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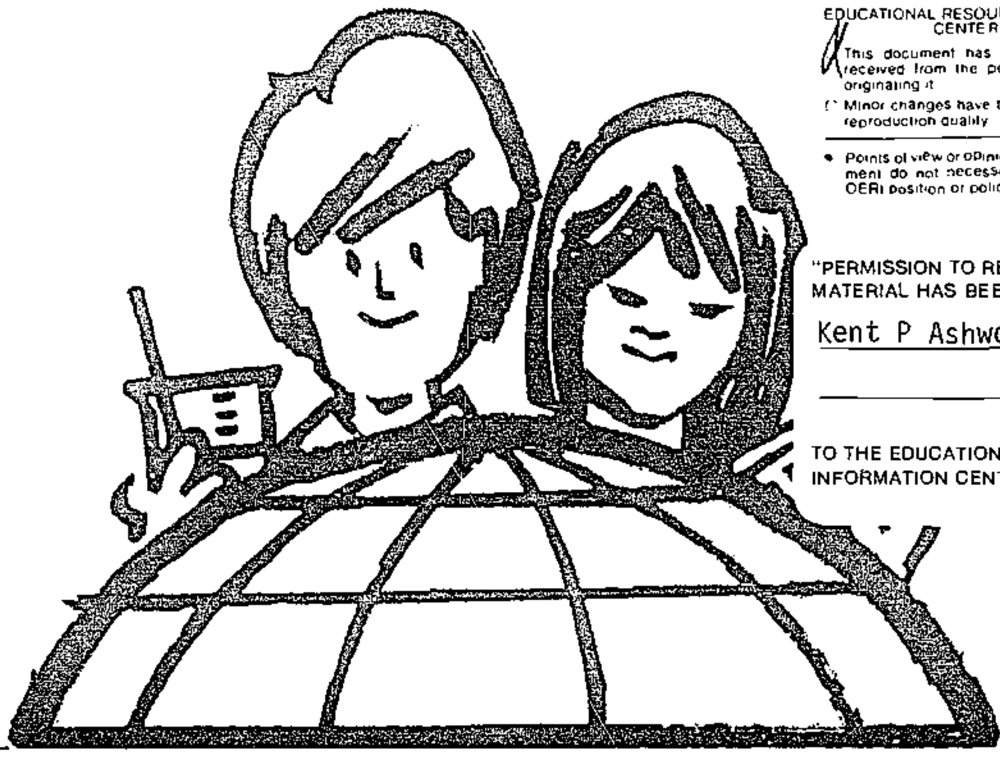
ABSTRACT

In February, 1988, random samples of students from five countries (Ireland, Korea, Spain, the United Kingdom, and the United States) and four Canadian provinces (British Columbia, New Brunswick, Ontario, and Quebec) were given an assessment of mathematics and science achievement, and a questionnaire. This document summarizes the results of these tests and compares achievement, experiences and attitudes across the international sample. Findings are organized by achievement, instruction and attitude, and topics for both science and mathematics. The context of the results for each country is summarized in a commentary. Appendices include procedures and data. (CW)

A World of Differences

An International Assessment of Mathematics and Science



IAEP '88

EDUCATIONAL TESTING SERVICE

The Study in Brief

Five countries and four Canadian provinces participated. (Canada does not have a federal system of education). A total of 12 student populations were included from:

British Columbia	New Brunswick (French)	Quebec (French)
Ireland	Ontario (English)	Spain
Korea	Ontario (French)	United Kingdom*
New Brunswick (English)	Quebec (English)	United States

Age Group: Students were 13 years old (born January 1, 1974—December 31, 1974), and were selected from public and private elementary, middle, and secondary schools.

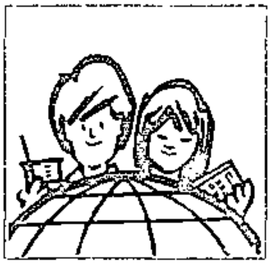
Samples: A random sample of about 2,000 students from 100 different schools was selected from each population. In the United States, the sample size was about 1,000 students in 200 schools. A total of 24,000 students was assessed.

Assessment: Students were administered a 45-minute mathematics assessment (63 questions) and a 45-minute science assessment (60 questions), selected from the total pool of 281 mathematics and 188 science questions used in the 1986 United States' National Assessment of Educational Progress (NAEP). In addition, students answered questions about their school experiences and attitudes, and teachers rated students' exposure to the concepts tested by the items.

Procedures: All countries and provinces followed standardized administration procedures and administered the assessments during February 1988.

*The United Kingdom sample was drawn from students in England, Scotland, and Wales.

A World of Differences



An International Assessment of Mathematics and Science

Archie E. Lapointe

Nancy A. Mead   Gary W. Phillips

January 1989

Report No. 19-CAEP-01

EDUCATIONAL TESTING SERVICE

IAEP '88

Educational Testing Service (ETS) is a private, nonprofit corporation devoted to measurement and research, primarily in the field of education. It was founded in 1947 by the American Council on Education, the Carnegie Foundation for the Advancement of Teaching, and the College Entrance Examination Board. ETS administers the National Assessment of Educational Progress (NAEP) under a grant from the U.S. Department of Education.

The Center for the Assessment of Educational Progress (CAEP) is a division of ETS devoted to innovative approaches to the measurement and evaluation of educational progress. The present core activity of CAEP is the administration of the National Assessment of Educational Progress. CAEP also carries out related activities, including state and international assessments and special studies such as the National Science Foundation-supported Pilot Study of Higher-Order Thinking Skills Assessment Techniques in Science and Mathematics.

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CONTENTS

Preface 5
Introduction 7
Highlights........ 10

PART I
MATHEMATICS

Chapter 1 Mathematics: The Findings 13
Chapter 2 Mathematics: Instruction and Attitudes 20
Chapter 3 Mathematics: Topics........ 26

PART II
SCIENCE

Chapter 4 Science: The Findings 35
Chapter 5 Science: Instruction and Attitudes 41
Chapter 6 Science: Topics........ 48
Chapter 7 Personal Learning Environments 54

PART III
CONTEXT AND COMMENTARY

British Columbia 62
Ireland........ 64
Korea........ 66
New Brunswick........ 68
Ontario 70
Quebec 72
Spain 74
United Kingdom 76
United States........ 78

Summary and Conclusions 80
Procedural Appendix........ 82
Data Appendix 90
Acknowledgements 94

FOREWORD

An important part of the mission of Educational Testing Service (ETS) is improving the measurement of educational achievement. Since its creation more than 40 years ago, ETS has invited scholars from all over the world to share the results of our research, to learn about our experiments with new measurement technology, and to contribute their critiques, suggestions, and ideas to our endeavors Distinguished guests from many countries have graced our Princeton campus every year since 1947 and have become our colleagues.

The first International Assessment of Educational Progress, reported in the pages that follow, takes this partnership one step further. We have proceeded from the research laboratory and the classroom to the demonstration project. Working with colleagues from five other countries, ETS's measurement specialists have translated and adapted the techniques perfected in the United States by the National Assessment of Educational Progress (NAEP), and together they have conducted mini-assessments in five different countries. Achievement results that permit comparisons and present valid and reliable findings are contained in this report.

The greater benefit in the minds of many, however, has been the opportunity each participating country has had to experiment with new measurement practices.

The cost-effectiveness of sampling techniques, the power and the limitations of Item Response Theory, and the usefulness of new reporting techniques have all been demonstrated, and their value in these various environments can now be judged more clearly. Experts in each of these countries have had hands-on experiences with the problems and the potential of these new assessment techniques.

ETS staff have benefited greatly from this experience and have been stimulated by the enthusiasm and the ideas of our international collaborators. We hope that this exercise has contributed in some small way to the broader understanding of how effective measurement can help to improve educational opportunity for all children.

Gregory R. Anrig
President
Educational Testing Service

INTRODUCTION

The title of this report, *A World of Differences*, suggests that from one culture to another, differing average levels of student achievement reflect differing aspirations with regard to education. Each culture has its idiosyncratic set of values and goes through cycles in which certain aspects of its schools' curricula are considered more important than others. Some societies expect educational institutions to achieve a whole range of goals having to do with physical and social as well as educational development, while others confine their focus to a narrower set of learning tasks. Within each society, educators establish specific objectives for what is taught and define a sequence for instruction; these factors differ from place to place. This variation is understandable and reasonable and underscores the folly of viewing comparative achievement results as an olympiad with narrowly defined rules and criteria.

In truth, the only justification for the disruption of student and professional lives caused by an international assessment is the improvement of learning. Results should provide teachers, school administrators, policymakers, and taxpayers with information that helps to define the characteristics of successful student performance and suggests areas for possible improvement and change. Evidence for success can be found not only in achievement results but also in student attitudes and perceptions, in teachers' instructional practices, in curricular emphases, and in societal values as expressed by a culture's support for education. These "educational indicators" are increasingly the focus of international research in education.[1]

Nonetheless, the competitive instincts of most modern societies typically cause them to view survey results as challenges to better performance. While most countries reasonably insist on fair and complete descriptions of elements that can explain differential performance, there remains the ambition to do better. To the extent that these ambitions are tempered by realistic understandings of important differences in societal goals, demographic characteristics, educational systems, and economic resources, they can be positive forces for building bridges to improved educational performance.

The International Association for the Evaluation of Educational Achievement (IEA) has demonstrated the value of comparative educational data in several previous studies.[2] IEA studies often involve 15 to 25 different countries, some with considerable expertise in measurement and statistics and others without. They start with an extensive process for defining the content-area domain, develop new test questions, and often span eight to ten years from start to finish.

[1]Organization for Economic Cooperation and Development, "International Educational Indicators: A Working Plan," April, 1988.

[2]Recent IEA mathematics and science studies are reported in International Association for the Evaluation of Educational Achievement, *The Underachieving Curriculum: Assessing U.S. School Mathematics from an International Perspective*, Stipes Publishing Company, Champaign, Illinois, 1987 and International Association for the Evaluation of Educational Achievement, *Science Achievement in Seventeen Countries: A Preliminary Report*, Pergamon Press, Oxford, England, 1988.

The subject of this report, the International Assessment of Educational Progress (IAEP), involved five countries and four Canadian provinces with extensive experience in large-scale assessment. The project was designed to capitalize on the content and technology of the United States' National Assessment of Educational Progress (NAEP). Through the use of existing assessment questions and procedures, significant cost and time savings were possible. As the pace of change accelerates and as more countries implement educational reform, these highly efficient procedures for monitoring international progress may become increasingly useful.

About the Project

Five countries and four Canadian provinces participated in the International Assessment of Educational Progress (IAEP), and in three cases provinces assessed two separate language groups.[3] Results of 12 student populations are therefore presented in this report:

British Columbia	New Brunswick (French)	Quebec (French)
Ireland	Ontario (English)	Spain
Korea	Ontario (French)	United Kingdom[4]
New Brunswick (English)	Quebec (English)	United States

From each population, a representative sample of 13-year-olds was assessed in mathematics and science. Samples were drawn at random from about 100 different schools selected with probability proportional to their size and included about 2,000 students. In the United States, the sample size was about 1,000 students from 200 schools. A total of approximately 24,000 students was surveyed. School participation rates ranged from 70 to 100 percent, and student participation rates, from 73 to 98 percent.[5]

Students were administered a 45-minute mathematics assessment consisting of 63 questions and a 45-minute science assessment made up of 60 questions. Items were selected from the total pool of 281 mathematics and 188 science questions used in the 1986 National Assessment of Educational Progress (NAEP). Questions were translated from English to French, Korean, and Spanish and then independently translated from the non-English language back to English. The back-translated versions were compared with the original English to ensure that the translations were accurate. Questions were also adapted for cultural differences. For example, units of measurement, the names of children, and species of plants and animals were changed to reflect local usage and environments. Students also answered questions about their school experiences and attitudes toward mathematics and science, and their teachers rated students' exposure to the concepts tested by the items.

[3]Canada does not have a federal system of education.

[4]The United Kingdom sample was drawn from students in England, Scotland, and Wales.

[5]See Procedural Appendix, p. 84-85.

A Word About Comparisons

The cliché has it that "comparisons are odious." They are also very difficult to make fairly and accurately, especially when human behavior is involved. Nonetheless, if rigorous procedures are followed and if the limitations of comparisons are kept in mind, comparative studies can provide invaluable information. The consistently high interest in the results of the IEA studies has demonstrated this repeatedly.

A host of factors must be considered when comparing the achievement levels of students from different provinces or countries. This project was able to collect information on only a few of these important variables:

- ☐ At what age do children begin school and how long is the school year?
- ☐ What concepts and skills have been taught by age 13?
- ☐ What practices do teachers use in the classroom?
- ☐ What home experiences support learning?
- ☐ What are students' attitudes about mathematics and science?
- ☐ What is the value placed on education in each of the various societies?

Varying achievement levels in a subject or in one aspect of a subject can legitimately be explained by any one of these factors or a combination of them. Survey data cannot establish causal relationships, but they can provide a context for examining achievement results and suggest questions for further study by policymakers, educators, and researchers.

Even with uniform procedures and careful monitoring, the goal of complete comparability is difficult to attain. Often local conditions necessitate modifications or compromise. This project insisted on uniform sampling procedures, high participation rates, standardized administration procedures, and rigorous data-analysis protocols. Specifics of the IAEP project implementation and data analysis are presented in the Procedural Appendix and a more detailed explanation is provided in the separate IAEP *Technical Report*.

HIGHLIGHTS

Mathematics

- In Korea, 78 percent of the 13-year-olds can use intermediate mathematics skills to solve two-step problems (Level 500 on a hypothetical 1,000 point scale) compared to only 40 percent of their counterparts in Ontario (French) and the United States.

- Forty percent of Korea's 13-year-old students understand measurement and geometry concepts and are successful at solving even more complex problems (Level 600). Less than 10 percent of those from Ontario (French) and the United States have the same level skills.

- Korea's 13-year-olds demonstrate the highest overall mathematics achievement, well above the mean of all participating countries and provinces. The other 11 populations cluster themselves into three lower-performing groups.

- Four countries and provinces perform above the mean: Quebec (French), British Columbia, Quebec (English), and New Brunswick (English). Achievement is about at the mean for five populations: Ontario (English), New Brunswick (French), Spain, the United Kingdom, and Ireland. Finally, below the mean are students from Ontario (French) and the United States.

- Thirteen-year-old boys and girls perform about at the same level in 10 of the 12 populations assessed. The two exceptions are Korea and Spain, in which boys outperform girls.

- Classroom instructional practices are similar in all of the countries and provinces assessed with most 13-year-olds (more than 70%) reporting that they regularly listen to teacher lectures and work mathematics problems on their own. Fewer students (less than one-third) report working in small groups on a regular basis.

- Despite their poor overall performance, about two-thirds of the United States' 13-year-olds feel that "they are good at mathematics." Only 23 percent of their Korean counterparts, the best achievers, share the same attitude.

- In about half of the comparisons, students perform better in various mathematics topics than their teachers' opportunity-to-learn ratings would suggest.

Science

- More than 70 percent of the 13-year-olds in British Columbia and Korea can use scientific procedures and analyze scientific data (Level 500 on a hypothetical 1,000 point scale), while only about 35 to 40 percent of their peers in the United States, Ireland, Ontario (French), and New Brunswick (French) demonstrate the same degree of competence.

- More than 30 percent of British Columbia's and Korea's students are able to apply more advanced scientific knowledge and principles (Level 600), compared to less than 10 percent of their counterparts in Ireland, Ontario (French), and New Brunswick (French).

- British Columbia's and Korea's 13-year-olds perform well above the mean on the science assessment; the other ten populations divide themselves into two distinct groups in terms of achievement.

- Half the populations perform about at the mean: the United Kingdom, Quebec (English), Ontario (English), Quebec (French), New Brunswick (English), and Spain. A second group of four, the United States, Ireland, Ontario (French), and New Brunswick (French), perform well below the mean.

- Thirteen-year-old boys outperform their female counterparts in science in all 12 populations assessed except the United Kingdom and the United States. The greatest difference was in Korea, where boys outperform girls by nearly 40 scale points.

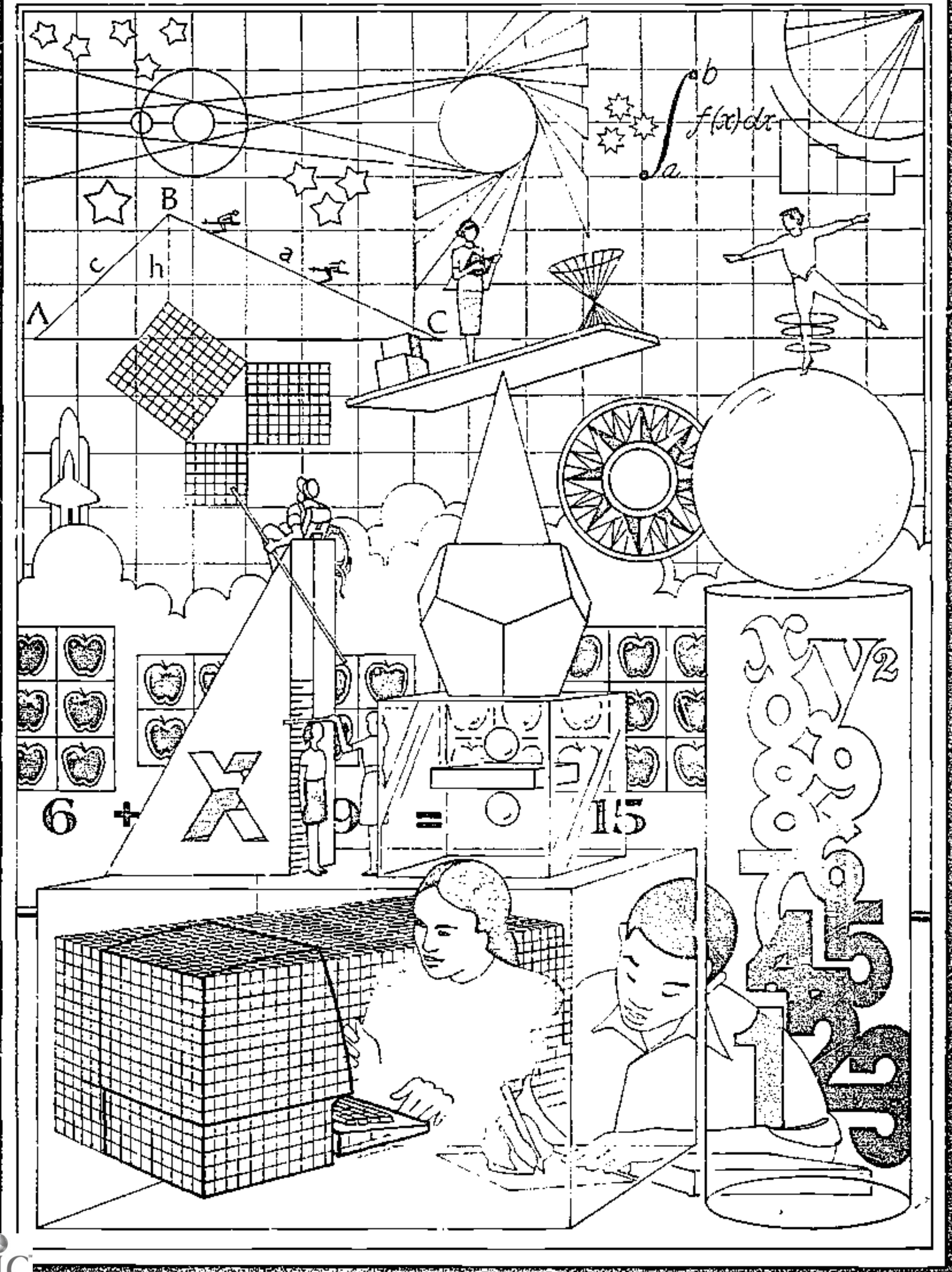
- Students in the United Kingdom report the most involvement with hands-on science experiments and those in New Brunswick (English) and the United States report the least involvement.

- In all populations except Spain, students generally perform better in science topics than their teachers' opportunity-to-learn ratings would suggest.

General

- In all countries and provinces assessed, the greater the amount of time spent watching television, the poorer student performance is in both mathematics and science. Survey data do not address cause and effect.

- Except in Spain and Ireland, more than 50 percent of the 13-year-olds report spending one hour or less each day doing homework assignments for all of their school subjects combined. The norm for Spanish and Irish students is two or more hours per day.


B
c
h
a
A
C
f(x)dx
6 + x
= 15
xy2

PART 1

MATHEMATICS

CHAPTER ONE

Mathematics: The Findings

Average Mathematics Proficiency

Overall performance on the mathematics questions is summarized as an average proficiency score for each of the 12 populations assessed (FIGURE 1.1). This score is expressed on a hypothetical scale that ranges from 0 to 1,000, with a mean of 500 and a standard deviation of 100.[6]

Korea's 13-year-olds achieved the highest average mathematics proficiency score, 568, well above the mean of 500. The other 11 student populations clustered themselves into three lower-performing groups.[7]

Quebec (French), British Columbia, Quebec (English), and New Brunswick (English) all performed above the overall average. Ontario (English), New Brunswick (French), Spain, the United Kingdom, and Ireland performed about at the mean for all populations. The lowest achievement was found in Ontario (French) and the United States, both with averages below the mean.

[6]The mathematics proficiency scale was developed using item response theory. One of the 63 mathematics questions was excluded from the scale because its pattern of performance varied considerably across populations. The reference group for the mean and standard deviation is the estimated total number of 13-year-olds across all 12 populations (about 5,384,000 students). More than 99 percent of the students' scores fall within the range of 200 to 800. See the Procedural Appendix and the IAEP *Technical Report* for a discussion of scale construction and differential item functioning.

[7]Comparisons of levels of proficiency among the 12 populations were conducted using a generalized Tamhane's multiple-comparison procedure for means with unequal variances. Ajit C. Tamhane, "A Comparison of Procedures of Means with Unequal Variances", *Journal of the American Statistical Association*, 1979, 74, pp 471-480.

FIGURE 1.1

Average Mathematics Proficiency, Age 13*

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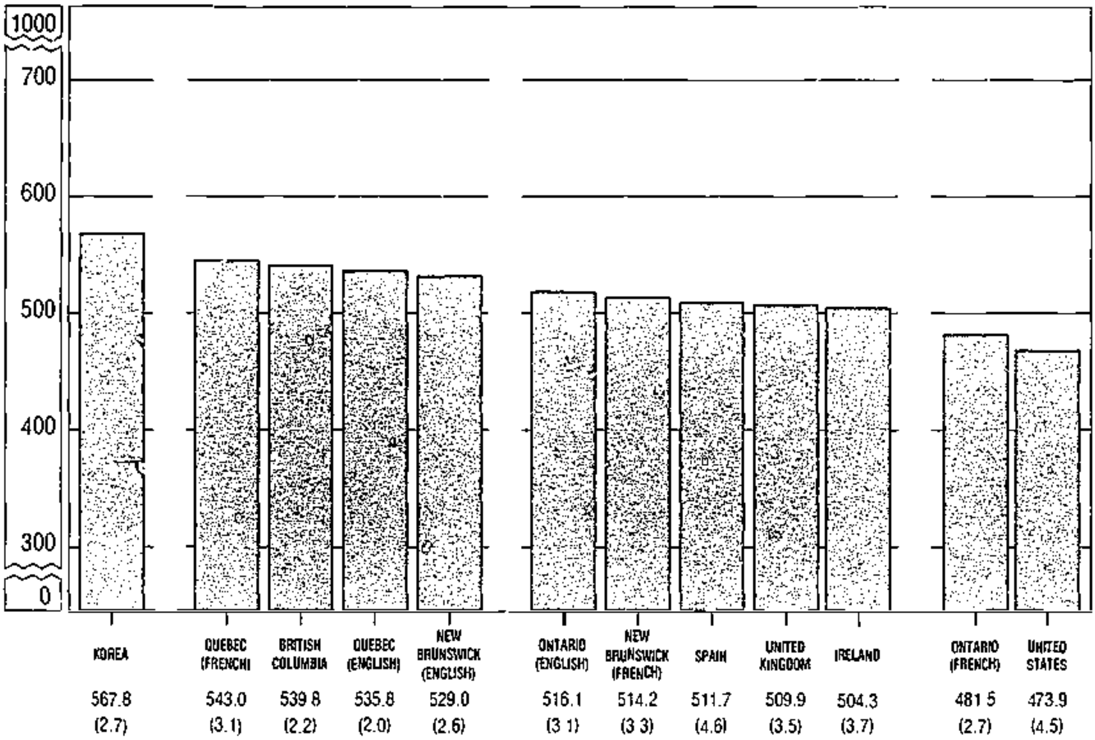
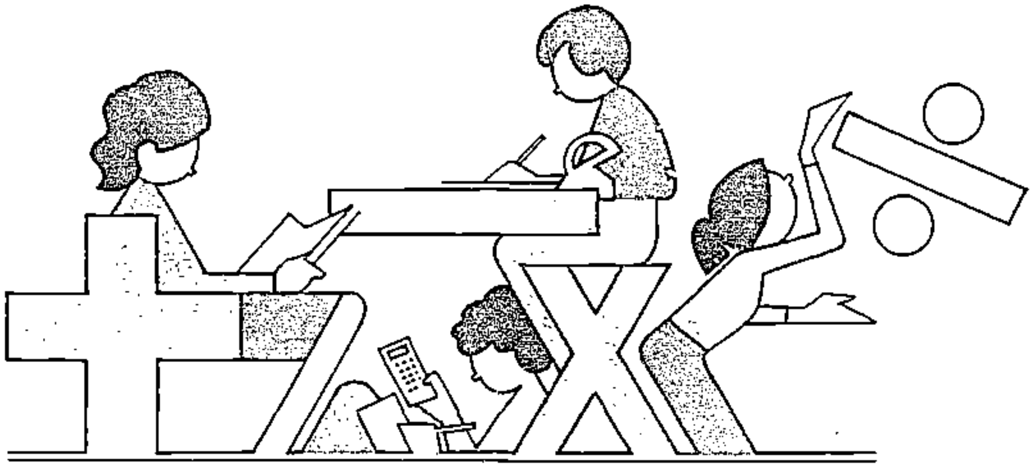


* Differences in performance between the four groups are statistically significant at the .05 level; differences in performance within groups are not statistically significant. Jackknifed standard errors are presented in parentheses.

Differences among the four groups are statistically significant; that is, there is a very low probability (less than 5 percent) that the observed differences are caused by uncertainties associated with sampling. These differences can be taken as real. However, within each of these groups, the differences in performance are not great enough to be significant. The average proficiencies for populations within each of the four groups are essentially equal.

Every statistic computed for this report carries its own error of estimation or standard error, usually expressed as plus or minus a specified number. This indicates that there is a 68 percent chance that the true value is within the range of the number plus or minus one standard error, and a 95 percent chance that it is within the number plus or minus two standard errors. In this report, the standard error is either represented graphically, written within parentheses next to or below each statistic, or the range is specified.



The IAEP Mathematics Proficiency Scale

When examining achievement results, the reader is always left with the question, "Is this good enough or should more be expected?" In an attempt to make the mathematics assessment results more meaningful, the project has defined five points along the mathematics proficiency scale—300, 400, 500, 600, 700—in terms of what students *know* or *can do* if they perform at that level. These "anchor" points or levels are also illustrated by sample questions chosen from the assessment to represent the kinds of tasks students at each level typically can address successfully.

With anchored proficiency scales, it is possible, for example, to inform the public that 85 percent of the 13-year-olds in a country or province can successfully carry out basic arithmetic operations, while only 40 percent can solve two-step problems. With this kind of information, educators and policymakers can make judgments about the adequacy of the mathematics skills of their young people, who face the demands of an increasingly technological and competitive world. Governments concerned about quality-of-life issues or the development of a nation's human resources can also interpret such findings in light of social or economic plans.

Anchor points along a performance scale can also be used as targets or goals for schools as they plan their programs for the future. Policymakers can consider, for example:

- ☐ What percentage of their 13-year-olds should be able to use basic operations and solve simple problems (i.e., achieve at Level 400)?

- ☐ What percentage should be able to understand measurement and geometry concepts and solve more complex problems (i.e., master the skills at Level 600)?

FIGURE 1.2 describes five levels of the IAEP mathematics scale and presents sample questions taken from the assessment.

FIGURE 1.2

Levels of Mathematics Proficiency

IAEP '88

LEVEL 300 Perform Simple Addition and Subtraction

Students at this level can add and subtract two-digit numbers without regrouping and solve simple number sentences involving these operations.

LEVEL 400 Use Basic Operations to Solve Simple Problems

Students at this level can select appropriate basic operations (addition, subtraction, multiplication, and division) needed to solve simple one-step problems. They are capable of evaluating simple expressions by substitution and solving number sentences. They can locate numbers on a number line and understand the most basic concepts of logic, percent, estimation, and geometry.

LEVEL 500 Use Intermediate Level Mathematics Skills to Solve Two-Step Problems

Students at this level show growth in all mathematics topics in the assessment. They demonstrate an understanding of the concept of order, place value, and the meaning of remainder in division, they know some properties of odd and even numbers and of zero; and they can apply elementary concepts of ratio and proportion. They can use negative and decimal numbers; make simple conversions involving fractions, decimals, and percents; and can compute averages. Students can use these skills to solve problems requiring two or more steps and can represent unknown quantities with expressions involving variables. Students can measure length, apply scales, identify geometric figures, calculate areas of rectangles, and are able to use information obtained from charts, graphs, and tables.

LEVEL 600 Understand Measurement and Geometry Concepts and Solve More Complex Problems

Students at this level know how to multiply fractions and decimals and are able to use a range of procedures to solve more complex problems. Students demonstrate an increased understanding of measurement and geometry concepts. They can measure angles found in simple figures, understand various characteristics of circles and triangles, can find perimeters and areas, and calculate and compare volumes of rectangular solids. Students are also able to recognize and extend number patterns.

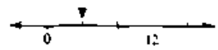
LEVEL 700 Understand and Apply More Advanced Mathematical Concepts

Students at this level have the ability to deal with properties of the arithmetic mean and can use data from a complex table to solve problems. They demonstrate an increasing ability to apply school-based skills to out-of-school situations and problems.

$29 = \square + 16$

What number should go in the box to make the number sentence above TRUE?

ANSWER ____________



What number does ▼ point to?

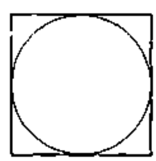
- ○ 1
- ○ 2
- ○ 3
- ○ 4

Here are the ages of five children.

13, 8, 6, 4, 4

What is the average age of these children?

- ○ 4
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 13
- ○ I don't know



The length of a side of this square is 6. What is the radius of the circle?

○ 2 ○ 3 ○ 4 ○ 6 ○ 8 ○ 9 ○ I don't know.

NUTRITIVE VALUE OF CERTAIN FOODS

	Measure	Calories	Protein (grams)	Carbohydrates (grams)
Banana, raw	1	100	1	26
Beef hamburger	3 oz	245	21	0
Whole milk	1 cup	160	9	12
Doughnut	1	125	1	16
Eggs, boiled	2 eggs	160	13	1

According to the table, what is the total amount of protein contained in two boiled eggs and one-half cup of whole milk?

ANSWER ____________

The Power of the Scale

Overall averages or means often mask important distinctions. Examining the percentages of the student populations achieving at or above each of the five descriptive scale points permits a consideration of more useful information. Many 13-year-olds are within one or two years of completing their study of mathematics. While it can be comforting to learn that almost 100 percent of a country's 13-year-olds have mastered basic addition and subtraction skills, it may be of concern that only 40 percent can use fractions, decimals, and percents. since the 60 percent of students who have not yet developed these skills may experience difficulty with secondary-school mathematics and, if their competence is not increased, may face serious problems dealing with the everyday quantitative problems that confront modern adults.

The results displayed in TABLE 1.1 detail the differences in performance among the various countries and provinces at each proficiency level.

All of the countries involved in the assessment share common goals for an improved quality of life for their citizens and for successful economic achievements in the world arena. Each society is experiencing rapid technological change that often translates into the need for employees who are better trained in mathematics and science. The 13-year-

TABLE 1.1

Percentages Performing At or Above Each Level of the Mathematics Scale, Age 13*

ETS IAEP '88

LEVEL ▷	Add and Subtract 300	Simple Problems 400	Two-Step Problems 500	Understand Concepts 600	Interpret Data 700
Korea	100	95	78	40	5
Quebec (French)	100	97	73	22	2
British Columbia	100	95	69	24	2
Quebec (English)	100	97	67	20	1
New Brunswick (English)	100	95	65	18	1
Ontario (English)	99	92	58	16	1
New Brunswick (French)	100	95	58	12	<1
Spain	99	91	57	14	1
United Kingdom	98	87	55	18	2
Ireland	98	86	55	14	<1
Ontario (French)	99	85	40	7	0
United States	97	78	40	9	1

*Jackknifed standard errors for percentages range from less than .1 to 2.4 and are provided in the Data Appendix.

olds of 1988 will be the 18-year-old workers of 1993—a not very distant future. If more than 75 percent of the 13-year-olds in a country are competent in intermediate mathematics skills, does that country have a significant social or economic advantage over a country in which only 40 percent of this age group has attained this proficiency level?

From another perspective, school administrators may need to question whether poor performance of 13-year-olds reflects a generally inadequate program or simply a situation in which concepts have not yet been taught because of the sequence of the curriculum. Performance results may signal the need to reconsider specific syllabi or broad educational standards.

The mathematics results illustrated in TABLE 1.1 demonstrate major differences in the percentages of 13-year-olds in various countries and provinces who have mastered different skill levels. Ninety-five percent or more of the students in Korea, Quebec (French), British Columbia, Quebec (English), New Brunswick (English), and New Brunswick (French) can use basic operations to solve simple problems (Level 400) compared to only 78 percent of their peers in the United States. Between 85 and 92 percent of the students from the other five populations demonstrate these same Level 400 skills.

Seventy-eight percent of Korean 13-year-olds can use intermediate skills to solve two-step problems (Level 500). In contrast, only 40 percent of their age-mates in Ontario (French) and the United States are able to achieve at that level or higher. The percentages of students in the other populations at Level 500 or above range from 55 to 73.

An impressive four out of 10 of Korea's 13-year-olds understand measurement and geometry concepts and can apply a range of problem-solving strategies to more complex problems (Level 600). Two out of 10 of British Columbia's and Quebec's (French and English) students did as well compared to fewer than one out of 10 of their peers from Ontario (French) and the United States.

The variation in performance among the countries and provinces is considerable at Level 500, reflecting a spread of 38 points between the highest and lowest percentages of students achieving at this level or above. At Level 400, there is a 19 point difference, and at Level 600, a 33 point discrepancy. These results suggest that in many countries there is a great deal of room for improvement in the way students are prepared for secondary school, especially with respect to those intermediate mathematics skills that are usually the focus of study in the middle-school years.

The Gender Gap

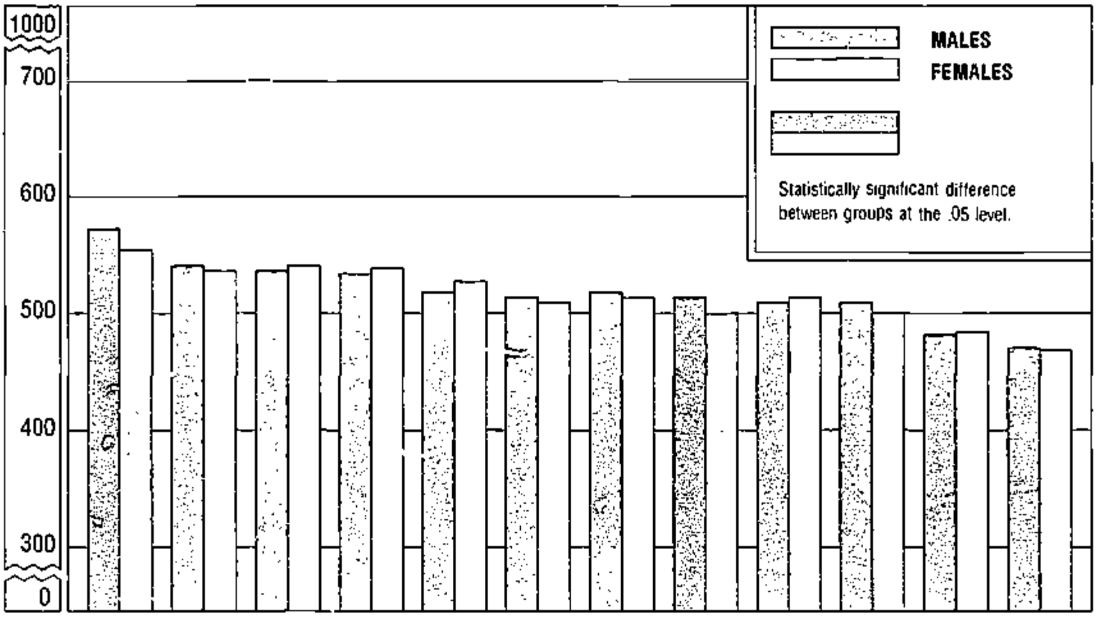
Many educational research studies have found performance differences between teenage boys and girls in mathematics.[8] The findings of this International Assessment of Educational Progress suggest a different picture, with 13-year-old boys and girls performing about at the same level in 10 of the 12 populations assessed (FIGURE 1.3). Only in Korea and Spain do boys at this age achieve significantly higher in mathematics than do girls.

[8] John A. Dossey, Ina V.S. Mullis, Mary M. Lindquist, and Donald L. Chambers. *The Mathematics Report Card: Are We Measuring Up? Trends and Achievement Based on the 1986 National Assessment.* National Assessment of Educational Progress, Educational Testing Service, 1988.

FIGURE 1.3

Average Mathematics Proficiency by Gender, Age 13*

IAEP '88



	KOREA	QUEBEC (FRENCH)	BRITISH COLUMBIA	QUEBEC (ENGLISH)	NEW BRUNSWICK (ENGLISH)†	ONTARIO (ENGLISH)	NEW BRUNSWICK (FRENCH)	SPAIN	UNITED KINGDOM	IRELAND	ONTARIO (FRENCH)	UNITED STATES
MALE	576.7 (3.4)	546.3 (4.2)	539.6 (2.8)	534.1 (3.0)	526.6 (4.3)	517.8 (4.4)	516.8 (4.2)	523.2 (5.3)	507.0 (5.0)	508.2 (5.7)	480.6 (3.4)	474.6 (6.4)
FEMALE	558.0 (3.9)	539.3 (3.0)	541.3 (2.6)	537.3 (2.[illegible])	529.0 (3.4)	514.6 (3.3)	513.4 (3.6)	499.9 (5.0)	512.5 (3.9)	499.6 (3.4)	482.7 (3.0)	473.2 (5.1)

* Jackknifed standard errors are presented in parentheses.

† Background data are missing from 31% of the New Brunswick (English) students. The resultant effect on the differences between groups for this particular province is estimated to be less than one standard error.

Where Do We Stand? Are the Results Good Enough?

Clearly both questions are appropriate and equally important in every country and province. The first one may have greater political significance, but answers to the second address the qualitative issues that permit policymakers and citizens to make informed choices about priorities that will affect their futures.

Thirteen-year-olds who have mastered the skills reflected in the descriptions of Levels 600 and 700 probably represent the pool from which most of tomorrow's mathematicians, engineers, and scientists will emerge. Do these results predict that certain populations will be responsible for a majority of the important achievements in these fields during the 21st century? Obviously, the answer to this question depends on the opportunities presented in each society and the support available to young people in each country to pursue and develop their interests.

PART I

MATHEMATICS

CHAPTER TWO

Mathematics: Instruction and Attitudes

The information gathered from students about their attitudes toward mathematics, how they spend their time in class, and the amount of homework they do after school is instructive. It is also confusing. Groups of students who do very well share attitudes and learning experiences with other populations who perform much less well on the assessment. For example, most students (more than 70%), whether they score high or low, think mathematics is useful in solving everyday problems, and listen to their teacher explain a mathematics lesson several times a week or more. Students from the best-performing population report doing more mathematics homework than is typical, as do students from one of the average-performing populations.[9]

Learning Mathematics

Classroom Activities. This study asked students a series of questions concerning their mathematics classroom activities, and TABLE 2.1 presents some of the highlights. Entries reflect percentages of students reporting frequent classroom activity, "almost every day" or "several times a week," of the types described. Other options provided to students were "once a week," "less than once a week," and "never." The frequency of these activities is not consistently related (positively or negatively) to achievement among these groups, so the performance data are not presented. For example, in some populations high performance is associated with listening to the teacher explain a mathematics lesson several times a week or more. In other populations high performance is associated with listening to the teacher only once a week, and in still others the high performers are those who report listening to the teacher less than once a week.

[9]In reading this chapter, note that background data are missing from 31% of the New Brunswick (English) students. The resultant effect on the differences among groups for this particular Province is estimated to be less than one standard error.

TABLE 2.1

Percentages Reporting High Frequency of Mathematics Classroom Activities, Age 13*

IAEP '88

	Listen to the teacher explain a mathematics lesson	Work mathematics problems alone	Work mathematics problems in small groups	Get individual help from teacher on your mathematics	Get help in mathematics from a classmate	Help a classmate do mathematics
Korea	71 (1.4)	76 (1.1)	18 (1.4)	6 (0.6)	38 (1.3)	33 (1.3)
Quebec (French)	97 (0.4)	89 (0.8)	16 (1.0)	24 (1.1)	17 (0.9)	21 (0.8)
British Columbia	94 (0.6)	90 (0.7)	15 (1.0)	24 (0.9)	35 (1.1)	46 (1.1)
Quebec (English)	94 (0.7)	90 (0.7)	13 (0.8)	23 (1.1)	27 (0.9)	46 (1.2)
New Brunswick (English)	93 (0.7)	91 (0.7)	11 (1.0)	21 (1.5)	28 (1.3)	39 (1.4)
Ontario (English)	95 (0.6)	86 (1.0)	17 (1.2)	20 (1.2)	32 (1.4)	46 (1.5)
New Brunswick (French)	97 (0.5)	93 (0.6)	17 (1.6)	28 (1.6)	22 (1.8)	28 (1.7)
Spain	98 (0.4)	93 (0.8)	31 (1.7)	28 (1.5)	33 (1.3)	53 (1.7)
United Kingdom	76 (1.9)	78 (0.8)	14 (0.9)	31 (1.5)	31 (1.2)	40 (1.2)
Ireland	96 (0.5)	80 (0.9)	17 (1.3)	19 (1.1)	15 (0.8)	27 (1.4)
Ontario (French)	96 (0.5)	84 (1.1)	22 (1.3)	19 (1.0)	30 (1.4)	34 (1.4)
United States	93 (1.0)	92 (0.9)	20 (1.7)	29 (2.1)	24 (1.6)	35 (1.4)

*Jackknifed standard errors are presented in parentheses.

The results indicate variety in instructional patterns across the populations. However, some classroom activities emerge as typical for all participants, particularly lecturing and seatwork. Most 13-year-olds (more than 70%) in all countries and provinces report that they regularly listen to teacher lectures and work mathematics problems on their own. Except in Spain, less than one-quarter of the students report working in small groups on a regular basis, a technique thought to improve performance and strongly recommended by many mathematics educators. About a third of the Spanish students say they work in small groups at least several times a week.

A very small percentage of Korean students (6%) report getting individual help from their teacher several times a week or more, probably a reflection of class sizes of 40 to 55 students. Indeed, less than a third of the students in any country or province say they regularly get individual help from their teachers.

In 8 of the 12 populations, between 25 and 40 percent of the students report that they interact with their peers at least several times a week, seeking assistance with their mathematics assignments. In the remaining four groups, less than one-fourth do so regularly. Offering to help a classmate with mathematics is reported as a common practice by about 40 to 55 percent of the students in six countries or provinces, while in the six other groups, between 20 and 35 percent report doing so regularly.

Homework. In addition to classroom activities, students all over the world reinforce their learning by doing homework assignments. Students in participating countries and provinces differ in the amount of homework they do (TABLE 2.2). Thirteen-year-olds from most groups do not spend much time on homework. Except in Korea and Spain, between 40 and 65 percent of the students report doing less than one hour of mathematics homework each week. Time spent on mathematics homework is only slightly higher for Korean and Spanish children. Forty-five percent of the Korean students and 37 percent of the Spanish students say they do one to two hours of homework in this subject weekly.

TABLE 2.2

Percentages Reporting Amounts of Weekly Mathematics Homework, Age 13*

ETS IAEP '88

	Less than 1 hour	1 to 2 hours	3 or more hours
Korea	32 (1.3)	45 (1.3)	23 (1.4)
Quebec (French)	44 (1.7)	36 (1.2)	20 (1.3)
British Columbia	44 (1.4)	36 (1.0)	21 (1.1)
Quebec (English)	43 (1.2)	35 (1.1)	23 (1.1)
New Brunswick (English)	49 (1.6)	31 (1.3)	20 (0.9)
Ontario (English)	43 (1.3)	37 (1.1)	20 (1.1)
New Brunswick (French)	44 (1.8)	30 (1.4)	26 (1.6)
Spain	35 (1.8)	37 (1.2)	28 (1.6)
United Kingdom	56 (1.5)	38 (1.2)	6 (0.6)
Ireland	64 (1.4)	23 (1.0)	14 (1.0)
Ontario (French)	55 (1.4)	29 (1.1)	16 (1.4)
United States	62 (1.8)	28 (1.5)	11 (1.4)

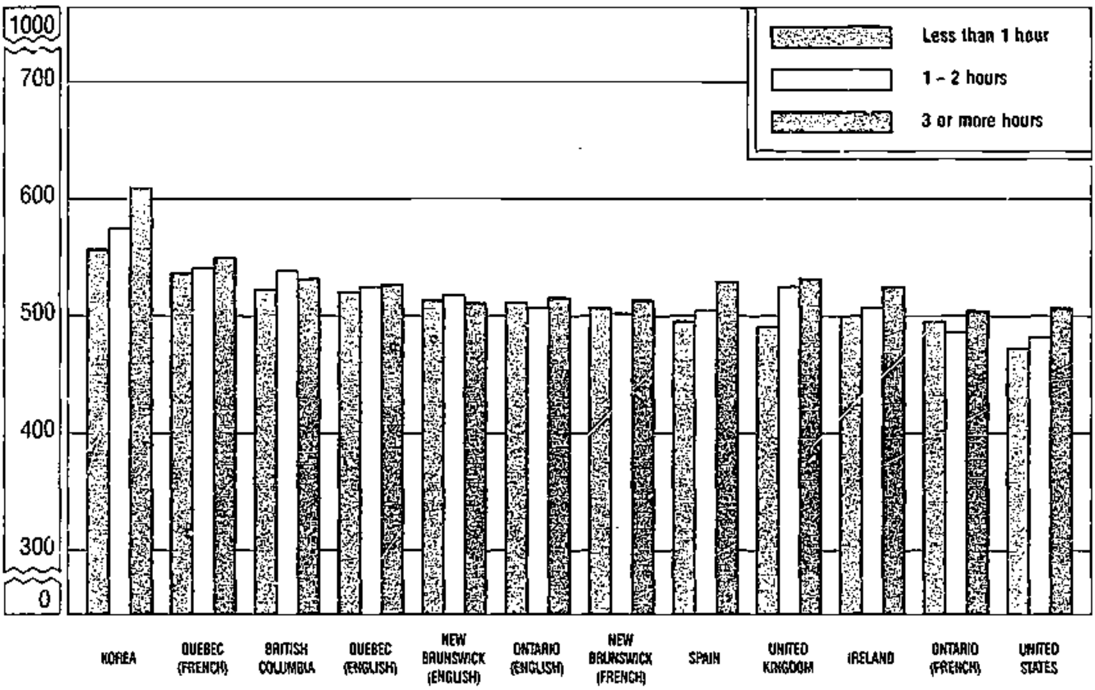
*Jackknifed standard errors are presented in parentheses. Percentages do not always sum to 100 due to rounding.

The results in FIGURE 2.1 show that for some countries and provinces, including Korea and Spain, increased time spent on mathematics homework is positively associated with higher mathematics achievement and for some groups it is not. This inconsistency is not surprising, considering the many purposes for which homework is used. In some cases equal amounts of homework are assigned to all students; in others homework is emphasized in advanced classes. In still others, extra homework is assigned to lower-achieving students in an effort to improve their performance.

FIGURE 2.1

Average Proficiency by Reported Amounts of Weekly Mathematics Homework, Age 13*

IAEP '88



* Jackknifed standard errors for proficiencies range from 3.0 to 10.8 and are provided in the Data Appendix.

Attitudes Toward Mathematics

Students were also asked about their attitudes toward mathematics, and TABLE 2.3 presents data on the percentage of students who say they "strongly agree" or "agree" to statements about mathematics, or respond that they "like mathematics a lot" or "a little."

TABLE 2.3

Percentages Responding Positively to Mathematics Attitude Questions, Age 13*

IAEP '88

	Mathematics is useful in solving everyday problems.	Mathematics is more for boys than for girls.	I am good at mathematics.	I like mathematics a little or a lot.
Korea	87 (0.7)	23 (0.9)	23 (1.1)	72 (1.2)
Quebec (French)	78 (1.0)	38 (1.1)	58 (1.2)	83 (1.0)
British Columbia	76 (1.0)	3 (0.4)	57 (1.0)	64 (1.0)
Quebec (English)	78 (0.9)	3 (0.3)	65 (1.0)	69 (1.4)
New Brunswick (English)	78 (1.0)	3 (0.4)	62 (1.6)	71 (1.5)
Ontario (English)	84 (0.9)	3 (0.5)	66 (1.4)	74 (1.1)
New Brunswick (French)	79 (1.4)	35 (1.5)	59 (1.3)	81 (1.3)
Spain	85 (1.1)	6 (0.7)	60 (1.6)	68 (1.5)
United Kingdom	80 (0.9)	4 (0.4)	47 (1.3)	80 (1.0)
Ireland	80 (0.8)	7 (0.7)	49 (1.2)	77 (1.0)
Ontario (French)	82 (0.9)	39 (1.2)	63 (1.2)	82 (0.9)
United States	76 (1.8)	6 (1.1)	68 (1.1)	72 (1.3)

*Jackknifed standard errors are presented in parentheses.

Most students (more than 75%) in all participating countries and provinces agree that mathematics is useful in solving everyday problems, suggesting that its importance and utility are widely accepted.

More than one-third of the students in the three French-speaking populations, and to a lesser degree the Korean students, agree that mathematics is more for boys than for girls. However, the translation of this question into French may have projected a more abstract concept, literally "mathematics is more *appropriate* for boys than for girls," and this may account for the differential responses of the French-speaking students. Moreover, this attitude is not reflected in differences in performance of males and females in these populations (see FIGURE 1.3).

About two-thirds of United States' 13-year-olds feel they "are good at mathematics" despite their poor overall performance, while only 23 percent of the Korean students, the best performers, have that same attitude. Nevertheless, students in all groups who give a positive response to this statement are higher mathematics performers than those who give a negative response. About 65 to 85 percent of the students from all surveyed countries and provinces indicate they "like mathematics" and these students are higher achievers than those who indicate that they do not like mathematics.

What Does It All Mean?

It would be comforting to point to two or three instructional strategies or student attitudes that are clearly related to success. However, the lack of consistency in this type of data is understandable, because of cultural and curricular differences as well as the difficulty of isolating factors that are clearly associated with mathematics performance. Seeking help from a teacher or classmate may be encouraged in certain environments and impossible in others. The amount of homework may reflect the diligence of a good student or the penalty for poor classroom performance. Cultural practices may affect the answer to the question, "Are you good at mathematics?" For example, Korea's researchers suggested it would be against their tradition of humility for many of their students to answer "yes" to this question.

Nonetheless, if these data arouse teachers' curiosity about their own practices or about the attitudes and perceptions of their students, positive change can and probably will occur. Even at this modest level, these findings may provide important clues to the eventual solutions of some of education's persistent problems.

PART I
MATHEMATICS

CHAPTER THREE
Mathematics: Topics

The sequence in which topics are presented and studied in each educational system is usually governed by a published or generally accepted syllabus or course of study. Guidelines are often established by committees of teachers and subject-matter experts, periodically revised as research and experience suggest improvements, and usually codified in textbooks and teachers' guides. These materials typically describe objectives, define sequences of topics to be presented, and often detail the relative emphasis to be applied to one content area as compared to another. These syllabi represent what is often referred to as the "intended curriculum" as different from either the "implemented" or the "achieved" curriculum.

The curriculum is "implemented" at the school and classroom level. This is where principals and teachers identify priorities for instruction, employ specific instructional materials, and use their own preferred teaching strategies. These local choices may restrict or expand students' opportunities to learn various content areas. A measure of the students' opportunity to learn is often obtained from teachers, who indicate whether or not their students have been taught the concepts tested by a particular question in an achievement test.

The third level of the curriculum is the "attained" curriculum. This refers to the knowledge and skills that actually have been learned by the students. How well the students do on achievement tests usually serves as a measure of the attained curriculum.

Two measures of curriculum are reported in this chapter. First, achievement results (the attained curriculum) are reported for six mathematics topics. Second, teachers' ratings of students' opportunity to learn the concepts tested by the items (the implemented curriculum) are presented for the same content areas. Information on the intended curriculum is presented in Part III in separate descriptions of the cultural and educational contexts of each participating country and province.

The 62 mathematics questions included in the final analyses of the IAEP were divided into six topics, as indicated in TABLE 3.1.[10] In the results that follow, achievement within each of these areas is described as the average percent of correct answers for the questions that measure the topic.[11] The proficiency scale used in the previous chapter summarizes overall performance in mathematics. The average percents correct describe achievement in content areas that are often included in the mathematics curriculum. Within each topic there are items that reflect many different levels of proficiency from low to high.

Unlike the scale scores reported earlier, average percents correct are influenced by the difficulty of the particular questions. Because of the variance in question difficulty, it is *not* appropriate to compare the level of the average percents correct in one topic, for example, Numbers and Operations, with those in another topic, for example, Geometry. Comparisons are indeed meaningful between the average percent correct of one country or province and that of another within the same content area. Because the number of questions within each category is relatively small, the results obviously do not represent a comprehensive assessment of that topic.

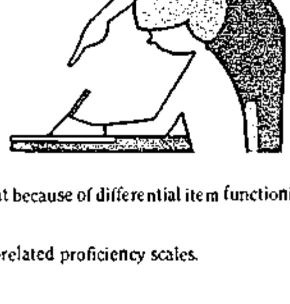
TABLE 3.1

Number of Mathematics Items by Topic*

IAEP '88

Numbers and Operations	Relations, Functions, and Algebraic Expressions	Geometry	Measurement	Data Organization and Interpretation	Logic and Problem Solving	Total
24	6	8	10	6	8	62

*In the analysis, one question was dropped from the 63-item mathematics assessment because of differential item functioning, to leave a total of 62.



[10]In the analysis, one question was dropped from the 63-item mathematics assessment because of differential item functioning, to leave a total of 62.

[11]The number of questions within each topic was insufficient for developing topic-related proficiency scales.

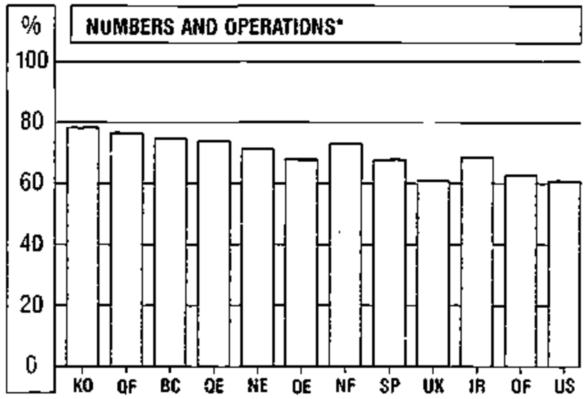
Numbers and Operations

This topic covers concepts of whole numbers, common fractions, decimal fractions, integers, and percents. Items measure addition, subtraction, multiplication, and division with these kinds of numbers as well as estimating the results of these types of computations. Properties of the number system and relationships such as place value, odd and even, the properties of zero, and ratio and proportion are also assessed by these questions.

The average percents correct for Numbers and Operations are presented in FIGURE 3.1. In general, the relative performance of countries and provinces on this topic mirrors their overall achievement in mathematics. Exceptions are apparent in the United Kingdom, where students perform less well in this topic than they do overall, and New Brunswick (French), where students perform at higher levels than they do overall.[12]

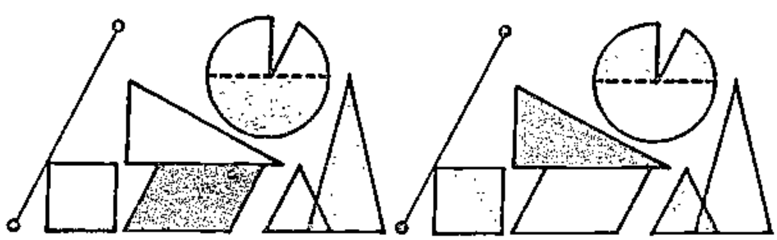
FIGURE 3.1. Average Percents Correct, Age 13

KO KOREA
QF QUEBEC (FRENCH)
BC BRITISH COLUMBIA
QE QUEBEC (ENGLISH)
NE NEW BRUNSWICK (ENGLISH)
OE ONTARIO (ENGLISH)
NF NEW BRUNSWICK (FRENCH)
SP SPAIN
UK UNITED KINGDOM
IR IRELAND
OF ONTARIO (FRENCH)
US UNITED STATES



* Jackknifed standard errors for proficiencies range from .5 to 1.0 and are provided in the Data Appendix.

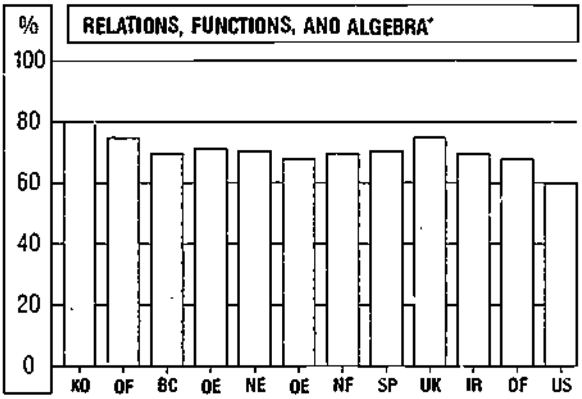
IAEP '88



[12]For these analyses of achievement by topic, populations are cited as deviating from their normal pattern if the difference between their deviation from the mean for the topic and their deviation from the overall mean is greater than twice the standard error of the difference between these deviations. This standard error was taken to be equal to the composite value of 1.35.

FIGURE 3.2
Average Percents Correct, Age 13

KO KOREA
QF QUEBEC (FRENCH)
BC BRITISH COLUMBIA
QE QUEBEC (ENGLISH)
NE NEW BRUNSWICK (ENGLISH)
OE ONTARIO (ENGLISH)
NF NEW BRUNSWICK (FRENCH)
SP SPAIN
UK UNITED KINGDOM
IR IRELAND
OF ONTARIO (FRENCH)
US UNITED STATES

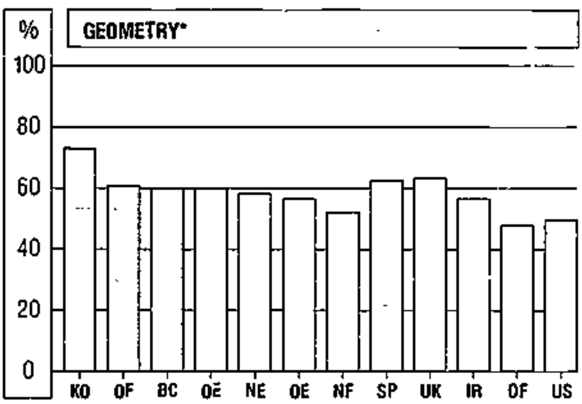


* Jackknifed standard errors for proficiencies range from .4 to 1.1 and are provided in the Data Appendix.

IAEP '88

FIGURE 3.3
Average Percents Correct, Age 13

KO KOREA
QF QUEBEC (FRENCH)
BC BRITISH COLUMBIA
QE QUEBEC (ENGLISH)
NE NEW BRUNSWICK (ENGLISH)
OE ONTARIO (ENGLISH)
NF NEW BRUNSWICK (FRENCH)
SP SPAIN
UK UNITED KINGDOM
IR IRELAND
OF ONTARIO (FRENCH)
US UNITED STATES



* Jackknifed standard errors for proficiencies range from .4 to 1.2 and are provided in the Data Appendix.

IAEP '88

Relations, Functions, and Algebraic Expressions

The tasks in this category assess the use of variables in expressions of relationships, translations from words to symbols, and use of variables to represent properties of operations and equality. Tasks involving solving equations and generalizing patterns are also included.

As seen in FIGURE 3.2, Relations, Functions, and Algebraic Expressions is a topic in which students from the United Kingdom do relatively well compared with their overall achievement. Also, performance is higher in Ontario (French) than their overall achievement and equals that of most of the populations in this study. British Columbia's students achieve less well in this topic than they do overall.

Geometry

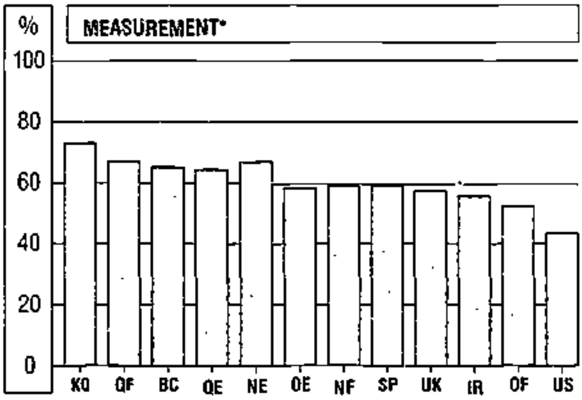
Questions in this category measure properties of and relationships among geometric figures such as circles, squares, rectangles, parallelograms, triangles, and angles. The assessment results for Geometry are presented in FIGURE 3.3. Korea, Spain, and the United Kingdom all perform relatively well in this topic compared with their performance overall. British Columbia and New Brunswick (French) students achieve at lower levels in Geometry than they do overall.

Measurement

Concepts of measurement and applications of measurement of length, area, and volume are included in this topic as well as understanding and using scales. The average percents correct for Measurement items, FIGURE 3.4, generally mirror overall achievement levels. Exceptions are New Brunswick (English), where students perform at higher levels than they do in mathematics overall, and the United States, where students perform less well than they do overall.

FIGURE 3.4
Average Percents Correct, Age 13

KO KOREA
QF QUEBEC (FRENCH)
BC BRITISH COLUMBIA
QE QUEBEC (ENGLISH)
NE NEW BRUNSWICK (ENGLISH)
OE ONTARIO (ENGLISH)
NF NEW BRUNSWICK (FRENCH)
SP SPAIN
UK UNITED KINGDOM
IR IRELAND
OF ONTARIO (FRENCH)
US UNITED STATES



* Jackknifed Standard errors for proficiencies range from .6 to 1.2 and are provided in the Data Appendix.

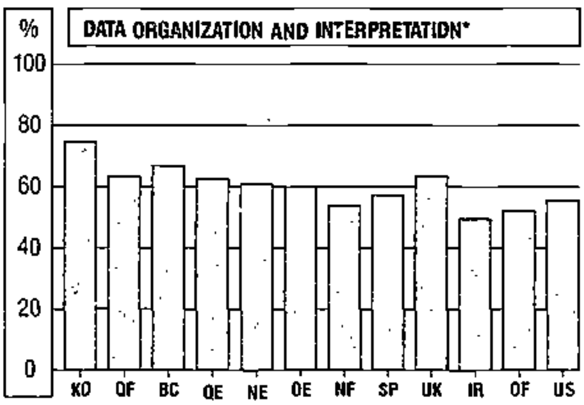
IAEP '88

Data Organization and Interpretation

Questions in this category assess organizing, analyzing, and interpreting data in tables, charts, and graphs. They also cover the concept of average. Students from Korea, the United Kingdom, and the United States perform at relatively higher levels in this topic than they do generally in mathematics. New Brunswick (French) and Irish students perform less well on these items than they do overall.

FIGURE 3.5
Average Percents Correct, Age 13

KO KOREA
QF QUEBEC (FRENCH)
BC BRITISH COLUMBIA
QE QUEBEC (ENGLISH)
NE NEW BRUNSWICK (ENGLISH)
OE ONTARIO (ENGLISH)
NF NEW BRUNSWICK (FRENCH)
SP SPAIN
UK UNITED KINGDOM
IR IRELAND
OF ONTARIO (FRENCH)
US UNITED STATES

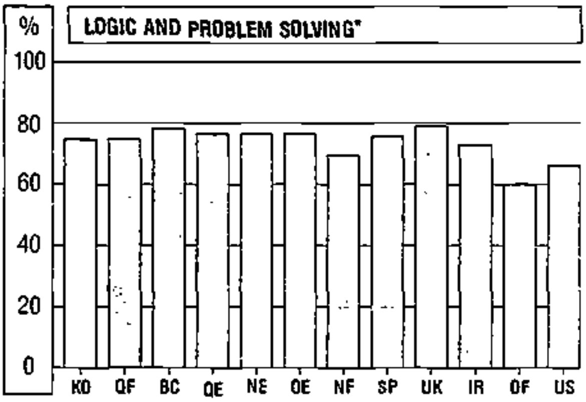


* Jackknifed standard errors for proficiencies range from .5 to 1.3 and are provided in the Data Appendix.

IAEP '88

FIGURE 3.6
Average Percents Correct, Age 13

KO KOREA
QF QUEBEC (FRENCH)
BC BRITISH COLUMBIA
QE QUEBEC (ENGLISH)
NE NEW BRUNSWICK (ENGLISH)
OE ONTARIO (ENGLISH)
NF NEW BRUNSWICK (FRENCH)
SP SPAIN
UK UNITED KINGDOM
IR IRELAND
OF ONTARIO (FRENCH)
US UNITED STATES



* Jackknifed standard errors for proficiencies range from .4 to 1.1 and are provided in the Data Appendix.

IAEP '88

Logic and Problem Solving

Questions in this topic assess an understanding of the tools of mathematics itself, those processes that are central to the extension and development of mathematics and its use. These methods cut across all mathematics content areas. Included are concepts of logic, sufficiency of data, and problem-solving strategies.

The results for this topic are presented in FIGURE 3.6. This is the one area in which Korean students are not the top performers. Quebec (French), New Brunswick (French), and Ontario (French) students also perform below their usual levels in this topic. One of the highest achieving groups is the sample of students from the United Kingdom, who score relatively well in this topic compared with their performance overall. Irish students also achieve at higher levels in Logic and Problem Solving than they do in mathematics in general.

Curricular Differences

The relative emphases on mathematics topics and the order in which they are introduced varies considerably from one country or province to another. It is likely that some of these curricular differences are reflected in these results by topic. Without further information, it is difficult to know whether relative strengths can be attributed to effective instruction, curricular emphases, or the sequence in which topics are introduced in the school curriculum.

Opportunity to Learn Mathematics by Topics

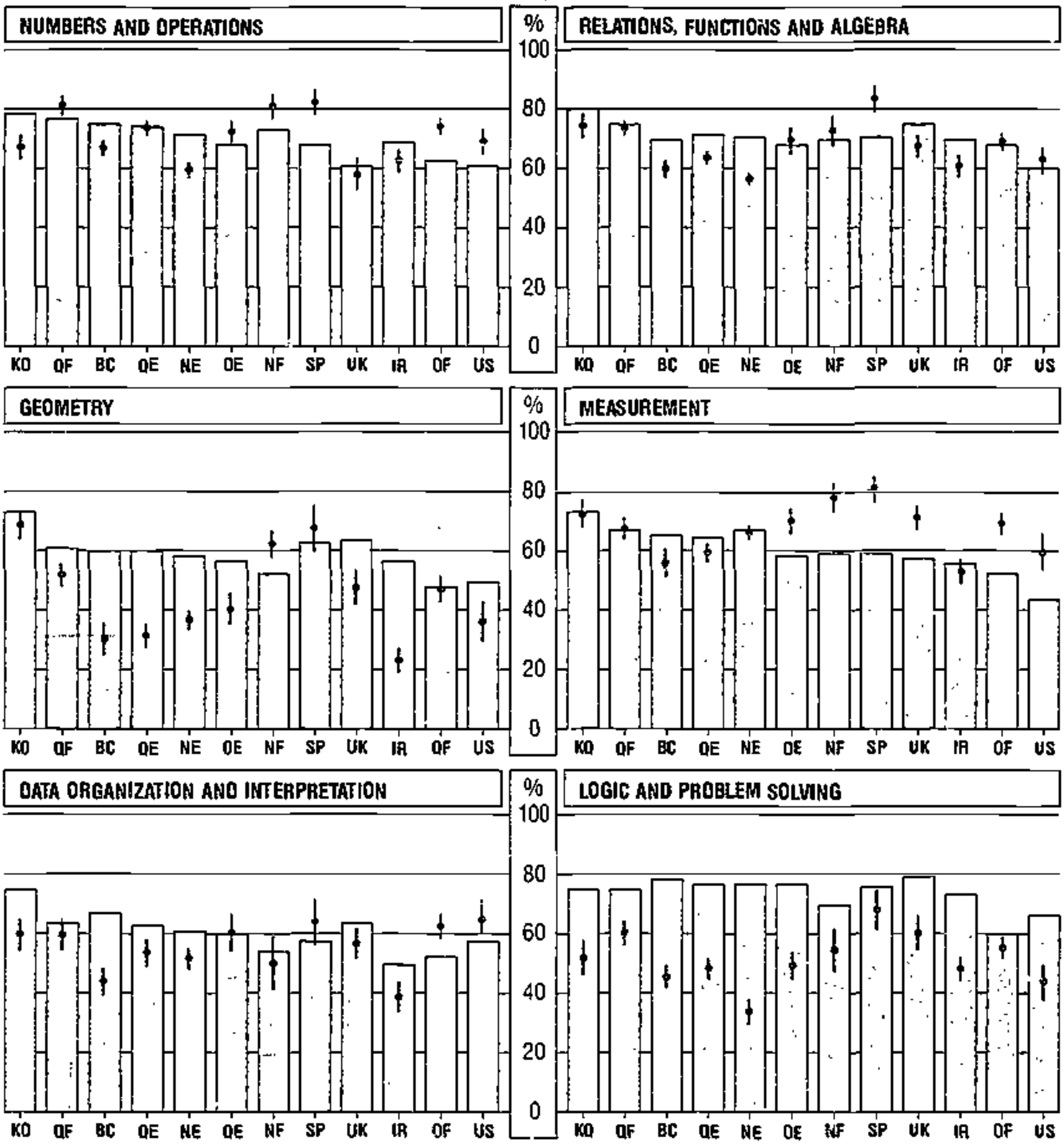
Additional information regarding differential performance is provided by a measure of students' exposure to the content tested by the IAEP mathematics items. In each participating school, a mathematics teacher or coordinator was asked to indicate the percentage of the seventh- and eighth-grade students in the school that had already had an opportunity to learn—at any time in the school programs—the concepts tested by each item in the mathematics assessment.[13] Response choices included "most (more than 75 percent)," "some (25 to 75 percent)," "few (fewer than 25 percent)," and "none."

[13] In some cases ratings were the consensus of several teachers at each grade, and in some cases more than one teacher in a grade in a school provided ratings and responses were weighted appropriately.

FIGURE 3.7

Average Percents Correct and Opportunity-to-Learn Ratings for Six Mathematics Topics, Age 13

KO KOREA
QF QUEBEC (FRENCH)
BC BRITISH COLUMBIA
QE QUEBEC (ENGLISH)
NE NEW BRUNSWICK (ENGLISH)
OE ONTARIO (ENGLISH)
NF NEW BRUNSWICK (FRENCH)
SP SPAIN
UK UNITED KINGDOM
IR IRELAND
OF ONTARIO (FRENCH)
US UNITED STATES



Average percent correct.

Average rating for opportunity to learn and 95% confidence interval. It can be said with 95% certainty that the average rating of the population is within this interval.

NOTE:
If bar terminates above the dot and confidence interval it indicates that student performance is higher than teacher estimates of student exposure to the concepts tested by the items.

IAEP '88

FIGURE 3.7 combines the achievement information on mathematics topics presented earlier with the average opportunity-to-learn ratings. The average percents correct (the bars) indicate the percentage of items in a topic that students on average have answered correctly. The average opportunity-to-learn rating (the dots) indicate the percentage of items in a topic to which students on average have been exposed. When the dot and its confidence interval are within the bar, student performance is higher than teacher estimates of student exposure to the concepts tested by the items.

In about half of the comparisons between average percents correct and opportunity-to-learn ratings, students perform better in mathematics topics than their teachers' ratings would suggest. This is true most often in Geometry and Logic and Problem Solving. Spain tends to have the highest estimates of opportunity to learn the material; however, Spanish students only score at about the overall average.

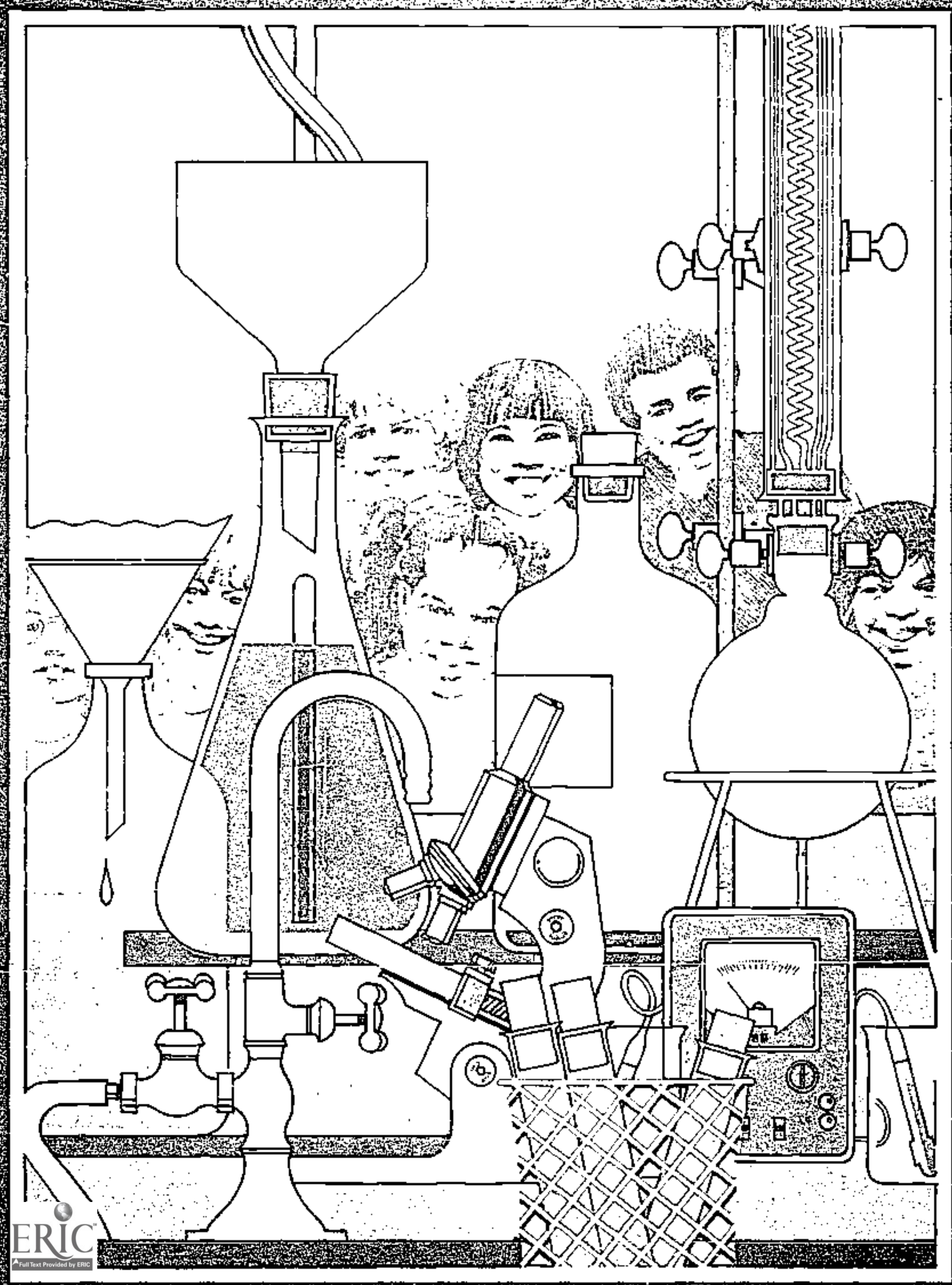
The analyses reported here focused exclusively on the results from schools in which more than 75 percent of the students had already had an opportunity to learn the content assessed. It was assumed that students in these schools had been "exposed" to the content. Ratings for grade 7 and grade 8 were weighted in proportion to the number of 13-year-olds in each of these grades. This provided an estimate of the percentage of questions to which an average 13-year-old had been exposed for each content area.[14] Specifics about this measure and its analysis are presented in the Procedural Appendix and a more detailed explanation is provided in the separate IAEP *Technical Report*.

More Evidence of International Differences

The student performance and opportunity-to-learn ratings by topic highlight the curricular differences between countries and provinces. Variation exists in what is taught and when it is taught. If decimal fractions are not taught until late in eighth grade, it is reasonable to expect poor performance on these questions by seventh and eighth graders assessed in February.

In many cases, the results of IAEP's opportunity-to-learn analyses do not follow the theoretical model that suggests students only learn what they are taught in school. However, these results are not altogether surprising. First, the ratings were global estimates at the school level, and raters may not have been fully aware of content coverage in all seventh-and eighth-grade classrooms or in the lower grades. Secondly, and perhaps more importantly, students extend their learning outside of school and can apply their knowledge to many new situations, including the IAEP mathematics tasks. Also, some aspects of mathematics, such as logical reasoning, develop as thinking matures and are not necessarily specific to the mathematics curriculum.

[14] The nonresponse rate of teachers translated into missing data for more than 10 percent of the student populations in New Brunswick (English), New Brunswick (French), Ontario (English), Ontario (French), Quebec (English), and the United States.



PART II
SCIENCE

CHAPTER FOUR
Science: The Findings

Performance on the science questions is summarized as an average science proficiency score for each of the populations assessed (FIGURE 4.1). This score is expressed by a hypothetical scale that ranges from 0 to 1,000 with a mean of 500 and a standard deviation of 100.[15]

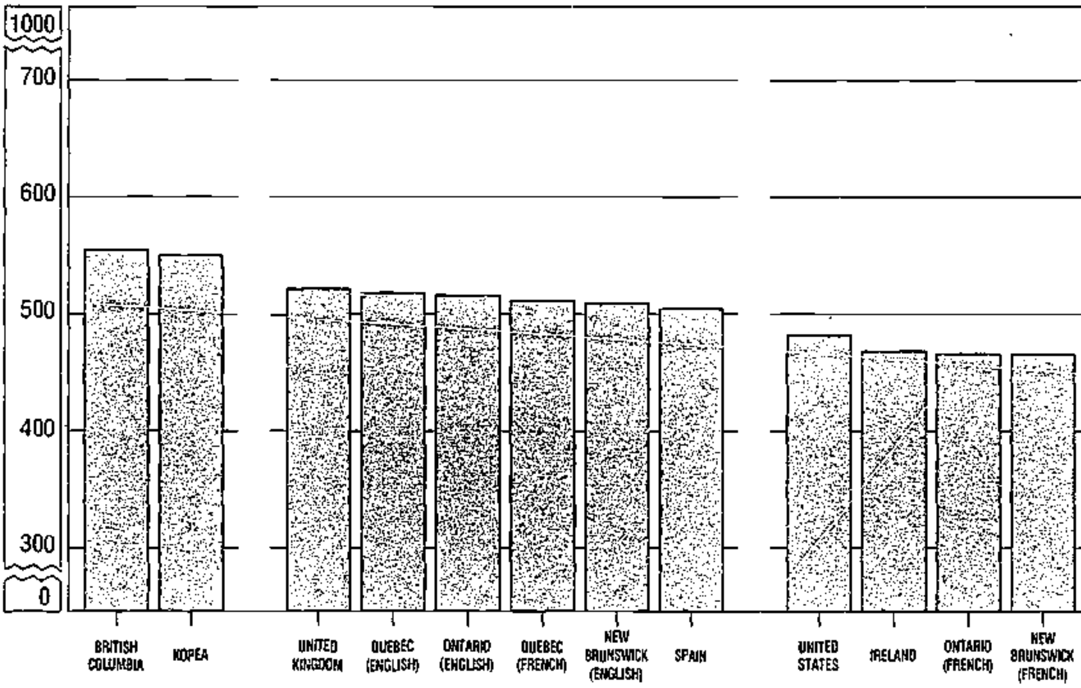
Two populations stand out in terms of average science performance: students from British Columbia (551) and those from Korea (550). The remaining countries and provinces fall into two lower-performing groups.[16]

Significantly below these two top performers, a group of six populations hovers around the 500 mean. They are the United Kingdom, Quebec (English), Ontario (English), Quebec (French), New Brunswick (English), and Spain. Another cluster of four populations, the United States, Ireland, Ontario (French), and New Brunswick (French) scores well below the mean. Proficiencies of countries and provinces within each of these groups are essentially equal.

[15]The science scale was developed using item response theory. Six of the 60 science questions were excluded from the final scale because patterns of performance on these items varied considerably across populations. The reference group for the mean and standard deviation is the estimated total number of 13-year-olds across all 12 populations (about 5,215,000 students). More than 99 percent of the students' scores fall within the range of 200 to 800. See the Procedural Appendix and the IAEP *Technical Report* for a discussion of scale construction and differential item performance.

[16]Comparisons of levels of proficiency among the 12 populations were conducted using a generalized Tamhane's multiple-comparison procedure for means with unequal variances. Ajit C. Tamhane, "A Comparison of Procedures for Multiple Comparisons of Means with Unequal Variances," *Journal of The American Statistical Association*, 1979, 74, pp 471-480.

FIGURE 4.1
Average Science Proficiency, Age 13*



British Columbia	Korea	United Kingdom	Quebec (English)	Ontario (English)	Quebec (French)	New Brunswick (English)	Spain	United States	Ireland	Ontario (French)	New Brunswick (French)
551.3	549.9	519.5	515.3	514.7	513.4	510.5	503.9	478.5	469.3	468.3	468.1
(2.1)	(2.9)	(3.7)	(2.8)	(2.7)	(3.3)	(2.7)	(4.3)	(4.8)	(3.5)	(2.2)	(3.9)

* Differences in performance between the three groups are statistically significant at the .05 level; differences in performance within groups are not statistically significant. Jackknifed standard errors are presented in parentheses.

The IAEP Science Scale

In today's societies, it seems important that all citizens have at least a basic understanding of scientific concepts. As taxpayers and voters, they are being called on to support the development of atomic energy, adopt programs that will improve the environment, pay for space programs, and embrace recommended health practices. However, it is less clear what percentages of the population must be at higher levels of scientific understanding in order for individuals to enjoy satisfying lives and for an economy to compete and prosper.

In order to make the results of the science assessment more understandable to policymakers and taxpayers who must make these judgments, the project has defined or "anchored" five points or levels on the science proficiency scale—(300, 400, 500, 600, and 700)—in terms of what students who perform at these levels *know* and *can do* related to science. These points or levels are also illustrated by sample questions chosen from the assessment to represent the kinds of tasks that students at each level typically can address successfully. The five levels and sample items are presented in FIGURE 4.2.

FIGURE 4.2
Levels of Science Proficiency

IAEP'SS

LEVEL 300 Know Everyday Science Facts

Students at this level know some general scientific facts of the type that can be learned from everyday experiences. For example, they exhibit some rudimentary knowledge concerning the environment and animals.

If you throw each of the following away after a picnic, which will decay the fastest and not harm the environment?

(A) An apple core (B) A plastic bottle
(C) A metal soft-drink can (D) A glass bottle

LEVEL 400 Understand and Apply Simple Scientific Principles

Students at this level exhibit a growing knowledge in the Life Sciences, particularly human biological systems, and can apply some basic principles from the Physical Sciences, including force. They also display a beginning understanding of some of the basic methods of reasoning used in science, including classification and interpretation of statements.

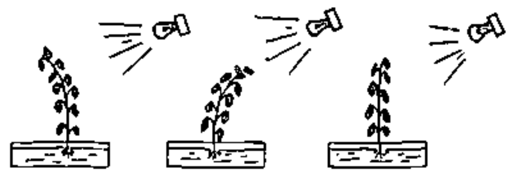
Which of the following is NOT a reflex action?

(A) Quickly closing your eyelid when something is about to hit your eye
(B) Falling over or tripping on a stone
(C) Pulling away your hand when you accidentally touch a hot iron
(D) Jerking your leg when the doctor taps your knee

LEVEL 500 Use Scientific Procedures and Analyze Scientific Data

Students at this level have a grasp of experimental procedures used in science, such as designing experiments, controlling variables, and using equipment. They can identify the best conclusions drawn from data on a graph and the best explanation for observed phenomena. Students also understand some concepts in a variety of science content areas, including the Life Sciences, Physical Sciences, and Earth and Space Sciences.

A teacher left a plant in a dark classroom during the school's ten day spring break. She placed a light near the plant, and she watered the plant well. When students returned to school after spring break, what do you think the plant looked like? Fill in the oval under the picture you choose.



(A) (B) (C)

(D) I don't know.

LEVEL 600 Understand and Apply Intermediate Scientific Knowledge and Principles

Students at this level demonstrate an understanding of intermediate scientific facts and principles and can apply this understanding in designing experiments and interpreting data. They also can interpret figures and diagrams used to convey scientific information. Students at this level can infer relationships and draw conclusions by applying facts and principles, particularly from the Physical Sciences.

Group A	Group B	Group C
Water vapor	Ice	Alcohol
Oxygen	Aluminum	Water
Air	Iron	Gasoline

The substances above, each at room temperature, have been classified into groups. On what property is the classification based?

(A) Chemical composition
(B) Specific heat
(C) State of matter
(D) Abundance within the Earth's crust

LEVEL 700 Integrate Scientific Information and Experimental Evidence

Students at this level can interpret experimental data that involves several variables. They also can interrelate information represented in a variety of forms—text, graphs, figures, and diagrams. Students can make predictions based on data and observations and are aware of limitations of extrapolation. Students demonstrate a growing understanding of more advanced scientific knowledge and concepts, such as the definition of a calorie or the concept of chemical change

A child sits at the end of a seesaw 6 meters long. The balance point is in the middle of the seesaw. The mass of the child is 25 kilograms. If your mass is 50 kilograms and you wish to balance the seesaw, at approximately what distance from the balance point would you need to sit on the opposite side?

(A) 0.5 meter (B) 1.5 meters (C) 2.0 meters (D) 3.0 meters

The Power of the Scale

Averages or means often hide important information. The availability of the five descriptive scale points permits a look at the percentages of students from each population that have acquired the knowledge and skills reflected by each of the defined levels (TABLE 4.1).

TABLE 4.1

Percentages Performing At or Above Each Level of the Science Scale, Age 13*

IAEP '88

	Know Everyday Facts	Apply Simple Principles	Analyze Experiments	Apply Intermediate Principles	Integrate Experimental Evidence
LEVEL ▷	300	400	500	600	700
British Columbia	100	95	72	31	4
Korea	100	93	73	33	2
United Kingdom	98	89	59	21	2
Quebec (English)	99	92	57	15	1
Ontario (English)	99	91	56	17	2
Quebec (French)	100	91	56	15	1
New Brunswick (English)	99	90	55	15	1
Spain	99	88	53	12	1
United States	96	78	42	12	1
Ireland	96	76	37	9	1
Ontario (French)	98	79	35	6	<1
New Brunswick (French)	98	78	35	7	<1

*Jackknifed standard errors for percentages range from less than .1 to 2.6 and are provided in the Data Appendix.

An examination of the data displayed in Table 4.1 is revealing in two ways: first, it demonstrates possible attainment levels and secondly, it illustrates the diversity of achievement across populations. These data, for example, show that the 13-year-olds in British Columbia as a group have acquired science knowledge and skills that are far superior to those of their counterparts in several other populations. The question arises concerning what is required for other countries and provinces to evidence similar success.

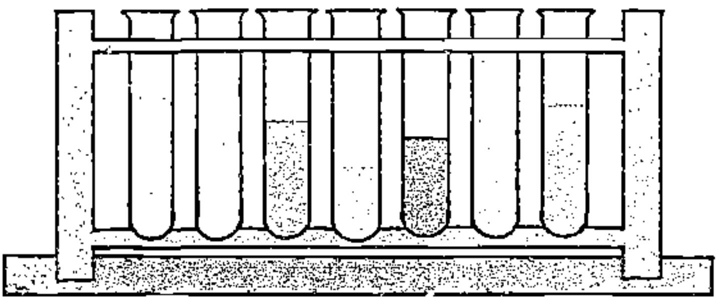
Obviously, there are a host of factors to be considered. Some, such as the school curriculum, the time devoted to science instruction, and the types of typical classroom activities, can be altered by the educational system. Other variables, such as socioeconomic conditions, the level of parents' education, and the societal value placed on the study of science, are largely beyond the power of the schools to alter.

Nonetheless, it is a challenge that 95 percent of British Columbia's 13-year-olds can apply simple scientific principles (Level 400), while less than 80 percent of those in the United States, Ireland, Ontario (French), and New Brunswick (French) demonstrate the same level of competence. The performance of the other populations is in between these two extremes.

Two countries, British Columbia and Korea, stand out, with more than 70 percent of their 13-year-olds able to use scientific procedures and analyze data (Level 500, the midpoint on the proficiency scale). Six other countries and provinces can claim that more than one-half of their students have achieved the same competencies. The remaining four populations, the United States, Ireland, Ontario (French) and New Brunswick (French), are at the lowest end of the scale, with only about 35 to 40 percent of their students at Level 500 or above.

Finally, more than 30 percent of British Columbia's and Korea's 13-year-olds can apply intermediate scientific knowledge and principles (Level 600), while fewer than one out of 10 of their peers in Ireland, Ontario (French), and New Brunswick (French) are able to do so.

The large ranges of findings at performance Levels 400 (19 percentage points), 500 (38 percentage points), and 600 (27 percentage points) certainly demand consideration. Moreover, increased percentages of students performing at the higher levels seem essential if an economy is to remain healthy and grow in today's competitive technological environment. Cultural values as well as educational practices must be examined if improvements are to be made.

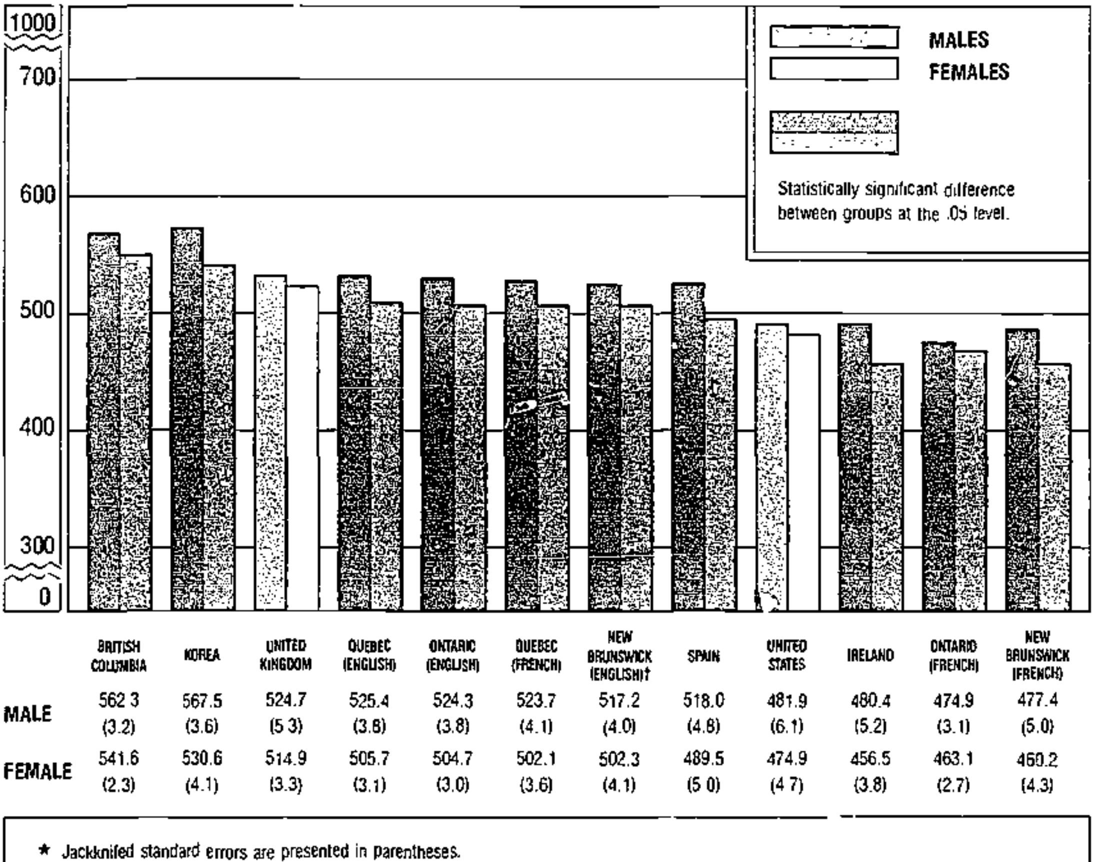


The Gender Gap

Approximately 50 percent of the population of 13-year-olds in every country and province is female. Consciously developing the knowledge and skills of young women represents a decision that can profoundly affect a country's economic achievement. There are far greater discrepancies between boys' and girls' performance in science than in mathematics (FIGURE 4.3). Males outperform females significantly in all populations except those of the United Kingdom and the United States. The greatest difference is in Korea, where males outperform females by nearly 40 scale points.

FIGURE 4.3
Average Science Proficiency by Gender, Age 13*

IAEP '88



	BRITISH COLUMBIA	KOREA	UNITED KINGDOM	QUEBEC (ENGLISH)	ONTARIO (ENGLISH)	QUEBEC (FRENCH)	NEW BRUNSWICK (ENGLISH)†	SPAIN	UNITED STATES	IRELAND	ONTARIO (FRENCH)	NEW BRUNSWICK (FRENCH)
MALE	562.3 (3.2)	567.5 (3.6)	524.7 (5.3)	525.4 (3.8)	524.3 (3.8)	523.7 (4.1)	517.2 (4.0)	518.0 (4.8)	481.9 (6.1)	480.4 (5.2)	474.9 (3.1)	477.4 (5.0)
FEMALE	541.6 (2.3)	530.6 (4.1)	514.9 (3.3)	505.7 (3.1)	504.7 (3.0)	502.1 (3.6)	502.3 (4.1)	489.5 (5.0)	474.9 (4.7)	456.5 (3.8)	463.1 (2.7)	460.2 (4.3)

* Jackknifed standard errors are presented in parentheses.

† Background data are missing from 32% of the New Brunsw[illegible]sh) stu[illegible]nts. The resultant effect on the differences between groups for this particular province is estimated to be less t[illegible] standard error.

Where Do We Stand? Are the Results Good Enough?

The answer to the first query is clear, but the challenge of the second is more troubling. It may be comforting to learn that close to 100 percent of today's 13-year-olds in all of the populations assessed know some everyday science facts. But what degree of scientific-reasoning skills must be developed to enable citizens to improve their lives and to supply the effective workers, scientists, and researchers necessary for the year 2000? The hope is that these results will enlighten the debate necessary for each country and province to reach consensus on these important issues.

PART II
SCIENCE

CHAPTER FIVE
Science: Instruction and Attitudes

It is reasonable to assume that parent, student, and teacher behaviors affect learning. A supportive parent, an attentive child, and a creative teacher would seem to be the ideal combination for success. Identifying the specific measurable behaviors that reflect these characteristics has been a challenge to researchers over the years. Survey results, as in this study, cannot establish causal links between such factors and student achievement. However, data on classroom practices, homework, support from home, and student attitudes can illustrate important differences in participating countries and provinces and provide a context for understanding their achievement results.[17]

Learning Science

Classroom Activities. Included in the questions about students' backgrounds was a series asking them about their science classroom experiences. The results are highlighted in TABLE 5.1. Entries reflect the percentage of students reporting frequent activity, "almost every day" or "several times a week," of the types described. Data are not provided for the other options, "once a week," "less than once a week," and "never." Frequency of these activities is not consistently related (positively or negatively) with performance among participating groups, so performance data are not presented.

[17] In reading this chapter, note that background data are missing from 32% of the New Brunswick (English) students. The resultant effect on the differences among groups for this particular province is estimated to be less than one standard error.

TABLE 5.1

Percentages Reporting High Frequency of Science Classroom Activities, Age 13*

ETS IAEP '88

	Read your science textbook	Solve written science problems	Watch a film or television program about science	Watch the teacher do experiments	Do experiments with other students	Do experiments by yourself
British Columbia	70 (1.4)	59 (1.2)	10 (0.9)	47 (1.5)	39 (1.5)	23 (1.2)
Korea	63 (1.2)	32 (1.4)	23 (0.9)	47 (1.4)	27 (1.7)	9 (0.6)
United Kingdom	23 (1.4)	31 (1.4)	4 (0.4)	38 (1.7)	57 (1.9)	38 (1.6)
Quebec (English)	52 (1.8)	52 (1.3)	9 (0.8)	32 (1.5)	31 (1.6)	21 (1.2)
Ontario (English)	31 (2.1)	37 (1.3)	11 (1.4)	26 (1.8)	23 (2.2)	18 (1.6)
Quebec (French)	45 (1.4)	62 (2.0)	17 (1.2)	38 (1.6)	31 (1.9)	17 (1.0)
New Brunswick (English)	60 (1.7)	48 (1.6)	8 (0.7)	25 (1.8)	10 (0.8)	8 (0.7)
Spain	66 (2.0)	66 (2.0)	28 (1.5)	51 (1.5)	16 (1.5)	15 (1.3)
United States	70 (1.8)	54 (2.0)	14 (1.6)	19 (1.5)	16 (1.9)	12 (1.1)
Ireland	56 (2.0)	28 (1.4)	8 (0.8)	35 (1.9)	14 (1.4)	10 (1.0)
Ontario (French)	20 (1.1)	48 (1.6)	17 (1.2)	29 1.4)	36 (1.6)	15 (1.0)
New Brunswick (French)	44 (1.9)	60 (2.2)	17 (1.4)	30 (1.4)	20 (1.3)	10 (0.9)

*Jackknifed standard errors are presented in parentheses.

In 7 out of 12 of the populations, most students (50% to 70%) report reading from their science textbook several times a week. About 45 percent of the students in Quebec (French) and New Brunswick (French) and fewer students (20% to 30%) in the United Kingdom and Ontario (English and French) say they read their textbooks that often. About one-third to two-thirds of the students in all populations regularly spend classroom time solving written problems. Except in Korea and Spain, few students say they regularly watch science films or television programs in class. About one-quarter of the Korean and Spanish students report viewing science programs several times a week or more.

Textbook reading, working on written problems, and viewing films or television programs are essentially passive activities. In order to learn higher-level concepts, science educators often recommend that students become involved in using scientific procedures by conducting experiments. However, teachers may face a number of barriers in this regard: lack of equipment, lack of laboratory space, or large class sizes.

In British Columbia, Korea, and Spain, students indicate that experimentation is often demonstrated by the teacher. About 50 percent of the students from these populations say they watch their teachers do experiments on a regular basis. Other populations do so less frequently. Almost 60 percent of the students from the United Kingdom and more than 30 percent of the students from British Columbia, and Quebec (English and French) report doing experiments with other students several times a week or more. Other populations report lower frequency of this activity. Fewer students do experiments on their own; generally 10 to 20 percent of the students report regular activity of this sort. Again, more students (38%) from the United Kingdom report regularly doing experiments on their own.

Students in the United Kingdom seem to be the most involved with hands-on experiments as demonstrated by teachers, with others, or by themselves, suggesting a priority among their teachers for this kind of activity. British Columbia's students also are regularly involved with all types of experiments. These two populations performed well on the IAEP multiple-choice items. However, they might have had greater opportunities to demonstrate their knowledge and skills on a performance-based test. The young people in New Brunswick (English) and the United States are the least involved in experimentation on a regular basis.

Homework. Students were also asked about science homework. Generally, students in all participating populations say they spend little time doing science homework (TABLE 5.2). Except in Spain, between one-half and three-quarters of the students report spending less than one hour per week on science homework. In Spain, 42 percent of the 13-year-olds report doing one to two hours of science homework a week and 19 percent report doing three hours or more weekly.

TABLE 5.2

Percentages Reporting Amounts of Weekly Science Homework, Age 13*

IAEP '88

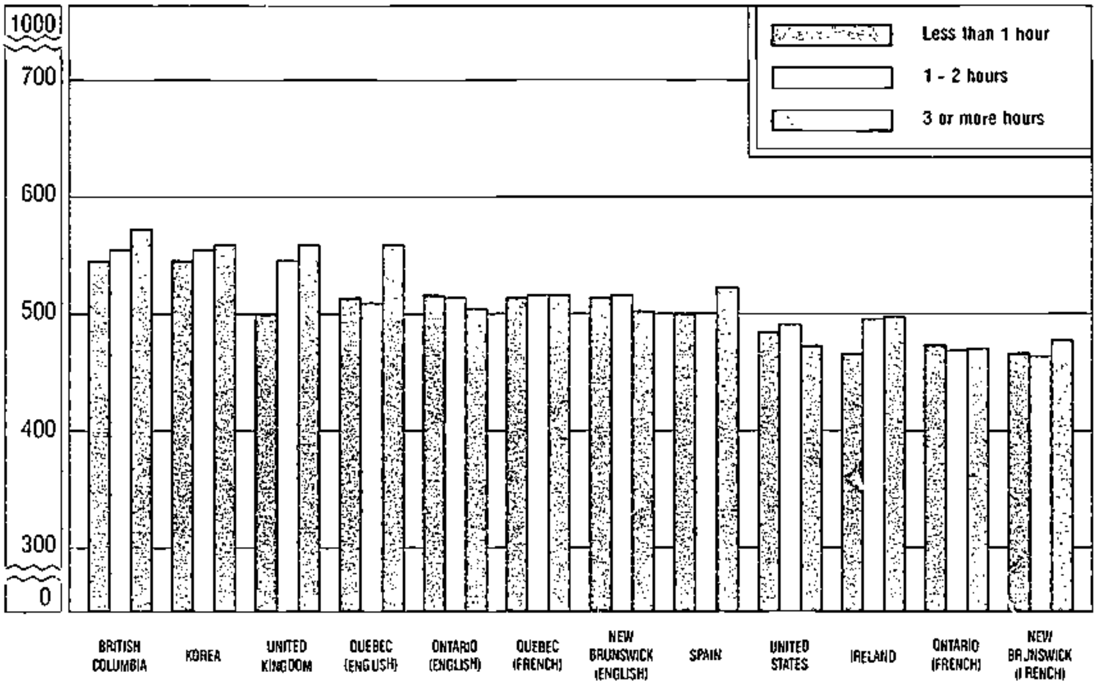
	Less than 1 hour	1 to 2 hours	3 or more hours
British Columbia	51 (1.4)	37 (1.2)	12 (0.8)
Korea	57 (1.1)	36 (1.1)	7 (0.5)
United Kingdom	60 (1.7)	35 (1.4)	5 (0.6)
Quebec (English)	63 (1.4)	30 (1.2)	7 (0.7)
Ontario (English)	72 (1.3)	24 (1.0)	4 (0.6)
Quebec (French)	69 (1.4)	26 (1.3)	5 (0.6)
New Brunswick (English)	62 (1.1)	29 (0.8)	8 (0.8)
Spain	39 (1.8)	42 (1.6)	19 (1.3)
United States	66 (1.8)	26 (1.6)	8 (1.0)
Ireland	70 (1.3)	25 (1.2)	6 (0.5)
Ontario (French)	69 (1.4)	24 (1.1)	7 (0.7)
New Brunswick (French)	68 (1.7)	23 (1.4)	9 (0.9)

*Jackknifed standard errors are presented in parentheses. Percentages do not always sum to 100 due to rounding.

As is the case in mathematics, the relationship between the amount of time spent on science homework and science proficiency is not consistent across all the populations (FIGURE 5.1). However, for the three top performers, British Columbia, Korea, and the United Kingdom, within each population the more time reported spent on science homework, the higher the science achievement.

FIGURE 5.1
Average Proficiency by Reported Amounts of Weekly Science Homework, Age 13*

IAEP '88



* Jackknifed standard errors for proficiencies range from 2.4 to 11.3 and are provided in the Data Appendix.

Home Involvement

Today, in most countries, science concepts are not learned exclusively in the classroom. Often parental interest in science supports or enhances school learning. Students were given a list of science activities and were asked whether or not someone at home ever engaged in these activities with them. The results are presented in TABLE 5.3.

TABLE 5.3

Percentages Reporting Home Involvement in Science Activities, Age 13*

IAEP '88

	Talk about what you are learning in science class	Talk about science topics	Watch a science program on television	Help you with your science homework	Help you work on a science project
British Columbia	55 (1.1)	40 (1.1)	38 (1.2)	49 (1.2)	51 (1.3)
Korea	53 (1.1)	31 (1.1)	71 (1.1)	18 (0.9)	33 (1.2)
United Kingdom	57 (1.3)	39 (1.3)	35 (1.3)	50 (1.2)	39 (1.4)
Quebec (English)	48 (1.4)	41 (1.0)	47 (1.1)	30 (1.4)	38 (1.5)
Ontario (English)	44 (1.4)	42 (1.6)	40 (1.2)	38 (1.4)	62 (1.7)
Quebec (French)	54 (1.2)	47 (1.2)	50 (1 4)	31 (1.4)	34 (1.3)
New Brunswick (English)	49 (1.7)	38 (1.3)	42 (1.2)	41 (1.5)	58 (1.5)
Spain	57 (1.5)	40 (1.6)	58 (1.7)	33 (1.5)	43 (1.5)
United States	53 (2.1)	42 (2.6)	37 (2.8)	47 (1.9)	56 (2.2)
Ireland	47 (1.3)	38 (1.5)	50 (1.2)	25 (1.1)	24 (1.1)
Ontario (French)	46 (1.2)	47 (1.5)	41 (1.2)	37 (1.1)	60 (1.3)
New Brunswick (French)	44 (1.6)	41 (1.4)	49 (1.8)	30 (1.4)	45 (1.3)

*Jackknifed standard errors are presented in parentheses.

In most populations, between 30 and 60 percent of the students report that someone at home asks about their science work in school, talks about scientific topics at home, or watches science programs on television. Watching science programs is very prevalent in Korea; more than 70 percent of Korean students report this kind of home activity. Korea has extensive, high-quality educational programming, especially in the sciences, and this is probably reflected in its students' viewing habits. Also Korean educators note that while the average education level of their students' parents is lower than that of parents from other participating populations, Korean parents are very supportive of their children's intellectual development.

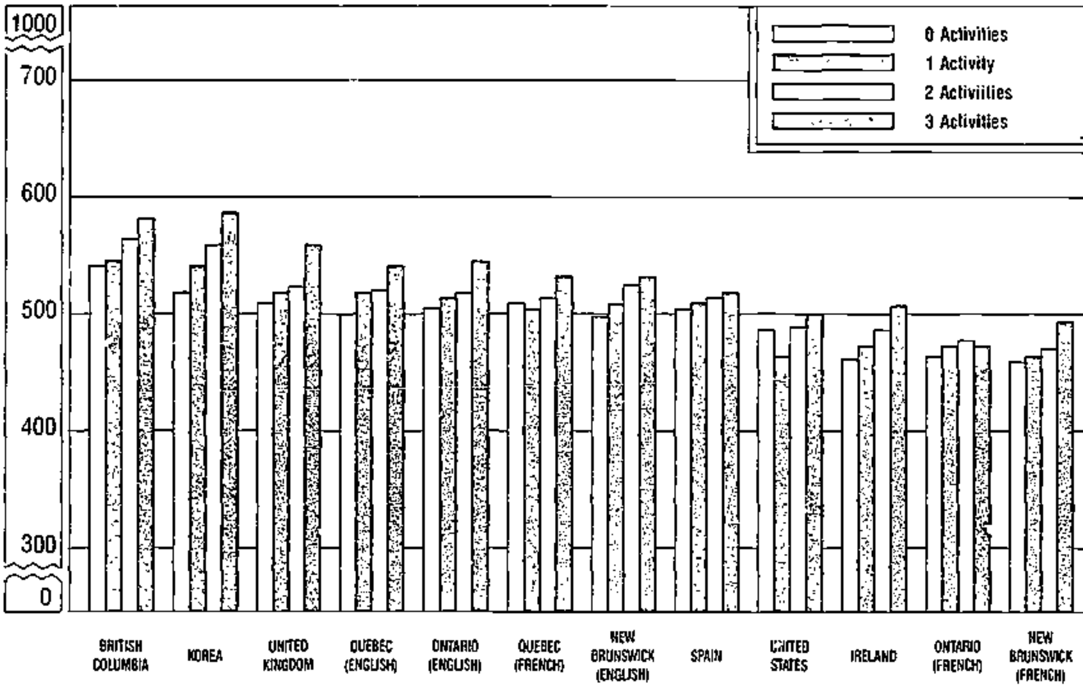
Generally, there is a positive relationship between the level of home involvement in science activities and student achievement (FIGURE 5.2). In all 12 populations, students who report home involvement in all three activities are the highest science performers, while students who experience no home involvement fare least well on the assessment.

Home involvement also takes the form of help with homework and science projects. The amount of this kind of home involvement varies from population to population. Fewer Korean students report this type of help. The relationship between this type of home involvement and achievement tends to be negative, suggesting that help from home on schoolwork may be forthcoming more often when students are doing poorly in school.

FIGURE 5.2

Average Proficiency Reported by Number of Science Activities with Someone at Home, Age 13*

IAEP '88



* Jackknifed standard errors for proficiencies range from 2.7 to 8.5 and are provided in the Data Appendix.

Student Attitudes Toward Science

Student attitudes toward science were also assessed and results are presented in TABLE 5.4. The table indicates the percentages of students who say they "strongly agree" or "agree" with statements about the utility and importance of science or who indicate they like science "a lot" or "a little."

Most students, between 50 and 85 percent, in all populations agree that learning about science is useful in everyday life and important for getting a good job. Also, between 65 and 85 percent of the students say they like science, and these students generally are higher performers than their peers who dislike science.

TABLE 5.4

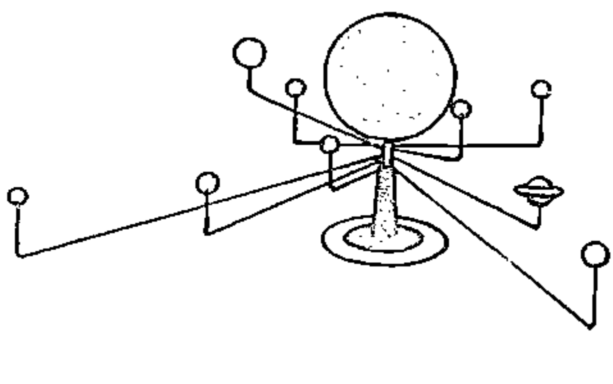
Percentages Responding Positively to Science Attitude Questions, Age 13*

IAEP '88

	Much of what you learn in science classes is useful in everyday life.	It is important to know some science in order to get a good job.	I like science a little or a lot.
British Columbia	52 (1.2)	72 (0.9)	72 (0.9)
Korea	82 (0.8)	64 (1.2)	82 (1.0)
United Kingdom	63 (1.1)	80 (1.0)	82 (1.0)
Quebec (English)	48 (1.2)	59 (1.3)	66 (1.2)
Ontario (English)	55 (1.7)	77 (1.1)	74 (1.0)
Quebec (French)	56 (1.3)	62 (1.2)	78 (0.9)
New Brunswick (English)	55 (1.5)	74 (1.2)	68 (1.4)
Spain	78 (1.6)	59 (1.5)	73 (1.6)
United States	50 (2.4)	70 (1.9)	68 (2.1)
Ireland	64 (1.5)	66 (1.2)	72 (1.5)
Ontario (French)	67 (1.3)	85 (0.9)	84 (0.9)
New Brunswick (French)	62 (1.5)	72 (1.4)	70 (1.5)

*Jackknifed standard errors are presented in parentheses.

Most countries and provinces could probably benefit from supporting positive attitudes about science and promoting its value in today's modern societies. Generating interest among parent groups and the general population about the content and the methods used by scientists might encourage young minds to pursue science-related school work and hobbies with greater enthusiasm and therefore with greater effect.



PART II
SCIENCE

CHAPTER SIX
Science: Topics

The concepts introduced in chapter three concerning the "intended curriculum" reflected in curriculum guides and textbooks, the "implemented curriculum" or the actual practices in schools and classrooms, and the "achieved curriculum" usually measured by student achievement are also relevant to the present discussion of various science topics. This chapter presents achievement results for five science categories and summarizes teachers' ratings of students' opportunities to learn the concepts assessed within these content areas.

The 54 science questions included in the final analysis of the IAEP assessment were divided into five topics as indicated in TABLE 6.1.[18] The results that follow present average percents correct for the items within each content area.[19] The proficiency scale summarizes overall performance in science. The average percents correct describe achievement in content areas often included in the science curriculum. Within each topic there are items that reflect many different levels of the proficiency scale from low to high.

As indicated in the discussion of mathematics topics results, it is appropriate to compare the average percents correct among countries and provinces for the same groups of questions, but it is *not* appropriate to compare the average for one topic with that of another within the same country or province. Also, because the number of questions within each category is relatively small, the results obviously do not represent a comprehensive assessment of each topic.

[18] In the analysis six questions were dropped from the 60-item science assessment because of differential item functioning, to leave a total of 54.

[19] The number of questions within each topic was insufficient for developing topic-related proficiency scales.

TABLE 6.1
Number of Science Items by Topic*

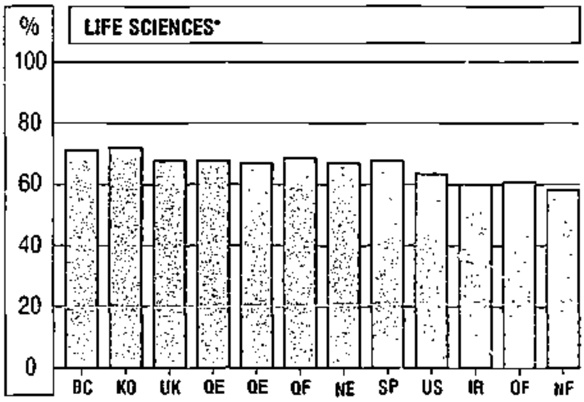
IAEP '88

Life Sciences	Physics	Chemistry	Earth and Space Sciences	Nature of Science	Total
14	10	8	8	14	54

*In the analysis, six questions were dropped from the 60-item science assessment because of differential item functioning, to leave a total of 54

FIGURE 6.1
Average Percents Correct, Age 13

BC BRITISH COLUMBIA
KO KOREA
UK UNITED KINGDOM
QE QUEBEC (ENGLISH)
OE ONTARIO (ENGLISH)
QF QUEBEC (FRENCH)
NE NEW BRUNSWICK (ENLGLISH)
SP SPAIN
US UNITED STATES
IR IRELAND
OF ONTARIO (FRENCH)
NF NEW BRUNSWICK (FRENCH)



* Jackknifed standard errors for proficiencies range from .4 to 1.0 and are provided in the Data Appendix.

IAEP '88

Life Sciences

This topic focuses on plants and animals, including the interdependence of living things, characteristics of different species, photosynthesis, growth and adaptation, and ecology. Also covered are characteristics of human biological systems. The relative performance of countries and provinces in Life Sciences mirrors their achievement in science overall, except for Quebec (French), where students perform relatively higher in this topic than they do overall. The average percents correct for Life Sciences are presented in FIGURE 6.1.[20]

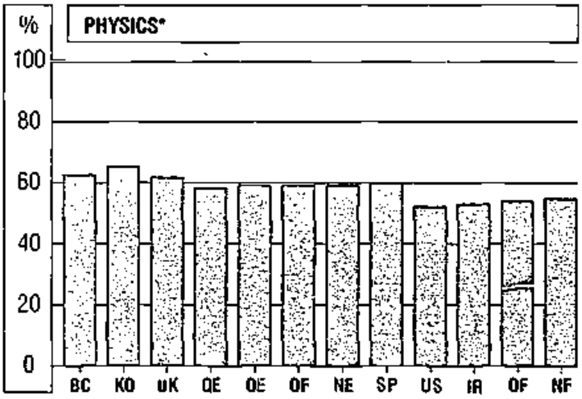
[20] For this and subsequent analyses of achievement by topic, populations are cited as deviating from their normal pattern if the difference between their deviation from the mean for the topic and their deviation from the overall mean is greater than twice the standard error of the difference between these deviations. The standard error was taken to be equal to the composite value of 1.35.

Physics

Questions in this category cover the concepts of force, distance, weight, volume, and acceleration. Also assessed are simple optics, such as mirrors and lenses, and very basic understandings of electricity. All populations perform in Physics about as well as they do in science overall, except New Brunswick (French) students, who perform at higher levels, and British Columbia students, who perform at lower levels than they do overall (FIGURE 6.2).

FIGURE 6.2
Average Percents Correct, Age 13

BC BRITISH COLUMBIA
KO KOREA
UK UNITED KINGDOM
QE QUEBEC (ENGLISH)
OE ONTARIO (ENGLISH)
QF QUEBEC (FRENCH)
NE NEW BRUNSWICK (ENLGLISH)
SP SPAIN
US UNITED STATES
IR IRELAND
OF ONTARIO (FRENCH)
NF NEW BRUNSWICK (FRENCH)



* Jackknifed standard errors for proficiencies range from .4 to .9 and are provided in the Data Appendix.

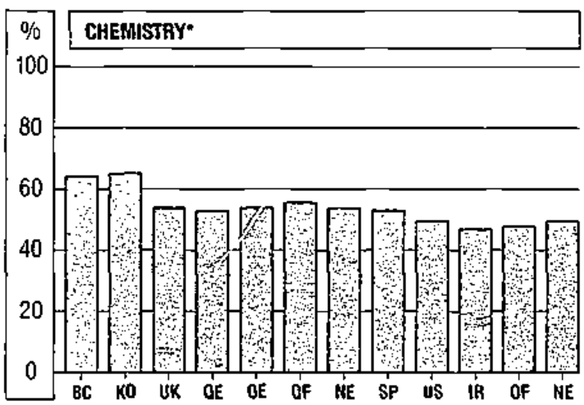
IAEP '88

Chemistry

Questions in this content area cover states of matter, the nature of solutions, reactions of matter, and very basic understandings of the atom. The range of achievement of participating countries and provinces is greater in Chemistry than in any other topic (FIGURE 6.3). Students from British Columbia and Korea have higher averages in Chemistry than they do for science in general, and students from the United Kingdom and Quebec (English) have lower averages than they do overall. Other populations perform about the same as they do for all science items.

FIGURE 6.3
Average Percents Correct, Age 13

BC BRITISH COLUMBIA
KO KOREA
UK UNITED KINGDOM
QE QUEBEC (ENGLISH)
OE ONTARIO (ENGLISH)
QF QUEBEC (FRENCH)
NE NEW BRUNSWICK (ENLGLISH)
SP SPAIN
US UNITED STATES
IR IRELAND
OF ONTARIO (FRENCH)
NF NEW BRUNSWICK (FRENCH)



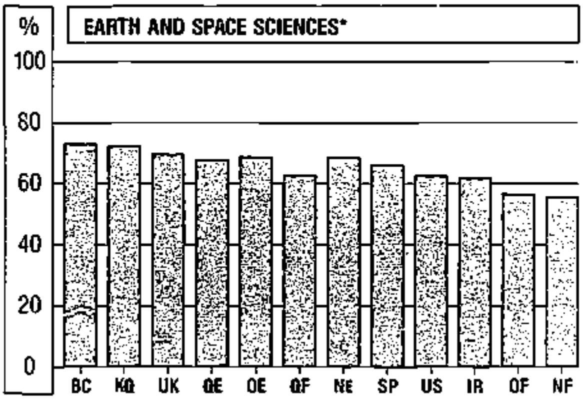
* Jackknifed standard errors for proficiencies range from .5 to 1.0 and are provided in the Data Appendix.

IAEP '88

FIGURE 6.4

Average Percents Correct, Age 13

BC BRITISH COLUMBIA
KO KOREA
UK UNITED KINGDOM
QE QUEBEC (ENGLISH)
OE ONTARIO (ENGLISH)
QF QUEBEC (FRENCH)
NE NEW BRUNSWICK (ENLGLISH)
SP SPAIN
US UNITED STATES
IR IRELAND
OF ONTARIO (FRENCH)
NF NEW BRUNSWICK (FRENCH)

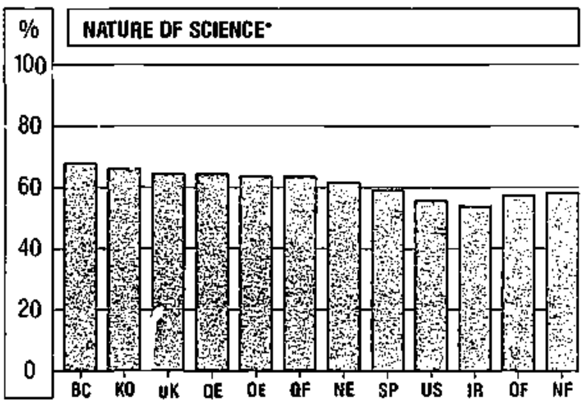


* Jackknifed standard errors for proficiencies range from .4 to 1.2 and are provided in the Data Appendix.

FIGURE 6.5

Average Percents Correct, Age 13

BC BRITISH COLUMBIA
KO KOREA
UK UNITED KINGDOM
QE QUEBEC (ENGLISH)
OE ONTARIO (ENGLISH)
QF QUEBEC (FRENCH)
NE NEW BRUNSWICK (ENLGLISH)
SP SPAIN
US UNITED STATES
IR IRELAND
OF ONTARIO (FRENCH)
NF NEW BRUNSWICK (FRENCH)



* Jackknifed standard errors for proficiencies range from .4 to 1.0 and are provided in the Data Appendix.

Earth and Space Sciences

This topic includes the earth's history, the earth's atmosphere, and physical aspects of the earth's surface. Also included are questions on the solar system and space exploration. Again, the pattern of performance in this area generally mirrors overall science achievement (FIGURE 6.4). Exceptions are Quebec (French) and New Brunswick (French) where students perform relatively lower in this topic when compared with their performance overall.

Nature of Science

This area assesses understanding of scientific methods irrespective of the content area. It includes questions on logic, testing hypotheses, using scientific equipment, designing experiments, and interpreting results. Korean students perform relatively lower in Nature of Science when compared with their overall high science achievement level (FIGURE 6.5). Achievement of other populations in this topic is at about the same level as their overall performance.

Opportunity to Learn Science by Topic

Following the same procedures as those for mathematics, a teacher or science coordinator in each participating school was asked to indicate the percentage of seventh- and eighth-grade students who had already had an opportunity to learn the concepts tested by each question in the science assessment.[21] The analysis of these data focuses exclusively on the results from schools in which more than 75 percent of the students had already had an opportunity to learn the content assessed. It was assumed that students in these schools had been "exposed" to the content. The ratings were weighted by the proportion of 13-year-olds in each of these grades and summarized across items in each topic area. This provided an estimate of the percentage of questions to which an average 13-year-old had been exposed for each content area.[22]

FIGURE 6.6 combines the achievement information on science topics presented earlier with the opportunity-to-learn ratings. The average percents correct (the bars) indicate the percentage of items in a topic that students on average have answered correctly. The average opportunity-to-learn ratings (the dots) indicate the percentage of items in a topic to which students on average have been exposed. When the dot and its confidence interval are within the bar, student performance is higher than teacher estimates of student exposure to the concepts tested by the items.

In all populations except Spain, students generally perform better in science topics than their teachers' ratings would suggest. Spanish teachers tend to estimate their students' exposure to science topics higher than teachers from the other countries and provinces, and Spanish students tend to achieve about at the level expected by their teachers.

Two factors may help to explain the opportunity-to-learn results. The first is that the teachers completing the questionnaires may not know a great deal about the content coverage in prior grades. This is evident from the British Columbia results, in which the eighth-grade teachers in secondary schools consistently assigned lower opportunity-to-learn ratings than the seventh-grade teachers in the province's elementary schools.

A second reason for opportunity-to-learn ratings being lower than the students' average percents correct may be because the science assessment tended to cover science concepts not taught exclusively in the school curriculum. Only about one-quarter of the science questions dealt with specific science knowledge. The remaining items assessed application and integration of science concepts, to which students may have been exposed outside of the school environment.

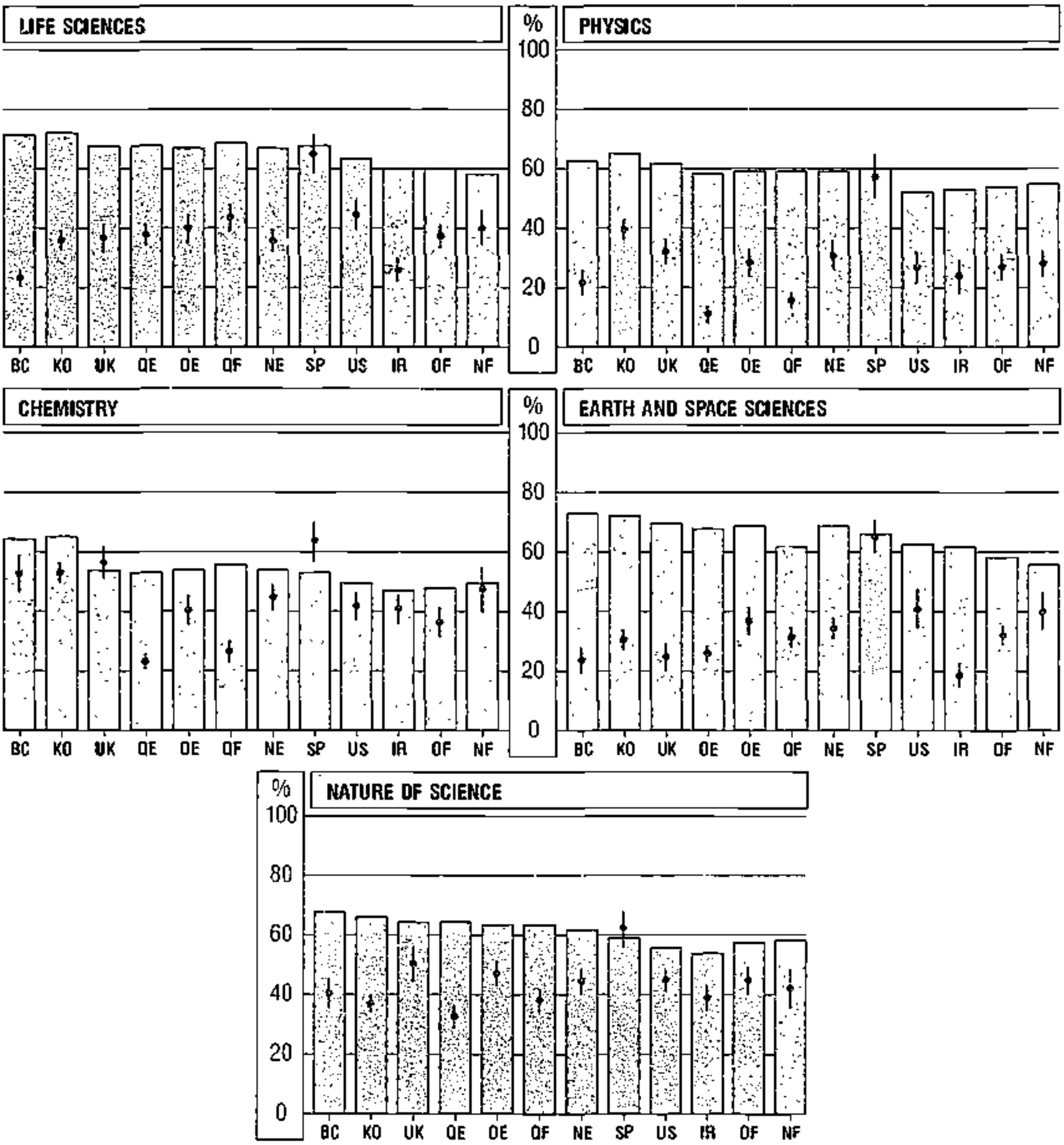
[21] In some cases, ratings were the result of the consensus of teachers at each grade, and in some cases more than one teacher in a school provided ratings and responses were weighted appropriately.

[22] Nonresponse rate of teachers translated into missing data for more than 10 percent of the student populations in Ireland, New Brunswick (English), New Brunswick (French), Ontario (English), Ontario (French), Quebec (English), Quebec (French), and the United States.

FIGURE 6.6

Average Percents Correct and Opportunity-to-Learn Ratings for Five Science Topics, Age 13

BC BRITISH COLUMBIA
KO KOREA
UK UNITED KINGDOM
QE QUEBEC (ENGLISH)
OE ONTARIO (ENGLISH)
QF QUEBEC (FRENCH)
NE NEW BRUNSWICK (ENGLISH)
SP SPAIN
US UNITED STATES
IR IRELAND
OF ONTARIO (FRENCH)
NF NEW BRUNSWICK (FRENCH)



Average percent correct.

Average rating for opportunity to learn and 95% confidence interval. It can be said with 95% certainty that the average rating of the population is within this interval.

NOTE:
If bar terminates above the dot and confidence interval it indicates that student performance is higher than teacher estimates of student exposure to the concepts tested by the items.

ETS IAEP '88

PART II

SCIENCE

CHAPTER SEVEN

Personal Learning Environments

In addition to specific information on mathematics and science, the assessment gathered general background information about television watching, homework, and interest in school from each student participating in the study. Results identify similarities and differences across geographic areas and substantiate and sometimes challenge conventional wisdom concerning the relationships between these characteristics and student achievement.

Television Viewing

Students were asked how much television they usually watch each day. The data in TABLE 7.1 indicates that the norm is two hours or less of viewing daily for Korea, Quebec (French), Spain, and Ireland, and three to four hours daily for the remaining populations. Smaller percentages of students, from 7 percent in Korea to 31 percent in the United States, report spending five or more hours in front of the television set.

FIGURE 7.1 shows that when these findings are related to performance, for every group, the greater the amount of time spent watching television per day, the poorer the performance in science. A similar relationship holds for mathematics.

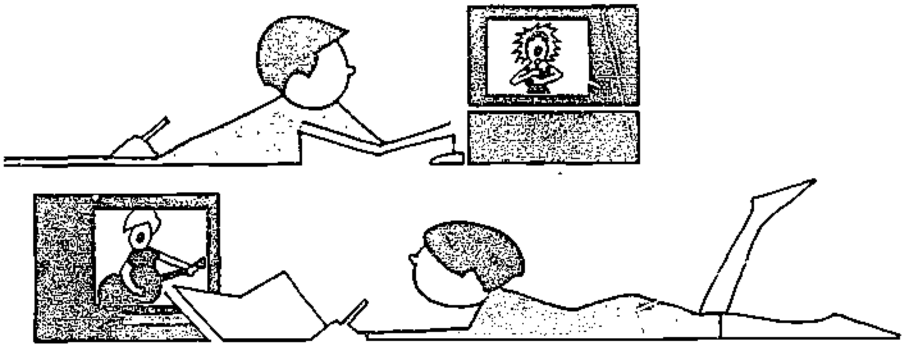


TABLE 7.1

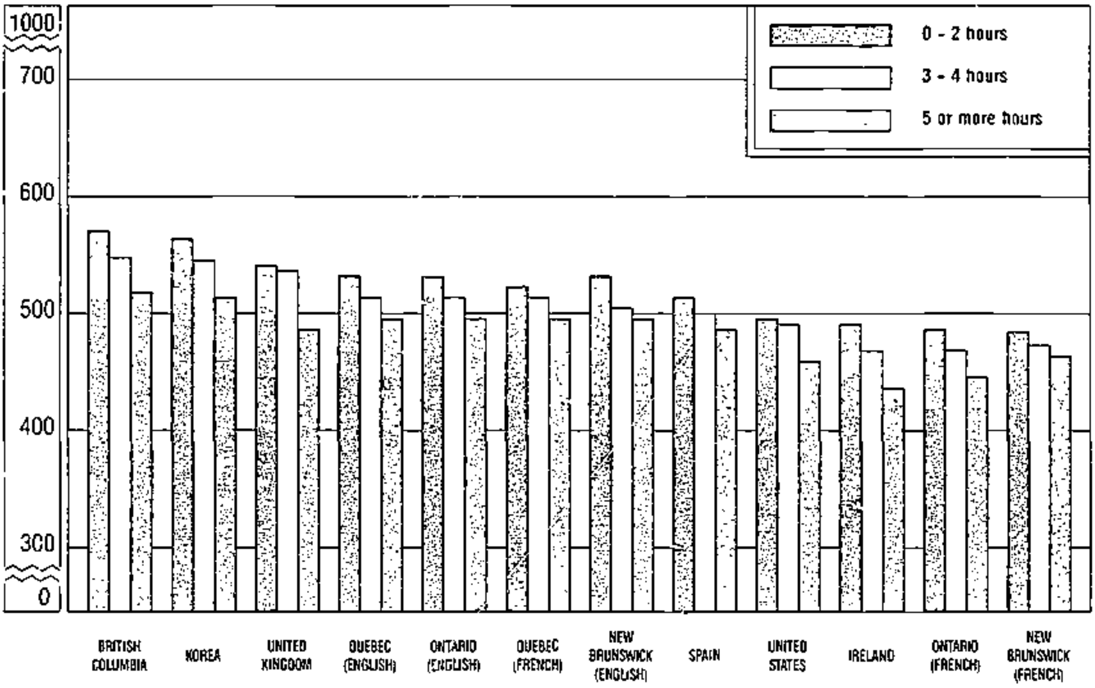
Percentages Reporting Amounts of Daily Television Viewing, Age 13*

IAEP '88

	2 hours or less	3 to 4 hours	5 or more hours
British Columbia	41 (1.0)	43 (1.0)	17 (0.9)
Korea	49 (1.5)	44 (1.3)	7 (0.6)
United Kingdom	28 (1.2)	45 (1.1)	27 (1.3)
Quebec (English)	37 (1.1)	44 (1.0)	19 (0.8)
Ontario (English)	35 (1.5)	43 (1.2)	22 (1.1)
Quebec (French)	49 (1.4)	40 (1.1)	11 (0.8)
New Brunswick (English)	29 (1.3)	49 (1.5)	22 (1.0)
Spain	46 (2.3)	41 (1.7)	13 (1.1)
United States	27 (1.4)	42 (1.7)	31 (1.6)
Ireland	45 (1.7)	41 (1.4)	14 (1.2)
Ontario (French)	33 (1.1)	46 (1.1)	21 (1.2)
New Brunswick (French)	31 (1.7)	48 (1.5)	22 (1.4)

*Students are those who have a science proficiency score Jackknifed standard errors are presented in parentheses Percentages do not always sum to 100 due to rounding.

FIGURE 7.1
Average Science Proficiency by Reported Amounts of Daily Television Viewing, Age 13*



* Jackknifed standard errors for proficiencies range from 2.7 to 7.4 and are provided in the Data Appendix.

Homework

Students were also asked how much time they usually spend on homework each day for all school subjects combined, and the options were "I don't usually have homework assigned," "I have homework but I don't usually do it," "1/2 hour or less," "1 hour," "2 hours," and "more than 2 hours."

Except for Spain and Ireland, most 13-year-olds (more than 50%) in participating countries and provinces report spending one hour or less daily on their school assignments (TABLE 7.2). More than 50 percent of the Spanish and Irish students say they do two or more hours of homework each day.

TABLE 7.2

Percentages Reporting Amounts of Daily Homework, Age 13*

IAEP '88

	None assigned	Don't do it	1 hour or less	2 or more hours
British Columbia	4 (0.5)	4 (0.5)	66 (1.2)	26 (1.1)
Korea	2 (0.3)	3 (0.3)	68 (1.1)	28 (1.2)
United Kingdom	8 (1.2)	2 (0.3)	54 (1.6)	35 (1.6)
Quebec (English)	2 (0.5)	3 (0.4)	62 (1.4)	33 (1.2)
Ontario (English)	5 (0.5)	3 (0.4)	68 (1.2)	25 (1.2)
Quebec (French)	1 (0.2)	1 (0.3)	67 (2.0)	31 (2.0)
New Brunswick (English)	3 (0.5)	5 (0.6)	74 (1.4)	19 (1.3)
Spain	1 (0.3)	1 (0.3)	39 (1.7)	59 (1.7)
United States	4 (0.9)	5 (0.8)	65 (2.4)	27 (2.0)
Ireland	1 (0.1)	2 (0.6)	41 (1.6)	57 (1.8)
Ontario (French)	6 (0.7)	2 (0.4)	69 (1.4)	24 (1.3)
New Brunswick (French)	3 (0.7)	1 (0.3)	72 (1.6)	24 (1.5)

*Students are those who have a science proficiency score. Jackknifed standard errors are presented in parentheses. Percentages do not always sum to 100 due to rounding.

When homework results are related to science performance, relationships tend to be confusing. In several populations the highest achievers are students who report doing two hours or more of homework daily. In others, the highest are those who say they spend one hour or less daily; and in one group all students perform roughly at the same level, including those who have no homework assigned and those who have homework but do not do it. The relationship between homework and mathematics performance is equally confusing. Reasons for this inconsistency may be the same as those identified in earlier chapters. Homework may be assigned differentially; sometimes enrichment assignments are given to better students, and sometimes remedial work is assigned to poorer students. Also, some students may finish assignments quickly during the school day, while others may take more time at home.

Students were also asked how often someone from home helped them with their homework: "almost every day," "once or twice a week," "once or twice a month," "never or hardly ever," or "don't have homework." Their responses are summarized in TABLE 7.3. Except in the United States, where help is more prevalent, only about 25 to 35 percent of students say they receive help once or twice a week. As seen earlier in similar mathematics and science-related questions, results suggest that poorer students are more likely to get regular attention at home.

TABLE 7.3

Percentages Reporting Frequencies of Help with Homework, Age 13*

IAEP '88

	Once or twice a week	Once or twice a month	Never or hardly ever	Don't have homework
British Columbia	36 (1.0)	20 (0.8)	43 (1.0)	1 (0.2)
Korea	22 (1.0)	17 (1.0)	61 (1.2)	1 (0.1)
United Kingdom	38 (1.2)	24 (1.1)	36 (1.2)	2 (0.5)
Quebec (English)	27 (1.2)	20 (0.8)	53 (1.2)	1 (0.2)
Ontario (English)	31 (1.3)	22 (1.0)	46 (1.3)	1 (0.2)
Quebec (French)	32 (1.2)	15 (0.9)	52 (1.2)	1 (0.2)
New Brunswick (English)	32 (1.4)	19 (1.0)	48 (1.4)	1 (0.3)
Spain	25 (1.4)	11 (0.9)	64 (1.7)	1 (0.1)
United States	47 (2.1)	14 (1.9)	37 (2.7)	2 (0.8)
Ireland	24 (1.2)	14 (0.9)	62 (1.5)	1 (0.2)
Ontario (French)	36 (1.0)	18 (0.9)	44 (1.1)	2 (0.4)
New Brunswick (French)	33 (1.4)	15 (0.9)	52 (1.4)	1 (0.2)

*Students are those who have a science proficiency score. Jackknifed standard errors are presented in parentheses. Percentages do not always sum to 100 due to rounding

Interest in School

As reflected in many oth r studies and surveys, about 50 to 85 percent of the students in all countries say they like school (TABLE 7.4). Curiously students in populations that are typical of high performers (Korea) and low performers (Ontario-French) in science report being the most enthusiastic about attending school.

The Personal Learning Environment

All the factors described in this chapter, television viewing, homework, help with homework, and interest in school, help define the student's personal learning environment. Although teacher assignments and parental guidance influence student behavior, students themselves often make the decisions about how they spend their time outside of school and on what tasks they concentrate their attention and effort. Television and

TABLE 7.4

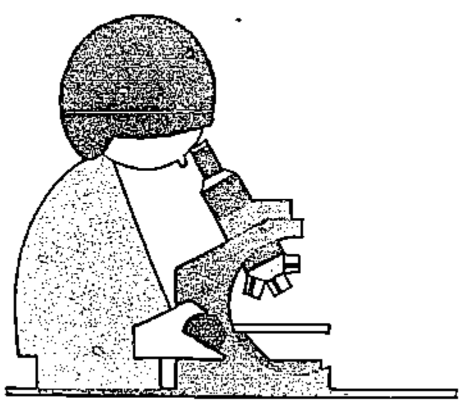
Percentages Reporting Liking and Disliking School, Age 13*

IAEP '88

	Like school	Undecided about school	Dislike school
British Columbia	64 (1.1)	18 (0.8)	19 (1.0)
Korea	85 (0.8)	8 (0.7)	8 (0.5)
United Kingdom	72 (1.2)	7 (0.7)	15 (1.0)
Quebec (English)	61 (1.4)	16 (1.0)	23 (1.0)
Ontario (English)	66 (1.2)	16 (1.0)	18 (1.0)
Quebec (French)	76 (1.0)	7 (0.5)	17 (0.9)
New Brunswick (English)	58 (1.7)	14 (1.3)	28 (1.2)
Spain	48 (2.3)	39 (1.9)	13 (1.4)
United States	64 (2.0)	14 (1.2)	22 (1.9)
Ireland	61 (1.7)	12 (0.8)	27 (1.7)
Ontario (French)	78 (1.2)	7 (0.6)	15 (1.0)
New Brunswick (French)	69 (1.7)	9 (0.8)	23 (1.7)

*Students are those who have a science proficiency score. Jackknifed standard errors are presented in parentheses. Percentages do not always sum to 100 due to rounding.

homework are often cited as competing for students' time and attention, and IAEP results suggest that television is the winner. Parents also make decisions about how they spend their own time, and these results suggest that mothers and fathers are more likely to spend some of their time helping their children with homework if the children are lower-performing students. Although creating an environment that encourages children to like school may not guarantee higher performance, it seems likely that parental and student involvement in meaningful educational activities is key to creating a personal environment conducive to learning.



PART III

Context and Commentary

In the United States there are 3,000,000 young men and women aged 13. In New Brunswick, Canada, there are only about 10,000. In many ways the diversity of the smaller group is probably as great as that of the larger, but the similarities are equally significant. While there are more subcultures reflected in one and supposedly more homogeneity in the other, anyone who has visited schools around the world will remember the feelings of familiarity in an eighth-grade classroom in Sevilla or Seoul or in a teachers' lounge in Dublin or Detroit.

In order to provide a context for results, IAEP asked educators from each participating country or province to describe their social and educational environments and to comment on their results.[23] For example, they reported the age at which their students typically begin school, the length of the school year, and the average class size. They also commented on the status of educational issues in the participating locations and the current emphasis (or lack thereof) on mathematics and science.

Each country and province is in a unique situation with respect to its social and educational programs. Some are engaged in broad waves of educational reform. Others are focused almost entirely on grave economic concerns. Still others are consumed with political matters.

This report will elicit different reactions from various segments of each political entity. In some cases, the story will be received with surprise, and in others, it will confirm existing perceptions. Conservative and progressive policymakers may view the same findings as indicative of very different problems. Our hope is that the data will be accepted as valid and reliable and viewed as useful for debates as well as supportive of positive changes.

[23] These sections were written by individuals participating in the project and reviewed by their organizations (see acknowledgments). The United States section was provided by the staff of the Center for Assessment of Educational Progress (CAEP) at Educational Testing Service. Statistical data provided by each country and province are drawn from a variety of sources and in some cases may not be strictly comparable. Data on the number of 13-year-olds are the sums of weights derived from the survey results. Because some schools and students were excluded from the assessment for a variety of reasons, these data may underrepresent the true total by up to five percent.

BRITISH COLUMBIA

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	Provincial Curriculum
2,926,000	504,000	34,000	5	185	23.4 (elem.) 24.5 (sec.)	Yes

Context

British Columbia's educational system is characterized by centralized control over the development of curriculum goals, objectives, and the provision of resources. The elementary core curriculum places considerable emphasis on mathematics and science. The Ministry of Education has traditionally taken a leadership role in establishing and maintaining educational standards through province-wide testing and evaluation programs. The results of evaluation studies and student achievement tests serve as useful indicators of system performance as well as fuel for discussions about public financial support for education.

A major function of education is seen as the transmission of knowledge and values that society considers important. It is generally felt that the school system plays a major role in students' intellectual development, a lesser role in their vocational development, and shares responsibility with the family and other agencies for students' social and human development.

Approximately 95 percent of the students attend public schools. The major task of public schools is developing students' ability to analyze critically, to reason and think independently, and to acquire basic learning skills and bodies of knowledge. Students are also expected to acquire a lifelong appreciation of learning, a curiosity about the world around them, and a capacity for creative thought and expression. The principal indicator of whether or not the system is meeting this goal is academic achievement, and schools are being held increasingly accountable by government and the public for performance.

The public school system enrolls approximately 500,000 students, has a teaching force of 27,000, and is organized into 75 school districts, that tend to be highly diverse both in terms of population size and geography. The province is characterized by both large-enrollment urban districts and small-enrollment rural districts, making the delivery of education services challenging. The average elementary school enrolls about 300 students, while typical secondary schools enroll about 800 students.

Teachers are highly experienced, averaging nearly 15 years of service. As the teaching force ages, considerable pressure will be placed on universities to fill the widening gap between supply and demand. Further demands will be placed on the school system as a result of a recent increase in enrollment following a number of years of decline. Another issue of current interest is the provision of educational services to an increasing number of children of immigrant families, many of whom are from Pacific Rim countries. This influx has placed heavy demands on schools to provide English-as-a-second-language instruction.

Commentary

Students performed very well on both the mathematics and science assessments, achieving higher average scores than most jurisdictions involved in the study. A high percentage of students was successful at the basic skills levels, and a significant percentage reached proficiency levels in both subject areas that reflect mastery of higher-order, critical-thinking, and problem-solving abilities.

Mathematics. Students ranked third in mathematics achievement. Up to and including Level 500, the performance of British Columbia's students was similar to that of the highest-ranking country (Korea). At Levels 600 and 700, the success of Korean students was nearly twice that of the province.

Among the cognitive levels addressed in the IAEP study, British Columbia's students, along with their Korean peers, were the highest performers on questions requiring problem solving. The acquisition of problem-solving skills is considered by the Ministry of Education to be of critical importance in the development of an educated person. Recent provincial assessments suggest that teachers have made concerted efforts to improve instruction in this area, which is emphasized in the new mathematics curriculum.

Although scores were not low in Geometry and Algebra, these areas were identified as relative weaknesses. Previous assessments have identified Geometry as a weakness, and the mathematics curriculum introduced in 1988 has attempted to address this issue.

Science. The achievement in science was exceptional with a ranking of first among all participating populations. Students scored consistently high on all content areas, excelling on questions requiring both knowledge and integration of scientific facts and principles, and especially on questions related to Chemistry. These findings are not surprising given the emphasis placed on problem solving and process learning in the elementary science curriculum. Recent assessments have found that teachers tend to integrate elementary science with other subjects, a fact that may help explain students' high standing on problem-solving questions. The percentages of students performing at all five proficiency levels in British Columbia were similar to those for Korea.

Opportunity to Learn. In sharp contrast to the students' strong performance, teachers indicated that students had little opportunity to learn the concepts tested in most of the science items and about half of the mathematics items. For many items, especially in mathematics, seventh-grade teachers indicated a greater opportunity to learn the concepts than did eighth-grade teachers. An explanation may lie in the fact that seventh-grade classes are typically found in elementary schools, while eighth-grade classes are in secondary schools. It appears that eighth-grade teachers are unfamiliar with the elementary mathematics and science curricula.

IRELAND

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	National Curriculum
3,360,000	861,000	66,000	4	184 (elem.) 180 (sec.)	30.3 (elem.)	Yes

Context

Eight grades of primary school serve children between the ages of 4 and 12. Although education is compulsory only between the ages of 6 and 15, about 60 percent of 4-year-olds and 97 percent of 5-year-olds are enrolled in primary school. Over half a million children attend the 3,266 publicly aided schools in the country. A small number of pupils attend private primary schools.

There are five or six grades in the four types of second-level schools: secondary, vocational, comprehensive, and community. Comprehensive and community schools are expected to provide a wide range of curricular offerings to their more than 300,000 students. From the age of 6 to 14, practically all children attend school. At age 15, the participation decreases to 91 percent, at 17 to 61 percent, and at 18 to 36 percent.

Prior to 1971, the primary-school curriculum was subject-centered, with heavy emphasis on rote learning of arithmetic and language skills. In line with a policy of Gaelicization, particular attention was paid to development of the Irish language and culture. In 1971, there was a change to a more child-centered curriculum, with more attention paid to individual differences and to discovery methods of learning. The curriculum guidelines laid down by the Department of Education address Religion, Irish, English, Mathematics, Art and Craft activities, Social and Environmental Studies, History, Civics, Geography, Music, and Physical Education. All primary-school teachers follow a common set of guidelines, but they have wide discretion in the choice of topics and the order in which they are presented. For second-level schools, the Department of Education prescribes curricula for a broad range of subjects that lead to public examinations—the Intermediate Certificate after three or four years and the Leaving Certificate after a further two or three years.

Since considerable official emphasis is placed on the Irish language, which is compulsory in all primary and second-level schools, the amount of time available for other areas of study (e.g., Mathematics or Science) is obviously decreased. In Social and Environmental Studies, children in primary school are introduced to the study of science mainly through Biology. In the final two years, pupils are introduced to basic concepts in the Physical Sciences.

The traditional curriculum in secondary schools laid a heavy emphasis on the humanities. Since the 1960s, there has been an effort to increase participation in scientific and technical areas of study: This is reflected in the numbers of students taking courses and public examinations in these areas, although the numbers are still not very large (e.g., in 1980, 18 percent of students took Leaving Certificate Chemistry and 14 percent, Leaving Certificate Physics). Large classes and lack of facilities have hampered the full implementation of the new curriculum and retarded innovation.

Commentary

Mathematics. In mathematics, Irish 13-year-olds performed, on average, better than their peers in the United States, about as well as students in the United Kingdom and Spain, but not as well as students in the Republic of Korea and most of the Canadian provinces. Like their peers in the other countries, most Irish students (98%) have mastered basic addition and subtraction tasks typical of Level 300. However, only 55 percent of Irish students were able to perform the problem-solving tasks typical of Level 500, compared to 78 percent of their Korean counterparts. They performed relatively well in Logic and Problem Solving and less well in Data Organization and Interpretation. Teacher responses generally indicated that students have been taught most mathematics topics except for Geometry, in which students did much better than would have been expected on the basis of the low teacher ratings.

Student self-reports confirmed that students spend a lot of time either listening to the teacher or working alone and relatively little time working in groups or with classmates. This is consistent with an instructional approach that places more emphasis on computational skills and less on problem solving and other higher-level skills. The absence of a gender difference is significant and may reflect a movement over the last 25 years to improve the participation and attainment levels of girls in mathematics.

Science. In science, Irish students lagged behind their peers in most of the other countries except the United States. While most (96%) have mastered everyday scientific facts (Level 300), a much smaller percentage (37%) could analyze experiments (Level 500). Teacher ratings of opportunity to learn indicated a fairly low level of exposure to science topics, particularly in the seventh grade, but more exposure to Chemistry and the Nature of Science than to Physics, Earth and Space Sciences, and Life Sciences.

Student self-reports of science classroom activity revealed a low level of practical work, both individually and with classmates. A disproportionate amount of time appears to be spent either reading textbooks or watching the teacher conduct experiments. Achievement was significantly higher for boys than for girls on the science assessment as a whole. This is not surprising given the greater percentage of boys taking courses in nature science, but it is a cause for serious concern.

Summary. In mathematics, these results illustrate the need for more attention to higher-level abilities than to routine computational skills. In science, there appears to be a strong case for the reexamination of its role in the curriculum, particularly with a view to increasing its attraction for girls.

KOREA

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	National Curriculum
40,432,000	9,667,000	903,000	6	220	55 (cities) 40 (rural)	Yes

Context

The Republic of Korea is an increasingly industrialized nation with a growing economy guided by a series of five-year development plans under a highly centralized government. The population, which is homogeneous in both ethnic origins and language, is more than 90 percent literate and growing at a slower pace than in the 1950s.

The Education Act of 1948 stipulates that the purpose of education is to "enable every citizen to perfect his personality, uphold the ideals of universal fraternity, develop a capability for self-support in life, and enable him to work for the development of a democratic state and for the common prosperity of all humankind."

In the 1970s reforms brought significant changes in curriculum and instructional techniques. The main thrust has been to develop an instructional system that draws not only on classroom lectures and the reading of textbooks but also on multiple learning materials and an extensive and very sophisticated set of television and radio programs. New learning materials and instructional techniques are being developed and field-tested regularly to discover more effective procedures.

The current instructional system proceeds through five stages that the teacher uses in carrying out study units or lessons: a) planning, following the directions in the teachers' guide; b) diagnosing students' strengths and weaknesses by means of test items in a workbook; c) guiding student learning by use of workbooks and television programs; d) extending learning through the use of formative test items in workbooks; and e) evaluating the results of student learning with summative tests.

Boys and girls ages 12 to 14 are generally enrolled in middle schools. Entrance examinations for these schools were abolished in 1969, and currently all applicants are assigned by computer to schools within a district. Ninety-nine percent of students in this age group graduate from elementary school and move on to middle school, which is free (tax-supported).

In middle schools, students study mathematics four hours per week during the first year and three to four hours per week during the second and third years. The same is true for science. There are generally 40 to 55 students in a classroom, and every student is assigned a permanent seat with teachers, rather than students, rotating for class changes. Because of the class sizes, the lecture method is the rule in most classrooms, but in science, various experiments in laboratories are emphasized.

Commentary

Mathematics. In mathematics, Korean students performed well above their peers in other countries and provinces in all topics except Logic and Problem Solving. They particularly excelled in Data Organization and Interpretation and Geometry, achieving well above the other populations in these two topics. This success may be attributed to textbook coverage of these two features of mathematics or emphasis by Korea's middle-school mathematics specialists.

In comparing the results of students on the IEAP items with those from earlier international assessments, performance is better than in the past, perhaps reflecting the closer "fit" of this particular set of items to Korea's curriculum. It will be the responsibility of the policymakers and educational leaders to determine if the levels of achievement in the various topics are acceptable or if they should be improved. The fact that 40 percent of 13-year-olds could successfully perform tasks at Level 600 on the mathematics performance scale, nearly double the percentage of the other countries, is a source of satisfaction.

Science. In science, Korea's 13-year-olds joined those from British Columbia as top performers across all five topics. Relative to their performance in science overall, students did better in Chemistry and worse in the Nature of Science. These results may reflect the patterns of the courses of study and the emphases of the curriculum. While it is gratifying to note that 33 percent of the 13-year-olds could successfully perform the tasks described as the ability to analyze scientific data (Level 600), it may be that improvements should be considered as the technologies of the future are contemplated.

Summary. Korea's success can be partially attributed to the nation's and parents' strong interest in education, reflected in a 220-day school year. While there is virtually no adult illiteracy in the country, only 13 percent of Korea's parents have completed some postsecondary education. They nonetheless see education as the hope for their children and grandchildren. Everyone recognizes that Korea's job market is very demanding and the scientific and technological areas carry high prestige.

Mathematics and science are areas of special interest and most middle schools and all secondary schools have specialists teaching these subjects. While there is a mandated national curriculum, teachers are free to select one of five approved textbooks for most courses. Korea will continue to stress improvements in these subjects through research, support, and specifically through the current establishment of 14 special science high schools (one in each province).

NEW BRUNSWICK

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	Provincial Curriculum
712,300	139,000	10,000	6	182	23.9	Yes

Context

In 1967, the provincial government took over the entire responsibility of public-school financing. The Schools Act vested in the Minister of Education the authority to prescribe school curriculum for all school districts.

Having become an officially bilingual province (English and French) in 1969, the province recognized its linguistic duality in establishing, in 1974, two parallel but separate education systems. Subsequently, school boards and schools were established on a linguistic basis. There are now 15 Francophone school districts with 46,002 students and 27 Anglophone school districts with 92,052 students. At the junior-high level (grades 7 to 9) there are 11,768 students (33%) in Francophone enrollments and 23,901 students (67%) in Anglophone enrollments. Each linguistic division of the Department of Education is responsible for its own curriculum. A structured science curriculum at the elementary level is a recent addition. The mathematics curriculum is currently undergoing transformation.

Mathematics and science are taught from the first year of school. In elementary (grades 1 to 6) and junior-high (grades 7 to 9) schools, teaching time in each subject is allocated as follows:

Francophone Schools

Grades	1 and 2	3 to 6	7	8 and 9
Mathematics	300 min/week	300 min/week	280 min/week	240 min/week
Science	70 min/week	90 min/week	160 min/week	160 min/week

Anglophone Schools

Grades	1 to 3	4 to 6	7 to 9
Mathematics	300 min/week	300 min/week	225 min/week
Science	60 min/week	100 min/week	180 min/week

There are variations of schedules within schools. However, regardless of the form of the scheduling, the province stresses the importance of maintaining a balance between all subject areas. All in all, there is strong interest at the provincial level in strengthening curriculum in mathematics and science, both at the elementary and at the junior-high levels, as well as in increasing the competence of teachers in those particular subjects.

Commentary

In general, the results of the IAEP were consistent with the expectations of the Department of Education's curriculum and evaluation personnel. With the exception of the results reported for the French-speaking students in science, the relative performance of New Brunswick 13-year-olds on both the mathematics and the science assessments was anticipated.

Mathematics. Revision and/or implementation of curriculum modification in New Brunswick is cyclical. Recently, a new and more relevant mathematics curriculum has been put into place in the elementary schools. The effect of this change is now bei[illegible] at the junior-high-school level. It is believed that if the 13-year-old boys and girls who took the IAEP mathematics assessment had been taught mathematics under the new curriculum, their performance would have been higher.

Science. Current curriculum and instructional practices also affected the performance of students on the science assessments. According to provincial curriculum guides, formal science instruction ranges from 60 minutes a week in the lower elementary grades to a maximum of 100 minutes per week by the end of grade six. However, in reality, the actual time devoted to science instruction is often much less, and science lessons are usually relegated to afternoons. Also, the quality of instruction appears to depend on the classroom teacher's own interest in and understanding of science. Very few elementary schools have science laboratories or other facilities related to the teaching and learning of science. Also, New Brunswick is a rural province lacking museums, planetariums, and science centers, which are often helpful in fostering positive attitudes toward the learning of science.

The lower results obtained by the 13-year-olds attending French-speaking schools can be attributed to a variety of factors. For example, a formal science curriculum guide for the elementary teachers and science in-service sessions for elementary and junior-high teachers have been available only recently. Also, new science textbooks have only recently been adopted for the elementary and junior-high schools, and the older programs did not emphasize the scientific method or its applications.

Summary. The IAEP results for both the mathematics and the science assessments were considered to be in line with the available committed resources. With the current implementation of new elementary and junior-high-school mathematics curricula, and with an increased focus on science instruction at these levels, we expect the results of all New Brunswick 13-year-olds to improve in the future.

ONTARIO

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	Provincial Curriculum
9,001,000	1,878,000	102,000	6	185	23.2 (elem.) 23.0 (sec.)	Yes

Context

Enrollments in publicly funded schools (public and Roman Catholic Separate) account for 97 percent of the school population for ages 6 to 16. Catholic schools educate about one-third of these students. Five percent of the population ages 6 to 15 attends French-language schools. These schools, for the most part, are part of the Separate school system. The last decade has seen a significant increase in "new Canadians" (recent immigrants), and multiculturalism is an important component of government policy at both the provincial and federal levels.

The Ministry of Education issues official curriculum guidelines and lists of approved textbooks. No formal streaming or tracking is provided through eighth grade, but students are expected to choose either the advanced (university-bound), general, or basic level for their ninth-grade courses. Students can obtain a secondary-school diploma following completion of 30 credits. Each credit involves 100 to 120 hours of instruction; 16 credits are compulsory for most students. Students wishing to attend university must take six credits at the academic course level. Prior to 1968, the Ministry of Education administered province-wide examinations as a basis for awarding the grade 13 diploma. These examinations were replaced in 1968, for postsecondary admission purposes, by the Ontario Test for Admission to College and University. These tests were subsequently discontinued in 1974.

Ontario participated in both the IEA Second International Mathematics Study and the IEA Second International Science Study during the early 1980s. Interest in province-wide assessment grew as a result of these activities, and 1987 saw the initiation of the provincial review process. Through the use of school-based multiple matrix item sampling, provincial levels of student achievement are obtained in the areas of science, mathematics, and first language. Teacher and school information, including student opportunity-to-learn data, are also collected. A pilot review of Canadian Studies Geography at grades 9 and 10 was conducted in 1986-1987, and grades 11 and 12 advanced-level Chemistry and Physics followed in 1987-1988. During the 1988-1989 school year, provincial reviews of grade 6 Reading and Mathematics are being conducted. The review process operates on a five-year cycle, assessing two subject areas each year.

The IAEP involvement comes at a time of heightened interest in education. Two recent government-initiated reports were critical of achievement levels obtained by students, and a select committee of the legislature has been established to examine the goals and directions in education. This study provides the first clear evidence of levels of Ontario Anglophone and Francophone student achievement in relation to achievement in other Canadian provinces and other countries.

Commentary

Educational policy and practice is in a period of transition and renewal. The performance of students can best be understood within this context.

Greater emphasis is being placed by the Ministry of Education on specificity of expectations for achievement in mathematics and science. New guidelines, which stress learning outcomes as well as process goals at all levels of the science curriculum, were issued in 1987 and 1988. A recent mathematics guideline at the intermediate level sets out detailed objectives. The present renewal of the primary and junior curricula includes the development of a policy document in mathematics.

Until recently, Ontario has not had standardized accountability mechanisms such as provincial assessments or examinations. Ontario's participation in both the IEA Second International Mathematics Study and Second International Science Study helped initiate a new provincial review process. These provincial reviews are based on the curriculum and help meet demands for public accountability and provide evidence of curriculum effectiveness, including measures of student achievement. The provincial review program is also used to support curriculum renewal at the provincial and local level. Continued participation in international studies will provide further comparative evidence.

Financial and legal recognition of French-language schools has a short history in Ontario. There continues to be a shortage of French-language educational resources and the relatively small percentage (5%) and the wide dispersion throughout the province of the Francophone community contributes to the difficulty of meeting the educational commitment to French-language education.

It is expected that Ontario's involvement in this international assessment will help to focus continuing efforts toward educational renewal in the province.

QUEBEC

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	Provincial Curriculum
6,541,000	1,209,000	74,000	6	180	23.2 (elem.) 24.2 (sec.)	Yes

Context

Education is compulsory for all children from the beginning of the school year in which they reach the age of 6 to the end of the school year in which they reach the age of 15. Children can attend kindergarten if they are five years old and about 99 percent do so.

The compulsory part of education is composed of an elementary level and a secondary level. Elementary education usually covers six years of study, although a child may occasionally go on to secondary school after only five years. In any event, students must start the secondary level after seven years in an elementary school. The duration of secondary-level studies is usually five years. Students enrolled in a vocational program may continue (or begin) their program during a sixth year. A school year comprises a minimum of 180 days of classes at both the elementary and secondary levels. At the preschool level, a school year represents 180 half-days.

Local school boards are responsible for providing educational services at the elementary and secondary levels in French, English, Inuit, or Amerindian languages according to the current regulations. Private education involves 3.7 percent of the students at the elementary level and 16.4 percent at the secondary level. Funding from the province covers approximately 60 percent of the operating expenses of subsidized private institutions.

The Ministry of Education establishes the programs of study that are offered in the schools. Each year the Ministry evaluates several of the programs being taught. This evaluation process involves administering examinations to a sample of students as well as sending questionnaires to teachers and administrators. The science and mathematics programs for 13-year-olds were recently evaluated using this process.

Each subject in a student's program is evaluated in light of the course objectives. In order to obtain a secondary-school diploma, a student must accumulate a minimum of 130 credits. The student must also pass compulsory examinations, most of which are prepared by the school board, although some are prepared by the Provincial Ministry. The latter sets uniform examinations in some basic disciplines for students in the Secondary IV and V. The passing grade is 60 percent for all subjects at the secondary level.

The probability of a student finishing secondary school and obtaining a diploma was 68 percent in 1987. Students who wish to pursue postsecondary studies do so at the college level: in 1987, 61 percent of young adults continued their education in colleges.

Commentary

Almost all 13-year-olds are in either grade 7 or grade 8. These two grade levels constitute the First Cycle of secondary education in this province.

Mathematics. The program of study in mathematics is compulsory and uniform for all students enrolled in the general-education courses of study. An analysis of the tasks presented in the IAEP mathematics assessment reveals that they are closely related to the mathematics programs that Quebec students follow in elementary and secondary schools. According to educators within the school community, the overall results on this assessment are comparable to those obtained in previous evaluations and satisfy their expectations of students' performance.

Science. Thirteen-year-olds have acquired most of their science understanding from three existing programs of study: Natural Science (elementary level), Ecology (grade 7), and Physical Sciences (grade 8). These programs are compulsory and uniform for all students registered in general education courses of study.

Many IAEP questions focused on topics that are not addressed in the existing programs of study. This lack of any strong relationship between the IAEP assessment content and the science programs seems to have been corroborated by the responses of teachers in the opportunity-to-learn questionnaire. Because of this disparity between program content and assessment content, it is rather difficult to determine to what extent the Quebec student performance corresponds to educational expectations. To some extent, the Quebec assessment surveyed the scientific knowledge and awareness that students acquire from their cultural and social milieus.

Findings. Overall results in the French and English populations were comparable. Male results were slightly higher than female results in science but not mathematics. A high percentage of students stated that they like school "a lot" or "a little." For many, mathematics is considered an important subject. Students reported that they learn mathematics by listening to the teacher explain a lesson and then working on problems alone, rather than spending time working problems in small groups.

SPAIN

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	National Curriculum
37,683,000	7,571,000	462,000	6	180	30	Yes

Context

Twenty years ago, special concerns about education were raised in Spain. This fact coincided with the rapid economic growth that took place in the 1960s. During this process of economic development, the need for a well-educated population became a high priority. Spain's middle class has satisfied its basic needs and is beginning to acquire economic capital that is available for investment. Education is viewed as a long-term investment, which can provide middle- and working-class children with an opportunity for social mobility, and as an important instrument in reducing social inequalities.

For these reasons and the opening of Spain to the developed world, all of Spanish society has exhibited a renewed interest in the educational system. In particular, this concern was articulated in the General Education Law of 1970. This law established the current organization of the educational system: preschool, ages 2 to 6; general basic education, ages 6 to 14 (compulsory and free); secondary education, ages 14 to 18 or 19. The secondary education level offers two possibilities: baccalaureate, ages 14 to 17, and course of university orientation, ages 17 to 18; and vocational training, ages 14 to 19.

Gradually, the desire for universal education codified into law is being realized and, as time goes by, the percentage of children in school has reached 100 percent at the general basic education level. Even though educational enrollment goals have been met, Spanish society is now convinced that attendance alone does not guarantee the desired equality of opportunity. Therefore, more than 15 years later, the need to reorganize the educational system has resurfaced. This reorganization includes adjusting the system to fit the current environment and addressing the qualitative aspects of education. There is a strong political will within the current government to pass educational reform legislation during the 1989-1990 school year.

Since the enactment of the Constitution of 1978, the central government has been responsible for all the functions and resources that are essential to assure the basic operation of the educational system: degrees, requirements for promotion, curriculum and scheduling standards, basic requirements for teachers, inspection, etc. But Spain is divided into 17 different autonomous communities, six of them self-governed with regard to education. These regions have the power to control the promotion of regional culture, some curriculum and schedule requirements (teaching of their own mother tongue in addition to Spanish, for example), and supplemental educational budgets, apart from the national budget assigned to each community. Therefore, there exists a minimum curriculum and schedule common to all students that can be added to but never decreased in each of these six territories. This diversity must be accommodated as plans for organizational and curriculum reform are considered and implemented.

Commentary

At present, Spain is involved in a process of major reform of the educational system. The reform process focuses on teaching methods in addition to school organization and curricular content. Currently, the general opinion is that education is very traditional, since the pupil is viewed as the recipient of knowledge and plays a role of passive participant in the process. Results of the IAEP tend to corroborate this impression. Students reported that most of their class time is spent listening to the teacher explain a lesson and that the help they get from the teacher is less than they receive from their classmates.

On the other hand, the results do not confirm a current criticism that accuses teachers of emphasizing factual learning and spending less time on the applications of this knowledge. The data seem to show that in both mathematics and science curriculum, coverage is very balanced. Students obtained mean percents correct that ranged between about 50 and 70 percent in all the topics. In spite of this, the relative position of Spain with respect to the other countries and provinces is very different, depending on the specific math or science topic. This leads to the conclusion that each country or province has its own set of priorities in each curriculum subject.

In addition to the great similarity of results within the different topics, there were wide performance differences for individual questions. Researchers have suggested performing factorial or cluster analyses of the data in order to study item groupings.

Homework was not consistently related to achievement in the two subjects assessed. Students whose achievement was at the median did a lot of homework, got little help at home, and reported the most indifferent attitude toward school.

Most populations participating in the assessment found differences in the performance of males and females in science but not in mathematics. In Spain, boys' achievement was better than girls' in both assessments. This fact confirms that there is still discriminatory treatment of girls in schools, at least from a qualitative point of view. In the formal educational levels, quantitative discrimination has disappeared; schooling rates are similar for boys and girls. In primary education (6 to 14 years old) the rate is 100 percent, and in secondary education (14 to 17 years old), around 60 percent for both sexes.

UNITED KINGDOM

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	National Curriculum
55,196,000	9,221,000	683,000	5	190	25.9 (elem.) 21.0 (sec.)	Yes (as of 1988)

Context

During the past few years, there has been increasing concern about standards of education. The recent Education Reform Act (1988) proposes major changes in education, including the introduction of a national curriculum and the establishment of a national testing system. Mathematics and science will form part of the national core curriculum to be studied by all pupils of compulsory school age. Students will be tested on this curriculum at ages 7, 11, 14, and 16. The reports of the working groups on the national mathematics and science curricula were published in August 1988 and are expected to have a profound impact in the 1990s.

Mathematics. In 1982, the Cockcroft Committee recommended that mathematics teaching at all levels should include opportunities for exposition by the teacher, discussion, practical work, practice of skills and routines, problem solving, and investigational work. Funds were provided by central and local government for curriculum development and assessment projects and for advisory teachers to work with schools, in order to promote a broader approach to mathematics teaching. The new 16+ examination, the General Certificate of Secondary Education, was administered for the first time in 1988 and has a more practical and problem-solving outlook than its predecessors.

A source of particular concern is the impact of new technology. So far, schools have not taken much advantage of the availability of electronic calculators and computers. However, the increasingly widespread use of these machines in society has been recognized in the recommendations to develop attainment targets and programs of study for children ages 5 to 16.

Science. Science education in the United Kingdom tends to be more process oriented than in many other countries, and some schools already offer their students a wide range of experiences in which to develop their scientific skills. Nevertheless, science educators have expressed concern about the shortcomings of British science education. At the primary level, teachers often lack a working knowledge of the sciences, and at the secondary level, there has been concern that syllabi were overloaded, emphasized recall rather than understanding, and reflected the traditional disciplines of Physics, Chemistry, and Biology at the expense of other areas such as Astronomy, Earth Science, and Technology. Furthermore, the government's policy that science should be studied by all students of compulsory school age, whether or not they are likely to follow a career in science and technology, has not always been fulfilled.

Pressures for change have increased, partly because of the needs of industry for a scientifically trained work force, and partly as a result of the government's policy to raise standards in all areas of the curriculum.

Commentary

Mathematics. In comparison with other populations, the United Kingdom did quite well ranking first, second, or third in most topics. In Measurement and Numbers and Operations, the picture was more bleak, with the ranks being ninth and eleventh, respectively. For some questions, the success rate of the British students was considerably lower than that of all other countries. Where it is possible to compare IAEP items with similar ones used in British surveys (mainly APU), the results seem comparable, with some a little below the British results and others a little above. However, students' poor performance in Numbers and Operations is put into perspective by that of other countries in this survey.

Gender differences in mathematics can only be considered impressionistically. It appears that, as in the 1981 IEA survey, the differences are not as marked in measurement items as would be expected from APU results at age 11 and 15. It seems possible that there may be a leveling off of the difference or even a reduction in the differences between boys and girls aged 11 to 13 years.

Science. The United Kingdom ranked third in Physics and Earth and Space Sciences, fourth in Nature of Science, and sixth in the Life Sciences and Chemistry. Britain's relatively high ranking on the Earth and Space Sciences is a little surprising since this topic is not normally emphasized in science classes. It may be that the information required to answer the questions was obtained from other subject disciplines or non-school sources such as the media. Some of the greatest gender difference in favor of boys were found in items concerned with Earth and Space Sciences.

For many years there has been widespread concern about the small proportions of girls continuing to study the Physical Sciences after age 14, and the recent report of the national science curriculum working group has recommended that further research should be undertaken into the different perceptions of and reactions to science by boys and girls. The results of this study show an overall pattern (which held for most populations and most science topics in the assessments) in which boys achieved higher scores than girls. However, the United Kingdom was one of two populations with no significant gender differences (the other was the United States). In addition, girls in the United Kingdom scored better than boys on questions concerned with the Nature of Science. In the recent IEA study (1988), for which testing took place in 1984, the size of the gender difference among 14-year-olds in England was slightly above the average for the 17 countries compared. However, it was slightly smaller than that of the United States, Canada (English-speaking), and Korea.

UNITED STATES

Total Population	School (K-12) Population	Number of 13-Year-Olds	Age School Begins	Number of Days in School Year	Average Class Size	National Curriculum
241,000,000	45,900,000	3,051,000	5	180	24	No

Context

The interest in improving standards in mathematics and science education has been very high since 1983, fueled by the two recent IEA studies in which United States' performance compared unfavorably with that of other countries. Education reform was an important issue in the recent presidential election. The last period of great interest in mathematics and science instruction occurred in the 1960s after Sputnik.

During the past 20 years American education generally seems to have succeeded in strengthening the basic skills of *all* of its students—minority and economically disadvantaged children as well as the sons and daughters of more affluent parents. National assessments consistently reveal a weakness in higher-order thinking skills in all subjects, and there is a growing concern and determination to improve these skills. Policymakers, business leaders, and educators agree that young Americans will need these skills in the 21st century if they are to lead satisfying lives and if the national economy is to prosper. Newspapers and other media discuss these issues regularly.

All young people are required by law to attend school until they reach the age of 16. Most begin school at about age 5 and complete their secondary education at about age 17 or 18. About 15 percent drop out before completing the high-school program. There are no nationally mandated curricula in mathematics or science, but some of the 50 states publish recommended courses of study for these subjects. Mathematics is taught to all students every day during the first eight years of school, usually by the regular classroom teacher, and is also required in most secondary schools. Less than half of all high-school students take courses beyond first-year Algebra and Geometry. The National Council of Teachers of Mathematics is recommending new standards that reflect a national consensus for mathematics education.

Science is much less formally taught in elementary schools, with usually about two to three hours of instruction per week. In secondary school, 85 percent of the students study Biology for a year or more, but only about 35 percent take Chemistry and fewer than 10 percent elect to study Physics.

Educators who have analyzed student weaknesses tend to fault the curricula, lack of laboratory facilities, and the inadequate training of teachers. There are strong initiatives underway to strengthen curriculum and to increase the competence of teachers. More mathematics and science courses are being required of all students. The content of those courses is being made more rigorous and tests are being required to monitor progress. The challenging priorities of American education include an equal and quality education for all American children *and* high levels of achievement in all curriculum subjects.

Commentary

The results of the IAEP confirm the findings of other international and national research projects on mathematics and science achievement. Respected educational leaders have stated publicly that achievement levels are distressingly low and unacceptable, especially in view of the requirements of today's and tomorrow's technological environments.

Mathematics. The position of the United States as last in overall achievement heightens concern for the future in an increasingly competitive world. Today's 13-year-olds will be the voters of 1993 and the country's employees of 1995. Their ability to understand mathematical concepts and solve problems will determine their individual success and the collective prosperity of the nation. While it is satisfying to see that close to 100 percent of our students from all segments of our society with a mastery of the basics (Level 300), the fact that only 40 percent of them are able to solve two-step problems (Level 500) is a matter for grave concern. Percentages at Levels 600 and 700 are even more modest and suggest that the pool of trained talent from which to draw our future scientists, engineers, and technicians is small indeed.

Comparisons with the more successful competitors suggest examining the impact of heavy television watching by students and the small amount of mathematics homework typically done. The importance attached to mathematics by schools and society in general also may be a factor.

Science. The United States has traditionally thought of itself as technologically innovative and in the forefront in science. These results are sobering and pose a serious challenge to our position in the world community. It is satisfying to observe that almost all of our 13-year-olds, including those from the most economically disadvantaged sectors of our society, know everyday science facts (Level 300). Nevertheless, that only 42 percent of them can use scientific procedures and analyze scientific data (Level 500) is clearly unacceptable. Students' attitudes about the subject need to be strengthened, and the subject must become a more important part of the school curriculum. There are major efforts underway to redefine and strengthen the treatment of the subject, to train teachers, and to enlist parents' and businesses' support for the study of science. These efforts must be given high priority.

Summary. The findings of this study will present yet another opportunity to call the attention of policymakers, the business community, and America's parents to the potential problems the country will face if the mathematics and science curricula are not strengthened. Past successes by the schools, e.g., with basic-skills improvement, offer convincing evidence that if there is clear and common agreement on our goals, the educational system will be responsive.

Summary and Conclusions

The similarities reflected in these pages are probably as remarkable as the differences. Countries as old as Korea and as young as Canada can boast that 95 percent of their 13-year-olds have mastered the basic arithmetic operations and can solve simple problems in mathematics. Populations as diverse as those of British Columbia and Spain have taught all of their 13-year-olds the basic scientific facts measured by this assessment.

Viewed historically, these are major achievements. These statements support the hypothesis that schools all over the world share common goals and similar curricula. Yet what captures attention are the differences. Thirty three percent of Korea's 13-year-olds can apply intermediate scientific knowledge and principles in designing experiments and interpreting data. Less than 10 percent of their Irish counterparts are able to do as well. Forty percent of these same Korean young people are able to apply a range of strategies to solving fairly complex mathematics problems. Less than 10 percent of their United States' age-mates can do so.

Reactions to these kinds of findings elicit competitive emotions and questions concerning why these differences exist.

- ☐ Are certain schools "better"?
- ☐ Is motivation different?
- ☐ Do students work harder in some countries?
- ☐ Do certain societies attach greater importance to science or mathematics?

These assessment data, along with the comments of the representatives of the various countries and provinces, credit the disparities to a combination of factors. Certain facts seem clear:

- ☐ Many societies are currently focusing attention on education and curriculum reform. This kind of attention seems to make a difference.
- ☐ Attitudes of students ar J parents are important.
- ☐ There is little consistency in the relationship between types of classroom activities and achievement.
- ☐ Students learn a lot about mathematics and science outside of the classroom.

The debate concerning the importance of these two school subjects during the next few decades will continue. The issues have to do with economic well-being, international leadership, and national defense. Where will the world's innovative discoveries, new solutions, and creative products come from in the future? Does it matter?

What seems reasonable to assume is that if any country's young people are well educated, they will have increased opportunities for more productive and more satisfying lives.

The hope is that these kinds of studies will encourage and illuminate the discussions that will clarify opinions, sharpen objectives, and improve educational effectiveness.

Procedural APPENDIX

Background

Since 1983 Educational Testing Service (ETS) has administered the National Assessment of Educational Progress (NAEP) as well as related projects, such as state assessments and the International Assessment of Educational Progress reported here. NAEP is an ongoing, congressionally mandated project established to conduct national surveys of the educational attainments of students in the United States. Its primary goal is to determine and report the status of and trends over time in educational achievement. NAEP was initiated in 1969 to obtain comprehensive and dependable national educational-achievement data in a uniform, scientific manner.

After conversations with the representatives of several foreign countries, ETS staff developed a proposal for an International Assessment of Educational Progress (IAEP) designed to achieve two objectives:

- ☐ Explore the feasibility of reducing the time and money requirements for international comparative studies by capitalizing on the NAEP materials and procedures.
- ☐ Permit interested countries to experiment with NAEP technologies to determine their appropriateness for local evaluation projects.

In February 1987, ETS staff called a meeting of interested parties to discuss the feasibility of an international assessment project. The results of that planning session were a series of requirements and a time frame for conducting an assessment of mathematics and science achievement of 13-year-olds.

With these specifications in place, ETS was able to obtain funding from the Department of Education and the National Science Foundation for overall coordination, sampling, data analysis, and reporting. Participating countries and provinces acquired support for local data collection and coordination.

Project implementation was carried out through a series of meetings in 1987 and 1988 devoted to selecting assessment items, reviewing pilot-test results, and reviewing and interpreting final results. Decisions were made collaboratively, and follow-up coordination was provided by ETS staff.

Student Assessment Instruments

Assessment questions were selected from the pool of 281 mathematics and 188 science questions used in the 1986 NAEP. Mathematics and science experts from each country and province reviewed questions in terms of how well they assessed aspects of their country's curricula and how well they could be translated and/or adapted to reflect the local culture. Participants selected 90 mathematics items and 83 science items for pilot testing. The questions were selected so that a variety of content categories and skill levels would be represented in each subject (see chapters 3 and 6 for descriptions of topics). The final selection also reflected a range of difficulties and item characteristics.

Selected questions were translated from English to French, Korean, and Spanish and then independently translated from the non-English language back to English. The back-translated versions were compared with the original English to ensure that the translations were accurate. Questions were also adapted for cultural differences. For example, units of measurement, the names of children, and species of plants and animals were changed to reflect local usage and environments. In addition to the translated assessments, two additional English forms were developed to adapt to local usage and environments, one for use in Canada and one for use in the United Kingdom and Ireland. Questions were then pilot tested with at least 100 students in each location. Participants assessing students in two languages conducted pilots for each population.

The results of the pilot tests were used by the participants to select the final 63 items in mathematics and 60 items in science that met the targets for content categories and skill levels identified earlier. All of the science questions used a multiple-choice format. Fourteen of the mathematics questions were open-ended and required students to calculate and write their answers in their booklets. Translations were improved as needed and the final versions were back-translated and checked for accuracy at ETS.

Two assessment booklets were assembled, one for each subject. Booklets contained three sections, each with about 20 questions ordered from easy to hard. Students were allowed 15 minutes to finish each section. In the United States and some other locations, six mathematics items and six science items drawn from the IEA assessments were added to the IAEP assessment, two at the end of each section. Results of these items are not included in this report.

In addition to the cognitive assessment, students were asked 32 background questions about their mathematics and science instruction, their attitudes toward these subjects, and related activities at home (television watching, homework, home involvement in science activities). Most of these questions were selected from prior NAEP assessments, but in some cases they were developed specifically for the IAEP. In addition to the core set of background questions administered to all participants, some countries and provinces added items of their own.

Sample Design and Survey Response

The four Canadian provinces decided to assess more than one population of students. New Brunswick, Ontario, and Quebec selected separate samples of English- and French-speaking students. British Columbia selected separate samples of public- and private-school students (all English-speaking), which were combined for data analysis. The United Kingdom selected its sample from England, Scotland, and Wales (English-speaking students). The sampling frame did not include students from the Inner London Educational Authority (approximately three percent of the total population). Spain sampled students throughout the country and provided assessment booklets in Castilian, Catalan, Basque, Galacian, and Valencian languages. All but about 250 of the students in Spain took the assessment in Castilian, and only these students were included in the data analysis.

The sample designs for each of the populations may be described as stratified cluster samples. The participants, however, were free to design their surveys independently as long as certain specific rules were followed. The principal requirement was that their data be amenable to analysis as a paired cluster design, thus permitting the use of a jackknife procedure for the estimation of standard errors.

With two exceptions, all of the surveys followed the same two-stage sampling process. In the first stage, schools were selected with probabilities proportional to estimated size (number of 13-year-old students). At the second stage, subsamples of students were randomly drawn from within each selected school. Typically, about 100 schools were selected at the first stage and about 2,000 students at the second stage.

In contrast to the other surveys in which individual students were sampled within each selected school, New Brunswick (French) selected intact classes of students for assessment. In the United States, the IAEP booklets were included along with the 1988 NAEP, which used a three-stage design in which the first-stage selections were metropolitan areas and counties, the second-stage units were schools, and students constituted the third.

In 1988, NAEP booklets were administered to two equivalent half samples of students, each including approximately 1,000 students meeting the age definition. The first sample was assessed from January 1988 through mid-

March and the second, from mid-March through May. The results for the United States are based on the responses of students in the first half sample. These students were sampled from about 200 schools, thus minimizing the effects of clustering.

Details of selection procedures and the calculation of student weights for each separate assessment survey are provided in the IAEP *Technical Report*. Achieved sample sizes and cooperation rates are provided in TABLES A.1 and A.2.

The school participation rate across all assessment materials for the United Kingdom was 70 percent, compared to 89 percent or higher in other locations. In New Brunswick (English), school participation rates for the background questionnaire were 80 percent, because one large school board had a long-standing policy on surveys that did not permit its students to provide background information (grade, sex, and other variables). The average student participation rate for New Brunswick (French) was lower than for other populations, 73 percent as compared with 89 percent or higher. This low figure may be due to inaccurate records for the number of eligible students.

Data Collection and Scoring Procedures

All countries and provinces used standardized administration procedures. School personnel or external administrators followed the same administration script. Each cognitive mathematics and science assessment required 45 minutes to administer, and the time devoted to the background questions varied depending on the number of additional items added by participants.

In all locations except the United States, students completed one assessment booklet in the morning and the other assessment booklet in the afternoon. In a random half of the sampled schools, mathematics was

TABLE A.1

Number of Students Assessed

IAEP '88

	Number of Students Assessed (Raw Data)			Weighted Number of Students Assessed		
	Mathematics	Science	Background	Mathematics	Science	Background
British Columbia	3,025	3,025	3,025	33,589	33,589	33,590
Ireland	2,253	2,244	2,257	65,927	65,927	65,928
Korea	2,243	2,243	2,243	902,516	902,516	902,516
New Brunswick (English)	2,047	2,041	2,402	6,175	6,159	6,446
New Brunswick (French)	1,548	1,539	1,520	3,536	3,539	3,500
Ontario (English)	2,008	2,018	2,015	97,154	97,605	97,605
Ontario (French)	2,075	2,075	2,075	5,010	5,010	5,010
Quebec (English)	2,090	2,013	2,152	5,934	6,005	6,058
Quebec (French)	2,186	2,169	2,189	67,582	67,433	67,466
Spain	1,756	1,756	1,756	462,158	462,158	462,159
United Kingdom	2,202	2,202	2,202	682,999	682,999	683,000
United States (Mathematics sample)	905		905	3,051,017		3,051,017
United States (Science sample)		859	859		2,882,291	2,882,291

assessed first, followed by science, and in the other half the order was reversed. Typically, the background questions were administered after one of the cognitive assessments. In the United States, two equivalent samples of students were assessed, one for mathematics and the other for science.

The assessment was administered in February 1988, except in the United States, where the data were collected during the January through middle-March NAEP assessment.

Assessment booklets were returned to a central location within each country and province. The shipments were checked for completeness, open-end mathematics items were scored as correct or incorrect following standardized scoring guides, and responses were keyed or scanned.

Each country and province was responsible for developing a data file following a standard format, checking ranges of responses, and resolving inconsistencies in the data. These files were then sent to staff at the Quebec Ministry of Education where they were again checked. Each participant also sent to Quebec a random sample of booklets so that the data files could be checked against the original documents. Files were also sent to ETS at Princeton, where weights were calculated and added to the files for the United States and Canadian participants. Weights were verified for the other participants.

Mean Percents Correct Analysis

Data analysis was conducted by a research team at Laval University, Quebec, in consultation with researchers and data analysts at ETS, Princeton. The first stage of analysis involved the calculation of the percentage of correct answers and standard errors for individual questions and groups of questions. For each population, the weighted percentage of correct answers was calculated for each question. Students who omitted questions at the ends of sections because they did not reach them were excluded from the calculations for those questions. For each percent correct, an estimate of its standard error w[illegible] calculated using a jackknife procedure. P[illegible]centages and standard errors were calculat[illegible] for all stu-

TABLE A.2

School and Student Cooperation Rates

IAEP '88

	Schools			Students within Schools (Mean Rate)		
	Mathematics	Science	Background	Mathematics	Science	Background
British Columbia (Private)	1.000	1.000	1.000	0.977	0.977	0.977
British Columbia (Public)	1.000	1.000	1.000	0.960	0.960	0.960
Ireland	0.971	0.971	0.971	0.901	0.898	0.903
Korea	0.943	0.943	0.943	0.975	0.975	0.975
New Brunswick (English)	0.954	0.954	0.800	0.924	0.926	0.927
New Brunswick (French)	0.906	0.906	0.896	0.735	0.729	0.729
Ontario (English)	0.963	0.963	0.963	0.938	0.938	0.937
Ontario (French)	0.972	0.972	0.972	0.956	0.955	0.956
Quebec (English)	0.968	0.968	0.968	0.981	0.960	0.981
Quebec (French)	0.947	0.947	0.947	0.974	0.969	0.977
Spain	0.893	0.893	0.893	0.976	0.976	0.976
United Kingdom	0.702	0.702	0.702	0.943	0.943	0.929
United States	0.869	0.872	0.872	0.899	0.897	0.901

dents in each population and also by sex and grade.

Percentages were also averaged across groups of items for each population. Each assessment was divided into several topics that experts agreed reflected content areas or skills in mathematics and science. Average percents correct and standard errors were computed across the questions in each of these topics and across all questions in mathematics and all questions in science. Items that did not perform in a similar fashion across all populations were excluded from these analyses (see discussion of differential item functioning).

IRT Scaling

The second stage of analysis involved the scaling of mathematics and science results using item response theory (IRT) technology. Two scales were developed, one characterizing mathematics performance, the other, science performance. The underlying principle of this methodology is that when a number of items require similar skills, the regularities observed across patterns of responses can often be used to characterize both the respondents and the tasks in terms of a relatively small number of variables. When aggregated through appropriate mathematical formulas, these variables capture the dominant features of the data. Using the scale, it becomes possible to talk about distributions of proficiency in a population or subpopulation, and to estimate the relationships between proficiency and background variables.

IRT defines the probability of answering a given question correctly as a mathematical function of proficiency or skill and certain characteristics of the question. Specifically, the IAEP used a three-parameter logistic model.

Differential Item Functioning

Because the IAEP was administered to 12 populations in six countries and in four languages, additional steps were added to the scaling procedure to ensure that scales were summarizing the same constructs in all groups. First, item parameters were estimated for each population separately and results were examined to ensure that the responses fit the IRT model. No questions were rejected for lack of model fit for any population at this stage.

Second, the Mantel-Haenszel statistic was used to identify questions that exhibited differential item functioning (DIF). A question functions differentially across populations if students of equal ability but from different populations have different probabilities of answering it correctly. For these analyses, the students from the United States were identified as the reference group and students from each of the other populations were identified as focal groups. The DIF analyses were performed separately for each population outside of the United States and compared with the United States for each mathematics and science question. The DIF statistic for a given focal group and question estimates the difference in the proportion of correct responses to the question between members of the focal group and members of the reference group after the students within the two groups have been matched on their overall ability level.

The 11 DIF statistics (one for each population outside of the United States) for a given question were then standardized by dividing by their standard errors. A measure of the degree of DIF across all populations was then computed as the corrected sum of squares of the 11 standardized DIF statistics. The questions were ranked in terms of their across-population DIF statistic and the magnitude of their ordered DIF statistics was compared with reference values that would be expected to be obtained if there were no differential item functioning for any question. Questions whose across-population DIF statistics were significantly larger than the reference values were identified as outliers. These questions were deemed as exhibiting differential item functioning. In mathematics, one question was identified as inappropriate for scaling purposes, and in science six questions were so identified.

Estimation of Proficiency Levels

Given these two steps for ensuring that responses of students from all populations met the requirements for IRT scaling, two scales were developed that summarized performance across all populations, one for mathematics and one for science. To equally represent all populations in the scaling process, random samples of 400 students for each subject were selected from each population, and the item parameters for the subject were estimated on the combined sample of 4,800 students. These parameters and the patterns of student responses were used to estimate ability levels for each assessed student. Results were arbitrarily expressed on a hypothetical scale that ranges from 0 to 1,000 and has a weighted mean of 500 and a standard deviation of 100 across all populations. Although the results for mathematics and science are expressed in the same units, it is not appropriate to compare scores on one scale with scores on the other.

Scale Anchoring

One of the IAEP's goals is to describe what students know and can do in easily understood terms and to stimulate debate about whether those levels of performance are satisfactory. An additional benefit of IRT methodology is that it provides for criterion-referenced interpretation of levels on a continuum of proficiency. Although the proficiency scales range from 0 to 1,000, hypothetically more than 99 percent of the students' scores fall within the range of 200 to 500. The five levels chosen for describing results in the report are 300, 400, 500, 600, and 700. Each level is defined by describing the types of mathematics or science tasks that most students attaining that proficiency level are able to perform successfully; each is illustrated by a typical benchmark question (see chapters 1 and 4). Data are provided that give the estimated proportion of students from each population that perform at or above each of the five proficiency levels.

In the scale-anchoring process, the IAEP identified questions from the 1988 assessment that were good discriminators between proficiency levels. A question was identified as a benchmark question at a given level if students at that level had at least a 65 to 80 percent probability of getting the question right, while students at the next lower level had a much lower probability of success; i.e., less than 50 percent and at least 20 percentage points lower than the probability at the higher level. Mathematics and science experts examined these empirically selected questions as well as the other questions in the assessment and used professional judgment to characterize each proficiency level. In some cases, only one or two questions were identified for a level (particularly for Levels 300 and 700), and experts had to make inferences about prerequisite skills or transfer of skills that students might also be demonstrating. They were aided by the previous experience of anchoring the same items when they were used in the 1986 NAEP mathematics and science assessments.

Opportunity-to-Learn Ratings

The assessment collected information from teachers on students' exposure to the material covered in the mathematics and science assessments. The purpose of collecting the opportunity-to-learn ratings was to see to what extent students in the participating populations had been exposed to various mathematics and science content areas. It was assumed that lack of coverage of a content area included in the assessment might be a reason for low performance in that area.

In each participating school, a mathematics teacher or coordinator was asked to indicate the percentages of the seventh- and eighth-grade students in the school who had already had an opportunity to learn—anywhere in the school program—the concepts tested by each item in the assessment. (In the United Kingdom ratings were obtained for eighth- and ninth-year students, the years in school that enroll the majority of 13-year-olds.) In some cases, all teachers within a grade in a school developed a consensus rating for that grade, and in some cases, several teachers in a grade provided separate ratings. Response options for the ratings were: "all or most (more than 75 percent)," "some (25 to 75 percent)," "few (fewer than 25 percent)," and "none." The same information was collected from science teachers and coordinators about the science questions.

The analyses of these data focused on schools in which more than 75 percent of the students had already had an opportunity to learn the content measured by a question. It was assumed that students in these schools had been exposed to the content.

In order to compare the opportunity-to-learn information with achievement results, the "most" ratings for grade 7 and for grade 8 were weighted in proportion to the number of 13-year-olds in each of these grades. Specifically, for each school for each question, a "most" rating was assigned a value of 1 and all other ratings a value of 0. The value for the grade 7 rating was multiplied by the number of seventh graders and the school weight, and the value for the grade 8 rating was multiplied by the number of eighth graders and the school weight. The results were then added together. In the case of multiple ratings from the same school for a grade, ratings were also weighted proportionally, e.g., each of three ratings was assigned a weight of one-third. Results were then summed across schools and divided by the sum of weights to obtain an average percentage of "most" responses for each item. Appropriate standard errors were calculated using a jackknife procedure. The weighted percentages of "most" responses were then averaged across questions within each topic and standard errors of these statistics were calculated.

Response rates for opportunity-to-learn ratings were low for several populations. For mathematics, the nonresponse rate of teachers translated into missing data for more than 10 percent of the student population in New Brunswick (English), New Brunswick (French), Ontario (English), Ontario (French), Quebec (English), and the United States. For science, the nonresponse rate of teachers translated into missing data for more than ten percent of the student populations in Ireland, New Brunswick (English), New Brunswick (French), Ontario (English), Ontario (French), Quebec (English), Quebec (French), and the United States.

DATA APPENDIX

Mathematics Proficiency Means and Jackknifed Standard Errors

	TOTAL	MALE	FEMALE
BRITISH COLUMBIA	539.8 (2.2)	539.6 (2.8)	541.3 (2.6)
IRELAND	504.3 (3.7)	508.2 (5.7)	499.5 (3.4)
KOREA	567.8 (2.7)	576.7 (3.4)	558.0 (3.9)
NEW BRUNSWICK (ENGLISH)	529.0 (2.6)	526.6 (4.3)	529.0 (3.4)
NEW BRUNSWICK (FRENCH)	514.2 (3.3)	516.8 (4.2)	513.4 (3.6)
ONTARIO (ENGLISH)	516.1 (3.1)	517.8 (4.4)	514.6 (3.3)
ONTARIO (FRENCH)	431.5 (2.7)	480.6 (3.4)	482.7 (3.0)
QUEBEC (ENGLISH)	535.8 (2.7)	534.1 (3.0)	537.3 (2.3)
QUEBEC (FRENCH)	543.0 (3.1)	546.3 (4.2)	539.3 (3.0)
SPAIN	511.7 (4.6)	523.2 (5.3)	499.9 (5.0)
UNITED KINGDOM	509.9 (3.5)	507.0 (5.0)	512.5 (3.9)
UNITED STATES	473.9 (4.5)	474.6 (6.4)	473.2 (5.1)

AMOUNTS OF WEEKLY MATHEMATICS HOMEWORK

	LESS THAN 1 HOUR	1-2 HOURS	3 HOURS OR MORE
BRITISH COLUMBIA	534.3 (3.4)	545.3 (3.2)	542.8 (4.0)
IRELAND	497.2 (3.9)	511.8 (5.3)	532.0 (6.6)
KOREA	552.1 (4.9)	562.4 (3.5)	602.9 (4.0)
NEW BRUNSWICK (ENGLISH)	522.2 (4.3)	536.0 (4.4)	530.2 (4.3)
NEW BRUNSWICK (FRENCH)	515.1 (4.0)	517.2 (4.9)	518.8 (4.2)
ONTARIO (ENGLISH)	515.9 (3.9)	511.4 (4.7)	525.7 (4.1)
ONTARIO (FRENCH)	480.0 (3.3)	474.3 (3.8)	502.3 (4.7)
QUEBEC (ENGLISH)	532.5 (3.0)	533.9 (3.0)	544.7 (4.1)
QUEBEC (FRENCH)	538.4 (3.6)	539.1 (4.3)	559.7 (4.0)
SPAIN	499.7 (6.7)	505.8 (5.2)	533.9 (4.8)
UNITED KINGDOM	491.3 (4.6)	533.8 (3.6)	535.8 (7.8)
UNITED STATES	467.8 (5.2)	476.8 (9.1)	506.6 (10.8)

AMOUNTS OF DAILY TELEVISION VIEWING

	0-2 HOURS	3-4 HOURS	5 HOURS OR MORE
BRITISH COLUMBIA	556.1 (2.7)	536.8 (2.9)	509.4 (3.7)
IRELAND	523.4 (3.6)	500.3 (3.6)	455.3 (8.6)
KOREA	580.0 (3.5)	560.8 (2.8)	537.3 (8.0)
NEW BRUNSWICK (ENGLISH)	548.7 (4.0)	524.6 (3.4)	507.9 (7.4)
NEW BRUNSWICK (FRENCH)	519.2 (4.7)	516.3 (3.8)	505.8 (4.9)
ONTARIO (ENGLISH)	537.0 (4.5)	515.4 (3.8)	485.9 (3.2)
ONTARIO (FRENCH)	497.4 (4.4)	481.3 (3.1)	457.6 (4.4)
QUEBEC (ENGLISH)	548.4 (3.0)	534.8 (2.9)	513.6 (3.9)
QUEBEC (FRENCH)	549.3 (3.3)	540.2 (3.8)	526.1 (5.1)
SPAIN	523.9 (6.5)	507.6 (4.1)	480.6 (5.5)
UNITED KINGDOM	529.1 (4.6)	520.1 (3.9)	475.1 (4.6)
UNITED STATES	494.0 (8.2)	482.7 (5.9)	442.8 (7.8)

Percentage of Students with Mathematics Proficiency At or Above Each Level and Jackknifed Standard Errors

	LEVEL 300	LEVEL 400	LEVEL 500	LEVEL 600	LEVEL 700
BRITISH COLUMBIA	99.7 (0.1)	94.9 (0.6)	69.5 (1.2)	23.8 (1.1)	2.0 (0.3)
IRELAND	98.3 (0.6)	86.5 (0.9)	54.7 (1.7)	14.2 (1.0)	0.8 (0.2)
KOREA	99.6 (0.1)	95.3 (0.5)	78.1 (1.1)	39.6 (1.3)	4.9 (0.5)
NEW BRUNSWICK (ENGLISH)	99.9 (0.1)	95.5 (0.6)	65.4 (1.4)	17.8 (1.1)	1.0 (0.3)
NEW BRUNSWICK (FRENCH)	99.6 (0.2)	94.6 (0.7)	58.3 (1.9)	11.6 (1.2)	0.4 (0.2)
ONTARIO (ENGLISH)	99.2 (0.2)	91.8 (0.7)	58.3 (1.5)	16.0 (1.3)	1.4 (0.4)
ONTARIO (FRENCH)	98.7 (0.3)	84.8 (1.1)	40.5 (1.5)	7.0 (0.7)	0.1 (< .1)
QUEBEC (ENGLISH)	99.8 (0.1)	96.7 (0.4)	67.3 (1.2)	20.2 (1.0)	1.4 (0.2)
QUEBEC (FRENCH)	99.9 (0.1)	97.2 (0.4)	72.7 (1.8)	21.8 (1.3)	1.7 (0.3)
SPAIN	99.2 (0.2)	90.7 (1.0)	57.0 (2.4)	14.3 (1.8)	1.3 (0.4)
UNITED KINGDOM	98.5 (0.3)	86.7 (1.0)	55.5 (1.7)	18.4 (1.2)	2.5 (0.4)
UNITED STATES	96.6 (0.7)	77.7 (2.1)	40.3 (2.2)	9.2 (1.0)	0.7 (0.4)

Mathematics Mean Percents Correct and Jackknifed Standard Errors by Topic

	NUMBERS AND OPERATIONS	RELATIONS, FUNCTIONS, ETC.	GEOMETRY
BRITISH COLUMBIA	76.6 (0.6)	70.5 (0.4)	59.4 (0.6)
IRELAND	67.9 (1.0)	69.0 (0.8)	56.4 (0.6)
KOREA	79.2 (0.6)	80.0 (0.4)	72.3 (0.6)
NEW BRUNSWICK (ENGLISH)	73.2 (0.6)	71.1 (0.5)	58.0 (0.6)
NEW BRUNSWICK (FRENCH)	72.9 (0.8)	69.2 (0.7)	52.6 (1.1)
ONTARIO (ENGLISH)	70.1 (0.7)	67.7 (0.6)	56.1 (0.8)
ONTARIO (FRENCH)	62.7 (0.7)	68.2 (0.6)	47.4 (0.9)
QUEBEC (ENGLISH)	75.9 (0.5)	72.3 (0.5)	59.4 (0.4)
QUEBEC (FRENCH)	77.9 (0.7)	75.6 (0.6)	60.9 (0.8)
SPAIN	68.6 (1.0)	70.6 (1.0)	62.7 (1.2)
UNITED KINGDOM	61.5 (0.9)	73.8 (0.7)	63.0 (0.8)
UNITED STATES	61.4 (1.0)	59.9 (1.1)	49.1 (0.9)

	MEASUREMENT	DATA ORGANIZATION, ETC.	LOGIC AND PROBLEM SOLVING
BRITISH COLUMBIA	63.4 (0.6)	64.7 (0.6)	77.3 (0.5)
IRELAND	55.3 (0.9)	48.1 (0.6)	72.3 (0.7)
KOREA	71.2 (0.7)	74.7 (0.7)	73.9 (0.6)
NEW BRUNSWICK (ENGLISH)	64.9 (0.7)	60.3 (0.8)	73.8 (0.6)
NEW BRUNSWICK (FRENCH)	59.3 (1.0)	52.4 (0.9)	66.5 (0.8)
ONTARIO (ENGLISH)	58.4 (0.9)	59.7 (0.9)	73.5 (0.6)
ONTARIO (FRENCH)	52.1 (0.8)	50.2 (0.7)	53.7 (0.6)
QUEBEC (ENGLISH)	62.8 (0.7)	62.3 (0.5)	74.1 (0.4)
QUEBEC (FRENCH)	65.1 (0.8)	62.1 (0.8)	73.9 (0.7)
SPAIN	59.4 (1.2)	55.5 (1.3)	72.3 (0.9)
UNITED KINGDOM	58.0 (0.8)	62.3 (0.8)	78.1 (0.6)
UNITED STATES	43.9 (1.1)	54.7 (1.2)	63.0 (1.1)

DATA APPENDIX

Mathematics Mean Opportunity-to-Learn Ratings and Jackknifed Standard Errors by Topic

	NUMBERS AND OPERATIONS	RELATIONS, FUNCTIONS, ETC.	GEOMETRY
BRITISH COLUMBIA	66.3 (1.6)	59.7 (1.5)	30.6 (2.2)
IRELAND	62.9 (1.9)	60.5 (1.9)	23.3 (2.0)
KOREA	67.2 (2.4)	74.5 (2.0)	67.7 (2.3)
NEW BRUNSWICK (ENGLISH)	58.7 (1.5)	57.2 (0.6)	37.0 (1.4)
NEW BRUNSWICK (FRENCH)	60.4 (2.3)	73.0 (2.6)	59.0 (4.1)
ONTARIO (ENGLISH)	72.4 (1.9)	68.9 (2.3)	40.9 (3.0)
ONTARIO (FRENCH)	74.2 (1.4)	68.8 (1.6)	46.6 (2.1)
QUEBEC (ENGLISH)	73.4 (1.1)	63.5 (1.3)	31.6 (1.7)
QUEBEC (FRENCH)	81.5 (1.5)	73.4 (1.2)	51.5 (2.1)
SPAIN	81.7 (2.2)	83.5 (2.3)	67.1 (3.9)
UNITED KINGDOM	57.7 (2.7)	66.2 (2.1)	47.2 (2.7)
UNITED STATES	69.0 (2.0)	62.0 (2.4)	36.1 (3.6)

	MEASUREMENT	DATA ORGANIZATION, ETC.	LOGIC AND PROBLEM SOLVING
BRITISH COLUMBIA	55.6 (2.2)	43.5 (2.2)	44.8 (1.9)
IRELAND	53.7 (2.2)	38.1 (2.3)	47.7 (1.9)
KOREA	72.9 (2.1)	59.6 (2.8)	51.7 (2.7)
NEW BRUNSWICK (ENGLISH)	67.1 (1.4)	51.2 (2.0)	32.9 (1.8)
NEW BRUNSWICK (FRENCH)	77.9 (2.7)	50.1 (4.4)	54.0 (3.6)
ONTARIO (ENGLISH)	69.2 (2.4)	60.2 (3.1)	40.8 (2.5)
ONTARIO (FRENCH)	69.2 (1.7)	62.3 (2.1)	55.0 (2.1)
QUEBEC (ENGLISH)	59.2 (1.4)	53.2 (2.0)	47.0 (1.7)
QUEBEC (FRENCH)	67.1 (1.8)	59.4 (2.5)	59.9 (2.0)
SPAIN	80.7 (2.4)	63.8 (3.7)	58.6 (3.5)
UNITED KINGDOM	71.1 (2.1)	55.5 (2.6)	59.3 (2.8)
UNITED STATES	59.4 (3.0)	65.6 (3.1)	42.4 (2.8)

Science Proficiency Means and Jackknifed Standard Errors

	TOTAL	MALE	FEMALE
BRITISH COLUMBIA	551.3 (2.1)	562.3 (3.2)	541.6 (2.3)
IRELAND	469.3 (3.5)	480.4 (5.2)	456.5 (3.8)
KOREA	549.9 (2.9)	567.5 (3.6)	530.6 (4.1)
NEW BRUNSWICK (ENGLISH)	510.5 (2.7)	517.2 (4.0)	502.3 (4.1)
NEW BRUNSWICK (FRENCH)	468.1 (3.9)	477.4 (5.0)	460.2 (4.3)
ONTARIO (ENGLISH)	514.7 (2.7)	524.3 (3.8)	504.7 (3.0)
ONTARIO (FRENCH)	468.3 (2.2)	474.9 (3.1)	463.1 (2.7)
QUEBEC (ENGLISH)	515.3 (2.8)	525.4 (3.8)	505.7 (3.1)
QUEBEC (FRENCH)	513.4 (3.3)	523.7 (4.1)	502.1 (3.6)
SPAIN	503.9 (4.3)	518.0 (4.8)	489.5 (5.0)
UNITED KINGDOM	519.5 (3.7)	524.7 (5.3)	514.9 (3.3)
UNITED STATES	478.5 (4.8)	481.9 (6.1)	474.9 (4.7)

AMOUNTS OF WEEKLY SCIENCE HOMEWORK

	LESS THAN 1 HOUR	1-2 HOURS	3 HOURS OR MORE
BRITISH COLUMBIA	545.3 (3.2)	554.3 (2.8)	571.7 (5.9)
IRELAND	462.4 (3.7)	495.7 (4.7)	498.7 (8.6)
KOREA	545.5 (3.4)	554.7 (3.6)	564.4 (7.6)
NEW BRUNSWICK (ENGLISH)	510.4 (3.5)	511.8 (5.1)	503.3 (8.4)
NEW BRUNSWICK (FRENCH)	468.5 (4.2)	464.9 (4.9)	476.3 (6.5)
ONTARIO (ENGLISH)	516.8 (2.9)	512.3 (5.0)	505.5 (11.3)
ONTARIO (FRENCH)	471.0 (2.4)	465.8 (3.3)	466.4 (10.0)
QUEBEC (ENGLISH)	513.5 (3.1)	511.2 (3.6)	559.2 (7.0)
QUEBEC (FRENCH)	512.7 (3.5)	518.5 (4.3)	518.2 (6.3)
SPAIN	499.9 (6.0)	500.4 (4.5)	522.2 (5.8)
UNITED KINGDOM	499.9 (3.7)	547.4 (4.1)	565.5 (9.5)
UNITED STATES	478.5 (5.6)	482.9 (7.5)	472.3 (7.6)

NUMBER OF SCIENCE ACTIVITIES WITH SOMEONE AT HOME

	0	1	2	3
BRITISH COLUMBIA	537.5 (3.3)	545.1 (2.7)	559.0 (4.0)	501.4 (3.5)
IRELAND	452.5 (4.6)	468.6 (4.9)	480.1 (4.2)	501.0 (6.0)
KOREA	519.2 (5.7)	538.0 (4.5)	559.0 (3.1)	564.6 (4.5)
NEW BRUNSWICK (ENGLISH)	496.5 (4.6)	503.0 (4.1)	524.3 (5.5)	527.0 (7.1)
NEW BRUNSWICK (FRENCH)	456.3 (5.2)	461.7 (4.7)	472.8 (5.9)	439.0 (5.4)
ONTARIO (ENGLISH)	507.7 (3.8)	510.9 (4.3)	516.6 (4.1)	540.6 (6.1)
ONTARIO (FRENCH)	460.9 (3.4)	472.4 (4.2)	474.0 (4.0)	472.8 (5.0)
QUEBEC (ENGLISH)	498.8 (4.7)	515.2 (3.4)	519.8 (3.7)	537.8 (4.4)
QUEBEC (FRENCH)	511.8 (4.0)	504.7 (4.2)	515.2 (4.7)	527.9 (4.7)
SPAIN	503.2 (6.3)	505.3 (6.0)	506.7 (5.6)	508.2 (6.4)
UNITED KINGDOM	507.3 (4.6)	514.8 (4.4)	518.3 (4.5)	559.7 (7.1)
UNITED STATES	480.4 (8.5)	460.5 (7.5)	486.5 (7.9)	497.7 (7.3)

AMOUNTS OF DAILY TELEVISION VIEWING

	0-2 HOURS	3-4 HOURS	5 HOURS OR MORE
BRITISH COLUMBIA	568.6 (3.0)	547.9 (2.7)	519.4 (4.2)
IRELAND	485.2 (4.7)	465.5 (3.2)	479.6 (6.0)
KOREA	562.4 (3.9)	543.1 (3.1)	517.9 (7.1)
NEW BRUNSWICK (ENGLISH)	531.4 (4.7)	504.8 (4.0)	493.0 (6.0)
NEW BRUNSWICK (FRENCH)	479.0 (4.8)	467.4 (4.0)	453.5 (6.8)
ONTARIO (ENGLISH)	531.9 (4.5)	[illegible] (3.6)	490.0 (3.9)
ONTARIO (FRENCH)	482.2 (4.1)	469.2 (2.8)	446.6 (4.6)
QUEBEC (ENGLISH)	530.6 (4.5)	512.8 (3.5)	491.1 (4.8)
QUEBEC (FRENCH)	522.2 (3.6)	509.0 (4.1)	490.7 (6.0)
SPAIN	514.5 (5.6)	500.5 (4.5)	477.6 (6.4)
UNITED KINGDOM	537.7 (5.1)	531.1 (3.9)	483.2 (5.3)
UNITED STATES	495.1 (7.4)	486.1 (4.4)	453.5 (6.7)

DATA APPENDIX

Percentage of Students with Science Proficiency At or Above Each Level and Jackknifed Standard Errors

	LEVEL 300	LEVEL 400	LEVEL 500	LEVEL 600	LEVEL 700
BRITISH COLUMBIA	99.7 (0.1)	95.2 (0.5)	71.9 (1.1)	30.6 (1.0)	4.1 (0.4)
IRELAND	95.7 (0.9)	75.6 (1.1)	37.2 (1.6)	9.1 (0.9)	0.5 (0.2)
KOREA	99.7 (0.2)	93.1 (0.7)	72.7 (1.4)	32.6 (1.3)	2.3 (0.4)
NEW BRUNSWICK (ENGLISH)	99.2 (0.2)	90.4 (0.7)	55.4 (1.5)	14.9 (0.9)	1.0 (0.3)
NEW BRUNSWICK (FRENCH)	98.0 (0.4)	77.9 (1.6)	35.3 (1.7)	6.8 (0.8)	0.4 (0.2)
ONTARIO (ENGLISH)	98.8 (0.3)	90.6 (0.9)	55.9 (1.3)	17.1 (1.1)	1.6 (0.3)
ONTARIO (FRENCH)	98.0 (0.4)	78.8 (0.8)	34.8 (1.1)	6.1 (0.6)	0.2 (0.1)
QUEBEC (ENGLISH)	99.5 (0.2)	91.8 (0.7)	57.4 (1.7)	14.8 (0.8)	1.5 (0.3)
QUEBEC (FRENCH)	99.6 (0.1)	91.5 (0.9)	56.3 (1.7)	15.2 (1.3)	0.8 (0.2)
SPAIN	99.1 (0.2)	88.0 (1.1)	53.5 (2.3)	12.2 (1.3)	0.6 (0.2)
UNITED KINGDOM	98.5 (0.3)	89.0 (1.0)	59.0 (1.8)	21.3 (1.4)	2.4 (0.4)
UNITED STATES	95.8 (0.8)	78.3 (1.9)	41.8 (2.6)	11.8 (1.1)	1.4 (0.4)

Science Mean Percents Correct and Jackknifed Standard Errors by Topic

	LIFE SCIENCES	PHYSICS	CHEMISTRY	EARTH AND SPACE SCIENCES	NATURE OF SCIENCE
BRITISH COLUMBIA	72.6 (0.4)	63.7 (0.4)	64.4 (0.5)	73.0 (0.4)	69.8 (0.4)
IRELAND	60.0 (0.6)	53.0 (0.5)	46.7 (0.8)	61.0 (0.8)	54.5 (0.8)
KOREA	72.7 (0.5)	67.6 (0.5)	65.9 (0.6)	71.3 (0.5)	65.8 (0.6)
NEW BRUNSWICK (ENGLISH)	66.0 (0.5)	59.3 (0.4)	53.8 (0.6)	68.2 (0.6)	63.0 (0.5)
NEW BRUNSWICK (FRENCH)	58.5 (0.7)	56.0 (0.7)	48.8 (0.8)	55.2 (0.7)	57.3 (0.8)
ONTARIO (ENGLISH)	67.4 (0.5)	59.8 (0.6)	52.8 (0.6)	68.0 (0.6)	63.9 (0.5)
ONTARIO (FRENCH)	60.1 (0.4)	55.1 (0.4)	46.9 (0.6)	57.4 (0.5)	56.6 (0.5)
QUEBEC (ENGLISH)	68.9 (0.5)	58.3 (0.5)	51.4 (0.6)	66.3 (0.5)	64.4 (0.6)
QUEBEC (FRENCH)	70.8 (0.6)	59.6 (0.6)	54.0 (0.7)	60.7 (0.7)	64.0 (0.6)
SPAIN	69.0 (0.6)	60.2 (0.8)	51.6 (1.0)	65.6 (1.2)	59.5 (0.8)
UNITED KINGDOM	68.4 (0.6)	62.2 (0.7)	52.4 (0.7)	68.8 (0.8)	64.2 (0.7)
UNITED STATES	64.0 (1.0)	52.9 (0.9)	47.7 (1.0)	61.4 (1.1)	56.0 (1.0)

Science Mean Opportunity-to-Learn Ratings and Jackknifed Standard Errors by Topic

	LIFE SCIENCES	PHYSICS	CHEMISTRY	EARTH AND SPACE SCIENCES	NATURE OF SCIENCE
BRITISH COLUMBIA	23.0 (1.4)	21.6 (1.7)	52.1 (3.0)	23.8 (1.9)	40.3 (2.2)
IRELAND	25.4 (1.7)	25.1 (1.7)	40.3 (2.6)	18.0 (1.9)	37.9 (2.1)
KOREA	35.5 (1.7)	39.7 (1.6)	52.8 (1.6)	30.4 (1.6)	36.4 (1.7)
NEW BRUNSWICK (ENGLISH)	34.7 (1.9)	31.1 (2.2)	43.9 (1.7)	33.4 (2.0)	44.6 (1.6)
NEW BRUNSWICK (FRENCH)	39.0 (3.1)	29.8 (3.5)	46.8 (3.7)	40.0 (3.6)	41.8 (3.4)
ONTARIO (ENGLISH)	39.9 (2.4)	28.5 (1.8)	39.0 (2.6)	36.4 (2.3)	46.9 (2.2)
ONTARIO (FRENCH)	36.6 (2.0)	26.3 (1.9)	36.6 (2.5)	31.3 (1.6)	44.4 (2.6)
QUEBEC (ENGLISH)	38.1 (1.3)	11.0 (1.1)	23.1 (1.4)	26.2 (1.2)	33.3 (1.7)
QUEBEC (FRENCH)	42.9 (2.1)	15.9 (1.3)	25.9 (1.8)	31.0 (1.6)	37.6 (1.8)
SPAIN	64.8 (3.3)	57.2 (3.6)	63.2 (3.3)	65.1 (2.7)	61.7 (2.7)
UNITED KINGDOM	36.0 (2.3)	32.2 (2.1)	55.6 (2.5)	23.9 (2.1)	49.9 (2.9)
UNITED STATES	44.1 (2.5)	25.9 (2.5)	41.7 (2.5)	40.3 (3.4)	42.1 (2.9)

Their Contributions Made *A World of Differences*

Any international project is necessarily complex because of cultural and linguistic differences. Success depends on the sensitivity and dedication of the individuals involved, who must consistently make the extra effort to communicate the issues and to grasp important nuances. This study indeed was fortunate to attract a group of gifted and talented people who consistently exceeded the expectations of vigorous standards and demanding schedules.

Solange Paquet, Léo Laroche, Denis Savard, and Paul Vachon from the Quebec Ministry of Education helped shape the early conception of the project and efficiently managed their province's activities during the entire effort. Their imagination, along with the enthusiastic support of Clare Burstall from the National Foundation for Educational Research in England and Wales (NFER) energized the idea into reality.

Wendy Keys, also from the NFER, coordinated the project for the United Kingdom with assistance from Derek Foxman, Dougal Hutchison, and Barbara Bloomfield. Scottish participation was made possible by Sally Brown, Graham Thorpe, and Susan Freshwater of the Scottish Council for Research in Education.

Mariano Alvaro of the Ministry of Education and Science in Spain along with his colleagues, Ignacio Gozanlo-Misol, Maria José Navas, Susana Marcos, and Modesto Escobar joined the fledgling project and coordinated Spain's participation. Jean Jae Lee, Woong Sup Yoon, and Jin Gyu Kim from the National Institute of Educational Evaluation successfully directed the activities in Korea. Thomas Kellaghan and Michael Martin from the Educational Research Center, St. Patrick's College, organized and managed Ireland's project.

In addition to Quebec, where Allen Patenaude from the Ministry of Education directed the English schools' participation, three other Canadian provinces successfully joined in the project, thanks to the consistent and effective efforts of Sylvio Chenard, Léo-Paul Charest, Guy Léveillé, and Laurie Boucher from the New Brunswick Ministry of Education (Francophone); Richard Harvey and Cary Grobe, New Brunswick Ministry of Education (Anglophone); William Lipischak, Ron Cussons, Dennis Raphael, Jacqueline Fortin-LaCoste, and François Lavictoire from the

Ontario Ministry of Education; and Barry Carbol and Michael Kozlow from the British Columbia Ministry of Education.

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The data analyses for the pilot tests for various countries and development of the data base for the final assessments were completed by Léo Laroche, with the assistance of Nicole Dessureault and Nathalie Laroche. Data analysis was managed by François Dupuis and Richard Bertrand at the University of Laval with the able and tireless assistance of Normand Dufour and Marc Létourneau.

Research staff at ETS provided consultative help, especially Eugene Johnson, Bob Mislevy, John Barone, Bruce Kaplan, and Ed Kulick. Ben King and Jim Ferris, also at ETS, designed the sampling scheme and monitored its implementation in all of the participating countries.

Nancy Mead at ETS acted as project director with Marion Epstein providing able backup and advice. Solange Paquet at Educan coordinated the Canadian data-analysis activities. She received assistance in translation from Verna Delaney.

Initial drafts of the manuscript benefited from the technical reviews of Eugene Johnson and Ann Jungeblut at ETS, John Dossey of Illinois State University, Senta Raizen of the National Center for Improving Science Education, Lyle Jones of the University of North Carolina, and the Board on International Comparative Studies in Education directed by Dorothy Gilford.

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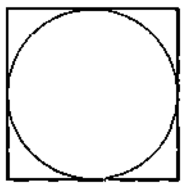
What proportion of your country's 13-year-old students would you expect to be able to answer questions like these?

MATHEMATICS
LEVEL 600



The length of a side of this square is 6. What is the radius of the circle?

Ⓐ 2 Ⓑ 3 Ⓒ 4 Ⓓ 6 Ⓔ 8 Ⓕ 9 Ⓖ I don't know.

SCIENCE
LEVEL 600

Group A	Group B	Group C
Water vapor	Ice	Alcohol
Oxygen	Aluminum	Water
Air	Iron	Gasoline

The substances above, each at room temperature, have been classified into groups. On what property is the classification based?

Ⓐ Chemical composition

Ⓑ Specific heat

Ⓒ State of matter

Ⓓ Abundance within the Earth's crust

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