, talking or writing about the content they are expected to learn, working on long-term projects, or working with tools, particularly computers (Lindquist et al., 1995; Weiss et al., 1994).

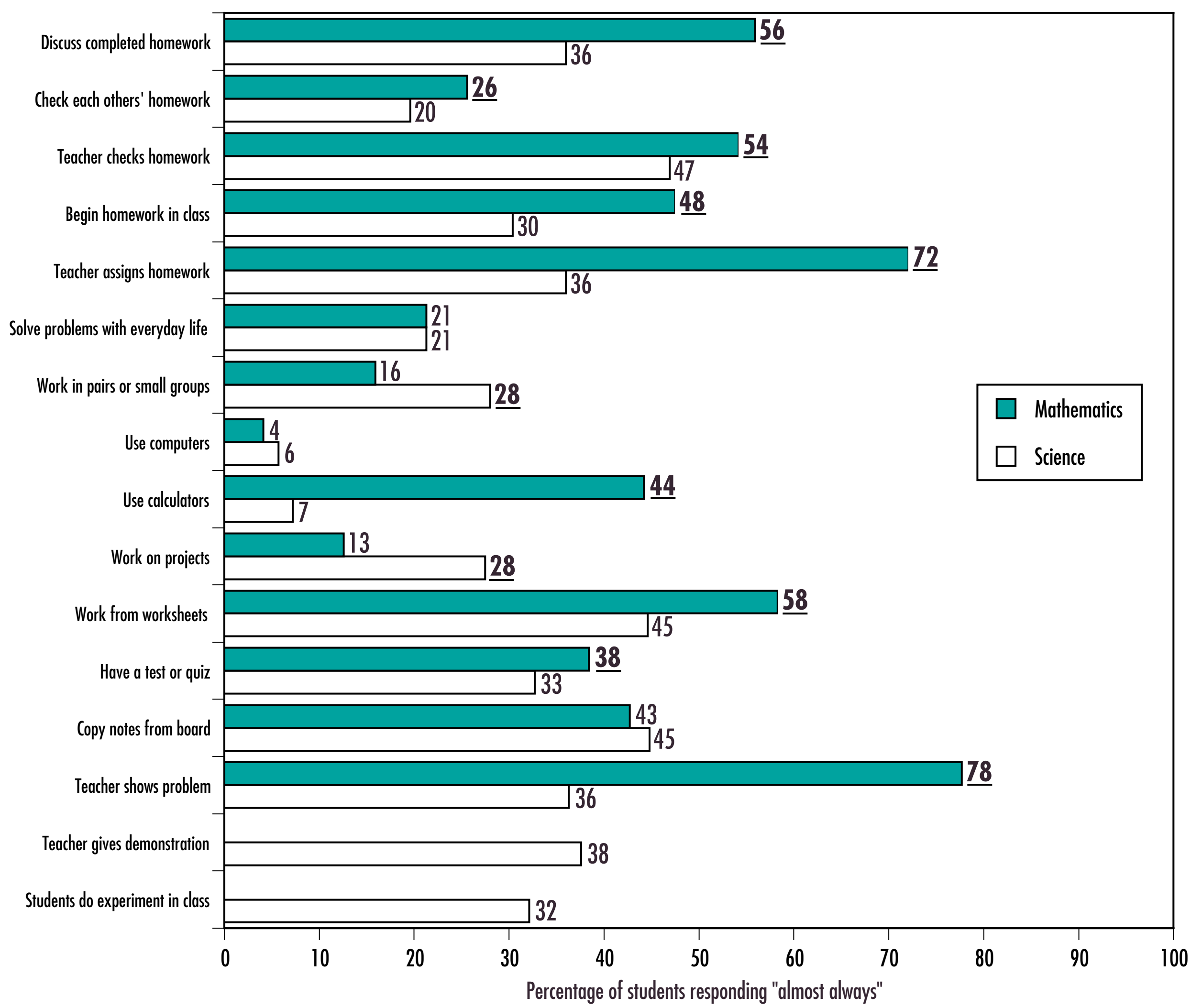
The TIMSS data bearing on these matters come from students' reports of classroom activities. These data are displayed in appendix table 4-26 (on page A-26) and in figure 4-26 and provide a picture consistent with what teachers themselves report. Using just the "almost always" responses, the most common events in mathematics classrooms are watching teachers demonstrate how to do problems (78 percent) and doing tasks related to homework—the teacher assigning it (72 percent) or checking it (54 percent), the class discussing it (56 percent), and students starting it in class (48 percent). Routine activities such as completing worksheet exercises (58 percent) and copying notes from the board (43 percent) also occupy student time on a fairly regular basis. The picture in science classrooms is more varied, where largely traditional activities such as these occur in fewer cases, reported by 20 to 47 percent of teachers. In fact, mathematics and science instruction differ in 9 of the 14 comparable areas covered by this question and, in every case, mathematics appears more likely to be taught in the way associated with the "process-product" paradigm.

In most cases, more learner-centered activities—small groups, computers, calculators, projects, and working everyday problems—are provided for less often. Apart from the use of calculators in mathematics lessons, which is common, students report that they engage in these activities "almost always" in 28 percent of cases at the most, and for some items more often in science than in mathematics.

Science teachers were asked a related set of questions about the strategies they use to provide links to the outside world. Responses to these questions are presented in appendix table 4-27 (on page A-27), which shows that the majority of science teachers use experiments and other "real-world links" in some lessons. The activities reported as happening in "most lessons" and "never" are of most interest.[15] Three activities tended to occur in "most lessons" in at least 15 percent of classrooms: students watching the teacher do an experiment (17 percent); conducting experiments (26 percent);

15 Few teachers reported any of these activities as being present in every lesson, so this category is not presented in the discussion.

Figure 4-26
Frequency of types of instructional activities; eighth-grade mathematics and science students



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
Some questions were asked to both mathematics and science teachers; some questions were asked only to mathematics or science teachers.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Student Questionnaire, 1995.

and doing other lab-related activities (15 percent). At the other end of the spectrum, about 80 percent of science classes never or almost never take field trips, about 50 percent never design the experiments they work on, and about 40 percent never work on long-term projects. In these respects, science classes fall short of constructivist expectations.

Promoting Higher Order Cognitive Processes

Standards in both mathematics and science emphasize the importance of students having regular opportunities to engage in reasoning, solve meaningful problems, and communicate using the concepts and language of the disciplines (NCTM, 1989; 1991a; National Research Council, 1996). The authors cited below suggest that although many teachers are making use of activities thought to foster development of higher order capabilities, few seem to take full advantage of the communications possibilities these tasks present. For example, most students in mathematics classes participate in discussions about problems and problem solving, but few are ever required to write about the processes they use or to justify the solutions they generate. Most students in science classes participate in laboratory activities at least once each week, as noted earlier, but few are ever required to write reports based on their laboratory work (Lindquist et al., 1995; Weiss et al., 1994).

TIMSS teachers answered several questions about their use of activities designed to engage students in the higher order cognitive processes promoted by standards. The questions and teachers' answers are presented in appendix table 4-28 (on page A-28). Responses to "most lessons" and "every lesson" are aggregated and displayed in figure 4-27. Two-thirds or more of teachers in each subject area ask students to explain the reasoning behind ideas in most or all lessons. This is, in general, the most frequently used strategy among those listed in both subject areas. In mathematics close to 60 percent of teachers also have students practice computations in most or all lessons. About one-third of teachers give students practice writing equations in mathematics and writing explanations of observations in science classes this frequently. Thirteen percent or fewer teachers routinely have students work on problems with no obvious solution; and 4 percent or fewer teachers have students use computers to solve problems most of the time. Teachers' responses differed significantly only in one of the areas examined; students use graphs and tables to represent relationships more frequently in science than in mathematics classes (26 percent vs. 12 percent). In all, the pattern evidenced by the teachers' responses to this set of items suggests that the direct instruction approach to teaching dominates middle school mathematics and science classrooms.

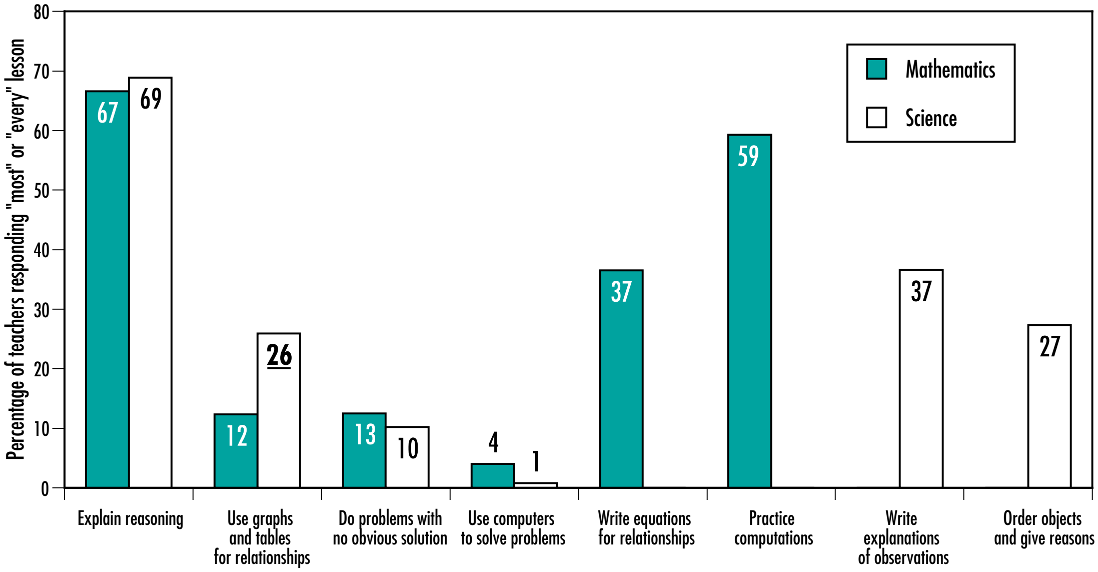
Responding to Students' Errors

Errors made by students are particularly significant events in instructional theory. Direct instruction models differentiate between careless errors and errors indicating that content is not well learned or not well understood. In the case of careless errors, theory suggests that the teacher simply correct the student and move on. Otherwise, the teacher should follow one of two approaches: (1) guide the student to the correct response using prompts, hints, or simpler questions; or (2) reteach the material (Rosenshine and Stevens, 1986). Constructivist models of teaching suggest another option, namely, generating a discussion among students about the correct answer and using that opportunity to discuss why and how one knows when an answer is correct.[16] In tapping this area, the TIMSS survey asked teachers how often they use

16 See, for example, the discussion in Ball (1991) and in Hollon et al. (1991).

Figure 4-27

Frequency of uses of instructional practices; eighth-grade mathematics and science teachers



NOTE:

Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.

Some questions were asked to both mathematics and science teachers; some questions were asked only to mathematics or science teachers.

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

strategies reflecting both direct instruction and constructivist views of appropriate followup on errors.

A summary of responses appears in appendix table 4-29 (on page A-29). While the range of response alternatives is limited to four, when responses to "most" and "every" lesson are combined, teachers are shown to choose two this frequently, in the main. They prompt the student to a correct response with a hint or another question (about 80 percent in most/every lesson) or they direct the question to other students and have the whole class discuss the correct answer (about 60 percent). Correcting student responses in front of the class and calling on another student for the correct response are used frequently by 17 percent or fewer mathematics and science teachers.

Homework

Homework refers to assignments that students are expected to complete outside of school.[17] Its main purpose is to reinforce the content of regular classroom lessons. Parents, educators, and the general public consider homework important for several reasons: It extends the amount of time that students spend on school-related learning; it provides an opportunity for students to develop good study habits, engage in independent learning, and develop mental discipline; it provides a vehicle for involving parents in the education of their children; and it promotes higher levels of academic achievement. Keith (1986) and Olympia et al. (1994) provide informative accounts of the educational literature on this topic.

17 In practice, however, teachers often give students enough time to do, or at least to start, the work in class.

Homework's contribution to student learning has been studied extensively by Keith (1986), Leone and Richards (1989), and Walberg and his colleagues (Paschal et al., 1984; Walberg, 1984a; 1984b). These studies claim to show that homework's impact on academic performance is quite strong. They argue that students who do more homework achieve at higher levels than do their peers, and lower ability students can achieve grades comparable to those of their more able classmates by increasing their homework and study time. They argue further that homework is a more powerful determinant of student outcomes than are factors related to family background and that the effects of homework on achievement are exceeded only by tested ability. Other research suggests that homework has its biggest impact when it is graded or commented on by teachers and a moderate impact when it is assigned but not followed up by teachers.

Many of these themes are reflected in the questions asked of mathematics and science teachers as part of the TIMSS survey. Teachers were asked how much homework they assign, the kinds of tasks usually assigned, and the nature of followup on completed assignments. In addition, students were asked how much time they actually spend on homework and how much time they spend on activities that might support or compete with homework. The homework of eighth-grade mathematics and science students is described in these terms in the discussion that follows.

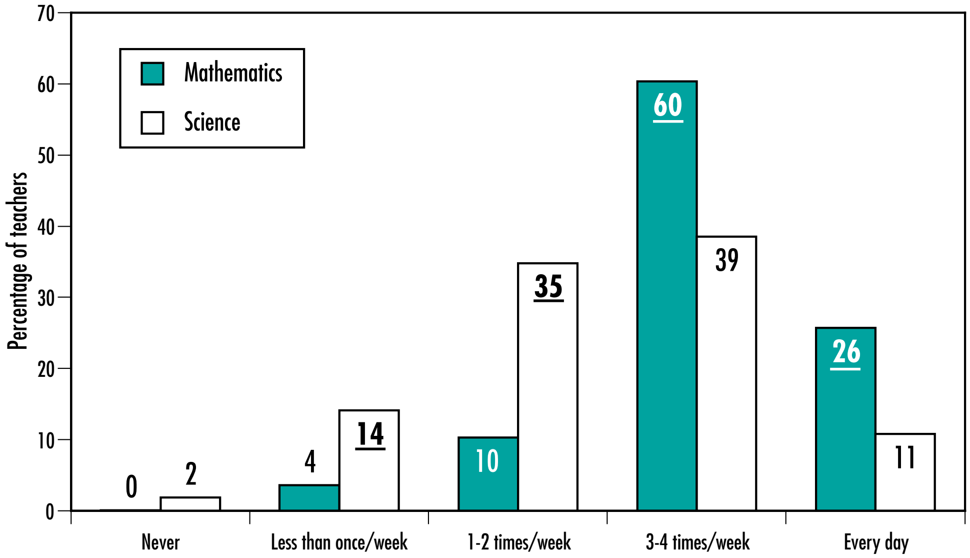
Amount of homework assigned. According to 1992 NAEP data, close to one-half of grade 8 students are assigned 30 minutes of mathematics homework each day and an additional 20 percent are assigned 45 minutes or more (Dossey et al., 1994). In science, homework time is not substantial at any grade level. At grade 8, more than 40 percent of students are assigned 1 hour or less of science homework per week.

The eighth-grade mathematics and science teachers participating in TIMSS were asked how often they assign homework and how many minutes it would take an average student to complete a typical assignment. Appendix table 4-30 (on page A-30) provides a summary of responses to both of these items. Figure 4-28 illustrates the frequency of homework assignments. As the data suggest, teachers who assign homework estimate that the typical assignment takes an average of 28 minutes in mathematics and 22 minutes in science.[18] Overall, mathematics teachers rarely make assignments taking less than 15 minutes and they assign homework more often—at least three times each week as compared to twice or less in science. In both cases the differences between mathematics and science teachers are statistically significant.

Amount of homework completed. Recent NAEP data show that teachers may overestimate the amount of time students actually spend on homework (Dossey et al., 1994; Jones et al., 1992). Most 14-year-olds report that they spend 1 to 2 hours each day on all academic work outside of school (NCES, 1993b) and 1 hour or less on homework in mathematics and science (Dossey et al., 1994). Appendix table 4-31 (on page A-31) places homework in the context of several other activities that engage students during out-of-school hours. TIMSS students report that on a normal school day they

18 If all teachers are considered, even those who report assigning no homework, the means are 23 minutes and 28 minutes, respectively; see table 4-30, panel b.

Figure 4-28
Frequency of homework assignments; eighth-grade mathematics and science teachers



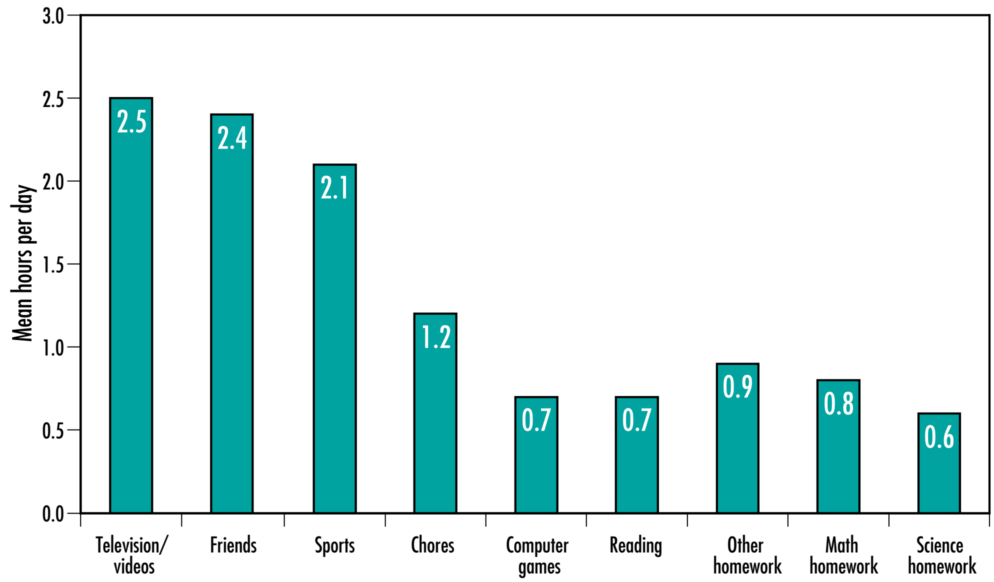
NOTE:
Percentages less than .5 have been rounded to 0.
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

spend less than 1 hour on each of mathematics and science homework as part of a total of about 2.3 hours on average for all homework.

Competing and supporting activities. Homework competes with other activities for student attention and not always successfully. Appendix table 4-31, panel a (on page A-31), displays the distribution of times and figure 4-29 (on page 142) shows the average number of hours students report spending on nine different activities during nonschool hours on a normal school day. Sports, friends, and television average between 2.1 and 2.5 hours; computer games, chores, and books average about 1 hour. Summing times across subjects, students spend close to 2.3 hours on all homework combined. Appendix table 4-31, panel b (on page A-31), shows that, during the course of a week, students are unlikely to supplement homework with other activities that focus on mathematics or science, such as additional lessons or clubs that meet before or after school.

Tasks assigned as homework. Although homework is a dominant topic of discussion among proponents of direct instruction, constructivist writings rarely make a distinction between work done at school and academic tasks that are to be done by students on their own time outside of school. Rather than focusing on when or where the work is done, standards-based reformers stress the kinds of work students are expected to do—"authentic" tasks that require thinking, communication, and problem solving

Figure 4-29
Student activities out of school hours; eighth-grade students



SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Student Questionnaire, 1995.

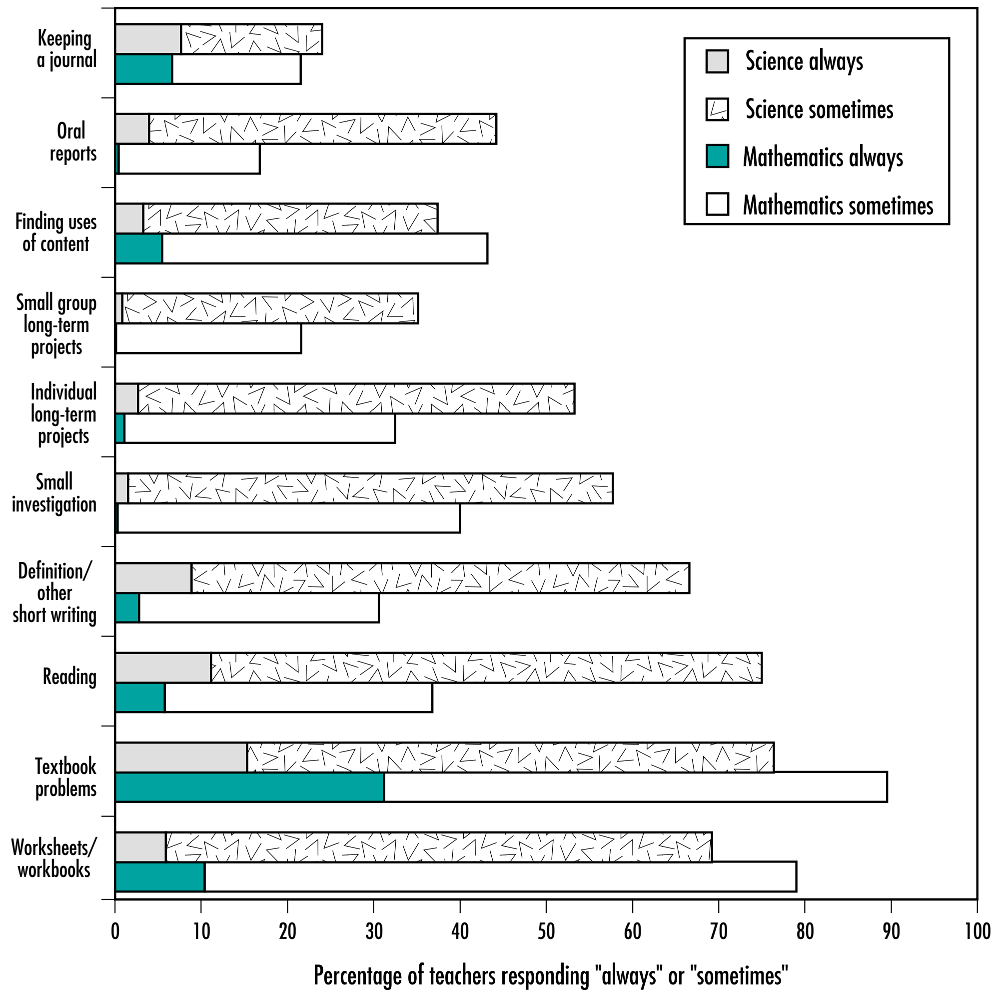
(NCTM, 1989; NRC, 1996). As a result of the increased emphasis on authenticity, many of the recommended tasks actually tie academic work to the home and community. For example, one popular mathematics assignment has students price items on a standard shopping list at several local stores or markets. The data are then used to explore concepts of variability and central tendency through practical questions concerning unit prices, average price, "best buy," most "price-friendly" store, and the like.

Research on out-of-school learning has painted a very different picture of the kind of homework students are given. Most assignments pose minimal demands on cognitive processes and do little to promote development of high-level study skills. In middle and high school science classes, for example, students often are asked to read or reread material or to memorize assigned sections of the text; they hardly ever are asked to take notes from or to develop outlines of what they have read. Often they are given handouts and worksheets to complete that can be answered simply by copying material directly from the textbook (Mergendoller et al., 1988; Thomas, 1993). Reviews of research on mathematics homework describe a similar pattern of assigning lower level tasks. Until recently, most homework focused on routine learning, primarily to provide facility with basic arithmetic concepts and computational procedures (Austin, 1976; 1979).

Appendix table 4-32 (on page A-32) displays teachers' reports of the kinds of homework tasks assigned to eighth-grade mathematics and science students. The nature of the tasks defined is such that not all, by their nature, would be candidates for regular assignment as homework. Additionally, while it is reasonably clear what "always" means, the meaning of "sometimes" is more equivocal. To accommodate this situation graphically, both the "sometimes" and "always" response categories are shown separately in figure 4-30 but stacked to allow both the separate examination of each and a notion of their combined value. Examining "always" responses, significance tests indicated that textbook problems are used more often as homework than any other kind of tasks in mathematics classes. In science classes, textbook problems are used no more often than other routine tasks such as worksheet problems, readings, and

Figure 4-30

Frequency of tasks assigned as homework; eighth-grade mathematics and science teachers



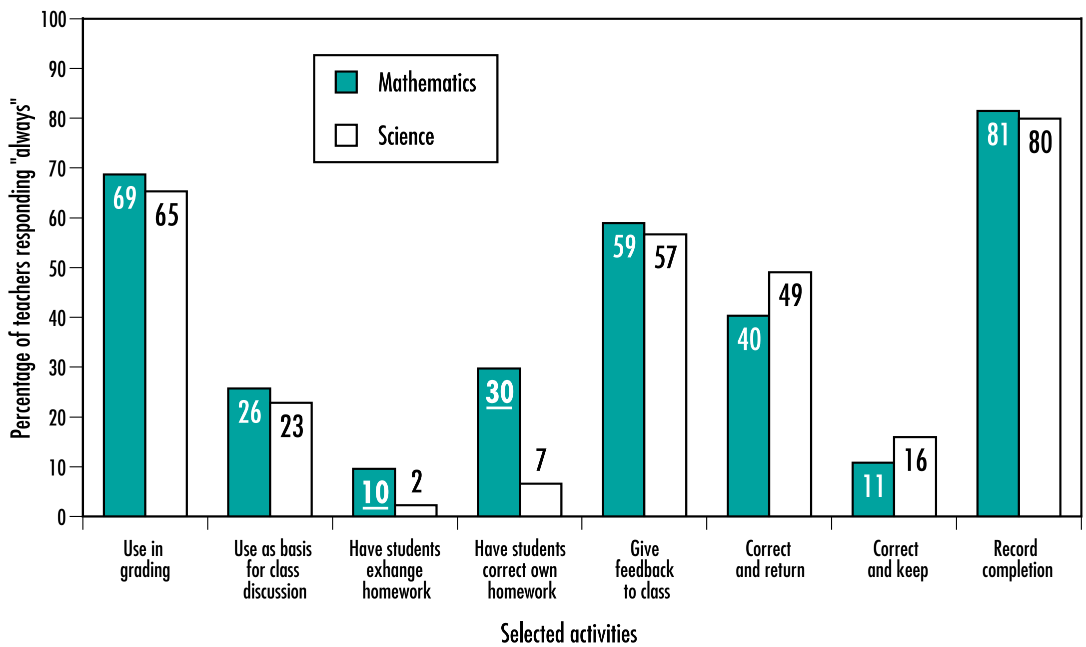
NOTE:
The base of the bar represents the percentage of teachers responding "always." The percentage of teachers responding "sometimes" is added for the total value shown.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

definitions. However science teachers do rely on textbook problems more often than any of the more constructivist-oriented tasks in the list, except for keeping a journal.

Seen from the perspective of what teachers do not assign as homework, the picture is simplified. At least 60 percent of mathematics teachers indicate that they "never" or "rarely" assign all of the tasks listed except work from textbooks and worksheets and "finding uses of content." Homework in science is more evenly spread across categories, perhaps due in part to the descriptive, nonquantitative nature of science at the eighth-grade level. But even in science, over one-half of science teachers rarely or never assign the forms of homework most favored by constructivist views of learning—group projects, finding uses of content, oral reports, and journals.

Followup on homework. As noted earlier, learning from homework is influenced to some extent by how teachers follow up on assignments. The TIMSS teacher questionnaires included questions on how completed assignments are treated: whether and by whom homework is corrected; how homework feeds back into the learning process; and how students are held accountable for homework. In general, the literature suggests that teachers consider feedback quite important and, consequently, collect and grade most assignments (Thomas, 1993). The data in appendix table 4-33 (on page A-33) suggest that this is also true of TIMSS classrooms. Since consistency is an important aspect of followup, figure 4-31 displays the proportion of teachers who report that they "always" engage in the various forms of followup.

Figure 4-31
Frequency of homework followup activities; eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

At a minimum, most teachers check whether the students did the homework; about 80 percent of teachers report that they always do this. Two-thirds of teachers use homework for grading students on a regular basis, and close to 60 percent provide feedback to the class on each assignment. On the collection, correction, and reporting of homework, teachers vary in their practices. About 23 to 26 percent use homework as a basis for class discussion; 40 to 50 percent correct and return it to the student; and 11 to 16 percent correct and keep homework papers. Differences between the subjects occurred in only one instance. More mathematics teachers (30 percent) than science teachers (7 percent) have students correct their own homework, and more mathematics teachers (10 percent) than science teachers (2 percent) have students exchange their homework for this purpose.

The homework of eighth graders. Homework, a foundation of American education, is seen by teachers to play an important role in eighth-grade mathematics and science classrooms. Most teachers assign homework on a regular basis, more often in mathematics classes than in science classes. In each case, teachers assign about 15 to 30 minutes of work. Homework generally includes a mix of activities but is dominated by routine activities—workbooks and textbook problems. However, science teachers are more likely to vary their assignments to include learner-centered tasks thought by constructivists to promote deep understanding of subject matter. Teachers follow up on homework in ways that are consistent with recommended practice. They almost always correct and grade homework, and most keep track of whether students complete the work. More than 60 percent factor homework into course grades, and teachers usually connect homework directly to classroom activities in some way—reviewing answers in class and/or building class discussions around the concepts and procedures covered.

Assessment

Teachers' beliefs about assessment and their use of assessment to determine students' progress are an important influence on the activities taking place in science and mathematics classrooms in American schools. A significant portion of the teachers' and students' school week is spent in various forms of assessment, and important decisions about students and the curriculum they receive are based on the results of assessment activities. Most public attention is given to formal testing and accountability programs using standardized measures. However, teachers surveyed in TIMSS generally consider other types of assessment to be more important and, for the most part, they use these other forms of assessment, including teacher-made tests and "alternative assessment" measures, more frequently. This activity fits with a broader trend toward the increased use of performance assessment measures in testing programs (Kane and Khattri, 1995), as well as for the purposes of monitoring students' academic progress. While teachers use assessment to address such policy-related data needs as determining student progress toward state educational standards, they also use a variety of assessment methods for more functional purposes, such as providing reports to parents and feedback to students. Additionally, the assessment instruments used by teachers in mathematics and science may differ depending on local and state policy. Nevertheless, despite all this activity, there is little empirical data available to identify the most useful assessment practices that support the stated purposes of assessment (Kane and Khattri, 1995).

The TIMSS questionnaire asked eighth-grade mathematics and science teachers two questions about the assessments they use: the importance they place on different types of assessment and how assessment information is used. Teachers' responses to these questions are described below.

Types of assessment. The first question asked teachers about the importance they place on different types of assessment methods and asked them to respond on a four-point scale in connection with each of the following assessment methods:

- Standardized tests, produced outside the school;
- Teacher-made short-answer or essay tests requiring students to explain their reasoning;
- Teacher-made multiple-choice, true-false, or matching tests;
- How well students do on homework assignments;
- How well students do on projects or practical/laboratory exercises;
- Observations of students; and
- Responses of students in class.

The seven forms of assessment listed fall into three general types of assessment: formal assessment (item 1); teacher-made tests (items 2 and 3); and alternative assessments (items 4 through 7). Formal assessments are measures used mainly to determine norms for national, state, and local comparisons. These formal measures become important at the classroom level where content standards and national and state performance comparisons are made.

Teacher-made assessments have been used traditionally to assess student progress in the curriculum; however, such tests have not received the attention in research given to other more formal forms of testing (Hange and Rolfe, 1994). Hewson et al. (1993) studied ways that science teachers use individual student testing and other measures to investigate student learning in classrooms and suggested three significant advantages of teacher-made tests over other forms of assessment:

- Specificity—questions can be developed that are directed at a specific item of information, thereby requiring less interpretation by the teacher;
- Completeness—there is a complete record for each item for each student in the class; and
- Uniformity—the same question is asked of each student.

These criteria are considered important for any evaluation procedures that are used for purposes of grading, since they can be used to ensure the fairness of the grading procedures and policies (Hewson et al., 1993).

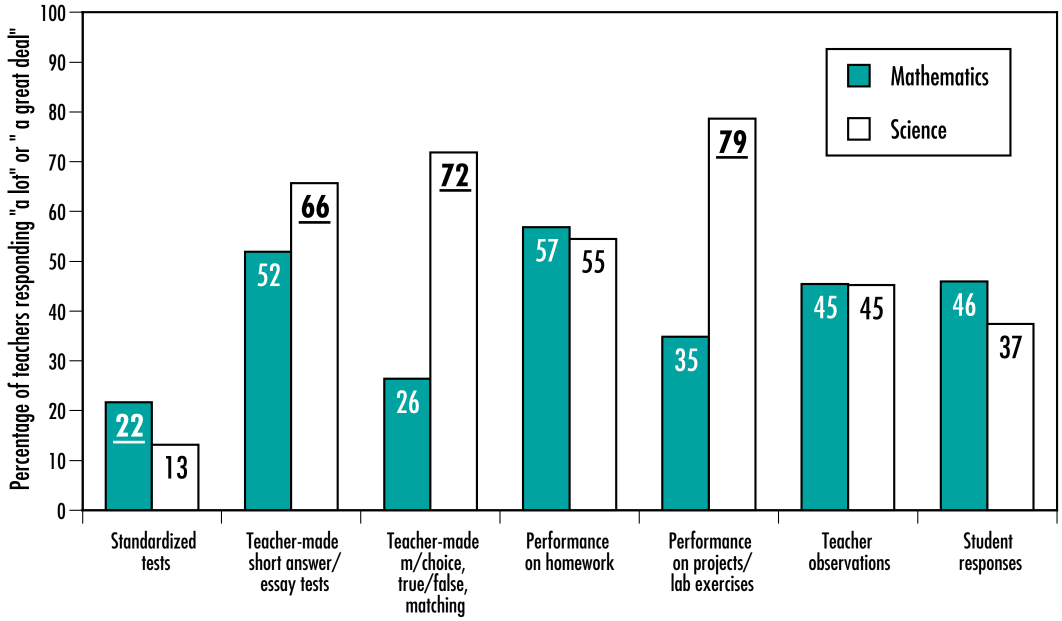
Alternative assessments include those termed "performance-based assessment" or "authentic assessment." Performance-based assessment and authentic assessment describe the use of student projects, homework, classroom observations, and class participation, as well as other activities that occur in the natural learning environment to assess student progress toward achievement of curricular goals. Performance-based assessment measures fall into five major categories: portfolios, which are a compilation of the students' work or products that are student driven; on-demand tasks, which are quick responses to problems; projects, which are either done individually or in collaboration with others; exhibitions, which are presentations of various kinds of work; and teacher-structured observations, which can be informal or formal and are usually used for diagnostic purposes (Kane and Khattri, 1995). Alternative assessment measures that are "authentic" require assessment practices to match instructional practices (Powell, 1993). The authentic assessment construct implies that student assessment is conducted under the same conditions in which learning is normally done. The TIMSS teacher questionnaires include four items that can be thought of as tapping the use of "alternative assessment" measures: homework assignments; projects or practical/laboratory exercises; observations of students; and responses of students in class.

Appendix table 4-34 (on page A-34) displays the distribution of teachers' responses. Figure 4-32 (on page 148) pictures the aggregate of the "quite a lot" and "a great deal" responses of teachers. Two aspects of the data are particularly notable. First, the majority of teachers in both subjects gave low priority to standardized tests—22 percent of mathematics teachers and 13 percent of science teachers indicate that they give standardized tests either "quite a lot" or "a great deal" of weight in assessing the work of students. Second, in comparison to mathematics teachers, science teachers appear to attach a greater value to tests of all kinds and to performance on projects and laboratory exercises. In general, teacher-made assessments and authentic assessments may be the preferred mode. Other evidence suggests that teachers use authentic measures to determine student knowledge and skills in ways that emphasize integration, analysis, and application of knowledge (Hange and Rolfe, 1994).

Uses of assessment. TIMSS teachers were asked to rate how often they use assessment information for six purposes: student grades; feedback to students; diagnosis of student learning problems; reporting to parents; assigning students to different programs or tracks; and planning for future lessons. The responses of the teachers are displayed in appendix table 4-35 (on page A-35), and the proportions reporting that they use assessment a "great deal" for the purposes listed are pictured in figure 4-33 (on page 149).

Figure 4-32

Weight given to different types of assessments; eighth-grade mathematics and science teachers



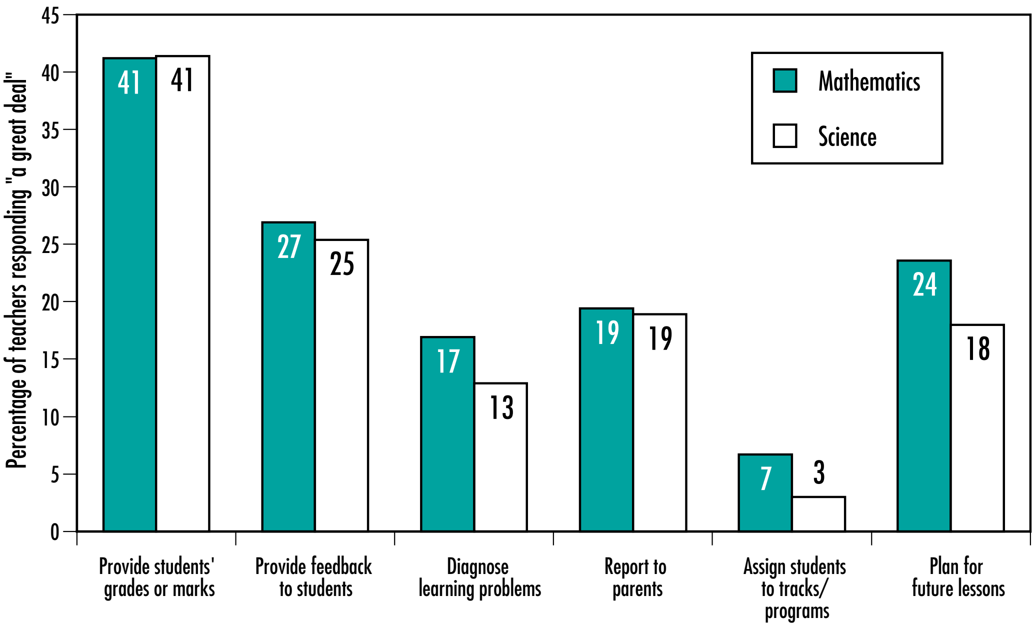
NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Although teachers of mathematics and science report somewhat different patterns in the importance they attach to different forms of assessment information, they use the information for similar purposes with great frequency. The most consistent use is to grade students; about 40 percent of mathematics and science teachers indicate that they use test information in this way "a great deal." Some 20 percent of teachers mention using the various forms of assessment "a great deal" to provide feedback to students on their performance, report to parents, and plan future lessons. The only exception to the overall pattern of widespread use of assessment by teachers is in the assignment of students to tracks or programs of study. Twenty-eight percent of mathematics teachers and 46 percent of science teachers report that they do not use assessment information in this way.

Mathematics and Science Instruction in the Middle School

Teacher and student responses to instructional practice questions suggest that traditional approaches are prevalent in mathematics and science classrooms. New topics are often introduced by the teacher explaining rules and definitions or talking from the textbook while students read along; students spend more time working as a whole class or independently than working in pairs or small groups. Students spend a fair

Figure 4-33
Extent of various uses of assessment; eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

amount of time doing problems from worksheets and textbooks, taking notes from the board, practicing computational skills, and taking quizzes or tests. They do more work with textbooks than with technology-based tools, and they participate in teacher-centered discussion more often than in dialogue with other students. Homework is given regularly and consists mainly of working through routine workbook exercises and/or textbook problems.

These typical patterns notwithstanding, teachers in many classrooms sometimes use approaches that are consistent with contrasting instructional reform strategies. They attempt to bridge the gap between school content and everyday experience when introducing new topics, and regularly, but not always frequently, they require students to engage in higher level processes, such as generating explanations, working with varied forms of representation, and tackling nonroutine problems. Most science teachers also have their students engage in hands-on activities in at least some lessons. Assessment practices, however, tend toward those recommended in reform documents; standardized tests are used infrequently and more teachers use teacher-based or "authentic" assessments more often.

On balance, the data provided by eighth-grade mathematics and science teachers in response to the TIMSS questions provides a picture of middle-school mathematics and science instruction that is consistent with the conclusions of recent NAEP and NSSME studies. New standards in mathematics and science education are not pervasively implemented in most eighth-grade classrooms (Dossey et al., 1994; Lindquist et al., 1995; National Science Foundation, 1996; Weiss et al., 1994), but there is evidence that they are present along with the traditional forms of direct instruction with both student-centered and teacher-centered practices.

VI. The Last Lesson

The discussion to date has been based largely on teachers' reports on what they do during the mathematics and/or science lessons they give to eighth graders. Presumably teachers respond by describing what they tend to do in most lessons and so one gets a general notion of how middle school teachers teach mathematics and science. TIMSS allows a complementary perspective on teaching, called here "The Last Lesson." As well as being asked about their instructional practices in general, eighth-grade mathematics and science teachers were asked to describe the content and structure of their most recent lesson—the topics covered, the order in which each activity occurred, and the allocation of time among various instructional activities. In this way, information was obtained on some of the mathematics and science lessons eighth graders were exposed to over April-May 1995. The intent of the following discussion is to describe the specifics of these lessons with the view to illustrating how the general practices reported by teachers are implemented in an actual classroom setting.

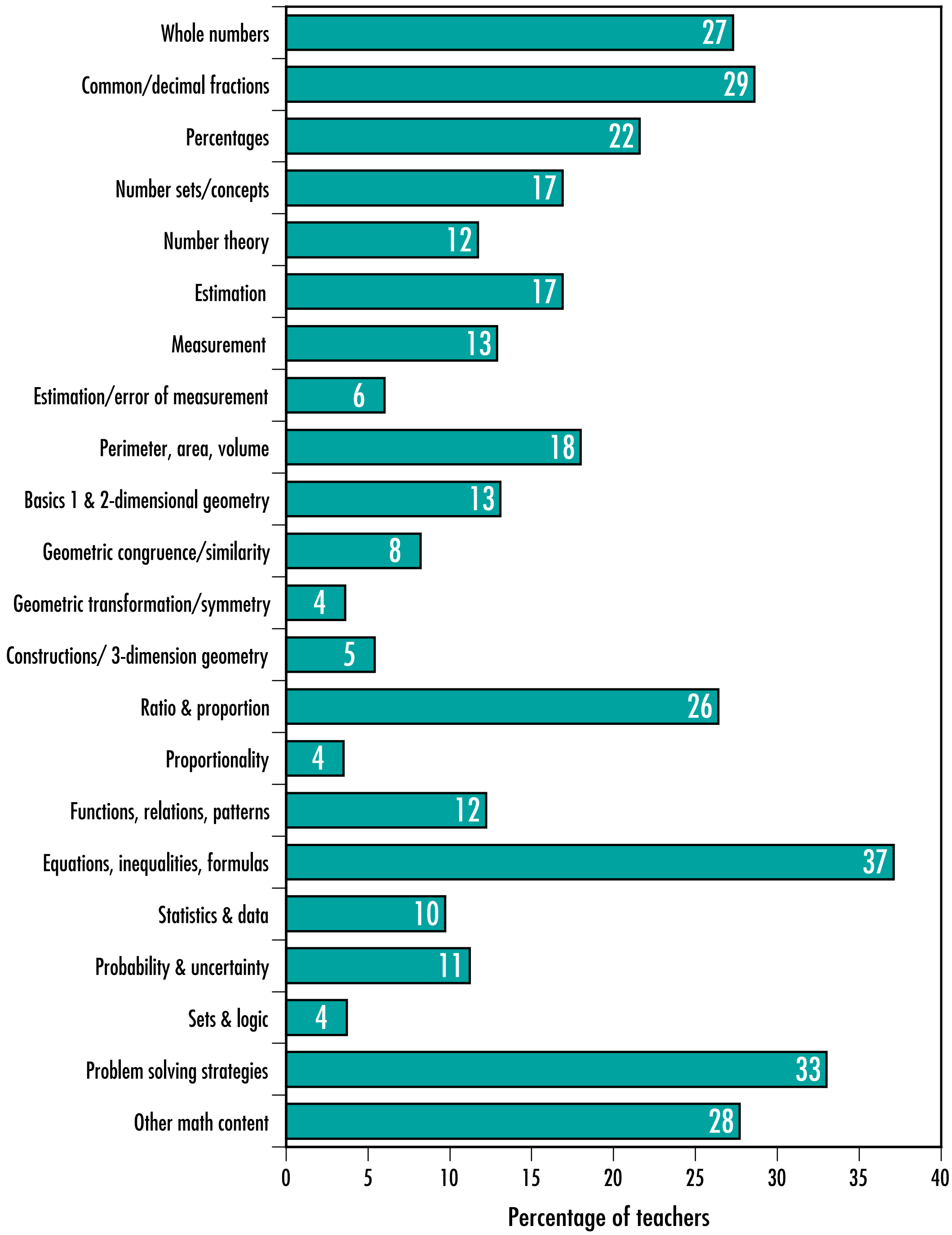
Lesson Content: Topics Covered in the Last Lesson

Teachers were asked to identify the subject of the last lesson by checking a list of topics taken from the TIMSS curriculum frameworks for mathematics and science (see Robitaille et al., 1994). Although both of these statements differ in particulars from those represented in national educational standards, the TIMSS framework and the standards for mathematics and science education share a great deal in terms of the topics they include and the emphases they reflect. Summaries of teachers' reports of last lesson coverage follow.

Mathematics Topics. Last lesson coverage in mathematics is summarized in appendix table 4-36 (on page A-36) and in figure 4-34 (on page 152). Topics in number dominate the nation's classrooms at this time of year; 46 percent of lessons in question addressed topics in this area, a percentage significantly higher than that reported for the other topic areas with the exception of functions and equations. Some 40 percent of mathematics teachers covered functions and equations, 28 percent focused on ratio and proportion, 22 percent were concerned with measurement issues, and 17 percent covered each of geometry and statistics/probability. Problem solving, an overarching theme of the NCTM Standards, was covered in 33 percent of lessons. Other topics that represent new emphases in the Standards such as number theory, functions, relations, and patterns, statistics and probability were reported in approximately 10 percent of these lessons.

There was some differentiation of more and less advanced topics within content areas. For example, number topics, which first appear in the NCTM Standards for grades K-5 (fractions, whole numbers, percentages, ratio and proportion) were reported by 22 to 29 percent of the teachers. More advanced concepts such as number theory, number sets, and estimation were the focus of between 12 and 17 percent of lessons. A similar pattern was seen in other areas of the TIMSS mathematics framework. In geometry, 13 percent of the lessons dealt with the "basics" but 4 percent dealt with concepts of

Figure 4-34
Topic coverage in the last lesson; eighth-grade mathematics teachers



SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

transformation and symmetry. In measurement, 18 percent of these lessons dealt with perimeter, area, and volume, with 6 percent covering measurement error.

Also interesting are differences in the characteristics of classes studying more and less advanced levels of mathematics (see appendix table 4-37 (on page A-37)). As reported earlier, roughly 80 percent of U.S. TIMSS schools provide differentiated coursework in mathematics. Using textbooks as a way of identifying different levels, mathematics classes were divided into 61 Algebra I classes,[19] 46 pre-algebra classes, and 142 regular eighth-grade mathematics classes. Figure 4-35 (on page 154) shows how the lesson topics varied over the three types of classes. The main differences are between algebra and regular classes with the former being exposed to more advanced topics than the latter; algebra classes get less measurement, less geometry, and less statistics/probability than regular classes, but more functions and equations and more other mathematics content. There are no significant differences between these tracks in the extent to which number topics are nominated. Earlier international comparisons showed that number concepts dominate the eighth-grade mathematics curriculum in the United States, while algebra and geometry are the norm in other nations (McKnight et al., 1987).

Science topics. The TIMSS science curriculum framework consists of 22 topics, categorized into seven core content areas, as shown in appendix table 4-38 (on page A-38) and in figure 4-36 (on page 155). Both presentations show the percentage of teachers reporting that each topic was the subject of the last lesson.[20] Clearly, earth science and physical science topics dominate; 50 percent of the topics mentioned were aspects of earth science and 60 percent related to physical science. In both instances these percentages are significantly higher than those of the other topics mentioned.

At the more detailed level of specific topics these data seem to indicate fairly clearly that at this time of the year—and, perhaps at any time of the year—virtually everything in the science curriculum is being taught in the nation's classrooms. No topic was reported by more than 35 percent of the teachers and no single topic dominated the list. Topics reported by no more than 10 percent of teachers included life cycles, genetics, diversity, kinetic/quantum theory and relativity theory.

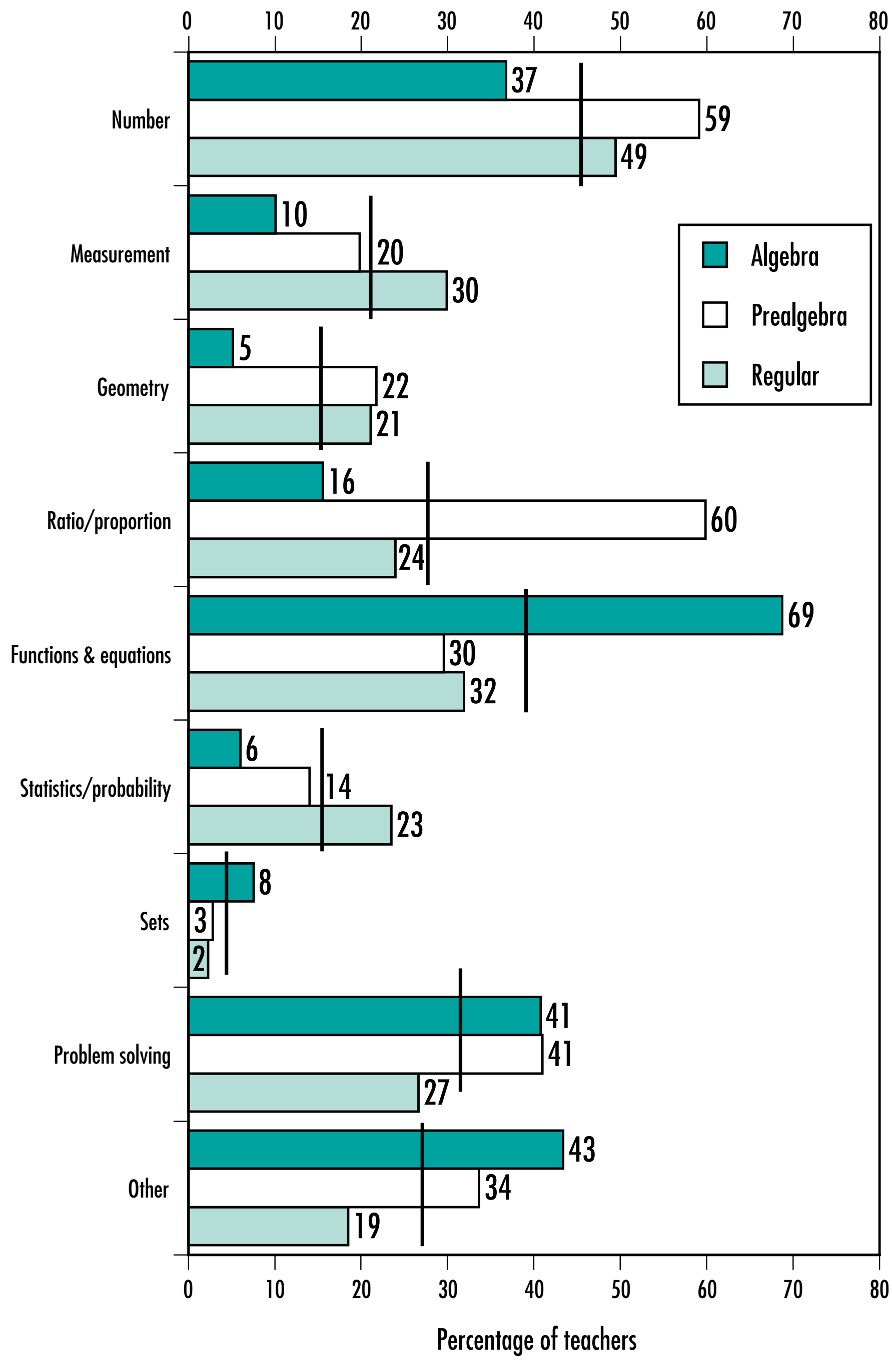
The picture of topic variation in the last lesson complements teachers' reports of how they divide their teaching time (see appendix table 4-7(on page A-7)). Data presented there suggested that science teachers spread their time mainly between physical, general, and earth science classes, with less time on life sciences and specialty areas. The extent of topic variation is consistent, as well, with key findings from the Second International Study of Science (SISS). SISS concluded that while eighth-grade curricula in other nations focus on one particular area of science, the U.S. curriculum is much broader and more diffuse in scope (Rosier and Keeves, 1991). Schmidt et al. (1997a; 1997b) report similar findings from analyses of curriculum documents and textbooks undertaken as a part of TIMSS.

19 Professor John Dossey, Illinois State University, kindly made these data available to us.

20 Note that the numbers in table 4-37 sum to more than 100 percent, an indication that even within individual classrooms the last lesson sometimes covered several topics.

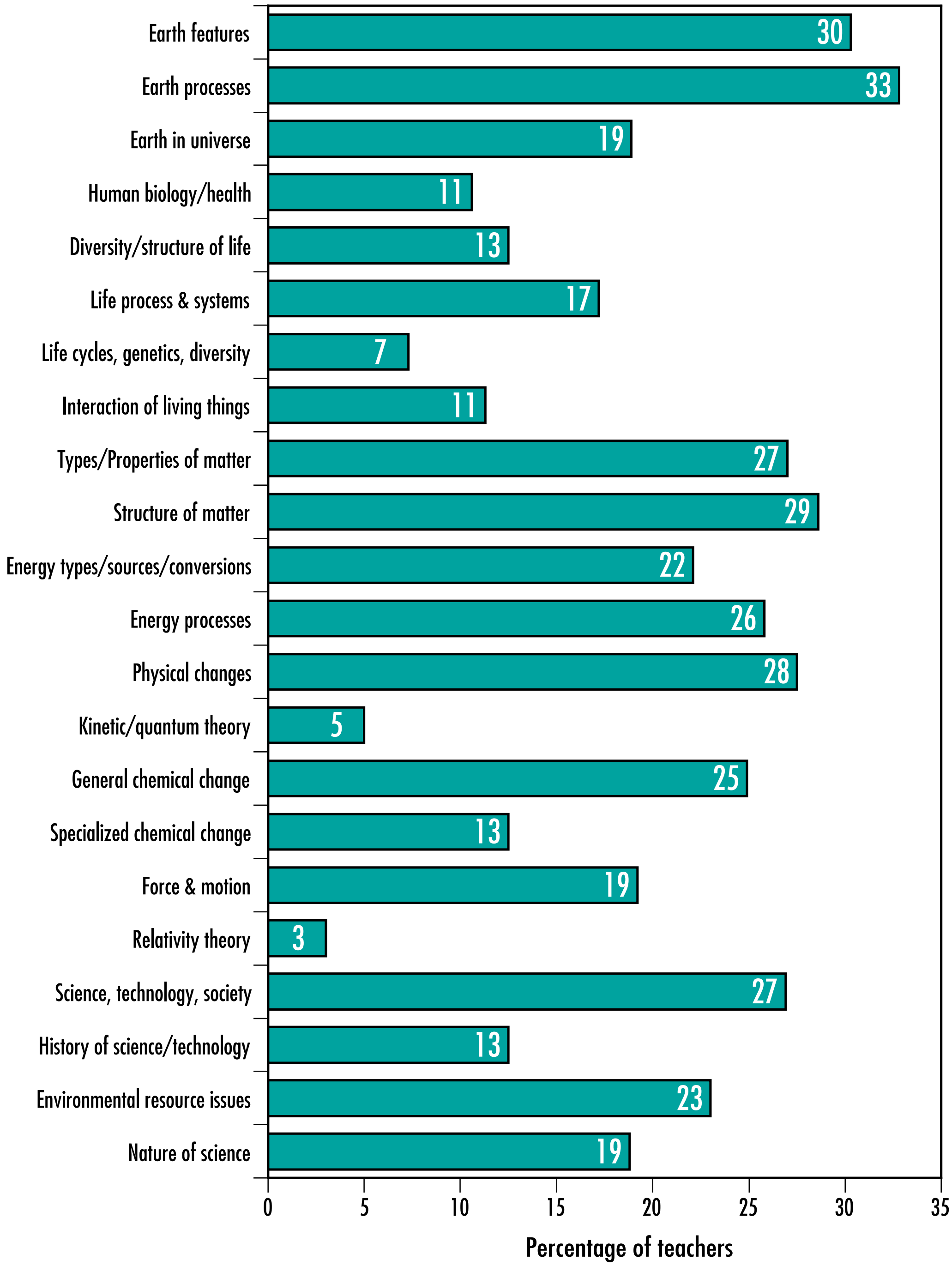
Figure 4-35

Topic coverage in last mathematics lesson, by class type; eighth-grade mathematics teachers



NOTE:
The line spanning the width of all three class types indicates the combined average. See appendix table 4-38 (on page A-38) for corresponding standard errors.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

Figure 4-36
Topic focus of last science lesson; eighth-grade science teachers



SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

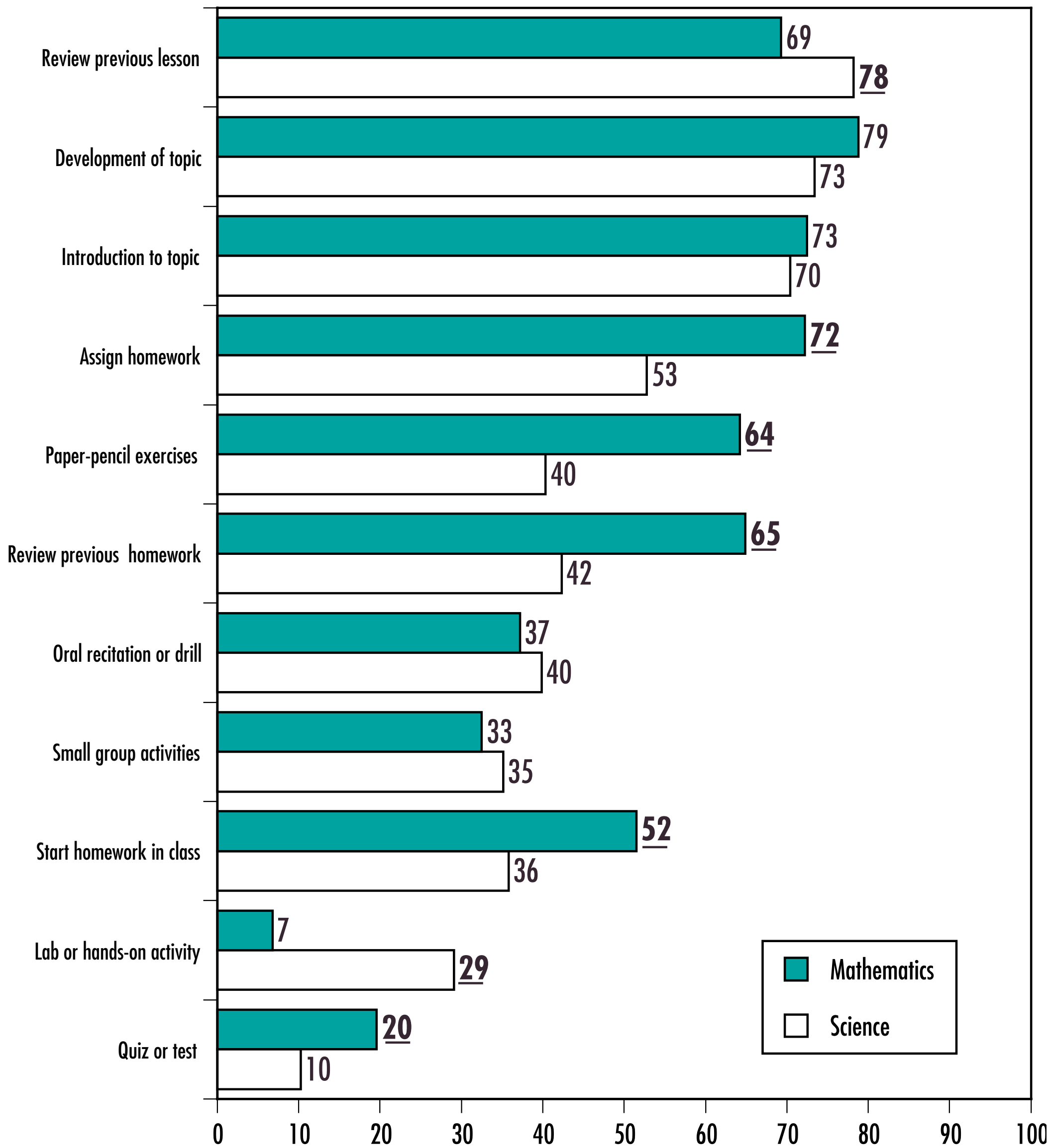
Instructional Activities During the Last Lesson

Teachers also answered questions about the instructional activities used in their most recent lesson. Like the questions designed to portray typical patterns of instructional practice, some of these questions dealt with activities promoted by the standards, such as small groups and hands-on or laboratory work, while others dealt with more conventional activities, such as homework, tests and quizzes. Teachers were asked to describe how their most recent lesson proceeded by indicating the order in which each activity occurred and the number of minutes spent on each. Teachers were informed that the list was not exhaustive and were asked to ignore events that did not fit or were not reasonable variations on the listed activities. The full list of activities covered in the survey and summaries of teachers' accounts are presented in appendix tables 4-39 and 4-40 (on pages A-39 and A-40).

Frequency of activities in the last lesson. Data showing the percentage of classrooms in which each type of activity took place in the last lesson are presented in appendix table 4-39, panel a (on page A-39), and in figure 4-37. No single activity occurred in every classroom though introduction, development, and review were mentioned by about 70 percent or more of both mathematics and science teachers. Activities related to homework also were quite common; homework was assigned in 72 percent of mathematics lessons and 53 percent of science lessons, reviewed in 65 percent of the mathematics lessons and 42 percent of the science lessons, and begun in class in 52 percent of the mathematics and 36 percent of science classes. Twenty percent of the mathematics teachers gave their classes a quiz compared to 10 percent for science teachers. Overall, significantly more mathematics teachers than science teachers reported that they: gave a quiz or test; allowed students to start their homework in class; began lessons by reviewing homework; assigned homework; and, assigned pencil and paper exercises to students.

Order of activities in the last lesson. Appendix table 4-39, panel b (on page A-39), shows each activity according to the mean order of appearance in the lesson. Limiting observations to the activities that were reported in at least one-half of the cases, instruction in both subjects seemed to proceed in a sequence much like that prescribed by direct instruction models (see Good and Grouws, 1979). Reviews tended to occur first in the lesson, with the teacher or class going over material and/or homework from the previous lesson. Topic introduction typically came next, followed by topic development. Independent practice, in the form of classroom exercises, generally occurred toward the end of the class period, and activities related to the new homework assignment occurred last. This sequence is similar to the cycle of activity repeated in many traditional classrooms day after day (Romberg and Carpenter, 1986). Each lesson starts with a review of the previous day's work, followed by work on new material, and ends with students starting a new homework assignment.

Figure 4-37
Occurrence of activities during the last lesson; eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

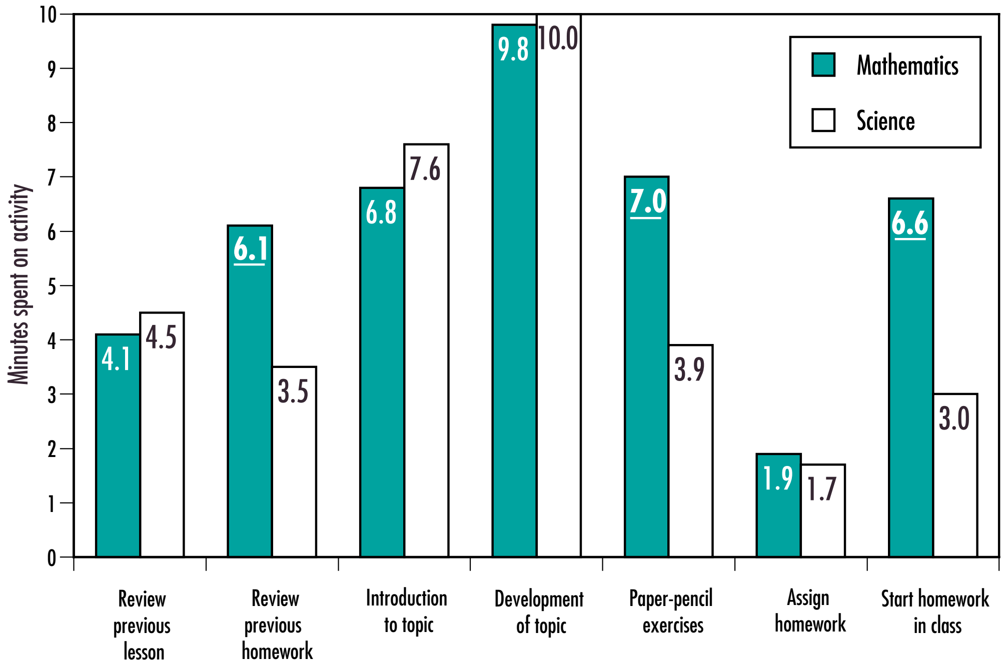
Allocation of time in the last lesson. Appendix table 4-40 (on page A-40) shows the average amount of time spent on each of these activities. Means in the first column (labeled "zero included") are based on all eighth grade TIMSS classrooms and so provide the best estimate of the average amount of time devoted to each activity across all classes. Means in the second column (labeled "zero excluded") were calculated using only classes in which the particular activity was reported. These numbers provide the best estimate of how much time is allocated to each activity when that activity is actually part of a lesson.

When all classrooms are used as the base and comparisons are limited to those activities reported in one-half or more of the lessons, several interesting similarities and differences are apparent in the allocation of time in mathematics and science lessons (figure 4-38). Across the nation eighth-grade mathematics teachers spent an average of 6 minutes reviewing homework assignments, 4 minutes reviewing the previous lesson, 7 minutes introducing the topic of the current lesson, 10 minutes developing this topic, 7 minutes in paper-and-pencil exercises, and 4 minutes in small group activities. Two minutes were given over to assigning homework and students spent an average of 7 minutes beginning this homework in class. For the most part science classes look the same. Where they differ is in spending less time reviewing homework, doing paper-and-pencil exercises and starting new homework in class, all instances in which teachers of mathematics allowed more time than did teachers of science.

The picture is somewhat different, however, if one focuses on only classes in which the particular activity was reported (the "zero excluded" column of appendix table 4-40 (on page A-40)). When these activities are actually part of the lesson, the data indicate that time allocations do not differ much between mathematics and science lessons. When they actually engage in one of these activities, mathematics and science teachers allocate about the same amount of time to it. Reviews of previous work took an average of 6 to 9 minutes; topic introduction typically lasted 9 to 12 minutes; topics were developed for an average of 12 to 14 minutes; paper-and-pencil exercises lasted about 11 minutes; and 9 to 13 minutes were allocated to allow students to get started on their homework. Tests of statistical significance indicate that science teachers spend more time on topic development, small group activities and laboratory activities than do mathematics teachers, but allow less time for students to do their homework in class.

The instructional activities described by teachers suggest that direct instruction models of teaching dominate the practice of pedagogy. Four types of activities arranged in a cyclical pattern characterize these lessons. The lessons begin by linking with what has gone before—previous lessons and previously assigned homework are reviewed as the basis for new content to come. In the second phase, the content of the current lesson is introduced and developed. Students then engage in independent work with the view to practicing the newly presented ideas and skills and, hence, reinforcing what was presented. In the fourth stage, further reinforcement

Figure 4-38
Time allocated to selected instructional activities in the last lesson (zero included); eighth-grade mathematics and science teachers



NOTE:
Where pairwise comparisons indicate significant differences, the higher number of the pair is shown in bold and is underlined.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Unpublished Tabulations, Population 2 Teacher's Questionnaire, 1995.

activities are assigned as homework to be completed by the next lesson where it will serve as the point of departure for a new cycle. As student and teacher reports presented earlier suggested would be the case, the kinds of learner-centered tasks promoted by standards were reported less often than more routine activities. Group activities were reported in just over one-third of the lessons.

Learning Mathematics and Science

In the course of TIMSS, more than 500 eighth-grade mathematics and science teachers answered some 500 questions about their teaching and themselves. These data allowed a simple description of the mathematics and science instruction and instructors of eighth graders in United States schools. A limited characterization of the teachers themselves was possible and showed eighth-grade mathematics and science teaching to be in the hands of largely qualified and experienced professional teachers, most of whom are white females in their early 40s. Teachers from ethnic minorities are under-represented.

For the most part, eighth-grade mathematics and science teachers are employed full-time, and about one-third of their time is spent in face-to-face teaching. The remainder seems to be spent in roughly equal parts in and out of school in teaching-related activities—student supervision, individual curriculum planning, grading student work and tests, and the like. These teachers see the way they teach limited by the range of student abilities they have to deal with, by uninterested and disruptive students, and by a shortage of facilities. As professionals, their autonomy appears to be limited, and collegiality is centered around curriculum planning. Teaching itself remains an act conducted in the privacy of one's own classroom.

TIMSS did not take a special interest in instructional resources but did allow some comment on the use of technology in these classrooms, to the extent that technology takes the form of calculators and computers. Basically, technology in classrooms is four-function calculators, a situation that puts practice in schools a long way behind the available technology. The provision of remedial and enrichment activities, and instructional time, were considered aspects of the total array of instructional resources available to teachers. Schools provided high levels of remedial instruction for mathematics in a variety of forms, but relatively low levels for science. There was, however, less of a difference in the provision of enrichment activities but, again, more was provided in mathematics.

Instructional practices in eighth-grade mathematics and science classrooms are similar: new topics are introduced by the teacher explaining rules and definitions, or talking from the textbook while students read along; students spend their time working as a whole class, or independently, rather than working in pairs or small groups; worksheets and textbooks, taking notes from the board, and practicing computational skills are also frequently used by teachers. These typical patterns not withstanding, teachers in some classrooms use approaches that are consistent with recommended instructional reforms: they attempt to bridge the gap between school content and everyday experience when introducing new topics; they often require students to engage in higher level processes such as generating explanations, working with varied forms of representation, and tackling nonroutine problems; and most (science) teachers also have their students engage in hands-on activities in at least some lessons. Mathematics and science teachers are also similar when it comes to assessment; various forms of teacher-made and authentic assessments are used more than standardized tests.

No description of instruction would be complete without a discussion of homework, a foundation of American education. The majority of lessons begin with a review of the homework assigned in the last lesson, and most conclude with the assignment of homework for the next lesson. It remains an important aspect of instruction in eighth-grade mathematics and science classrooms, especially mathematics classes. Overall, assignments are dominated by routine—workbooks and textbook problems—though science teachers are more likely to vary their assignments to include learner-centered tasks thought to promote deep understanding of subject matter.

5. Summary

Achievement and Instruction in Eighth-Grade Mathematics and Science

Like most International Association for the Evaluation of Educational Achievement (IEA) studies developed over the past 30 years, the Third International Mathematics and Science Study (TIMSS) is first and foremost about achievement and secondarily about instruction and curriculum. Measures of the achievement of students and of the instructional practices of their teachers made up the bulk of the surveys and are the substance of the analyses reported earlier. The primary intent of these analyses was to portray the place of the United States among the 41 TIMSS nations in terms of United States eighth graders' performance in mathematics and science. Secondarily, the report described the instructional practices of the teachers of these eighth graders with the view to offering a context for the reasons why United States students show the levels of performance that they do.

In determining the U.S. international standing among the TIMSS nations, the analyses identified countries whose average levels of achievement were significantly higher than, significantly lower than, and not significantly different from the United States. The findings are as follows. From the perspective of relative standing in mathematics, the United States is not among the top 50 percent of nations. U.S. eighth graders, on average, turn in scores that place them lower than 20 of the 41 nations and lower than the overall international average. U.S. students do better than their peers in 7 countries, and their performance is indistinguishable from that of students in 13 other nations. This performance places the United States at a distance from the goal of being first in the world by the year 2000.

However, U.S. eighth graders do better at science. They outperform their peers in 15 nations, are the equal of students in a further 16 countries, and are outpaced by 9 countries—Singapore, the Czech Republic, Japan, Korea, Bulgaria, the Netherlands, Slovenia, Austria, and Hungary. While not exactly first in the world in science either, U.S. eighth graders are ahead of the international average and do better than more than one-third of the participating nations.

Five percent of U.S. eighth graders make it into the top 10 percent of all students internationally. They are similarly underrepresented in the top 25 percent and the top 50 percent of TIMSS' students, with 18 percent and 45 percent respectively making these cutoffs. By the criterion applied here one-half of the U.S. top 10 percent get into the world top 10 percent. By contrast, U.S. eighth graders are overrepresented among the world's best in science. Thirteen percent make it into the top 10 percent internationally, 30 percent qualify for the top 25 percent of students from all countries, and 55 percent are members of the top 50 percent internationally. U.S. eighth graders are certainly overrepresented among the best science students in the world.

With regard to the content-specific areas of mathematics and science, U.S. eighth graders' performance is variable. In comparison to the international average, U.S. eighth graders are below average on geometry, measurement and proportionality; about average on fractions and number sense; and above average on data representation, analysis and probability. In the case of science a handful of countries do better than the U.S. in the areas of earth, life and environmental sciences. In chemistry and physics, the United States is about average.

There is no precise answer to the question of whether U.S. performance on TIMSS represents an improvement. In previous international studies the United States has not performed above the international average in mathematics. This fact, along with the evidence from TIMSS, suggests that U.S. middle school students probably have not improved much over the past three decades relative to the international average. In the case of science, the relative performance of U.S. students has never been above the average of all (participating) nations in other international studies; in all except TIMSS, the United States has been lower. However, the evidence of TIMSS suggests that U.S. eighth graders may be doing a little better in science than they have in the past.

The performance of different sectors of the eighth-grade population varies considerably. Where the mathematics performance of white eighth graders exceeds the international average and is lower than 12 of the 41 TIMSS nations, the performance of black and Hispanic eighth graders places them below the international average and lower more than 35 of the 41 TIMSS nations. In addition, students whose parents have low levels of education, those who are less well-off economically, students from immigrant families, those from non-English-speaking backgrounds, and students from "nontraditional" families also turn in lower levels of performance. The performance of these population groups spans the range of country performance; some groups do as well as the best among the 41 TIMSS nations, and others are the equal of nations with the lowest levels of mathematics and science knowledge. At the other end of the spectrum, population groups considered to be advantaged – students who are white, have college-educated parents, come from well-off families, live with both biological parents , and so on – do better. However, the overall pattern is that, for mathematics, they turn in a mean score not significantly different from the international average, but in the case of science, consistently exceed the international average.

Where does the problem lie? TIMSS probably will not be able to offer definitive answers but, at the very least, it should be able to provide a context for understanding the results. Some of this information has already entered the public arena. Instructional practices have been implicated in the past and have generated widespread efforts at reform. TIMSS offers evidence in this respect based on information from the 500 or so eighth grade mathematics and science teachers who answered some 500 questions about their teaching and themselves. An overview of the findings follows.

For the most part eighth-grade mathematics and science teachers are white females in their early 40s. Most of these teachers are employed full-time, and they spend about one-third of their time in face-to-face teaching. The remainder is spent in roughly equal parts in teaching-related activities in and out of school—student supervision, individual curriculum planning, grading student work and tests, and the like. However, their autonomy is limited, and such collegiality as exists is centered around curriculum planning.

On the whole, instructional practices differ little between eighth-grade mathematics and science classrooms. The majority of lessons begin with a review of the homework assigned in the last lesson, and most conclude with the assignment of homework for the next lesson. Teacher tend to emphasize rules and definitions as a way of introducing new topics. Students more frequently spend their time working as a whole class or independently, rather than working in pairs or small groups. Worksheets and textbooks, taking notes from the board, and practicing computational skills are also used often by teachers. Overall, then, the instructional activities described by teachers suggest that direct instruction models of teaching dominate the teaching of mathematics and science in the eighth grade. The lessons begin by linking with what has gone before—previous lessons and previously assigned homework are reviewed as the basis for new content to come. In the second phase, the content of the current lesson is introduced and developed. In the third stage, students engage in independent work with the view to practicing the newly presented ideas and skills and, hence, reinforcing what was presented. In the fourth stage, further reinforcement activities are assigned as homework to be completed by the next lesson where it will serve as the point of departure for a new cycle.

Ideally one would like to link teachers' instructional practices to the achievement of students and, in this way, identify effective teachers and effective teaching practice. This is, in fact, what TIMSS set out to do. It is the principal reason for the emphasis on teaching behaviors in the teacher questionnaires and for the explicit linking of teachers to students that was part of the study design. The intent was to statistically link teachers' instructional practices to the average achievement levels of classrooms and in this way, highlight effective instructional practices in each of the participating countries.

Such a linking is possible within the TIMSS data but it is not a particularly fruitful exercise since the statistical relationships demonstrated suggest that instructional practices are only weakly related to classroom achievement in the aggregate. In the past this fact has sometimes been interpreted to mean that teachers' instructional efforts have little effect on what students' learn. This is an unfortunate conclusion to reach since the weak relationships are a function of the survey design. Students enter eighth grade with knowledge, beliefs, and orientations accumulated over 7 years of schooling and some 13 to 14 years of family life. What teachers do within the space of a school year is unlikely to radically alter the achievement level of the class as a whole and so create a sizable correlation between teacher instructional practices and student achievement at the classroom level. The best hope to demonstrate the relationship between teachers' instructional practices and student achievement is to look at the relationship to growth in achievement over the year, rather than absolute levels of achievement. Recognizing this, the original design of TIMSS was one that required a pre- and posttest to measure this growth. Unfortunately, most of the participating nations were unable to support both a pre- and a posttest, so the study reverted to a simple cross-sectional, single-testing design. As a result, the present analyses can offer no more than circumstantial evidence on what matters for the learning of mathematics and science.

Nevertheless, the study of instructional practices and the variation in these between countries is a study in its own right. It was identified as such in some of the design papers which contributed to the development of TIMSS; see for example, Griffith et al. (1991) and Robitaille and Nicol (1993). The study of instructional practices offers, for example: an indication of where in the world U.S. proposals for instructional reform are already in effect; a notion of the extent of the variation in teaching practices within the U.S. and the other participating countries; the possibility of identifying patterns of practice and the way in which these vary across countries; and so on. This is the daily bread of a large number of those engaged in the study of teaching and the instruction of teachers.

Like all studies TIMSS has strengths and limitations. The fact that it was possible to gain the consensus of some 41 nations about what should be assessed in mathematics and science, and what should be asked of students, teachers and schools, should not go unremarked. When taken together with the efforts made to ensure international comparability of results through international standardization of measures, quality control procedures, strict adherence to reporting standards, and the timely release of the data into the public arena, TIMSS takes on the status of a unique international comparative study. As is often said, there is much to be learned from TIMSS, and much of this is yet to come. As the research community comes to grips with the potential within the TIMSS data one would expect to see more and more information emerge to the benefit of those who teach mathematics and science, and to those who think more abstractly about how it should be taught.

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Appendix A: Tables

Appendix table 4-1.
Demographic characteristics; eighth-grade mathematics and science teachers, 1995

	Math Teachers		Science Teachers	
4-1a. Race/ethnicity	%	s.e.	%	s.e.
White	88.5	2.7	90.2	2.3
Black	7.6	2.1	6.8	2.1
Hispanic	1.7	1.1	1.5	0.9
Asian	1.2	1.1	1.1	0.2
Other	1.1	0.6	0.5	0.5
N	239		219	
% missing	2.8		5.6	

NOTE:
Response category 'American Indian' collapsed into 'other' .

	Math Teachers		Science Teachers	
4-1b. Gender	%	s.e.	%	s.e.
Female	63.7	3.8	53.1	4.8
Male	36.3	3.8	46.9	4.8
N	243		221	
% missing	1.2		4.7	

	Math Teachers		Science Teachers	
4-1c. Age	%	s.e.	%	s.e.
< 25 years	5.2	1.8	4.5	1.4
25-29 years	11.8	3.3	16.7	2.8
30-39 years	18.8	3.3	25.9	2.2
40-49 years	44.6	4.6	28.6	4.0
50-59 years	16.7	2.9	21.4	4.0
> 59 years	2.9	1.3	3.0	1.4
N	244		226	
% missing	0.8		2.6	
mean	42		41	
s.e.	0.61		0.80	

NOTE:
The mean was calculated using category mid-points.
SOURCE:
U.S. Department of Education, National Center for Education Statistics,
Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-2.
Education, teaching, and grade level experience; eighth-grade mathematics and science teachers, 1995

	Mathematics Teachers		Science Teachers	
4-2a. Education				
Which is the highest level of formal education you have completed?				
	%	s.e.	%	s.e.
BA/BS Teacher training	54.4	4.9	54.0	3.9
MA/PHD Teacher training	43.9	4.8	38.5	4.0
BA/BS No Teacher training	0.9	0.5	2.8	0.7
MA/PHD No Teacher training	0.7	0.5	4.8	1.7
N	243		226	
% missing	1.2		2.6	

4-2b. Years of teaching experience

By the end of this school year, how many years will you have you been teaching altogether?

	Mathematics Teachers		Science Teachers	
	%	s.e.	%	s.e.
1-2 years	12.0	3.1	14.7	2.5
4-5 years	14.7	2.8	18.2	3.8
6-10 years	11.7	2.0	15.6	2.8
11-20 years	26.0	3.3	21.9	3.0
more than 20 years	35.7	3.5	29.6	4.1
N	241		223	
% missing	2.0		3.9	
mean	15.34		13.69	
s.e.	0.82		0.94	

NOTE:
The mean was calculated by using catagory mid-points.

4-2c. Grade Level Experience

At which of these grade levels have you taught in the past 5 years?

	Mathematics Teachers		Science Teachers	
	%	s.e.	%	s.e.
Middle school only	60.5	4.1	75.0	3.8
Middle/ High school	27.8	3.6	18.4	3.6
Middle/ Elementary school	9.8	2.0	5.7	1.4
Elementary/ Middle/ High school	1.9	1.2	0.9	0.6
N	239		223	
% missing	2.8		3.9	

SOURCE:
U.S. Department of Education, National Center for Education Statistics,
Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995

Appendix table 4-3.
Familiarity with curriculum documents; eighth-grade mathematics and science teachers, 1995
Indicate your familiarity with each of the following documents:

	no such document		not familiar		fairly familiar		very familiar				fairly familiar very familiar	
Math Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
NCTM Standards	0.0	0.0	14.4	3.4	47.2	3.9	38.4	3.6	235	4.5	85.6	3.4
SEA Curriculum Guide	2.4	1.4	34.1	4.4	37.2	4.1	26.4	3.3	233	5.3	63.6	4.7
School District Curriculum Guide	5.8	1.9	10.4	2.7	35.4	5.0	48.5	5.3	234	4.9	83.9	3.1
School Curriculum Guide	16.1	2.5	6.9	1.7	25.5	4.3	51.5	4.6	231	6.1	77.0	2.8
NAEP Frameworks	2.6	1.1	73.4	3.3	21.5	3.2	2.5	1.1	233	5.3	24.0	3.2
SEA Assessment	3.0	0.9	55.8	3.6	25.2	2.4	16.0	3.2	233	5.3	41.2	3.5
Science Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
AAAS Benchmarks	0.2	0.2	74.3	2.8	21.2	2.6	4.3	2.0	228	1.7	25.5	2.9
SEA Curriculum Guide	2.9	1.4	32.9	4.8	39.5	5.1	24.7	3.8	225	3.0	64.2	4.9
School District Curriculum Guide	6.1	1.9	15.3	3.5	27.3	4.4	51.2	4.7	226	2.6	78.6	4.3
School Curriculum Guide	12.9	2.6	6.3	1.9	27.0	3.9	53.8	4.4	228	1.7	80.8	3.5
NAEP Frameworks	1.9	1.2	82.4	3.2	10.7	1.7	4.9	2.0	227	2.2	15.7	2.8
SEA Assessment	1.4	0.9	59.3	4.8	28.0	4.2	11.3	1.8	228	1.7	39.4	4.6

NOTE:
Percentages for combined categories used in figures are shaded.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-4.

Level of topic preparation; eighth-grade science teachers, 1995

How well prepared do you feel you are to teach....

	not well prepared		somewhat prepared		sufficiently prepared			
	%	s.e.	%	s.e.	%	s.e.	N	% missing
Earth's Features	5.0	2.2	28.2	4.3	66.8	4.9	225	3.0
Energy	3.2	1.6	34.6	4.2	62.2	4.8	224	3.4
Light	5.4	1.9	42.3	5.0	52.4	5.0	223	3.9
Human Tissues & Organs	8.2	2.5	34.4	4.0	57.4	5.1	223	3.9
Human Metabolism	12.9	2.8	39.2	3.6	47.9	3.9	224	3.4
Human Reproduction	7.6	2.2	30.5	4.4	61.9	4.8	225	3.0
Human Genetics	10.6	2.3	45.0	4.0	44.3	4.4	224	3.4
Measurement	2.8	1.9	12.5	2.8	84.7	4.0	225	3.0
Data Preparation/Interpretation	1.9	1.7	14.9	3.0	83.2	4.1	225	3.0

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-5.

Beliefs about the nature and teaching of mathematics (science); eighth-grade mathematics and science teachers, 1995

To what extent do you agree or disagree with each of the following statements?

Mathematics	**strongly disagree**		**disagree**		**agree**		**strongly agree**				**(agree+ strongly agree)**	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Math is primarily an abstract subject.	11.7	2.6	57.3	4.6	28.9	3.9	2.2	0.9	239	2.8	31.0	3.9
Math is primarily a formal way of representing the real world.	1.0	0.8	19.9	3.7	67.9	3.9	11.2	2.4	236	4.1	79.1	3.7
Math is primarily a practical & structured guide for addressingreal situations.	0.0	0.0	11.2	2.0	69.5	3.4	19.3	2.7	236	4.1	88.8	2.0
If students are having difficulty, an effective approach is to give them more practice by themselves during the class.	20.1	3.6	57.6	4.5	19.5	3.2	2.9	0.9	237	3.7	22.3	3.0
Some students have a natural talent for math and others do not.	3.5	1.4	15.0	2.4	64.2	3.8	17.2	3.4	237	3.7	81.4	2.8
More than one representation should be used in teaching a math topic.	0.0	0.0	1.7	1.0	46.6	3.9	51.7	3.7	238	3.3	98.3	1.0
Math should be learned as sets of algorithms or rules that cover all possibilities.	10.9	2.4	53.9	3.8	32.6	3.4	2.6	0.9	236	4.1	35.2	3.6
Basic computational skills on the part of the teacher are sufficient for teaching elementary school math.	42.3	3.7	40.4	3.6	11.5	3.3	5.8	1.7	236	4.1	17.3	3.8
A liking for & understanding of students are essential for teaching math.	0.8	0.3	2.7	1.0	40.9	4.2	55.7	4.1	235	4.5	96.5	1.1
Science												
Science is primarily an abstract subject	17.9	2.1	63.9	3.2	18.1	3.2	0.1	0.1	222	4.3	18.2	3.2
Science is primarily a formal way of representing the real world.	1.4	0.8	14.3	2.3	69.7	4.3	14.7	3.6	222	4.3	84.3	2.6
Science is primarily a practical & structured guide for addressing real situations.	0.0	0.0	12.0	2.9	66.0	4.6	22.0	3.8	222	4.3	88.0	2.9
Some students have a natural talent for science and others do not.	6.3	1.5	31.8	3.8	51.8	3.7	10.2	2.8	223	3.9	62.0	3.2
It is important for teachers to give students prescriptive & sequential directions for science experiments.	3.3	1.3	20.8	3.1	48.9	5.1	27.1	4.0	220	5.2	75.8	3.6
Focusing on rules is a bad idea. It gives students the impression that the sciences are a set of procedures to be memorized.	15.3	2.9	52.7	4.8	26.1	3.2	5.9	2.9	219	5.6	32.0	3.7
If students get into debates in class about ideas or procedures covering the sciences, it can harm their learning.	56.5	3.7	40.7	3.8	0.7	0.7	2.1	1.8	225	3.0	2.8	1.9
Students see a science task as the same task when it is represented in in two different ways.	4.6	1.5	52.6	3.9	41.9	4.2	0.8	0.4	218	6.0	42.8	4.2
A liking for & understanding of students are essential for teaching science.	1.3	0.8	9.1	2.7	43.2	3.6	46.4	4.0	224	3.4	89.6	2.7

NOTE:
Percentages for combined categories used in figures are shaded.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-6.

Student skills required for success in mathematics (science); eighth-grade mathematics and science teachers, 1995

To be good at mathematics (science) at school, how important do you think it is for students to...

	not important		somewhat important		very important			
Mathematics	%	s.e.	%	s.e.	%	s.e.	N	% missing
Remember formulas and procedures	3.0	1.1	54.0	3.5	43.0	3.5	239	2.8
Think in sequential manner	0.6	0.6	20.0	2.7	79.5	2.8	240	2.4
Understand concepts	0.0	0.0	11.1	3.0	88.9	3.0	240	2.4
Think creatively	2.0	0.9	32.7	3.8	65.4	4.0	239	2.8
Understand math use in real world	0.0	0.0	18.3	2.7	81.7	2.7	240	2.4
Support solutions	2.4	2.4	16.9	3.3	80.8	4.1	239	2.8
Science	%	s.e.	%	s.e.	%	s.e.	N	% missing
Remember formulas and procedures	10.8	2.4	63.7	4.1	25.5	4.0	221	4.7
Think in sequential manner	1.3	0.9	19.1	2.5	79.6	2.9	224	3.4
Understand concepts	0.7	0.7	15.4	2.4	84.0	2.5	225	3.0
Think creatively	0.2	0.2	26.7	3.6	73.0	3.7	224	3.4
Understand science use in real world	0.3	0.3	20.5	3.4	79.2	3.5	225	3.0
Support solutions	0.0	0.0	13.9	3.0	86.1	3.0	225	3.0

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-7.
Hours per week spent teaching and on teaching-related activities; eighth-grade mathematics and science teachers, 1995

	Mathematics teachers				Science teachers			
	mean	s.e.	N	% missing	mean	s.e.	N	% missing
4-7a. Total scheduled hours per week	**25.7**	**0.66**	**225**	**8.5**	**25.2**	**0.56**	**204**	**12.1**
4-7b. Scheduled teaching hours per week	mean	s.e.	N	% missing	mean	s.e.	N	% missing
Mathematics	12.66	0.89	246	0.0	0.48	0.09	232	0.0
General science	0.20	0.06	246	0.0	2.76	0.49	232	0.0
Physical science	0.10	0.06	246	0.0	3.90	0.84	232	0.0
Earth science	0.02	0.02	246	0.0	3.98	0.83	232	0.0
Life science	0.13	0.06	246	0.0	0.99	0.33	232	0.0
Biology	0.00	0.00	246	0.0	0.24	0.14	232	0.0
Chemistry	0.06	0.04	246	0.0	0.11	0.05	232	0.0
Physics	0.01	0.01	246	0.0	0.10	0.04	232	0.0
Other subjects	1.63	0.43	246	0.0	0.79	0.17	232	0.0
Total mathematics hours scheduled	12.66	0.89	246	0.0	0.48	0.09	232	0.0
Total science hours scheduled	0.51	0.06	246	0.0	12.08	0.69	232	0.0
TOTAL hours scheduled	14.79	0.94	246	0.0	13.35	0.63	232	0.0
4-7c. Nonteaching hours scheduled	mean	s.e.	N	% missing	mean	s.e.	N	% missing
Student supervision	4.1	0.38	246	0.0	5.5	0.81	232	0.0
Student counseling	0.3	0.08	246	0.0	0.7	0.22	232	0.0
Administration	0.3	0.07	246	0.0	0.3	0.06	232	0.0
Individual curriculum planning	1.9	0.20	246	0.0	2.3	0.49	232	0.0
Cooperative curriculum planning	1.0	0.18	246	0.0	0.9	0.15	232	0.0
Non-student contact	0.8	0.14	246	0.0	0.8	0.15	232	0.0
TOTAL (these tasks)	8.4	0.55	246	0.0	10.5	1.31	232	0.0
4-7d. Outside of school hours	mean	s.e.	N	% missing	mean	s.e.	N	% missing
Preparing or grading tests	2.7	0.09	244	0.8	2.2	0.10	229	1.3
Reading or grading other work	2.8	0.17	235	4.5	2.4	0.15	226	2.6
Planning lessons by yourself	2.4	0.10	241	2.0	2.2	0.12	229	1.3
Student meetings	2.0	0.18	239	2.8	1.2	0.09	228	1.7
Parent meetings	0.7	0.04	242	1.6	0.6	0.05	224	3.4
Professional activities	0.9	0.07	238	3.3	1.0	0.08	225	3.0
Student records	1.6	0.11	240	2.4	1.5	0.09	229	1.3
Administrative tasks	2.0	0.12	243	1.2	2.0	0.12	229	1.3
TOTAL (these tasks)	14.9	0.50	244	0.8	12.9	0.51	230	0.9
TOTAL (b+c+d)	38.1	1.43	235	4.5	36.7	1.47	232	0.0

NOTE:
Items measured in periods were converted to hours using the principal's report of the avarage length of a period.
The mean for school-related after hours activities was based on category midpoints.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995

Appendix table 4-8.

Grade levels taught; eighth-grade mathematics and science teachers, 1995

At which grade level are you teaching mathematics (science) during this school year?

	Mathematics		**Science**	
	%	s.e.	%	s.e.
eighth-grade only	58.3	4.0	62.3	3.8
8th + 1 additional grade	26.4	4.2	22.4	3.9
8th + 2 additional grades	9.5	2.6	8.5	3.1
8th + 3 additional grades	4.8	2.0	4.2	1.4
8th + 4 additional grades	1.0	0.5	1.3	0.9
N	246		227	
% missing	0		2.16	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-9.

Level of influence on selected topics; eighth-grade mathematics and science teachers, 1995

How much influence do you have on each of the following:

	none		little		some		a lot			
Math Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Subject matter	8.7	2.7	18.2	2.8	34.9	3.6	38.2	4.4	243	1.2
Textbooks	19.5	3.8	19.0	2.6	35.7	3.5	25.8	3.4	243	1.2
Supply money	36.6	4.9	30.9	4.0	28.2	3.5	4.3	1.8	243	1.2
Supply purchases	7.5	2.0	26.2	3.4	43.1	2.8	23.2	3.3	243	1.2
Science Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Subject matter	12.3	2.5	10.7	2.0	34.4	3.7	42.6	4.8	229	1.3
Textbooks	18.0	3.2	18.8	3.2	28.3	4.4	34.9	4.5	229	1.3
Supply money	34.4	3.8	31.6	4.1	23.0	3.2	11.1	3.5	228	1.7
Supply purchases	5.0	1.5	14.9	2.4	38.9	3.7	41.2	3.4	228	1.7

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-10.
Professional activities; eighth-grade mathematics and science teachers, 1995

4-10a. Cooperative curriculum planning

About how often do you have meetings with other teachers in your subject area to discuss and plan curriculum or teaching approaches?

	Mathematics		Science	
	%	s.e.	%	s.e.
never	9.7	3.3	11.5	2.1
once or twice a year	19.4	2.5	23.6	3.7
every other month	10.3	1.8	14.9	3.2
once a month	25.0	4.2	19.2	2.6
once a week	16.1	2.5	15.1	3.6
two or three times a week	11.0	3.2	10.3	3.2
almost every day	8.4	2.4	5.3	1.2
N	245		227	
% missing	0.4		2.2	

4-10b. Observing teaching

Excluding any team teaching partners, how often do you visit another teacher's classroom to observe their teaching?

	Mathematics		Science	
	%	s.e.	%	s.e.
never	64.1	3.3	59.9	3.6
annually	13.8	2.8	13.6	1.7
semi-annually	9.8	1.9	10.0	2.2
bi-monthly	3.7	1.4	3.2	1.3
monthly	7.3	2.0	7.6	2.1
weekly	1.3	0.7	3.7	1.6
more than once a week	0.0	0.0	2.1	1.4
N	238		227	
% missing	3.3		2.2	

4-10c. Demonstrating teaching

Excluding any team teaching partners, how often does another teacher visit your classroom to observe your teaching?

	Mathematics		Science	
	%	s.e.	%	s.e.
never	60.6	2.9	51.8	4.3
annually	13.6	2.3	16.6	2.6
semi-annually	12.4	2.9	14.8	2.5
bi-monthly	4.8	1.3	4.1	1.2
monthly	6.4	2.0	9.9	3.2
weekly	1.0	0.4	2.7	1.6
more than once a week	1.2	1.1	0.0	0.0
N	237		223	
% missing	3.7		3.9	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-11.
Class size; eighth-grade mathematics and science classes, 1995

	Mathematics		Science	
Number of Students	%	s.e.	%	s.e.
<5	0.0	0.0	0.1	0.1
5-9	2.1	1.3	0.1	0.1
10-14	3.4	1.8	1.7	1.5
15-19	14.7	2.8	13.0	3.2
20-24	26.9	3.2	23.6	5.1
25-29	32.1	3.7	40.7	5.6
30-34	16.5	2.6	14.7	3.3
>35	4.3	0.9	6.2	1.8
N	225		232	
% missing	8.5		0.0	
mean	**24.5**		**25.6**	
s.e.	0.43		0.56	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-12.

Reported achievement level of class; eighth-grade mathematics and science teachers, 1995

Compared with other students in the United States at this grade level, estimate what percent of students in your class have... high achievement levels, middle achievement levels, or low achievement levels.

	Mathematics		**Science**	
	%	s.e.	%	s.e.
High achievement level	16.2	2.3	8.7	2.2
Middle achievement level	37.0	3.7	45.6	4.6
Low achievement level	14.9	2.5	11.5	2.5
Mixed achievement level	31.87	4	34.2	3.6
N	228		211	
% missing	7.3		9.1	

NOTE:
Achievement levels assigned on basis of more than 50 percent of students; 'mixed' is the residual category.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-13.

Constraints on teaching; eighth-grade mathematics and science teachers, 1995

In your view to what extent do the following limit how you teach your mathematics (science) class?

	not at all		a little		quite a lot		a great deal				(quite a lot+ a great deal)	
Mathematics	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Different student abilities	4.9	1.6	50.7	3.5	33.0	3.8	11.5	2.8	240	2.4	44.5	3.9
Different student backgrounds	43.4	4.2	42.7	3.9	10.8	2.4	3.2	1.2	242	1.6	14.0	2.8
Special student needs	37.0	3.6	47.7	4.1	11.0	2.4	4.3	0.9	241	2.0	15.3	2.5
Uninterested students	7.8	1.7	41.4	3.3	33.2	3.2	17.5	2.6	242	1.6	50.8	3.2
Disruptive students	15.7	3.1	45.4	3.5	21.3	2.6	17.5	2.8	242	1.6	38.9	3.8
Interested parents	62.3	2.9	25.4	2.9	10.0	2.6	2.4	0.8	239	2.8	12.3	2.7
Uninterested parents	26.6	3.8	41.8	3.8	18.9	2.4	12.6	2.8	242	1.6	31.5	3.8
Shortage of computer hardware	36.1	3.9	36.7	3.0	17.1	3.1	10.1	1.6	241	2.0	27.2	3.5
Shortage of computer software	37.5	4.0	36.6	3.6	18.0	3.1	7.9	1.5	240	2.4	25.9	3.3
Shortage of other student equipment	33.5	3.5	46.5	4.1	16.3	2.6	3.7	1.3	240	2.4	20.0	3.3
Shortage of demonstration equipment	37.4	4.2	42.7	4.0	15.7	2.2	4.2	1.4	241	2.0	19.9	2.4
Inadequate facilities	61.7	4.7	25.3	4.5	9.5	2.0	3.5	0.9	242	1.6	13.0	2.2
High student/ teacher ratio	28.4	3.1	42.4	3.4	15.4	2.3	13.8	2.8	242	1.6	29.2	3.0
Low teacher morale	55.2	4.3	33.1	3.8	6.6	1.8	5.1	1.7	243	1.2	11.7	2.2
Low student morale	27.5	3.9	43.4	3.6	18.9	2.6	10.2	1.3	242	1.6	29.1	3.2
Threat to safety	76.3	2.9	16.9	2.3	3.7	1.4	3.1	1.3	242	1.6	6.8	1.4
Science	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Different student abilities	8.4	1.9	49.5	4.4	31.6	3.4	10.5	3.2	226	2.6	42.1	4.4
Different student backgrounds	27.2	3.5	58.6	3.8	10.9	2.4	3.1	1.2	226	2.6	14.0	3.0
Special student needs	35.4	4.7	44.3	4.4	13.6	2.8	6.7	1.8	224	3.4	20.3	3.4
Uninterested students	9.6	20.2	44.6	4.2	27.2	3.6	18.5	3.5	226	2.6	45.8	4.2
Disruptive students	12.5	3.2	36.8	3.0	26.1	2.4	24.7	3.3	226	2.6	50.7	3.7
Interested parents	62.8	4.8	24.2	4.3	11.5	2.5	1.5	0.8	221	4.7	13.0	2.9
Uninterested parents	31.1	3.7	38.0	3.8	22.1	3.8	8.8	1.8	223	3.9	30.9	3.9
Shortage of computer hardware	31.5	4.6	30.6	3.2	21.4	3.3	16.5	3.0	224	3.4	37.9	4.3
Shortage of computer software	27.4	4.7	33.0	3.5	22.7	3.2	16.9	2.9	224	3.4	39.6	4.2
Shortage of other student equipment	18.5	3.7	37.8	3.9	27.9	3.8	15.8	3.8	226	2.6	43.7	3.9
Shortage of demo equipment	20.2	3.5	34.9	3.2	25.8	3.8	19.1	3.7	226	2.6	44.9	3.8
Inadequate facilities	32.8	3.8	34.7	3.7	16.2	2.9	16.2	2.6	223	3.9	32.5	3.2
High student/ teacher ratio	24.1	3.1	38.0	3.9	23.3	4.0	14.7	3.7	226	2.6	38.0	4.1
Low teacher morale	53.0	3.3	32.0	3.5	10.0	2.2	4.9	2.6	226	2.6	15.0	3.9
Low student morale	27.1	3.4	46.3	4.9	20.3	3.5	6.4	1.9	226	2.6	26.6	3.9
Threat to safety	60.0	4.1	24.8	2.5	10.0	2.8	5.1	2.6	225	3.0	15.2	3.8

NOTE:

Percentages for combined categories used in figures are shaded.

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-14.

Shortages of computer hardware, software, and calculators; population 2 schools, 1995

Is your school's capacity to provide instruction affected by a shortage or inadequacy of any of the following?

	Mathematics Instruction						**Science Instruction**					
	Hardware		**Software**		**Calculators**		**Hardware**		**Software**		**Calculators**	
	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.
none	14.1	2.5	11.2	2.5	41.1	3.7	10.0	2.5	8.4	2.5	23.2	3.5
a little	24.2	3.4	24.4	3.1	33.8	3.2	22.3	3.5	21.7	3.4	32.8	4.3
some	36.9	3.6	39.8	3.3	16.2	3.2	35.2	3.8	39.8	3.8	28.7	3.9
a lot	24.9	2.7	24.9	2.9	8.9	2.1	32.5	3.4	30.1	3.3	15.3	3.2
N	155		155		155		155		155		154	
% missing	16.2		16.2		16.2		16.2		16.2		16.8	

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 School Questionnaire, 1995.

Appendix table 4-15.
Student access to calculators during lessons; eighth-grade mathematics and science teachers, 1995

How many of your students have access to calculators during mathematics (science) lessons?

	Mathematics		**Science**	
	%	s.e.	%	s.e.
none	7.2	1.7	15.2	1.9
about 1/4	5.2	1.5	21.7	3.6
about 1/2	5.0	1.6	10.8	2.2
about 3/4	4.2	1.1	11.9	2.7
almost all	78.4	3.3	40.3	3.8
N	242		225	
% missing	1.6		3.0	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-16.
Student use of calculators in the classroom; eighth-grade mathematics and science teachers, 1995

How often do students in your class use calculators for the following activities?

	hardly ever		once or twice a month		once or twice a week		every day				(every day+ once or twice a week)	
Mathematics	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Checking answers	17.4	3.3	10.8	2.3	16.5	3.2	55.4	4.6	242	1.6	71.8	3.9
Tests and exams	31.0	3.9	22.9	3.7	21.7	3.4	24.3	4.6	244	0.8	46.1	4.1
Routine computation	22.9	3.6	8.9	2.2	16.1	3.0	52.1	5.1	244	0.8	68.2	4.1
Solving complex problems	11.4	2.5	12.2	2.3	23.0	3.8	53.4	4.7	243	1.2	76.4	3.5
Exploring number concepts	23.7	2.9	17.5	3.0	22.7	3.9	36.1	3.6	244	0.8	58.9	4.2
Science	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Checking answers	50.8	3.4	29.7	3.8	17.2	3.3	2.3	1.2	221	4.7	19.5	3.6
Tests and exams	67.7	3.5	22.6	3.0	6.4	2.2	3.3	1.4	221	4.7	9.7	2.6
Routine computation	39.3	4.0	33.0	4.5	19.7	3.2	8.0	1.8	220	5.2	27.7	3.5
Solving complex problems	46.7	3.7	35.1	3.9	14.4	3.3	3.9	1.3	221	4.7	18.2	3.6
Exploring number concepts	68.7	3.8	19.6	3.6	10.4	2.7	1.4	0.4	221	4.7	11.7	2.7

NOTE:
Percentages for combined categories used in figures are shaded.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher's Questionnaire, 1995.

Appendix table 4-17.
Student use of calculators in the classroom; eighth-grade students, 1995
How often does this happen in your mathematics (science) lessons...We use calculators?

	Mathematics		**Science**	
	%	s.e.	%	s.e.
never/almost never	10.1	1.6	51.8	2.2
once in a while	20.2	1.4	30.0	1.5
pretty often	25.5	1.2	11.0	0.8
almost always	44.2	2.6	.2	0.6
N	6,892		6,727	
% missing	2.8		5.1	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Student Questionnaire, 1995.

Appendix table 4-18.
Use of computers during instruction; eighth-grade mathematics and science teachers, eighth-grade students, 1995

4-18a. Solving exercises or problems

In your lessons, how often do you usually ask students to do the following...
Use computers to solve exercises or problems

	Mathematics Teachers		Science Teachers	
	%	s.e	%	s.e.
never	76.2	3.3	72.9	4.9
some lessons	19.8	3.2	26.3	4.9
most lessons	1.3	0.9	0.8	0.6
every lesson	2.6	2.3	0.0	0.0
N	243		227	
% missing	1.2		2.2	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

4-18b. Student reports of computer use in class

How often does this happen in your mathematics (science) classes...We use computers?

	Mathematics Classes		Science Classes	
	%	s.e.	%	s.e.
never	68.9	2.5	65.4	2.2
once in a while	20.6	1.8	19.5	1.5
pretty often	6.4	0.9	9.4	0.8
almost always	4.1	0.6	5.7	0.6
N	6,877		6,694	
% missing	3.0		5.5	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Student Questionnaire, 1995.

4-18c. Student attitude on computer use

How much do you like using computers in...

	Mathematics Classes		Science Classes	
	%	s.e.	%	s.e.
don't use computers	54.7	1.7	53.4	1.7
dislike a lot	2.0	0.2	1.6	0.2
dislike	4.5	0.5	5.2	0.4
like	20.1	1.0	21.8	1.0
like a lot	18.6	1.0	18.0	0.9
N	6,921		6,897	
% missing	2.3		2.7	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Student Questionnaire, 1995

Appendix table 4-19.

Course differentiation in mathematics and science; population 2 schools, 1995

Do all students in Grade 8 follow the same course of study in math/science?

	Mathematics		**Science**	
	%	s.e.	%	s.e.
Yes	20.4	3.3	83.2	3.5
No	79.6	3.3	16.8	3.5
N	153		149	
% missing	17.3		19.5	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 School Questionnaire, 1995.

Appendix table 4-20.
Remedial and enrichment provisions; population 2 schools, 1995

4-20a. Provision of remedial teaching

Does your school provide remedial teaching in mathematics (science)?

	Mathematics		Science	
	%	s.e.	%	s.e.
Yes	78.5	3.8	38.5	3.8
No	21.5	3.8	61.5	3.8
N	149		141	
% missing	19.5		23.8	

4-20b. Organization of remedial teaching

If so, how is this organized?

	Mathematics			Science		
	%	s.e.	N	%	s.e.	N
Within class groups	53.8	3.8	117	59.5	5.7	54
Pull-out instruction	54.1	4.8	117	33.0	6.0	54
Before/after school instruction	69.2	5.2	117	82.1	4.1	54
Other	73.5	4.9	117	53.1	8.8	54

4-20c. Provision of enrichment activities

Does your school provide extra enrichment activities in mathematics (science)?

	Mathematics		Science	
	%	s.e.	%	s.e.
Yes	82.2	3.7	64.7	3.6
No	17.8	3.7	35.3	3.6
N	151		150	
% missing	18.4		18.9	

4-20d.Organization of enrichment activities

If so, how is this organized?

	Mathematics			Science		
	%	s.e.	N	%	s.e.	N
Within class groups	53.9	4.1	124	60.0	4.7	97
Pull-out instruction	53.7	4.7	124	39.7	5.8	97
Before/after school instruction	66.5	5.5	124	66.6	5.3	97
Other	76.4	4.9	124	72.3	5.0	97

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 School Questionnaire, 1995.

Appendix table 4-21.
Instructional time for eighth-grade students; population 2 schools, 1995

4-21a. School instructional time	**mean**	**s.e.**
instructional days per year	179	0.3
instructional hours per week	26	1.0
instructional periods per week	30	1.1
minutes per period	50	1.0

4-21b. Mathematics instruction (hours/year)	**mean**	**s.e.**
nontracked classes	146	2.9
tracked (highest)	145	2.6
tracked (lowest)	142	2.5

4-21c. Science instruction (hours/year)	**mean**	**s.e.**
nontracked classes	138	2.4
tracked (highest)	151	3.6
tracked (lowest)	145	4.7

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 School Questionnaire, 1995.

Appendix table 4-22.

Resources used in lesson planning, eighth-grade mathematics and science teachers , 1995

When planning mathematics/science lessons, how much do you rely on ...

	never		rarely		sometimes		always			
Math Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Own previous lesson	6.8	1.5	10.4	2.8	51.2	3.6	31.6	2.7	242	1.6
School plan	61.5	3.4	18.0	2.2	17.4	3.4	3.1	1.2	244	0.8
Other teachers	33.4	3.5	29.5	3.0	34.1	2.7	3.0	0.9	243	1.2
Student text	7.5	2.3	11.5	2.2	53.9	4.4	27.2	4.4	242	1.6
Other resource books	6.4	2.8	7.2	1.7	76.4	4.1	10.1	2.4	243	1.2
Teacher guide/text	3.5	1.3	11.6	2.2	54.9	4.0	30.0	4.3	244	0.8
Standardized exams/tests	14.5	2.4	32.7	3.8	47.6	4.3	5.2	1.1	244	0.8
Science Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Own previous lesson	7.5	2.5	4.5	1.7	50.9	4.3	37.1	4.1	224	3.4
School plan	55.8	4.3	27.0	3.4	15.1	3.1	2.1	1.7	226	2.6
Other teachers	38.4	3.9	27.4	3.9	33.1	3.2	1.2	0.5	226	2.6
Student text	3.4	1.0	13.1	2.7	57.9	3.7	25.7	3.3	225	3.0
Other resource books	3.0	2.5	4.6	1.5	69.1	3.8	23.4	4.4	225	3.0
Teacher guide/text	4.2	1.9	9.3	2.1	56.9	4.1	29.6	4.0	226	2.6
Standardized exams/tests	22.6	3.6	35.5	3.9	32.0	3.4	9.9	3.0	225	3.0

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-23.

Resources used in making instructional decisions; eighth-grade mathematics and science teachers, 1995

In planning mathematics (science) lessons, what is your main source of written information when ....

	deciding which topics to teach		deciding how to present topics		selecting exercises for class/homework		selecting exercises for assessments	
Math Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Other resource books	2.4	1.0	27.7	3.3	19.7	3.6	37.3	4.2
Student text	7.1	2.2	9.3	2.1	29.6	3.8	12.2	3.0
Teacher text	21.2	3.3	50.7	4.0	46.8	3.7	36.3	4.4
School curriculum guide	23.5	2.8	2.7	0.9	1.7	0.6	3.1	1.1
District curriculum guide	39.4	4.1	6.5	2.2	2.2	1.1	4.3	1.6
State assessment guidelines	6.5	1.4	3.1	1.3	0.1	0.1	6.8	1.6
N	226		221		224		222	
% missing	8.1		10.2		8.9		9.8	
Science Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.
Other resource books	4.6	1.8	28.5	3.9	26.4	3.7	29.8	3.3
Student text	4.3	1.9	6.5	2.0	17.0	2.5	8.6	2.2
Teacher text	19.8	4.1	49.3	4.7	46.6	3.7	41.8	4.3
School curriculum guide	26.1	4.8	8.6	3.2	4.4	2.0	3.7	1.3
District curriculum guide	41.9	4.3	5.1	1.3	5.6	1.6	13.3	3.0
State assessment guidelines	3.4	1.7	2.1	1.7	0.1	0.2	2.9	1.8
N	223		220		222		219	
% missing	3.9		5.2		4.3		5.6	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-24.

New topic introduction; eighth-grade students, 1995

When we begin a new topic in mathematics (science), we begin by...

	never		once in a while		pretty often		almost always			
Mathematics	%	s.e.	%	s.e	%	s.e	%	s.e.	N	% missing
Teacher explains rules	4.5	0.4	11.0	0.7	24.3	0.7	60.1	1.2	6,902	2.6
Discuss problem related to everyday life	22.7	1.0	34.5	1.2	24.4	0.9	18.4	0.8	6,883	2.9
Work in pairs or small groups	28.6	1.6	34.8	1.1	20.5	0.9	16.0	1.1	6,862	3.2
Teacher asks what students know	18.9	1.0	27.0	0.8	31.0	0.9	23.1	0.9	6,854	3.3
Look at textbook while teacher talks	10.1	1.1	18.9	1.1	28.3	0.9	42.7	1.8	6,861	3.2
Solve example related to new topic	5.0	0.4	12.9	0.8	29.5	0.9	52.6	1.1	6,877	3.0
Science	%	s.e.	%	s.e	%	s.e	%	s.e.	N	% missing
Teacher explains rules	6.4	0.6	14.2	0.6	30.3	0.9	49.1	1.2	6,703	5.4
Discuss problem related to everyday life	15.5	0.7	27.6	1.0	32.9	0.7	23.9	1.0	6,678	5.8
Work in pairs or small groups	15.5	1.0	26.6	0.9	30.7	1.0	27.2	1.2	6,655	6.1
Teacher asks what students know	11.8	0.7	23.4	0.9	35.0	0.6	29.8	1.0	6,643	6.3
Look at textbook while teacher talks	12.3	1.1	20.2	1.0	29.6	1.0	37.9	1.4	6,653	6.1
Solve example related to new topic	12.4	0.6	25.2	0.9	32.6	0.7	29.9	0.9	6,667	5.9

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study;, Population 2 Student Questionnaire, 1995.

Appendix table 4-25.

Teacher-student interaction; eighth-grade mathematics and science classes, 1995

In mathematics (science) lessons, how often do students ...

	never/ almost never		some lessons		most lessons		every lesson				(most + every lesson)	
Math Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Work individually- no assistance	28.9	4.3	52.0	3.6	16.6	2.7	2.6	0.9	243	1.2	19.1	3.0
Work individually-teacher assists	0.0	0.0	47.9	3.5	42.4	3.8	9.5	2.0	243	1.2	52.1	3.5
Work together-teacher-centered	3.8	1.3	47.7	4.0	37.4	4.6	11.1	2.3	242	1.6	48.5	4.5
Work together-students interact	18.3	3.8	60.3	4.1	17.8	3.7	3.6	1.1	241	2.0	21.4	3.7
Work in groups-no assistance	23.7	3.8	64.2	4.3	9.9	2.3	2.2	1.0	239	2.8	12.1	2.7
Work in groups-teacher assists	3.9	1.1	70.3	3.2	22.0	2.9	3.8	1.4	239	2.8	25.9	2.9
Science Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Work individually- no assistance	13.4	2.1	73.2	2.8	13.1	2.7	0.4	0.3	227	2.2	13.4	2.7
Work individually-teacher assists	2.5	1.3	64.6	3.9	30.4	3.8	2.5	1.2	228	1.7	32.9	3.9
Work together-teacher-centered	3.9	1.2	61.4	4.8	28.9	3.8	5.8	2.3	225	3.0	34.7	4.9
Work together-students interact	17.6	2.9	60.7	4.5	21.3	4.7	0.4	0.3	227	2.2	21.8	4.7
Work in groups-no assistance	15.0	2.8	74.1	3.9	10.9	2.6	0.0	0.0	226	2.6	10.9	2.6
Work in groups-teacher assists	7.2	2.0	65.1	3.3	26.2	3.1	1.6	1.2	224	3.4	27.8	3.1

NOTE:
Percentages for combined categories used in figures are shaded.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-26.

Instructional activities; eighth-grade mathematics and science students, 1995

How often does this happen in your lessons?

	never		once in a while		pretty often		almost always			
Mathematics	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Discuss completed homework	8.5	0.9	13.5	0.9	22.1	0.9	55.9	1.8	6,894	2.7
Check each others' homework	33.6	2.0	23.0	1.3	17.7	1.0	25.6	2.5	6,878	2.9
Teacher checks homework	7.0	0.8	17.1	1.4	21.7	1.0	54.2	2.0	6,870	3.1
Begin homework in class	6.0	0.4	19.2	1.0	27.4	0.9	47.5	1.6	6,886	2.8
Teacher assigns homework	1.3	0.3	9.6	1.4	17.0	1.1	72.1	2.3	6,864	3.1
Solve problems with everyday life	13.6	0.8	34.3	1.0	30.8	1.0	21.3	1.0	6,884	2.9
Work in pairs or small groups	17.0	1.5	41.3	1.5	25.8	1.4	15.9	1.1	6,883	2.9
Use computers	68.9	2.5	20.6	1.8	6.4	0.9	4.1	0.6	6,877	3.0
Use calculators	10.1	1.6	20.2	1.4	25.5	1.2	44.2	2.6	6,892	2.8
Work on math projects	33.5	1.6	39.9	1.2	14.0	0.7	12.6	0.6	6,881	2.9
Work from worksheets	2.7	0.3	11.9	0.6	27.2	0.9	58.3	1.3	6,893	2.7
Have a test or quiz	0.6	0.1	14.3	0.9	46.7	1.1	38.4	1.2	6,900	2.6
Copy notes from board	8.4	0.6	24.8	1.5	24.1	0.8	42.7	1.8	6,906	2.6
Teacher shows problem	1.2	0.1	4.7	0.5	16.4	0.8	77.7	1.1	6,917	2.4
Science	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Discuss completed homework	15.4	1.2	21.2	0.8	27.3	0.7	36.0	1.4	6,666	5.9
Check each other's homework	34.0	2.0	24.5	1.0	21.8	1.0	19.6	1.4	6,690	5.6
Teacher checks homework	9.7	0.8	17.2	1.1	26.3	0.9	46.9	1.6	6,689	5.6
Begin homework in class	15.8	1.0	25.0	1.2	28.8	0.7	30.4	1.4	6,716	5.2
Teacher assigns homework	6.4	0.7	26.8	1.9	30.8	1.2	36.0	1.8	6,639	6.3
Solve problems with everyday life	16.4	0.7	32.6	0.9	29.7	0.7	21.3	0.8	6,719	5.2
Work in pairs or small groups	10.2	1.1	24.8	1.1	36.9	1.3	28.0	1.2	6,707	5.4
Use computers	65.4	2.2	19.5	1.5	9.4	0.8	5.7	0.6	6,694	5.5
Use calculators	51.8	2.2	30.0	1.5	11.0	0.8	7.2	0.6	6,727	5.1
Work on science projects	7.8	1.0	30.9	1.1	33.7	0.9	27.5	0.8	6,706	5.4
Work from worksheets	4.6	0.5	16.1	1.2	34.7	0.9	44.6	1.5	6,717	5.2
Have a quiz or test	2.1	0.4	21.0	1.4	44.3	1.0	32.7	1.4	6,721	5.2
Copy notes from the board	7.6	0.8	19.1	1.0	28.6	1.1	44.8	1.6	6,744	4.8
Teacher shows problems	8.5	0.7	22.3	0.8	33.0	0.8	36.3	1.2	6,756	4.7
Teacher gives demonstration	8.2	0.8	23.4	1.0	30.8	0.8	37.6	1.3	6,698	5.5
Students do experiment in class	12.8	1.1	25.6	1.2	29.5	0.9	32.1	1.4	6,715	5.2

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study Population 2 Student Questionnaire, 1995.

Appendix table 4-27.
Use of experiments; eighth-grade science teachers, 1995

In your science lessons, how often do students ...

	never/ almost never		some lessons		most lessons		every lesson			
	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Watch you demonstrate experiments	9.9	2.3	73.1	3.7	16.8	3.6	0.1	0.1	230	0.9
Conduct their own experiments	11.0	3.2	62.7	5.1	25.9	5.0	0.4	0.2	229	1.3
Watch film/video of experiments	26.5	3.4	66.0	4.8	8.5	3.2	0.0	0.0	228	1.7
Go on a science field trip	77.3	3.3	22.6	3.2	0.2	0.2	0.0	0.0	229	1.3
Design their own experiments	53.1	4.2	44.0	3.9	2.9	1.0	0.0	0.0	228	1.7
Do projects lasting a week or more	41.7	5.4	56.2	5.2	2.2	1.2	0.0	0.0	228	1.7
Do other lab-related activities	27.6	4.2	57.4	4.5	14.5	3.5	0.5	0.3	217	6.5

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-28.
Cognitive demands of instruction; eighth-grade mathematics and science teachers, 1995

In your math/science lessons, how often do you usually ask students to do the following?

	never/ almost never		some lessons		most lessons		every lesson				(most + every)	
Mathematics	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Explain reasoning	1.2	0.4	32.2	4.4	43.6	3.7	23.1	3.0	242	1.6	66.6	4.4
Use graphs and tables for relationships	14.3	2.9	73.4	3.4	10.7	2.7	1.7	0.6	243	1.2	12.3	2.8
Do problems with no obvious solution	24.9	3.5	62.6	4.0	10.6	2.6	1.9	0.9	241	2.0	12.5	2.7
Use computers to solve problems	76.2	3.3	19.8	3.2	1.3	0.9	2.6	2.3	243	1.2	4.0	2.5
Write equations for relationships	5.6	1.7	58.0	4.1	30.8	3.4	5.6	2.2	242	1.6	36.5	3.8
Practice computations	10.3	2.1	30.4	3.5	37.0	4.4	22.2	4.4	243	1.2	59.3	3.6
Science	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Explain reasoning	0.0	0.0	31.1	3.7	49.5	3.8	19.4	2.7	228	1.7	68.9	3.7
Use graphs and tables for relationships	1.7	1.7	72.5	3.5	23.7	3.6	2.2	0.8	229	1.3	25.9	3.7
Do problems with no obvious solution	30.6	3.9	59.2	3.7	7.5	2.0	2.7	1.3	228	1.7	10.2	1.8
Use computers to solve problems	72.9	4.9	26.3	4.9	0.8	0.6	0.0	0.0	227	2.2	0.8	0.6
Write explanations of observations	3.2	1.1	60.3	3.8	28.4	3.8	8.1	1.5	229	1.3	36.6	3.8
Order objects and give reasons	12.9	3.2	59.9	4.3	22.6	2.9	4.7	0.9	229	1.3	27.3	3.0

NOTE:
Percentages for combined categories used in figures are shaded.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-29.

Error correction strategies; eighth-grade mathematics and science teachers, 1995

In your math/science lessons, how frequently do you do the following when a student gives an incorrect response during a class discussion?

	never/ almost never		some lessons		most lessons		every lesson				(most lessons + every lesson)	
Mathematics	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Correct student's error	38.6	3.5	49.0	3.8	8.4	2.1	3.9	1.1	239	2.8	12.4	2.7
Prompt student	1.0	0.6	21.3	3.4	55.5	3.8	22.1	3.3	241	2.0	77.7	3.5
Call on another student	21.7	2.9	67.5	3.6	9.8	2.2	1.0	0.8	240	2.4	10.8	2.5
Discuss correct answer	0.6	0.5	38.0	3.9	49.2	3.9	12.3	2.2	242	1.6	61.4	3.9
Science	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Correct student's error	38.4	3.8	46.9	3.6	13.4	2.6	1.4	0.6	225	3.0	14.8	2.7
Prompt student	1.7	1.1	16.4	2.6	63.0	4.3	18.9	3.2	226	2.6	81.9	2.9
Call on another student	17.1	2.9	65.9	3.4	16.7	2.8	0.3	0.2	226	2.6	17.0	2.8
Discuss correct answer	1.7	0.8	38.6	3.1	39.7	3.5	20.0	2.4	226	2.6	59.7	3.2

NOTE:
Percentages for combined categories used in figures are shaded.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-30.
Frequency and minutes of homework assigned; eighth-grade mathematics and science teachers, 1995

4-30a. Frequency of homework assignments

How often do you usually assign mathematics (science) homework?

	Mathematics		Science	
	%	s.e.	%	s.e.
never	0.1	0.1	1.9	1.0
less than once a week	3.6	1.3	14.1	3.3
once or twice a week	10.3	2.1	34.8	4.0
3 or 4 times a week	60.3	4.3	38.5	4.5
every day	25.7	3.2	10.8	2.0
N	243		222	
% missing	1.2		4.3	
less than 3 times per week	13.9	2.7	49.8	4.3
at least 3 times per week	86.1	2.7	50.2	4.3

4-30b. Minutes of homework assigned

How many minutes of mathematics (science) homework do you usually assign your students?

	Mathematics		Science	
	%	s.e.	%	s.e.
do not assign homework	0.3	0.2	3.2	1.5
less than 15 minutes	5.4	1.7	16.8	3.3
15-30 minutes	69.2	3.5	66.4	4.5
31-60 minutes	22.4	2.7	13.5	3.5
61-90 minutes	2.5	1.7	0.0	0.0
more than 90 minutes	0.3	0.3	0.0	0.0
N	241		226	
% missing	2.0		2.6	
mean (assigned homework)	28.3	1.2	22.3	1.1
mean (overall)	28.4	1.2	23.1	1.1

NOTE:
Calculation of mean based on category mid-points.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-31.
Use of out of school time; eighth-grade students, 1995

4-31a. Daily activities

On a normal school day, how much time do you spend before or after school doing each of these things?

	none		<1 hour		1-2 hours		4-5 hours		>5 hours					
	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	**mean**	s.e.
Other homework	15.7	0.9	52.5	0.9	26.7	0.8	4.1	0.3	1.0	0.2	6841	3.5	0.9	0.02
Science homework	24.8	1.3	57.2	1.2	16.2	0.6	1.3	0.2	0.5	0.1	6808	3.9	0.6	0.01
Math homework	18.4	1.1	55.0	1.0	24.2	0.9	1.8	0.2	0.6	0.1	6831	3.6	0.8	0.02
Books	39.9	0.9	38.0	0.9	16.0	0.7	3.9	0.3	2.1	0.2	6786	4.2	0.7	0.02
Sports	15.5	0.7	18.1	0.6	36.2	0.9	19.7	0.8	10.5	0.7	6817	3.8	2.1	0.04
Chores	10.6	0.4	49.3	0.9	29.4	0.6	7.3	0.5	3.5	0.4	6814	3.9	1.2	0.03
Friends	5.6	0.4	23.7	0.9	34.1	0.9	22.6	0.8	14.1	0.8	6813	3.9	2.4	0.05
Computer games	47.1	0.9	32.3	0.8	14.5	0.5	3.3	0.2	2.9	0.3	6775	4.4	0.7	0.03
Television	3.9	0.2	18.3	0.7	40.0	0.9	24.7	0.6	13.1	0.9	6884	2.9	2.5	0.06

4-31b. Weekly activities

During the week, how much time before and after school do you spend on...

	none		<1 hour		1-2 hours		4-5 hours		>5 hours					
	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	**mean**	s.e.
Extra math lessons	68.1	1.2	22.3	0.8	8.1	0.6	1.0	0.2	0.5	0.1	6762	4.6	0.3	0.02
Extra science lessons	77.5	0.8	17.2	0.6	4.4	0.3	0.7	0.1	0.3	0.1	6661	6.0	0.2	0.01
Math/science clubs	90.5	0.6	5.7	0.4	2.7	0.4	0.8	0.1	0.4	0.1	6648	6.2	0.1	0.01
Paid job	65.6	1.2	7.4	0.4	10.5	0.6	9.7	0.6	6.8	0.5	6709	5.3	1.0	0.03

NOTE:
Means based on category mid-points.
SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Student Questionnaire, 1995.

Appendix table 4-32.

Tasks assigned as homework; eighth-grade mathematics and science teachers, 1995

If you assign mathematics/science homework, how often do you assign each of the following kinds of tasks?

	do not assign		never		rarely		sometimes		always			
Math Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Worksheets/workbooks	0.0	0.0	6.0	1.5	15.1	1.9	68.6	3.8	10.3	3.4	240	2.4
Textbook problems	0.0	0.0	3.1	1.3	7.5	3.2	58.3	4.5	31.1	3.4	240	2.4
Reading	0.3	0.3	30.4	3.3	32.5	3.4	31.0	3.7	5.6	2.0	239	2.8
Definition/other short writing	0.3	0.3	30.1	4.1	39.0	3.9	27.8	3.7	2.7	1.1	238	3.3
Small investigation	0.0	0.0	23.4	2.3	36.6	3.2	39.7	2.6	0.2	0.2	241	2.0
Individual long-term projects	0.0	0.0	35.9	3.3	31.5	3.1	31.4	3.0	1.0	0.4	240	2.4
Small group long-term projects	0.0	0.0	42.5	3.2	35.9	3.3	21.5	2.6	0.1	0.1	238	3.3
Finding uses of content	0.5	0.5	26.0	3.5	30.4	2.8	37.7	3.6	5.4	1.2	238	3.3
Oral reports	0.0	0.0	46.9	3.6	36.3	3.5	16.4	2.7	0.3	0.2	240	2.4
Keeping a journal	1.0	1.0	56.8	3.7	20.7	2.6	14.9	3.4	6.5	1.6	238	3.3
Science Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Worksheets/workbooks	1.8	1.0	7.8	2.1	21.3	3.1	63.3	3.4	5.9	1.5	226	2.6
Textbook problems	2.2	1.0	8.7	2.8	12.8	3.0	61.1	4.2	15.3	3.4	225	3.0
Reading	1.8	1.0	9.2	1.8	14.0	2.9	63.9	4.3	11.1	2.4	226	2.6
Definition/other short writing	1.8	0.9	5.5	1.7	26.1	3.9	57.7	4.7	8.9	2.2	226	2.6
Small investigation	1.8	1.0	5.8	1.5	34.7	3.0	56.2	3.6	1.5	0.9	227	2.2
Individual long-term projects	3.4	1.9	7.5	2.5	35.8	4.2	50.6	4.2	2.7	1.1	228	1.7
Small group long-term projects	1.8	1.0	24.0	3.6	39.1	3.5	34.3	3.7	0.9	0.7	227	2.2
Finding uses of content	1.8	1.0	17.4	3.6	43.4	4.0	34.1	4.9	3.3	1.1	226	2.6
Oral reports	1.8	1.0	24.9	3.8	29.1	3.8	40.3	3.7	4.0	2.0	226	2.6
Keeping a journal	1.8	1.0	48.4	4.1	25.8	4.5	16.4	3.6	7.6	1.9	228	1.7

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-33.

Homework followup activities; eighth-grade mathematics and science teachers, 1995

If students are assigned written homework, how often do you do the following?

	do not assign		never		rarely		sometimes		always			
Math Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Record completion	0.1	0.1	0.4	0.3	0.8	0.3	17.1	2.8	81.4	2.9	238	3.3
Correct and keep	0.1	0.1	30.0	4.0	27.8	4.3	31.1	3.0	10.8	2.0	233	5.3
Correct and return	0.1	0.1	5.2	1.5	13.8	2.0	40.6	4.5	40.2	4.7	235	4.5
Give feedback to class	0.1	0.1	0.3	0.3	4.9	2.1	35.8	4.3	58.7	3.9	237	3.7
Have students correct own	0.1	0.1	5.5	2.0	15.9	3.4	48.8	3.7	29.4	3.3	238	3.3
Have students exhange homework	0.1	0.1	23.4	2.8	21.8	3.0	45.0	4.1	9.5	3.4	237	3.7
Use as basis for class discussion	0.1	0.1	1.3	0.7	13.7	2.9	59.2	3.5	25.5	3.5	237	3.7
Use in grading	0.1	0.1	0.6	0.5	4.2	1.4	26.3	4.2	68.6	4.3	239	2.8
Science Teachers	%	s.e.	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Record completion	1.8	1.0	3.1	1.8	0.0	0.0	15.2	2.5	79.9	3.0	229	1.3
Correct and keep	1.8	1.0	30.5	3.2	18.0	3.0	33.6	4.2	16.0	2.8	223	3.9
Correct and return	1.8	1.0	2.0	0.7	7.8	2.5	39.3	4.7	49.1	4.7	228	1.7
Give feedback to class	1.8	1.0	0.4	0.4	3.2	1.2	38.0	4.6	56.7	4.8	226	2.6
Have students correct own	1.8	1.0	13.7	3.2	25.8	3.2	52.2	4.1	6.6	1.5	228	1.7
Have students exhange homework	1.8	1.0	24.7	3.5	22.7	3.9	48.6	4.1	2.3	1.0	229	1.3
Use as basis for class discussion	1.8	1.0	3.5	1.0	4.9	1.7	67.1	3.9	22.8	3.9	226	2.6
Use in grading	1.8	1.0	0.2	0.2	4.4	1.7	28.4	4.0	65.3	4.0	226	2.6

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-34.
Weight given to different types of assessment; eighth-grade mathematics and science teachers, 1995

In assessing the work of students in your mathematics/science class, how much weight do you give each of the following types of assessment?

	none		little		quite a lot		a great deal				(quite a lot + a great deal)	
Math	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Standardized tests	29.1	3.0	49.2	3.5	21.1	2.0	0.6	0.4	240	2.4	21.7	2.0
Teacher-made short answer/essay tests	16.8	3.1	31.4	2.7	39.9	3.3	12.0	2.4	240	2.4	51.9	3.8
Teacher-made m/choice, true/false, matching	34.3	3.0	39.3	3.6	21.0	3.1	5.5	2.6	239	2.8	26.4	3.9
Performance on homework	1.9	0.9	41.2	4.4	49.4	4.3	7.4	2.6	239	2.8	56.8	4.4
Performance on projects/lab exercises	30.1	3.8	35.1	3.7	30.3	3.3	4.5	1.3	239	2.8	34.8	3.4
Observations of students	17.3	3.4	37.3	3.2	39.0	4.2	6.5	1.5	238	3.3	45.4	3.7
Responses of students in class	16.0	3.0	38.1	3.5	37.2	3.4	8.7	2.3	241	2.0	45.9	3.3
Science	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing	%	s.e.
Standardized tests	43.6	4.3	43.3	3.8	12.3	2.9	0.9	0.5	229	1.3	13.2	2.9
Teacher-made short answer/essay tests	1.3	1.0	33.0	4.2	48.1	3.7	17.5	3.4	229	1.3	65.7	4.2
Teacher-made m/choice, true/false, matching	5.1	1.9	33.0	3.0	57.9	4.1	14.0	3.4	229	1.3	71.9	3.3
Performance on homework	4.0	1.7	41.4	3.5	49.0	4.0	5.5	1.9	229	1.3	54.5	3.7
Performance on projects/lab exercises	2.0	1.3	19.4	3.4	67.8	3.3	10.8	1.9	228	1.7	78.6	3.2
Observations of students	6.7	1.5	48.2	5.6	40.2	4.6	5.0	2.0	228	1.7	45.2	5.0
Responses of students in class	11.4	2.6	51.2	5.1	33.1	4.5	4.3	2.1	229	1.3	37.4	4.7

NOTE:
Percentages for combined categories used in figures are shaded.
SOURCE:
Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-35.

Uses of different kinds of assessment; eighth-grade mathematics and science teachers, 1995

How often do you use the assessment information you gather from students to...

	none		little		quite a lot		a great deal			
Math	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Provide students' grades or marks	0.0	0.0	3.3	0.9	55.6	3.8	41.2	4.1	241	2.0
Provide feedback to students	0.0	0.0	9.2	2.6	63.9	3.1	26.9	3.5	242	1.6
Diagnose learning problems	6.4	2.5	14.8	2.6	61.9	3.6	16.9	3.0	242	1.6
Report to parents	0.2	0.2	19.6	3.3	60.8	4.1	19.4	3.5	242	1.6
Assign students to tracks/programs	27.8	2.7	42.2	3.4	23.2	3.5	6.7	1.8	241	2.0
Plan for future lessons	0.3	0.3	13.5	2.6	62.6	4.6	23.6	3.9	241	2.0
Science	%	s.e.	%	s.e.	%	s.e.	%	s.e.	N	% missing
Provide students' grades or marks	1.3	1.0	5.3	1.8	52.0	3.6	41.4	2.9	227	2.2
Provide feedback to students	0.9	0.9	11.2	2.3	62.6	4.2	25.4	3.8	229	1.3
Diagnose learning problems	4.2	0.8	40.7	4.5	42.1	4.2	12.9	2.7	228	1.7
Report to parents	0.5	0.3	27.4	2.4	53.3	4.2	18.9	3.8	228	1.7
Assign students to tracks/programs	46.2	3.9	38.2	3.4	12.7	2.7	3.0	1.3	227	2.2
Plan for future lessons	1.5	0.4	25.1	3.5	55.4	3.5	18.0	2.9	226	2.6

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-36.

Topic focus of the last mathematics lesson; percentage of eighth-grade mathematics teachers nominating topic, 1995

For each of the following mathematics topics, indicate whether it was the subject of the lesson.

	%	s.e.
Whole numbers	27.4	3.6
Common/decimal fractions	28.8	3.4
Percentages	21.7	3.1
Number sets/concepts	16.9	2.9
Number theory	11.9	2.4
Estimation	17.0	2.5
TOTAL number	**46.3**	**3.5**
Measurement	13.0	2.3
Estimation/error of measurement	6.1	1.2
Perimeter, area, volume	18.1	2.9
TOTAL measurement	**22.2**	**2.7**
Basics 1 & 2-dimensional geometry	13.2	2.5
Geom congruence/similarity	8.3	1.4
Geom transformation/symmetry	3.7	1.6
Constructions/4-dimension geometry	5.5	1.7
TOTAL geometry	**16.6**	**2.3**
Ratio & proportion	26.5	3.5
Proportionality	3.5	1.1
TOTAL ratio/proportion	**27.5**	**3.5**
Functions, relations, patterns	12.4	2.3
Equations, inequalities, formulas	37.4	3.9
TOTAL functions and equations	**39.4**	**3.9**
Statistics & data	9.8	2.1
Probability & uncertainty	11.2	2.2
TOTAL statistics/probability	**16.7**	**2.7**
Sets & logic	3.8	1.4
Problem solving strategies	33.1	3.6
Other math content	28.3	2.8
N	237	
% missing	3.7	

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-37.

Topics covered in last mathematics lesson; percentage of eighth-grade mathematics teachers nominating topic group by class type, 1995

For each of the following mathematics topics indicate whether it was the subject of the lesson.

	All classes			Regular classes			Prealgebra classes			Algebra classes		
Topic Groups	%	s.e.	N	%	s.e.	N	%	s.e.	N	%	s.e.	N
Number	46.3	3.5	117	49.4	4.8	67	59.1	8.4	28	36.8	7.1	22
Measurement	22.2	2.7	67	29.9	3.9	44	19.8	5.1	13	10.1	2.7	10
Geometry	16.6	2.3	44	21.1	3.1	28	21.8	5.7	12	5.2	2.5	4
Ratio/proportion	27.5	3.5	76	24.0	4.5	35	59.9	7.4	28	15.6	4.7	13
Functions and equations	39.4	3.9	104	31.9	4.4	45	29.6	7.0	16	68.8	7.2	43
Statistics/probability	16.7	2.7	43	23.5	4.9	32	14.1	6.5	7	6.0	2.2	4
Sets	3.6	1.4	8	2.3	1.4	3	2.8	1.9	2	7.6	4.1	3
Problem solving	31.7	3.5	82	26.7	4.3	40	41.0	7.4	22	40.8	9.6	20
Other	26.7	2.7	66	18.5	3.7	27	33.7	7.2	16	43.4	6.1	23

NOTE:
Mathematics classes grouped according to level of mathematics implied by textbook used; 'regular', 'prealgebra', 'algebra'.
SOURCE:
Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-38.

Topic focus of the last science lesson; percentage of eighth-grade science teachers nominating topic, 1995

For each of the following science topics, indicate whether it was the subject of the lesson.

	%	s.e.
Earth features	30.3	4.5
Earth processes	32.8	5.1
Earth in universe	18.9	2.4
TOTAL earth science	**50.2**	**5.2**
Human biology/health	10.6	3.3
Diversity/structure of life	12.5	2.7
Life process & systems	17.2	3.3
Life cycles, genetics, diversity	7.3	1.8
Interaction of living things	11.3	2.4
TOTAL life science	**29.0**	**4.0**
Types/properties of matter	27.0	4.6
Structure of matter	28.6	3.9
Energy types/sources/conversions	22.1	4.0
Energy processes	25.8	3.8
Physical changes	27.5	4.8
Kinetic/quantum theory	5.0	1.5
Gen'l chemical change	24.9	4.1
Specialized chemical change	12.5	3.3
Force & motion	19.2	4.2
Relativity theory	3.0	1.7
TOTAL physical science	**59.7**	**4.7**
Science, technology, society	26.9	3.3
History of science/technology	12.5	2.1
Environmental resource issues	23.0	3.7
Nature of science	18.8	2.2
N	231	
% missing	0.4	

SOURCE:

U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-39.

Occurrence and order of instructional activities in the "last lesson"; eighth-grade mathematics and science teachers, 1995

Indicate how your lesson developed....write in the order in which activities...took place.

	Mathematics		**Science**	
4-39a. Occurrence	%	s.e.	%	s.e.
Quiz or test	19.6	3.1	10.3	2.1
Lab or hands-on activity	6.8	1.8	29.1	4.1
Start homework in class	51.5	3.6	35.8	3.9
Small group activities	32.5	4.2	35.2	4.2
Oral recitation or drill	37.2	4.1	39.9	4.6
Review previous homework	64.9	3.8	42.3	3.8
Paper-pencil exercises	64.2	3.2	40.4	4.2
Assign homework	72.2	4.2	52.8	4.0
Introduction to topic	72.5	3.5	70.4	3.3
Development of topic	78.8	3.1	73.4	4.7
Review previous lesson	69.3	3.1	78.2	2.8
4-39b. Rank Order of Activities	mean	s.e.	mean	s.e.
Review previous lesson	1.6	0.1	1.3	0.1
Review previous homework	1.8	0.0	2.2	0.2
Introduction to topic	2.6	0.1	2.6	0.1
Oral recitation or drill	2.9	0.1	2.7	0.2
Development of topic	3.5	0.1	3.3	0.1
Quiz or test	2.8	0.3	3.8	0.8
Small group activities	4.8	0.2	4.2	0.2
Lab or hands-on activity	5.2	0.6	4.5	0.3
Paper-pencil exercises	4.6	0.1	4.7	0.2
Assign homework	5.5	0.1	5.2	0.2
Start homework in class	6.2	0.2	5.8	0.3

NOTE:
An activity was defined as 'occurring' if it was ranked or if minutes were indicated. Standard errors less than .05 are rounded to 0.0.
SOURCE:
U.S. Department of Education, National Center for Education Statistics,
Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

Appendix table 4-40.

Length of activities during the "last lesson"; eighth-grade mathematics and science teachers, 1995

Indicate how your lesson developed....estimate the amount of time you spent on each [activity].

	zero included		zero excluded	
Mathematics	mean minutes	s.e.	mean minutes	s.e.
Review previous lesson	4.1	0.22	5.8	0.29
Quiz or test	2.1	0.36	10.8	0.89
Oral recitation or drill	2.8	0.45	7.3	0.74
Review previous homework	6.1	0.52	9.1	0.51
Introduction to topic	6.8	0.86	9.4	0.97
Development of topic	9.8	0.55	12.4	0.62
Small group activities	4.4	0.63	13.5	0.97
Paper-pencil exercises	7.0	0.44	10.8	0.59
Assign homework	1.9	0.19	2.7	0.25
Start homework in class	6.6	0.82	12.5	1.15
Lab or hands-on activity	0.8	0.21	13.1	2.38
Science	mean minutes	s.e.	mean minutes	s.e.
Review previous lesson	4.5	0.31	6.2	0.27
Quiz or test	1.1	0.28	13.0	1.89
Oral recitation or drill	2.8	0.63	7.3	1.29
Review previous homework	3.5	0.54	8.8	1.09
Introduction to topic	7.6	0.52	11.5	0.61
Development of topic	10.0	0.77	14.4	0.79
Small group activities	5.5	0.80	17.0	1.36
Paper-pencil exercises	3.9	0.50	10.9	0.83
Assign homework	1.7	0.18	3.4	0.39
Start homework in class	3.0	0.43	9.3	1.04
Lab or hands-on activity	5.5	0.85	21.5	2.02

SOURCE:
U.S. Department of Education, National Center for Education Statistics, Third International Mathematics and Science Study; Population 2 Teacher Questionnaire, 1995.

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