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ABSTRACT

The science achievement of American students ages 9, 13, and 17 was measured during the 1976-77 school year. Overall, 543 different questions were asked in the cognitive assessment of science at the three age levels. The questions were developed according to a two-dimensional matrix. One dimension, the classification of the cognitive abilities required to answer specific science questions, was divided into four categories: (1) knowledge; (2) comprehension; (3) application; and (4) analysis, synthesis, and evaluation. The other dimension divided the domain of science into three major areas: content, process, and science and society. The questions illustrate various topics of the biological sciences, earth sciences, physical sciences, and integrated topics such as equilibrium, evolution, and probability. This document gives examples of several types of questions, and gives a summary of student performance categorized according to age, sex, ethnic background, region, size and type of community, and level of parental education. (BB)

E ACHIEVEMENT IN THE SCHOOLS

This report is made pursuant to contract No. OEC-0-74-0506. The amount charged to the Department of Health, Education, and Welfare for the work resulting in this report (inclusive of the amounts so charged for any prior reports submitted under this contract) is $25,930,530. The names of the persons, employed or retained by the contractor, with managerial or professional responsibility for such work, or for the content of the report are as follows: Roy Forbes (see Acknowledgments).

The cost figure cited above represents the total amount of money expended since late 1973 on assessments in art, career and occupational development, reading, writing, social studies/citizenship, science, basic life skills, mathematics and consumerism, resulting, to date, in numerous reports, papers, articles, presentations and assessment materials, many of which are used in state and local assessment programs. A complete list of all such materials is available upon request.

SCIENCE ACHIEVEMENT IN THE SCHOOLS

A SUMMARY OF RESULTS FROM THE 1976–77 NATIONAL ASSESSMENT OF SCIENCE

Science Report No. 08-S-01

by the
National Assessment of Educational Progress

Education Commission of the States
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FOREWORD

When the U.S. Office of Education was chartered in 1867, one charge to its commissioners was to determine the nation's progress in education. The National Assessment of Educational Progress (NAEP) was initiated a century later to address, in a systematic way, that charge.

Each year since 1969, National Assessment has gathered information about levels of educational achievement across the country and reported its findings to the nation. NAEP surveys the educational attainments of 9-year-olds, 13-year-olds, 17-year-olds and young adults (ages 26—35) in 10 learning areas: art, career and occupational development, citizenship, literature, mathematics, music, reading, science, social studies and writing. Different learning areas are assessed every year, and all areas are periodically reassessed in order to measure change in educational achievement. National Assessment has tested more than 720,000 young Americans since 1969.

Learning area assessments evolve from a consensus process. Each assessment is the product of several years of work by a great many educators, scholars and lay persons from all over the nation. Initially, these people design objectives for each subject area, proposing general goals they feel Americans should be achieving in the course of their education. After careful reviews, these objectives are given to exercise (item) writers, whose task it is to create measurement tools appropriate to the objectives.

When the exercises have passed extensive reviews by subject-matter specialists, measurement experts and lay persons, they are administered to probability samples. The people who compose these samples are chosen in such a way that the results of their assessment can be generalized to an entire national population. That is, on the basis of the actual performance of about 2,500 9-year-olds on a given exercise, we can generalize about the probable performance of all 9-year-olds in the nation.

After assessment data have been collected, scored and analyzed, National Assessment publishes reports to disseminate the results as widely as possible. Not all exercises are released for publication. Because NAEP will readminister some of the same exercises in the future to determine whether the performance level of Americans has increased, remained stable or decreased, it is essential that they not be released in order to preserve the integrity of the study.

ACKNOWLEDGMENTS

Many organizations and individuals have made substantial contributions to this report. Not the least of those to be gratefully acknowledged are the administrators, teachers and students who cooperated so generously during the collection of the data.

Special acknowledgment must go to science educators listed in Appendix D for their efforts in the development of the science assessment and to Norris Harms and Jan Pearson for their coordination of the development efforts. The administration of the science assessment was conducted by the Research Triangle Institute, Raleigh, North Carolina, and the Measurement Research Center, Iowa City, Iowa.

The actual preparation of this report was a collaborative effort of the National Assessment staff. Special thanks must go to the following people: Ingrid Van Royen and James Damon for data processing support; Betty Homler for secretarial support; Fred Daniels, Marci Reser and Paula Pitchford for production; and Rexford Brown for editing. Statistical analyses for this report were supervised by David Wright. The report was written by Robert Crane.

Roy H. Forbes
Director

CHAPTER 1

WHAT THE SCIENCE ASSESSMENT MEASURES

Introduction

The science achievement of American students ages 9, 13 and 17 has been measured three times by the National Assessment of Educational Progress (NAEP). The first science assessment took place during 1969 and 1970, the second assessment during the 1972—73 school year and the most recent one during the 1976—77 school year. As in previous assessments, this most recent assessment involved the contributions of a number of scholars in the field, education experts and lay persons. As a result of National Assessment's experience in the development of science achievement measures over the past 10 years, and the suggestions made in the most recent development cycle, the 1976—77 science assessment is an extremely comprehensive measure of the scientific literacy of young Americans. Overall, 543 different questions were asked in the cognitive assessment of science at three age levels. Approximately 72,000 students participated in the science assessment, and about 2,500 answered a given question.

For purposes of the assessment, the domain of science was treated in terms of two broad dimensions. One dimension, the classification of the cognitive abilities required to answer specific science questions, is based on a condensed and simplified version of *Taxonomy of Educational Objectives, Cognitive Domain*.[1] The cognitive taxonomy dimension is divided into four categories: the first three levels developed in the *Taxonomy of Educational Objectives* — *knowledge, comprehension* and *application* — and a fourth level that combines the *analysis, synthesis* and *evaluation* levels.

The other dimension divides the domain of science into three major areas: (1) *content*, the body of knowledge of science; (2) the *process* by which that body of knowledge comes about; and (3) *science and society*, the implications of that body of knowledge for mankind. These three major areas are subdivided into specific components. The *science content* area includes the traditional disciplines of biology, physical science and earth science, as well as integrated topics, a newly developing area that stresses principles that apply universally across the traditional disciplines. The *processes of science* include methods of inquiry and scientific decision making. *Science and society* includes persistent societal problems, science and self, and applied science.

This two-dimensional matrix became the basis for the development of questions for the science assessment. Table 1 indicates the number of science questions in the 1976—77 assessment that are classified in each category of the matrix for each age group. As Table 1 illustrates, each major area of science has been measured on the taxonomic levels, insuring a broadly based assessment of scientific literacy as experts in the field define it.

Although each question was assigned to only one taxonomic level, items were often categorized in two or more specific areas of science because they overlap in what they

[1] *Taxonomy of Educational Objectives. The Classification of Educational Goals. Handbook 1. The Cognitive Domain*, ed. Benjamin Bloom (New York: David McKay and Co., Inc., 1956).

TABLE 1. Number of Questions Classified in Each Category of the 1976–77 Science Assessment at Each Age Level

	Age	Taxonomic Levels				Totals
		Knowledge	Comprehension	Application	Analysis, Synthesis and Evaluation	
Content						
Biology	9	12	39	16	0	67
	13	16	35	22	4	77
	17	14	29	23	4	70
Physical science	9	8	49	19	1	73
	13	4	34	38	3	79
	17	9	21	42	2	74
Earth science	9	9	19	3	0	31
	13	6	31	4	4	45
	17	3	29	5	4	41
Integrated topics	9	0	1	1	0	2
	13	0	6	7	0	13
	17	0	8	8	1	17
Processes						
Process methods	9	2	15	16	8	41
	13	2	20	23	12	57
	17	2	16	30	13	61
Decision making	9	0	1	0	0	1
	13	0	1	9	1	11
	17	0	1	14	2	17
Science and society						
Persistent societal problems	9	2	5	5	0	12
	13	5	29	14	1	49
	17	5	31	19	2	57
Science and self	9	3	10	1	0	14
	13	8	10	4	1	23
	17	8	10	5	2	25
Applied science and technology	9	0	1	0	0	1
	13	0	11	1	2	14
	17	0	14	4	2	20

measure. This classification system is illustrated by the following item:

Estuaries are areas along coastlines in which salty ocean water mixes with fresh river water. Which one of the following statements about ocean life in these areas is correct?

- ⬭ There is very little animal life, but much plant life.
- ⬬ These are major breeding areas for many kinds of ocean life.
- ⬭ Many tiny animals grow there, but the water is not deep enough for big animals.
- ⬭ There is little ocean life there because it is too salty for fresh water fish and not salty enough for ocean fish.
- ⬭ I don't know.

This item, administered to both 13- and 17-year-olds, was classified as a comprehension question. However, since it is directly or indirectly related to earth sciences, biology and persistent societal problems it was classified in each of these specific areas as well.

The Major Areas of the Science Assessment

Although all of the 543 questions administered during the 1976–77 science assessment cannot be detailed here, a variety of questions from each of the areas is provided in this section. A complete set of the items that have been released to the public can be found in another publication.[2]

The Content Areas

The content areas of the science assessment represent those facts, concepts, principles, conceptual schemes, inquiry skills and other aspects of science that are necessary for an understanding of the natural world. The area is divided into four components: biological science, physical science, earth science and integrated topics. These components are further divided into various topics. (See Exhibit 1.)

[2] *The Third Assessment of Science, 1976—77, Released Exercise Set* (Denver, Colo.: National Assessment of Educational Progress, May 1978).

EXHIBIT 1. The Content Areas of the Science Assessment

Biological Science

Systematics
Cell theory
Energy transformations
Heredity
Systems
Evolution
Ecology
Behavior
Growth and development
Germ theory and disease

Earth Science

Meteorology
Geology
Oceanography
Astronomy

Physical Science

Matter
Combinations
Waves
Electricity and magnetism
Mechanics

Integrated Topics

Models
Equilibrium
Change
Evolution
Growth
Time/space
Systems
Cycles
Probability

Biological sciences. Biological science, the study of living organisms, is divided into 10 topics: systematics, cell theory, energy transformations, heredity, systems, evolution, ecology, behavior, growth and development, and germ theory and disease. A sampling of the biology questions follows:

Sample Item 1

Taxonomic Level:	Application
Topic:	Ecology
Administration Age:	9
Percentage of Correct Responses:	49%

If you put too much fish food in an aquarium, the fish may die because

- ⬭ the fish would eat too much.
- ⬭ the fish would kill each other fighting for the food.
- ⬬ the uneaten food would decay and use up the oxygen in the water.
- ⬭ I don't know.

Sample Item 2

Taxonomic Level:	Analysis, Synthesis and Evaluation
Topic:	Heredity
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13 — 33% Age 17 — 69%

Here is a diagram showing the genes for fur color in guinea pigs.

Parents:	Male EE Brown fur		Female ee White fur	
Offspring:	Female Ee Brown fur	Female Ee Brown fur	Male Ee Brown fur	Male Ee Brown fur

According to the diagram, what kind of trait is brown fur in guinea pigs?

- Recessive
- Dominant
- Blended inheritance
- Sex-linked

- I don't know.

Sample Item 3

Taxonomic Level:	Comprehension
Topic:	Evolution
Administration Ages:	9 and 13
Percentages of Correct Responses:	Age 9 — 53% Age 13 — 80%

No human being has ever seen a dinosaur. What is the best evidence that dinosaurs once lived?

- Pictures in museums
- Fossils
- Pictures on the walls of caves
- Present animals that have evolved from them

- I don't know.

Sample Item 4

Taxonomic Level:	Knowledge
Topic:	Cell Theory
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13 — 39% Age 17 — 53%

When a cell of a plant stem divides, each new cell has

- half the number of chromosomes as the parent cell.
- twice the number of chromosomes as the parent cell.
- the same number of chromosomes as the parent cell.

- I don't know.

Physical sciences. Physical science is divided into five topics: matter, combinations, mechanics, waves, electricity and magnetism. A sampling of the physical science questions follows:

Sample Item 5

Taxonomic Level:	Comprehension
Topic:	Waves
Administration Age:	9
Percentages of Correct Responses:	Part A — 75% Part B — 79% Part C — 49% Part D — 61%

If you spend a lot of time listening to very loud sounds, could each of these things happen to you? Fill in one oval in each box.

		Yes	No	I don't know.
A.	You might not be able to hear as well any more.	●	○	○
B.	Inside parts of your ears might be damaged.	●	○	○
C.	It might affect the way you feel.	●	○	○
D.	Your health might improve.	○	●	○

Sample Item 6

Taxonomic Level:	Application
Topic:	Electricity and Magnetism
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13 — 44% Age 17 — 60%

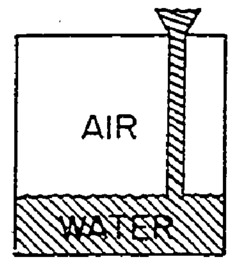
The bulb in your two-battery flashlight burned out. Each battery is one and one-half volts. What voltage light bulb should you buy as a replacement?

○ Three-fourths volt
○ One and one-half volts
○ Two volts
● Three volts
○ Six volts

○ I don't know.

Sample Item 7

Taxonomic Level:	Comprehension
Topic:	Matter
Administration Age:	13
Percentages of Correct Responses:	70%



No more water will go into the can. Why?

○ Air pushes harder than the water.
○ Air is heavier than the water.
● Air takes up space and must get out to let the water in.
○ The water doesn't want to go in.

○ I don't know.

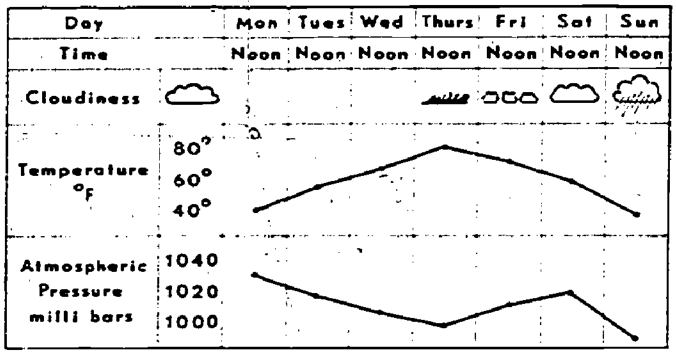
Earth sciences. Earth science is divided into four topics: meteorology, geology, oceanography and astronomy. A sampling of the items used to assess earth sciences follows:

Sample Item 8

Taxonomic Level:	Analysis, Synthesis and Evaluation
Topic:	Meteorology
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13: Part A — 51% Part B — 62% Age 17: Part A — 59% Part B — 82%

Look at the information in the diagram below and answer the questions on this and the following page.

WEATHER DATA FOR SUN CITY



A. Which one of the following conditions might have predicted rain on Sunday?

- ⬭ The pressure was dropping, and the temperature was rising.
- ⬭ The pressure was rising, and the temperature was dropping.
- ⬬ The pressure was dropping, and the temperature was dropping.
- ⬭ The pressure was rising, and the temperature was rising.

- ⬭ I don't know.

B. Look at the diagram for the days Monday through Thursday. Choose the best description of the relationship between temperature and pressure for those days.

- ⬭ As the temperature rose, the pressure remained the same.
- ⬭ As the pressure rose, the temperature remained the same.
- ⬭ As the pressure rose, the temperature dropped.
- ⬬ As the temperature rose, the pressure dropped.

- ⬭ I don't know.

Sample Item 9

Taxonomic Level:	Comprehension
Topic:	Astronomy
Administration Ages:	9, 13 and 17
Percentages of Correct Responses:	Age 9 — 33% Age 13 — 45% Age 17 — 50%

A star is most like

- ⬭ a comet.
- ⬭ a meteor.
- ⬭ the moon.
- ⬭ a planet.
- ⬬ the sun.

- ⬭ I don't know.

Sample Item 10

Taxonomic Level:	Comprehension
Topic:	Geology
Administration Age:	17
Percentage of Correct Responses:	50%

Which statement best describes how the earth's surface changes over billions of years?

- ⬭ A flat surface is gradually pushed up into steeper and steeper mountains until the world is covered with mountains.
- ⬭ Very steep mountains gradually wear down until most of the world is worn down to sea level.
- ⬬ Very steep mountains gradually wear down into flat surfaces that may be again pushed up into mountains, and so on over and over again.
- ⬭ Very steep mountains and flat plains stay side by side for billions of years with little change.

- ⬭ I don't know.

Integrated topics. Integrated topics were designed to include that knowledge that is common to all science disciplines. The area is important because of its general application of fundamental concepts. Assessment in integrated topics includes the following: models, equilibrium, change, evolution, growth, time/space, systems, cycles and probability.

Sample Item 11

Taxonomic Level:	Comprehension
Topic:	Systems
Administration Age:	17
Percentages of Correct Responses:	Part A — 71% Part B — 57% Part C — 83% Part D — 80% Part E — 59% Part F — 72% Part G — 81%

Can each of the items below be thought of as a system?

	Yes	No	I don't know
A. Street	●	○	○
B. Toaster	●	○	○
C. Automobile	●	○	○
D. Farm	●	○	○
E. House	●	○	○
F. Person	●	○	○
G. Football team	●	○	○

Sample Item 12

Taxonomic Level:	Comprehension
Topic:	Evolution
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13 — 31% Age 17 — 51%

Astronomers sometimes talk about the evolution of a star. When they do this, the astronomers are probably talking about the star's

○ brightness.
○ motion in the skies.
○ position in the galaxy.
● gradual change.
○ turning speed.

○ I don't know.

Sample Item 13

Taxonomic Level:	Comprehension
Topic:	Time/Space
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13 — 58% Age 17 — 71%

Life span, erosion, tides, seasons, city growth, automobile production, electrical use, plant growth, and epidemics can all be measured in terms of

○ weight.
○ length.
● time.
○ mass.
○ force.

○ I don't know.

The Process Area

The process area of the science assessment is divided into the processes of inquiry and scientific decision making. These two components consist of the generalizable methods, activities, inquiry skills, conceptual schemes and empirical emphases associated with the scientific endeavor. Because the new science curricula developed in the last two decades have stressed methods of thinking and acting, the measurement of these skills is necessary to reflect science achievement in the broadest sense. Exhibit 2 provides the various topics associated with each of the process components.

EXHIBIT 2. The Process Area of the Science Assessment

Processes of Inquiry	Scientific Decision Making
Models	Problem definition
Assumptions	Criteria development
Communications	Identification of constraints
Measurements	Model generation
Classification	Developing solutions
Observing	
Experimenting	
Interpretation of data	

Processes of inquiry. Scientific inquiry includes eight topics: models, assumptions and values of science, communications, measurements, classification, observation, experimenting and interpretation of data. The items measuring these eight topics reflect the methods that are used to develop the content of science. Some examples of the questions used in the assessment follow:

Sample Item 14

Taxonomic Level:	Application
Topic:	Measurements
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13 — 53% Age 17 — 70%

Barbara weighs a frog four different times and gets these weights: 14.1 grams, 14.4 grams, 15.0 grams, and 15.3 grams. The average is 14.7 grams.

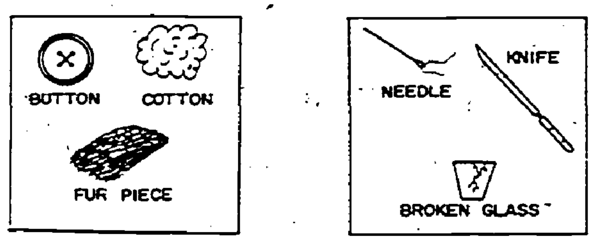
The weight of the frog is probably closest to

- ⬭ 14.1 grams.
- ⬭ 14.4 grams.
- ● 14.7 grams.
- ⬭ 15.0 grams.
- ⬭ 15.3 grams.

- ⬭ I don't know.

Sample Item 15

Taxonomic Level:	Analysis, Synthesis and Evaluation
Topic:	Classification
Administration Age:	9
Percentage of Correct Responses:	26%



A kindergarten teacher arranged six objects in different ways as shown in the pictures above. Why did he arrange the objects this way?

- ● He did not want the children in his kindergarten class to hurt themselves.
- ⬭ He wanted to teach the children in his kindergarten class the difference between metal and nonmetal objects.
- ⬭ He wanted to find out whether there were more soft objects or hard objects.

- ⬭ I don't know.

Sample Item 16

Taxonomic Level:	Comprehension
Topic:	Observing
Administration Age:	17
Percentage of Correct Responses:	87%

Some grape leaves were accidentally sprayed with paint. Those leaves did not get moldy. Other unsprayed grape leaves did get moldy. This discovery led to a way to protect fruit trees and vines from many diseases caused by mold.

This shows that

- ⬬ unexpected results are sometimes useful.
- ⬭ science and technology work together.
- ⬭ scientific laws are the result of careful experimentation.
- ⬭ measurement is important in science.
- ⬭ I don't know.

Sample Item 17

Taxonomic Level:	Comprehension
Topic:	Interpretation of Data
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13: Part A — 78% Part B — 61% Part C — 94% Part D — 53% Part E — 71% Part F — 75% Age 17: Part A — 84% Part B — 72% Part C — 98% Part D — 64% Part E — 78% Part F — 90%

Dan and Rose want to find out whether the fifteen-year-old boys in their school are taller, on the average, than the fifteen-year-old girls. The school nurse has the following information about each student. Which information would be useful for answering their question and which information would not be useful?

	Useful	Not useful	I don't know.
A. Last name, first initial	⬭	⬬	⬭
B. Year and date of birth	⬬	⬭	⬭
C. Height	⬬	⬭	⬭
D. Weight	⬭	⬬	⬭
E. Date height and weight were measured	⬬	⬭	⬭
F. Sex of student	⬬	⬭	⬭

Scientific decision making. The decision-making component of the science assessment contains five main topics: problem definition, criteria development, identification of constraints, model generation and developing solutions. While decision-making skills are not unique to science issues, there has been an increasing demand for citizens to be able to apply these skills to concerns of a scientific nature. The ability to make informed decisions using scientific information is increasingly a goal of science education.

Sample Item 18

Taxonomic Level:	Application
Topic:	Identification of Constraints
Administration Age:	17
Percentages of Correct Responses:	Part A — 80% Part B — 77% Part C — 84% Part D — 68% Part E — 61%

The city council must decide whether to use a piece of land to build a factory or a park. There is a conflict between those who favor economic growth and those concerned with environmental quality. Is each of the following a statement of a goal or desired outcome of the solution chosen, or a statement of a barrier or obstacle to the solution of the problem?

	Goal	Barrier	I don't know.
A. Both purposes cannot be achieved on the same land at the same time.	⬭	⬬	⬭
B. There is no other land available that is as good for either purpose.	⬭	⬬	⬭
C. The decision should be acceptable to a majority of the citizens.	⬬	⬭	⬭
D. The decision should not greatly increase air pollution or unemployment.	⬬	⬭	⬭
E. The local newspaper is pushing strongly for using the area for a park and will fight any compromise.	⬭	⬬	⬭

Sample Item 19

Taxonomic Level: Application

Topic: Model Generation

Administration Ages: 13 and 17

Percentages of Correct Responses: Age 13 — 58%
Age 17 — 71%

Many people are affected by a tropical disease which is carried by a certain type of insect. What should biologists attacking the problem do first?

- ⬭ Destroy all those insects
- ⬬ Predict what may happen if all those insects were destroyed
- ⬭ Not worry, because there are no tropical diseases in this country
- ⬭ Leave all the insects alone
- ⬭ I don't know.

Science and Society Area

The area of science and society is divided into three components: persistent societal problems, science and self, and applied science/technology. These components reflect the general goal of science education that students should understand the implications of science for their own lives and the lives of other people. Exhibit 3 lists the various topics considered in each of the science and society components.

Persistent societal problems. This component assesses students' understanding of some current problems related to our society's technological development. Four topics are considered: health and safety, environment, growth and resource management.

Sample Item 20

Taxonomic Level: Application

Topics: Growth and Resource Management

Administration Ages: 13 and 17

Percentages of Correct Responses: Age 13 — 34%
Age 17 — 47%

Some people think that the solution to coal, gas and oil shortages is to switch over to electricity. In other words, if we run out of gas and oil we can just switch over to electric cars. What is wrong with this idea?

- ⬬ Most electricity is produced from coal, gas and oil.
- ⬭ If we switch over to electricity many people will lose their jobs.
- ⬭ It has been proven that it is impossible to build electric cars in great quantities.
- ⬭ Electricity is far too expensive.
- ⬭ There is nothing wrong with this idea.
- ⬭ I don't know.

EXHIBIT 3. The Science and Society Area of the Science Assessment

Persistent Societal Problems	Science and Self	Applied Science/Technology
Health and safety Environment Growth Resource management	Everyday use of science Personal health, nutrition and safety	Applications in biological science Applications in physical science Applications in earth science Changes in science/technology

Sample Item 21

Taxonomic Level:	Knowledge
Topic:	Environment
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13 — 29% Age 17 — 37%

What is the major cause of air pollution in most large American cities?

- ⊂⊃ Factories
- ⊂⊃ Open trash burners
- ⊂⊃ Fog
- ● Cars
- ⊂⊃ I don't know.

Sample Item 22

Taxonomic Level:	Comprehension
Topic:	Health and Safety
Administration Age:	9
Percentage of Correct Responses:	53%

Today, almost no one gets polio because

- ⊂⊃ doctors have found new drugs which cure polio when it happens.
- ⊂⊃ bad water, which used to cause polio, has been cleaned up.
- ⊂⊃ people eat better food and get more exercise, so they are healthie
- ● people are given a vaccine which keeps them from getting polio.
- ⊂⊃ I don't know.

Science and self. This component assesses the everyday use of science by the individual, and personally relevant topics such as health, nutrition and safety.

Sample Item 23

Taxonomic Level:	Knowledge
Topic:	Nutrition
Administration Ages:	13 and 17
Percentages of Correct Responses:	Age 13: Part A — 72% Part B — 90% Part C — 80% Part D — 38% Part E — 40% Part F — 56% Part G — 90% Part H — 26% Part I — 52% Age 17: Part A — 72% Part B — 94% Part C — 86% Part D — 57% Part E — 59% Part F — 76% Part G — 88% Part H — 51% Part I — 54%

Is each of the following foods rich in protein?

	Yes	No	I don't know.
A. Sugar	⊂⊃	●	⊂⊃
B. Beef	●	⊂⊃	⊂⊃
C. Cheese	●	⊂⊃	⊂⊃
D. Potatoes	⊂⊃	●	⊂⊃
E. Lettuce	⊂⊃	●	⊂⊃
F. Peanut butter	●	⊂⊃	⊂⊃
G. Milk	●	⊂⊃	⊂⊃
H. Fruit	⊂⊃	●	⊂⊃
I. Beans	●	⊂⊃	⊂⊃

Sample Item 24

Taxonomic Level:	Comprehension
Topic:	Safety
Administration Ages:	9, 13 and 17
Percentages of Correct Responses:	Age 9: Part A — 81% Part B — 86% Part C — 43% Part D — 77% Part E — 87% Age 13: Part A — 73% Part B — 96% Part C — 73% Part D — 96% Part E — 94% Age 17: Part A — 70% Part B — 97% Part C — 83% Part D — 98% Part E — 96%

Is each of the following a safe or unsafe practice?

	Safe	Unsafe	I don't know.
A. Using a light weight extension cord with an electric heater	○	●	○
B. Storing paint thinner near the gas hot water heater	○	●	○
C. Keeping drain cleaner on an open shelf near the bathroom sink	○	●	○
D. Reading operating instructions for all electrical appliances before using them	●	○	○
E. Using a fork to remove toast stuck in a toaster while the toaster is still plugged in	○	●	○

Applied science and technology. The topics in this component deal with the application of knowledge in biological, physical and earth sciences to a variety of societal issues, and an understanding of the potential payoffs and/or dangers of various scientific and technological endeavors.

Sample Item 25

Taxonomic Level:	Comprehension
Topic:	Application of Biological Science
Administration Age:	17
Percentages of Correct Responses:	Part A — 56% Part B — 81% Part C — 76%

Sixty years ago a farmer had an average yield of 50 bushels per acre in his corn field. Today, a farmer using the same field averages 100 bushels of corn per acre. Is each of the following a likely explanation for the change?

	Yes	No	I don't know
A. The climate has changed so that corn grows better now.	○	●	○
B. The farmer is using different kinds of corn plants which have been bred to give more corn per plant.	●	○	○
C. The increase of pollution in the air has made the farmer's plants become stronger to resist pollution and also to produce more corn.	○	●	○

Sample Item 26

Taxonomic Level:	Comprehension
Topic:	Application of Physical Science
Administration Age:	17
Percentage of Correct Responses:	42%

It is known that certain gases condense around crystals. What is this knowledge used for?

- ○ Detecting radio signals
- ● Seeding clouds to make rain
- ○ Making certain crops mature faster
- ○ Measuring ocean depths
- ○ I don't know.

National Performance Levels on Selected Questions

In order to provide an indication of the accomplishments and gaps in ability of 9-, 13- and 17-year-olds on the more than 500 questions asked in the science assessment, the results of science items at each age level are summarized in the lists that follow. In order to provide a broad sampling of what students have achieved at each age level, the questions are divided into five categories based on percentages of students giving correct responses. Within each category, examples of performance are provided at several taxonomic levels.

What 9-Year-Olds Know and Can Do

More than 80% of the 9-year-olds:

- Knew that a caterpillar will grow up to look like a butterfly, not a grasshopper, a bat or a praying mantis (91%).
- Understood that roots, not leaves, stems or flowers, hold plants in the soil (88%).
- Understood how to read a simple bar graph (85%).
- Could apply their knowledge of how a plant develops from a seed to a plant with flowers in order to select the correct sequence of development from among four choices (83%).

Sixty-one to 80% of the 9-year-olds:

- Could apply their knowledge of ecosystems to an understanding of why populations will stop increasing in size when there is a limited amount of food, space and air (77%).
- Given a list of five common instruments, knew that a telescope is used to view the planets (71%).
- Could determine whether a cat, a ship, a pencil, a bush, a fish, a television or a chair belongs with a group of animate or inanimate objects (67%).
- Understood that in summer there are more hours of sunlight, not the same or fewer hours than in winter (61%).

Forty-one to 60% of the 9-year-olds:

- Understood that sugar will dissolve faster in hot tea than in iced tea (56%).
- Could evaluate how certain objects have been categorized to emphasize the concepts of hardness and softness, rather than the concepts of dangerous and nondangerous, or metallic and nonmetallic (52%).
- Knew that a year is based on the amount of time it takes the earth to revolve around the sun, not the time measured by a clock, the phases of the moon or the time it takes light to travel (51%).
- Could apply their knowledge of nutrition to select a balanced menu over menus that emphasize mainly carbohydrates and fats, protein, or carbohydrates alone (46%).

Twenty-one to 40% of the 9-year-olds:

- Given a list of options, understood that an egg and a bean seed are alike because they both contain stored food (36%).
- Could evaluate how certain objects have been categorized to emphasize the concepts of dangerous and nondangerous, rather than the concepts of softness and hardness, or metallic and nonmetallic (26%).
- Could apply their knowledge of the directions "right," "left" and "front" to draw and label a diagram (24%).
- Knew the normal human body temperature is 98.6 degrees Fahrenheit (23%).

Twenty percent or less of the 9-year-olds:

- Understood that the biological role of the male in human reproduction is to fertilize the egg, not protect or provide for the female or give her the egg (19%).
- Could apply the principle of condensation of water to examples that illustrate the cooling and heating processes (19%).
- Given a list of five common instruments, knew that a barometer is used to measure atmospheric pressure (16%).
- Understood that water displacement is dependent on the size of an object, not the shape or weight of the object (7%).

What 13-Year-Olds Know and Can Do

Over 80% of the 13-year-olds:

- Understood that a child tends to look like his parents because of the cells that came from his parents, not because he gets their blood, eats similar food and lives in similar surroundings (94%).
- Given a list of five common instruments, knew that a telescope is used to view the planets (91%).
- Could analyze a simple scientific experiment in which three plants are exposed to varying amounts of light, in order to ascertain that the purpose of the experiment is to test the effects of different amounts of light on bean plants, not to test how high bean plants will grow in the dark, whether bean plants are as green as pea plants, how to get the most beans, or the effect of water and warmth on their growth (85%).
- Could apply their knowledge of the meaning of the term "model" to distinguish between things that are and are not models (82%).

Sixty-one to 80% of the 13-year-olds:

- Knew that fluoride, not calcium, chlorine, iodine or iron, is added to water to prevent tooth decay (73%).
- Understood that water freezing in a crack, not dew evaporating, decaying tree leaves or melting snow, is most likely to make the rock break open (72%).
- Could analyze the information on a graph of weather data in order to choose the best description of the relationship between temperature and pressure for a given period (62%).

Forty-one to 60% of the 13-year-olds:

- Understood that venereal disease is common today among people in all kinds of communities, not only among poor people, criminals, city people, young people or people over 25 (60%).
- Could analyze a graph showing linear progression in order to choose, from a list of four options, the most predictable price for a product in the future (56%).
- Knew that it is the function of the blood to protect against disease, carry food to cells, carry waste materials from cells and carry oxygen to all parts of the body, but not to digest food (50%).
- Could apply the concept that the "average" of all measurements taken by a group of 30 students will probably be closer to the actual length than any 1 result, the average of the 10 largest results, the average of the 10 smallest results or the largest result (41%).

Twenty-one to 40% of the 13-year-olds:

- Understood that harvesting, not yield, growth or use of fertilizers, is the major problem of planting high-yield grains in underdeveloped countries (36%).

- Could evaluate the meaning of information on a line graph that shows the irregular movement of a beetle over a 10-minute period, not that the beetle was looking for food, trying to climb a wall or changing direction every half minute (34%).

- Knew that cars, not open trash burners, fog or factories, are the major cause of air pollution in most large American cities (29%).

- Could apply their knowledge that sunshine is needed for life on this planet for a variety of different life forms such as plants, animals and insects (26%).

Twenty percent or less of the 13-year-olds:

- Understood that "no smoking" signs are meant to control the supply of burnable material that could start a fire, that foam fire extinguishers are meant to control the supply of oxygen available for a fire and that heavy electrical wires and brick walls are meant to control high temperatures of a fire (20%).

- Knew whether or not such foods as sugar, beef, cheese, milk and fruit are rich in protein (17%).

- Could apply their understanding of the advantage of the "pecking order" in animal behavior to their selection of "survival of the strongest" as the reason for this behavior as opposed to inheritance, experience or the reduction of stress and fighting (15%).

- Given a list of possible meanings, understood what the phrase "a chance of rain" actually implies (14%).

What 17-Year-Olds Know and Can Do

More than 80% of the 17-year-olds:

- Understood that venereal disease is common among people in all kinds of communities, not only among poor people, criminals, city people, young people or people over 25 (93%).

- Knew that the main function of the kidneys is to remove waste materials from the blood, not digest food, circulate the blood or produce red blood cells (89%).

- Given a list of claims, could analyze an advertisement to find out whether or not each claim is made (87%).

- Could apply planning theory to select the most accurate definition of a problem that has conflicting environmental and economic benefits (82%).

Sixty-one to 80% of the 17-year-olds:

- Knew that the cell, not the organ, tissue, organism or population, is the simplest biological unit of structure (80%).

- Could apply the concept of the prediction of consequences to choosing the best course of action to take in dealing with a disease-carrying insect (71%).

- Understood the concept of energy transformation as it applies to four examples of possible change (71%).

- Could analyze a schemata of genetic make-up to establish that brown fur color according to that schemata is a dominant trait, not a recessive, blended inheritance or sex-linked trait (69%).

Forty-one to 60% of the 17-year-olds:

- Could apply their knowledge about the effects of relative humidity on evaporation to two examples of the possible effects of 100% relative humidity (60%).

- Knew that when the cell of a plant stem divides, each new cell has the same number of chromosomes as the parent cell, not half the number or twice the number (53%).

- Understood that coating an iron nail with oil, painting it or putting it in a dry place will keep it from rusting, but that wrapping it in a wet towel or dipping it in vinegar will not keep it from rusting (49%).

Twenty-one to 40% of the 17-year-olds:

- Understood the physical principle of a mixture and could choose a diagram that best illustrates it (40%).
- Knew that cars, not open trash burners, fog or factories are the major cause of air pollution in most large American cities (37%).
- Understood that if you are looking to the west and see the full moon near the horizon, it is nearly sunrise, not noon, sunset or midnight (34%).
- Could apply decision-making theory to cases in which the information would cost more than a wrong decision, the information might not be acceptable, one has experience in making decisions, or time is a crucial element (27%).

Twenty percent or less of the 17-year-olds:

- Knew that in the human female the fertilization of the egg usually occurs in the oviduct, not the cervix, ovary, uterus or vagina (16%).
- Could apply the concept that there is always measurement error to a variety of circumstances (12%).
- Understood that a wide variety of consumer products such as plastics, synthetic fabrics, etc., are petroleum products (12%).
- Given a range of options from best to worst, knew how the infant survival rate in the United States compares to that in other countries (3%).

As the discussion in this chapter indicates, the 1976—77 science assessment is a comprehensive look at the achievement of American students in science, and provides an excellent model for the development of assessment instruments in the area. Readers interested in a more detailed analysis of the data for individual items will find that information in the forthcoming technical report and exercise appendix volume.

CHAPTER 2

A SUMMARY OF STUDENT PERFORMANCE IN SCIENCE

The focus of this report is groups of students' achievement in science throughout the nation. National Assessment, unlike most testing programs, does not report scores for individuals.[1] Rather, NAEP presents data about *groups* of students' responses to certain exercises. Definitions of the groups discussed in this report are presented below.

Reporting Groups Defined

Age

Results are presented for 9-, 13- and 17-year-olds enrolled in school at the time of the assessment.

Sex

Results are presented for both males and females.

Racial/Ethnic Background

Results are presented for blacks, whites, Hispanics and others.

Percent White Composition of the School

Results are presented for (1) schools in which enrollment is less than 60% white and (2) schools in which enrollment is more than 60% white.

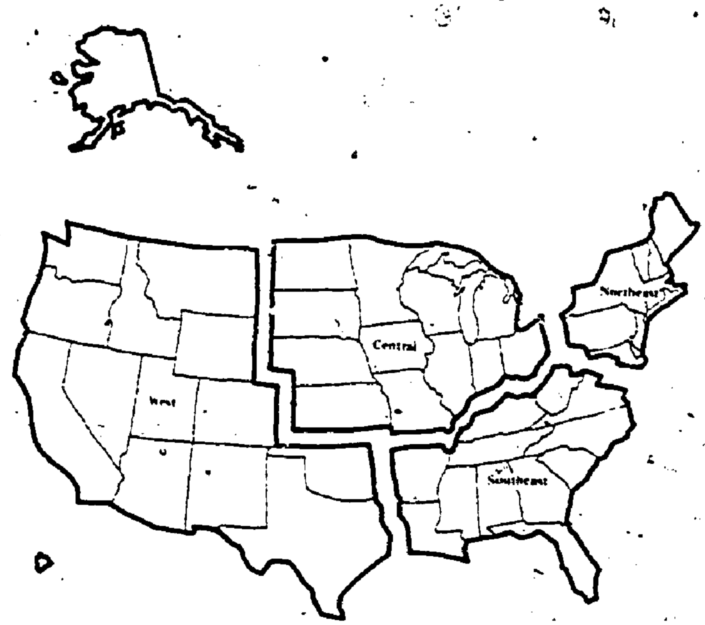
Grade Level in School

Results are presented for each age group by grade level. At age 9, results are presented for students below 3rd grade, 3rd graders, 4th graders and those above 4th grade; at age 13, for students below 7th grade, 7th graders, 8th graders and those above 8th grade; at age 17, for students below 10th grade, and for 10th, 11th and 12th graders.

The grade in which most students are enrolled is defined as the modal grade for each age level. At age 9, it is 4th grade; at age 13, it is 8th grade; at age 17, the modal grade is the 11th.

Region

Using the U.S. Office of Business Economics categories the country has been divided into four regions — Northeast, Southeast, Central and West. States included in each region are shown on the following map.



[1]More detailed information on the methodology employed by National Assessment can be found in the *General Information Yearbook*, Report 03/04-GIY, 1971–72 and 1972–73 Assessments (Denver, Colo.: National Assessment of Educational Progress, 1974). Specific chapters on sampling, objectives and exercise development, administration, data processing and analysis procedures can be found in this volume.

Census Region

Using the U.S. Bureau of the Census categories the country has been divided into nine regions. They are listed on the chart that follows.

Census Regions

New England

Connecticut
Maine
Massachusetts
New Hampshire
Rhode Island
Vermont

Middle Atlantic

New Jersey
New York
Pennsylvania

East North Central

Illinois
Indiana
Michigan
Ohio
Wisconsin

West North Central

Iowa
Kansas
Minnesota
Missouri
Nebraska
North Dakota
South Dakota

South Atlantic

Delaware
District of Columbia
Florida
Georgia
Maryland
North Carolina
South Carolina
Virginia
West Virginia

East South Central

Alabama
Kentucky
Mississippi
Tennessee

West South Central

Arkansas
Louisiana
Oklahoma
Texas

Mountain

Arizona
Colorado
Idaho
Montana
Nevada
New Mexico
Utah
Wyoming

Pacific

Alaska
California
Hawaii
Oregon
Washington

Size of Community

Big city. Students in this group attend schools within the city limits of cities with a population over 200,000.

Fringes around big cities. Students in this group attend schools within metropolitan areas served by cities with a population greater than 200,000 but outside the city limits.

Medium city. Students in this group attend schools in cities having a population between 25,000 and 200,000 not classified in the fringes-around-big-cities category.

Smaller places. Students in this group attend schools in communities having a population less than 25,000 not classified in the fringes-around-big-cities category.

Type of Community

These communities are defined by an occupational profile of the area served by a school as well as the size of the community in which the school is located.

Advantaged-urban communities (high metropolitan). Students in this group attend schools in or around cities with a population greater than 200,000 where a high proportion of the residents are in professional or managerial positions.

Disadvantaged-urban communities (low metropolitan). Students in this group attend schools in or around cities with a population greater than 200,000 where a high proportion of the residents are on welfare or are not regularly employed.

Level of Parental Education

Students' reports on the education level completed by their parents were classified into three categories: (1) those whose parents did not graduate from high school, (2) those who have at least one parent who graduated from high school but did not continue beyond high school and (3) those who have at least one parent who has had some post high school education.

Types of Reading Matter in the Home

Each student was asked whether his or her family received a newspaper and magazines regularly, whether there were more than 25 books in the home and whether there was an encyclopedia in the home. Responses were classified into the following three categories: (1) students responding "yes" to two or less questions, (2) students responding "yes" to three questions and (3) students responding "yes" to all four questions.

Description of the Data

Exhibits 4 through 21 provide summaries of achievement for students ages 9, 13 and 17. The summaries represent the mean percentage of students who correctly answered a composite of all cognitive science questions asked at a given age. At age 9, the means are based on 209 questions; at age 13, on 284 questions; and at age 17, on 213 questions. Each graph provides achievement summaries for selected groups within the total national sample. Performance is described by sex, racial/ethnic background, region of the country, community size and type, grade level in school, racial composition of the school, reported level of parental education and types of reading matter within the home. Percentages of the national sample in each reporting group can be found in Appendix A.

Each bar in Exhibits 4 through 21 represents the mean achievement for a particular group at a particular age. The smaller bar within each bar extends two standard errors above and below the mean achievement for that group. The horizontal line across each graph represents the mean achievement of the total age population described in the study.

A standard error of the sample mean is an estimate of the sampling variability among the means of all possible samples; it is used to estimate the precision of the mean obtained in a particular sample. Intervals of two standard errors below to two standard errors above a particular statistic would include the average of the statistic in approximately 95% of all possible samples. An interval computed in this way is a 95% confidence interval. For example, the mean achievement of Northeastern 13-year-olds is 51.2%. Two standard errors of this mean is calculated at 0.9 percentage points. A 95% confidence interval for this group would include 51.2% ±0.9, or the range from 52.1% to 50.3%.

Summary of Group Results

The performance levels of most of the reporting groups were highly consistent across the three age levels assessed. That is to say, groups that tend to perform above or below the national average at one age tend also to do so at the other ages as well.

While the achievement differences reported here point to areas of concern, readers are cautioned not to ascribe these differences in achievement levels solely to membership in the particular group described by the label. Research has shown that any number of socioeconomic, school-related and environmental factors contribute to performance on achievement tests. Since no known factor or cluster of factors adequately describes an entire group, and since the factors are interrelated in a variety of ways, care must be taken not to overgeneralize based on these data. While the data in Exhibits 4 through 21 accurately describe the achievement levels of various groups of students, caution must be taken not to attribute a cause-and-effect relationship to these factors.

Exhibits 4 through 12 illustrate the relationship between achievement in science and racial/ethnic background, sex and the region in which the students live. The graphs show that certain groups consistently performed above or below the national average at each age assessed.

The overall percentages of white students and male students who answered science questions correctly are consistently above the national levels at each age. Nevertheless, there is substantial variation within these broad groups. Some groups of white and male students are shown to be falling below the national average.

White Students

Whites who are male, go to schools that are at least 60% white, are at or above the modal grade for students their age, reside in advantaged-urban communities and have access to at least four types of reading matter in their homes all performed above the national average at their age. However, whites who are at low grade levels, come from disadvantaged-urban communities and have less than three types of reading matter in their homes all performed below the national level for their age.

Male Students

While males tended to perform above the national average at their age, this was not the case for males from the Southeastern states, black males, males who reported that their parents have not graduated from high school and males who were below the modal grade level for their age.

The overall percentages of black and Hispanic students, female students and Southeastern students who answered science questions correctly were consistently below the national level at ages 9, 13 and 17. However, there are considerable differences in the performance levels within these broad groups as well. In some cases achievement is at or above the national average; in other cases there are clear patterns of higher achievement related to socioeconomic status.

Black and Hispanic Students

Hispanic students at the modal grade level tended to perform a little below the national average for their age. Among black students, the achievement of those living in advantaged-urban communities (high metro) is near or above the overall performance of their age mates (age 13). The availability of reading matter in the home appears to be related to achievement as well. The percentage of black students at each age answering science questions correctly consistently increased with an increase in the reported types of reading matter in the home.

Female Students

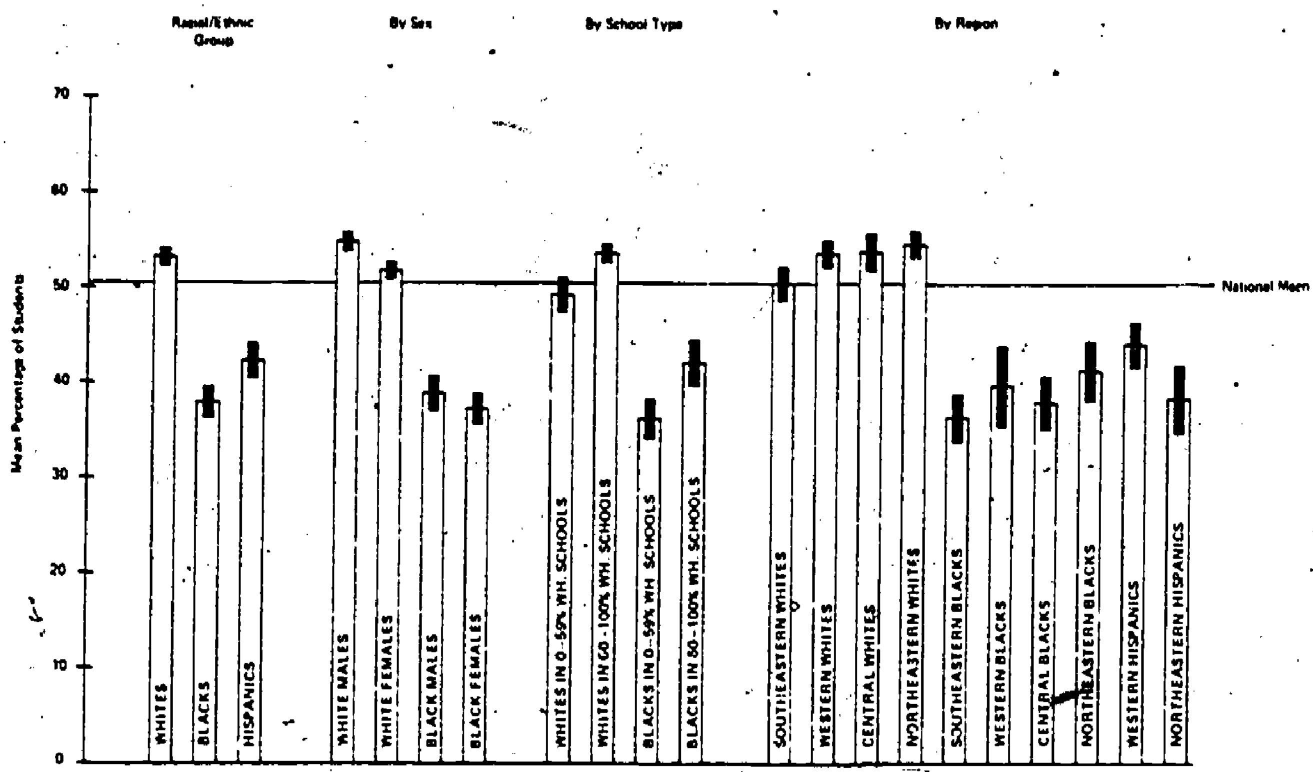
Not all female students performed below the national level for their age. The percentages of females in the Central and Northeastern states, those who are white and those at or above the modal grade for students at their age answering science questions correctly tended to be at the national average. Females whose parents are educated beyond high school performed above the national average at all three ages.

Southeastern Students

Although Southeastern students generally performed below the national average, Southeastern whites' scores are at the national level at all three ages. Among Southeastern students at or above the modal grade for students at their age, achievement levels are close to or equal to the national average as well.

Exhibits 13, 14 and 15 illustrate the relationship between achievement and the grade in which students were enrolled in

EXHIBIT 4. Mean Percentages of Selected Groups of White, Black and Hispanic Students Answering Science Questions Correctly, Age 9



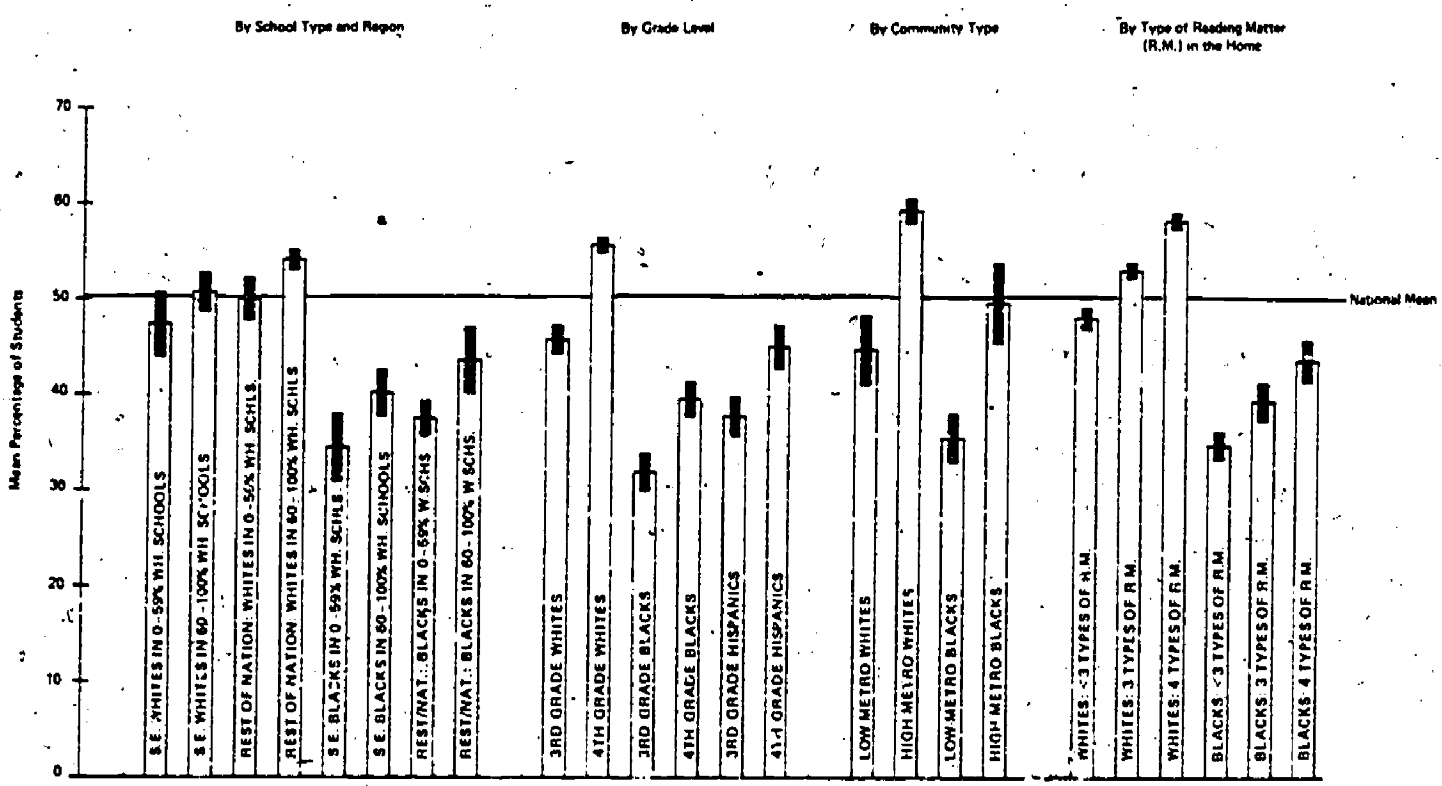


EXHIBIT 5. Mean Percentages of Selected Groups of Male and Female Students Answering Science Questions Correctly, Age 9

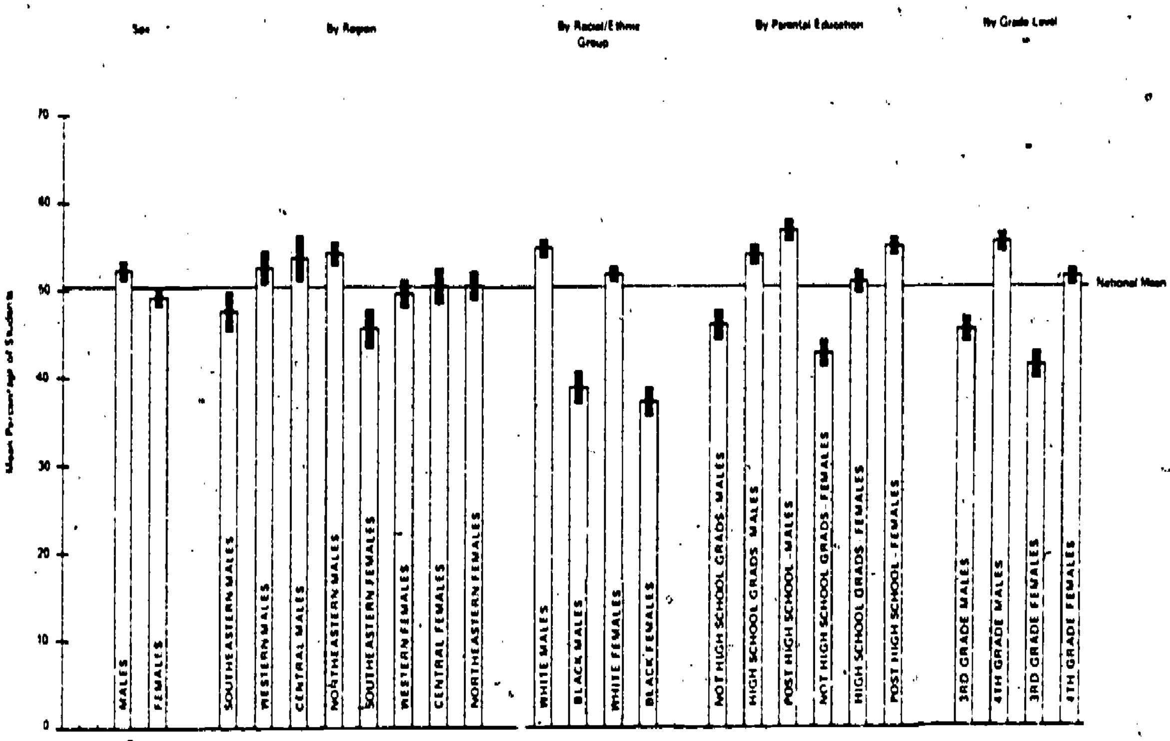


EXHIBIT 6. Mean Percentages of Selected Groups of Students in Various Regions Answering Science Questions Correctly, Age 9

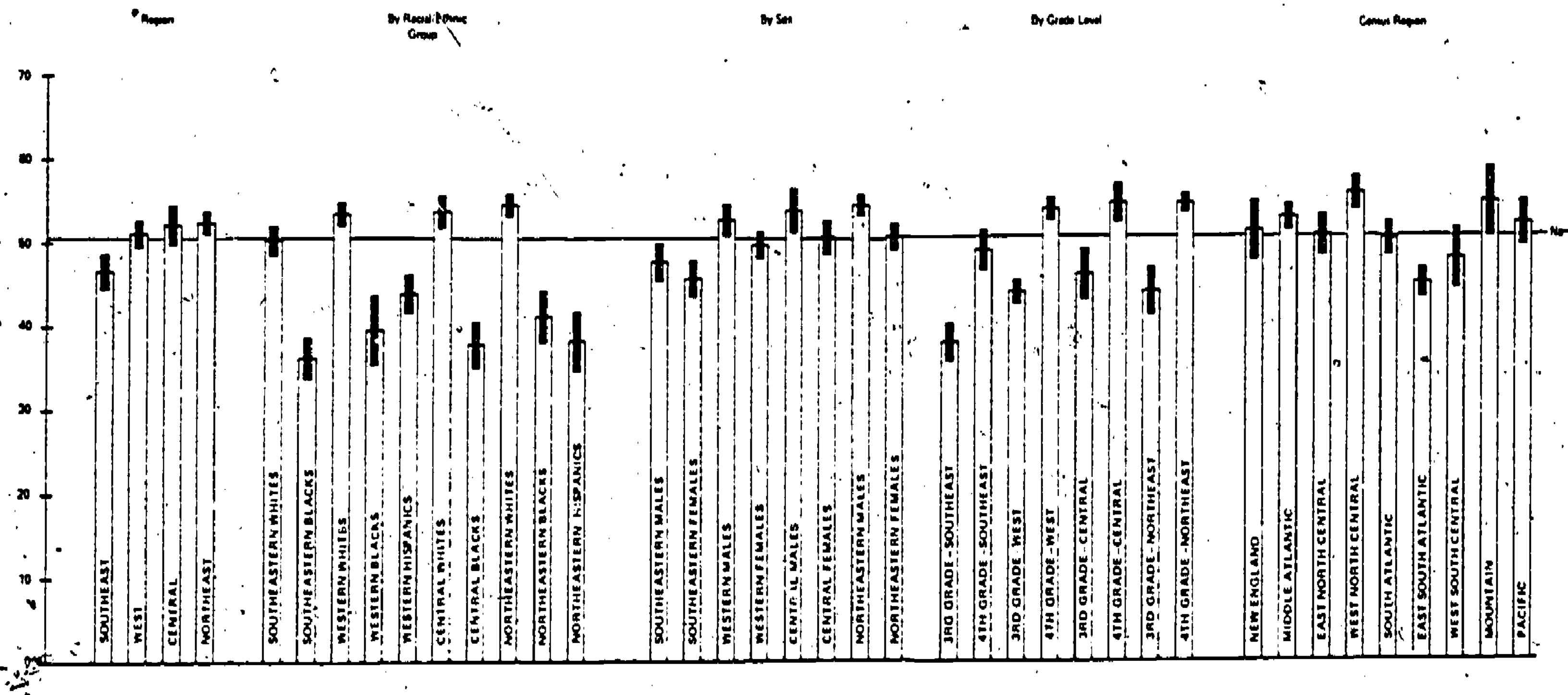
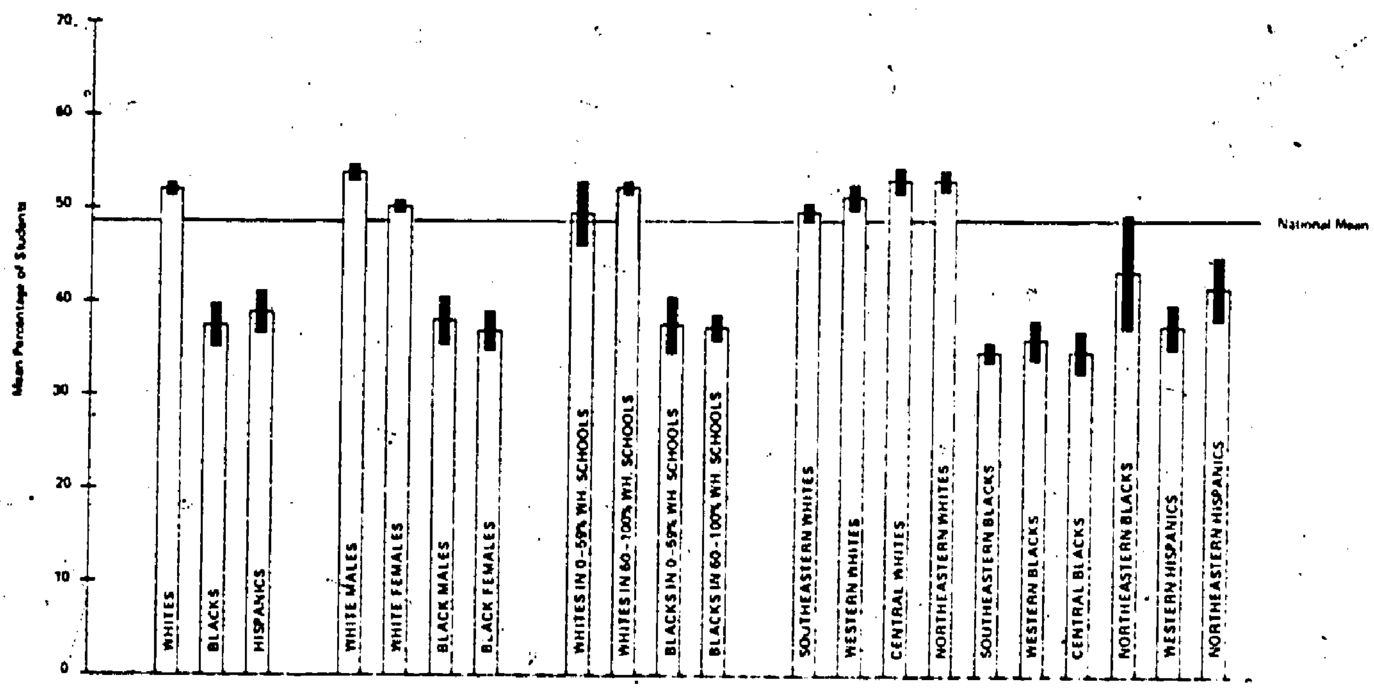


EXHIBIT 7. Mean Percentages of Selected Groups of White, Black and Hispanic Students Answering Science Questions Correctly, Age 13



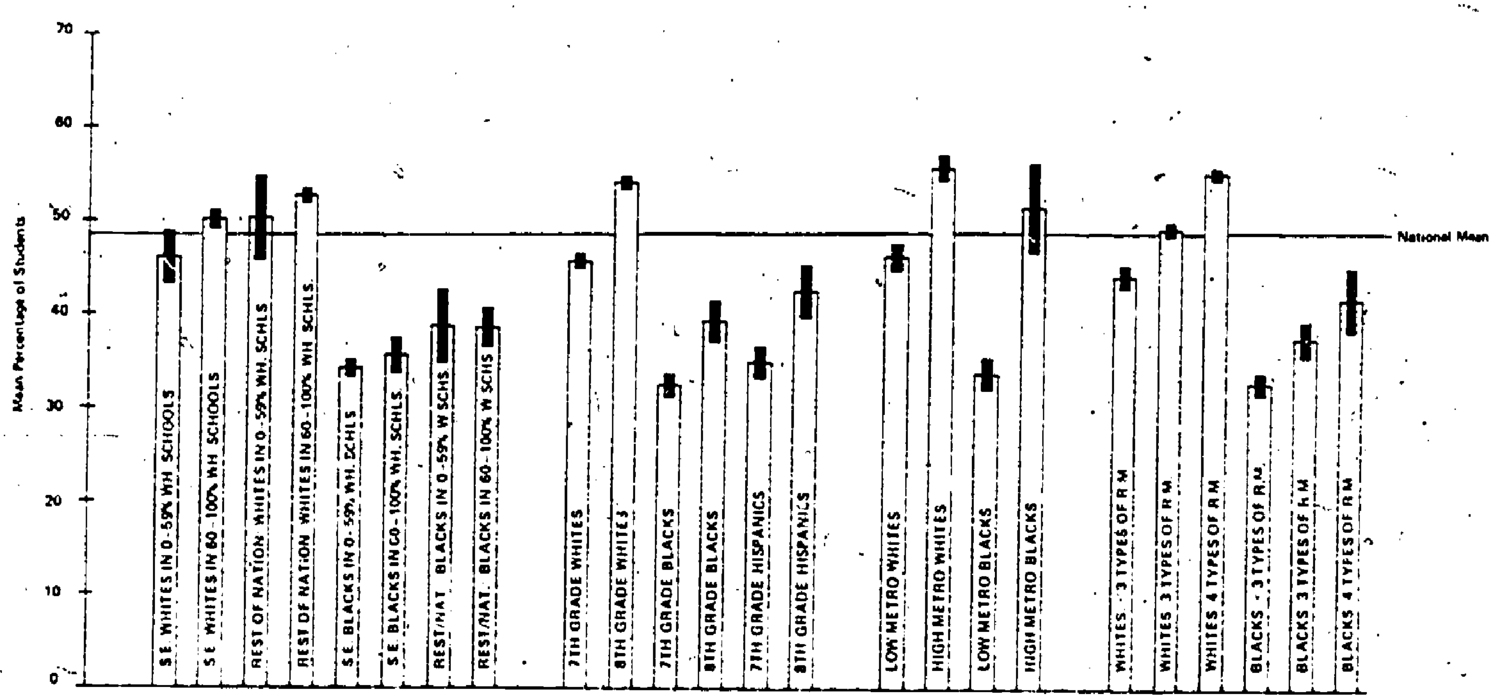


EXHIBIT [illegible] Mean Percentages of Selected Groups of Male and Female Students Answering Science Questions Correctly, Age 13

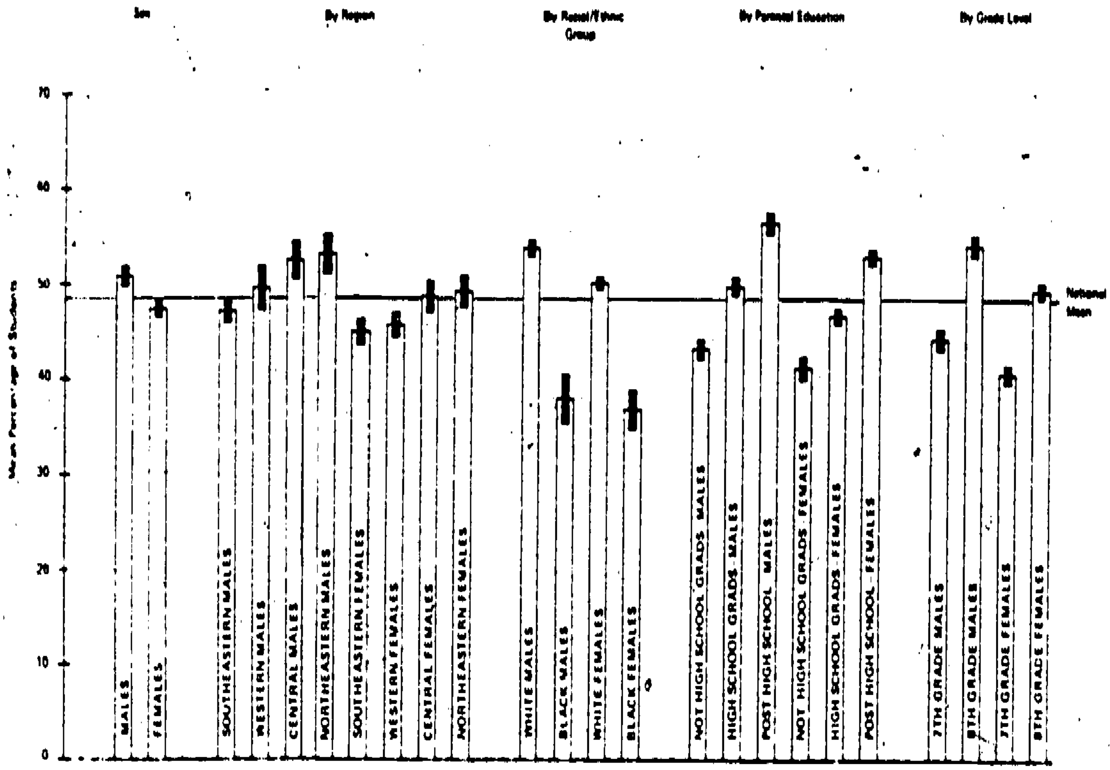


EXHIBIT 9. Mean Percentages of Selected Groups of Students in Various Regions Answering Science Questions Correctly, Age 13

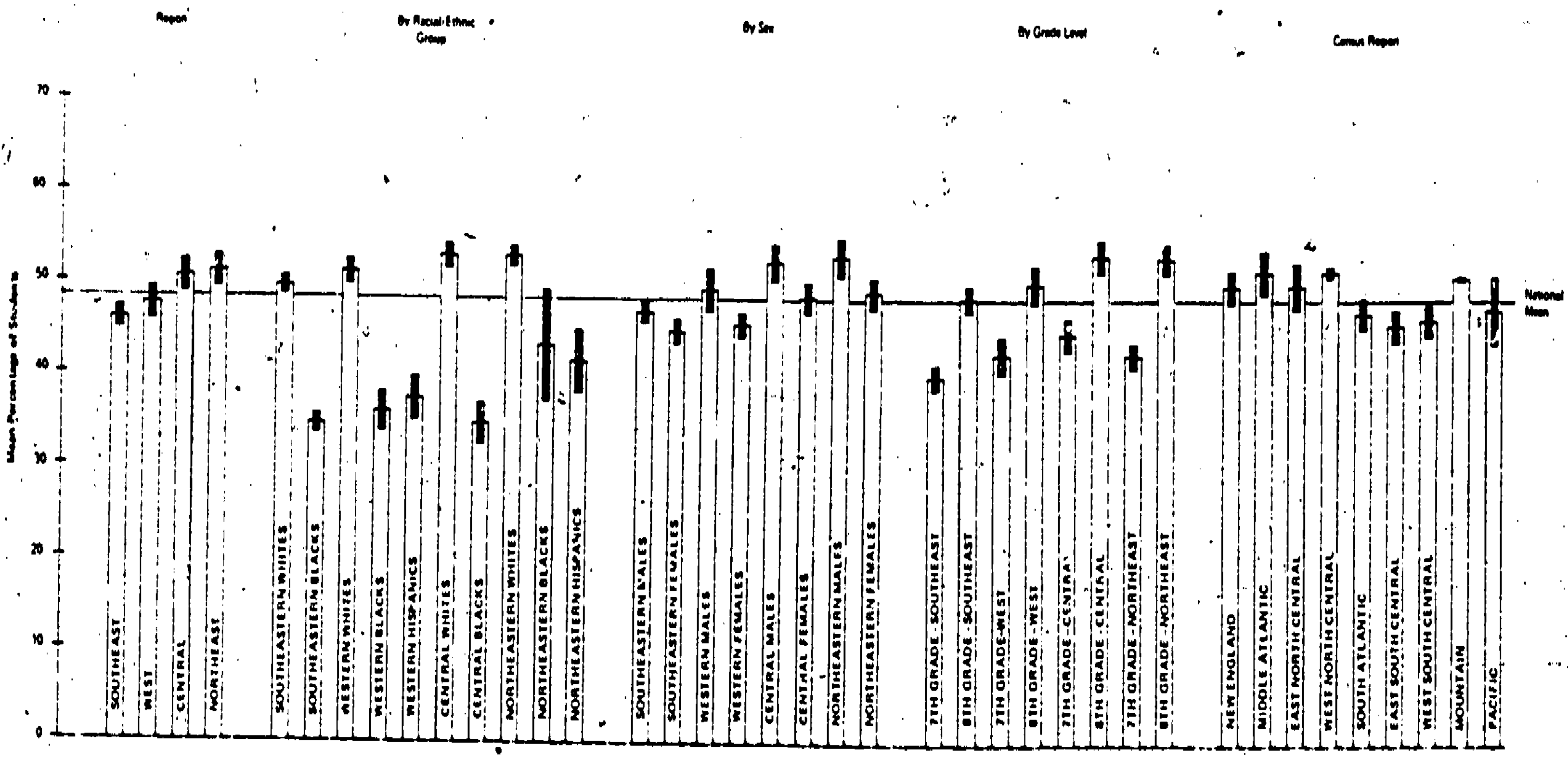
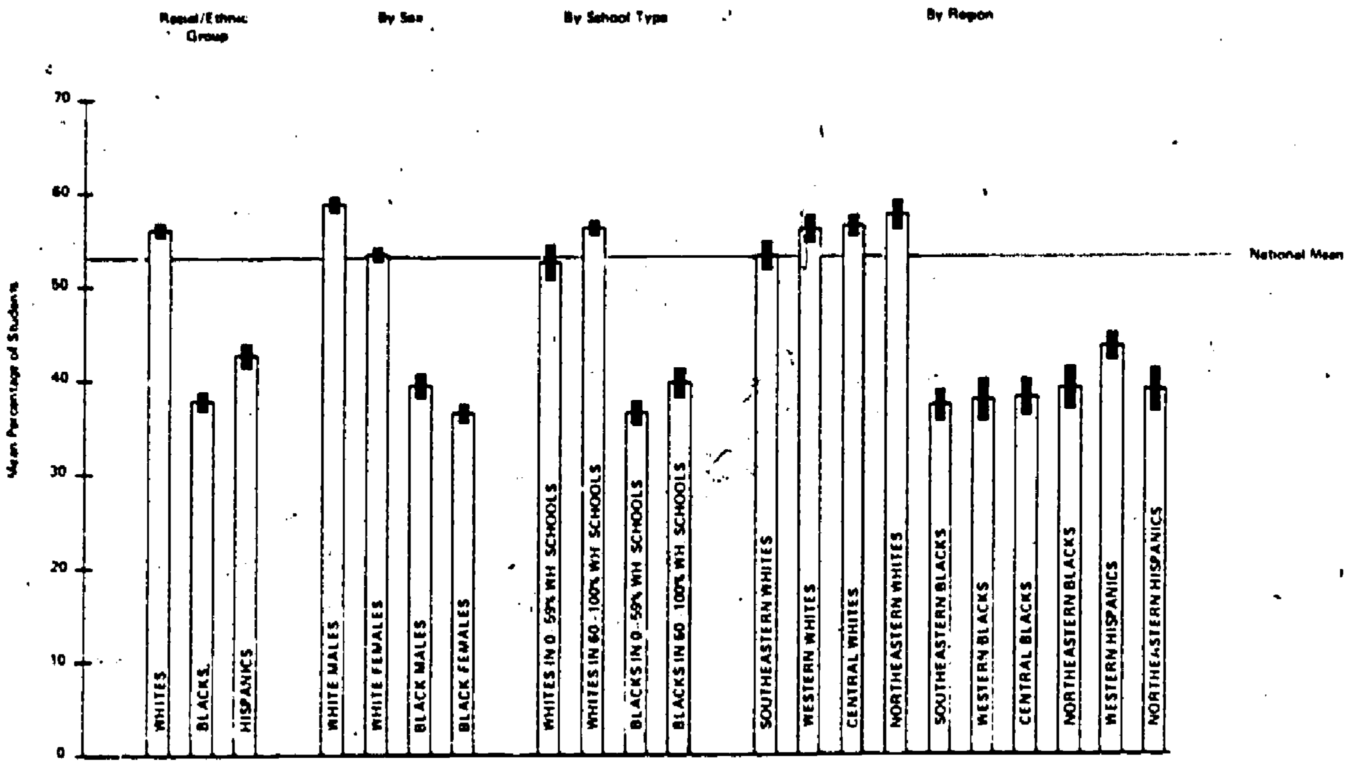


EXHIBIT 10. Mean Percentages of Selected Groups of White, Black and Hispanic Students Answering Science Questions Correctly, Age 17



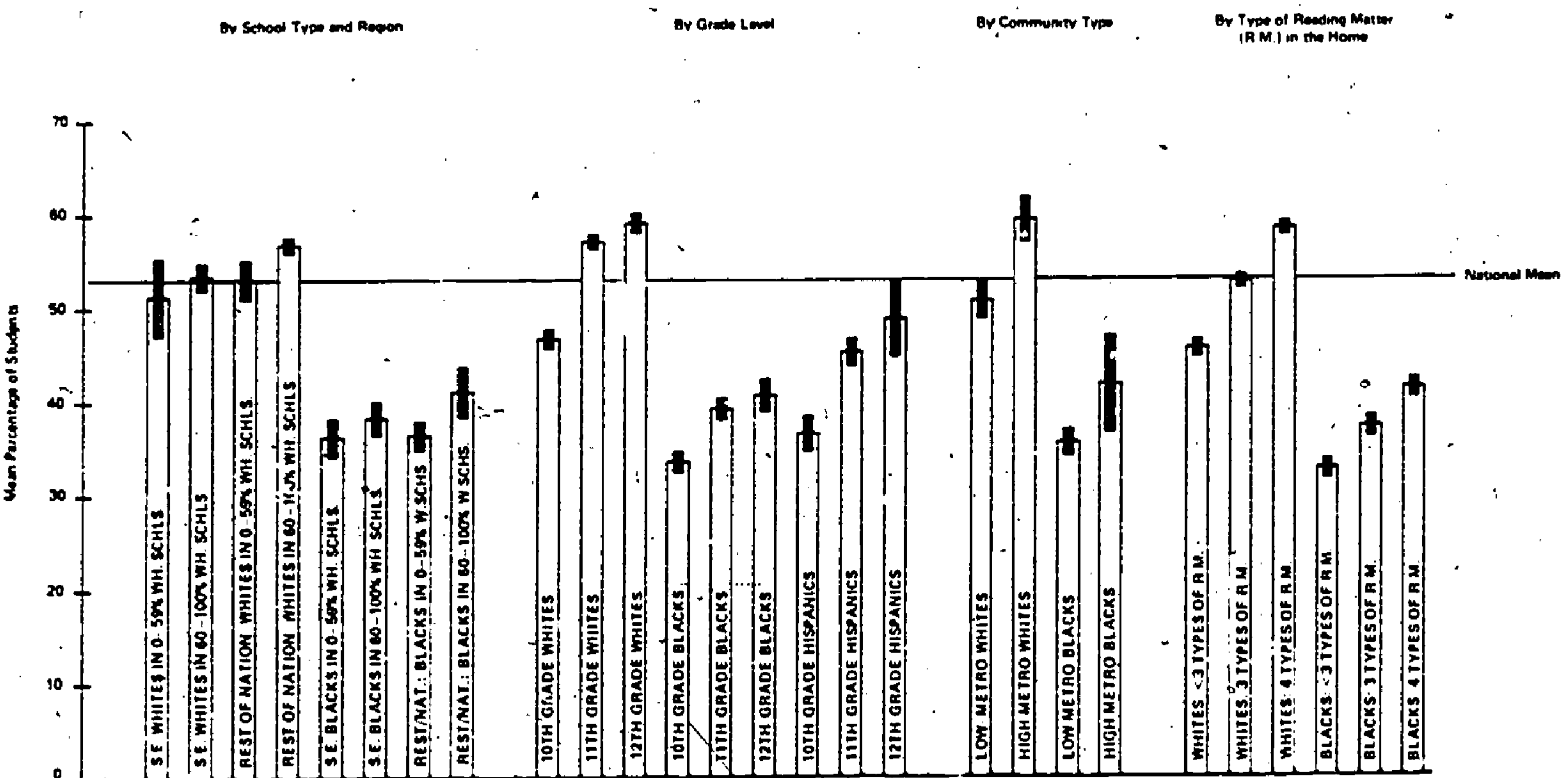


EXHIBIT 11. Mean Percentages of Selected Groups of Male and Female Students Answering Science Questions Correctly, Age 17

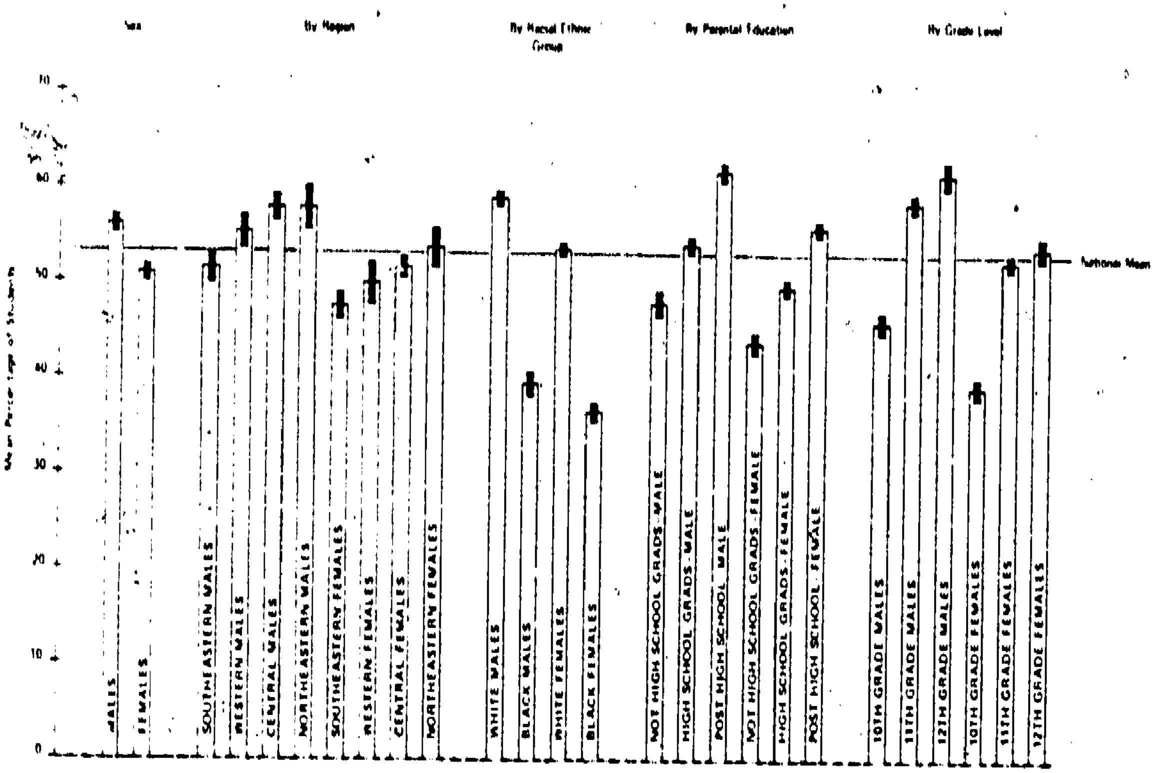


EXHIBIT 12. Mean Percentages of Selected Groups of Students in Various Regions Answering Science Questions Correctly, Age 17

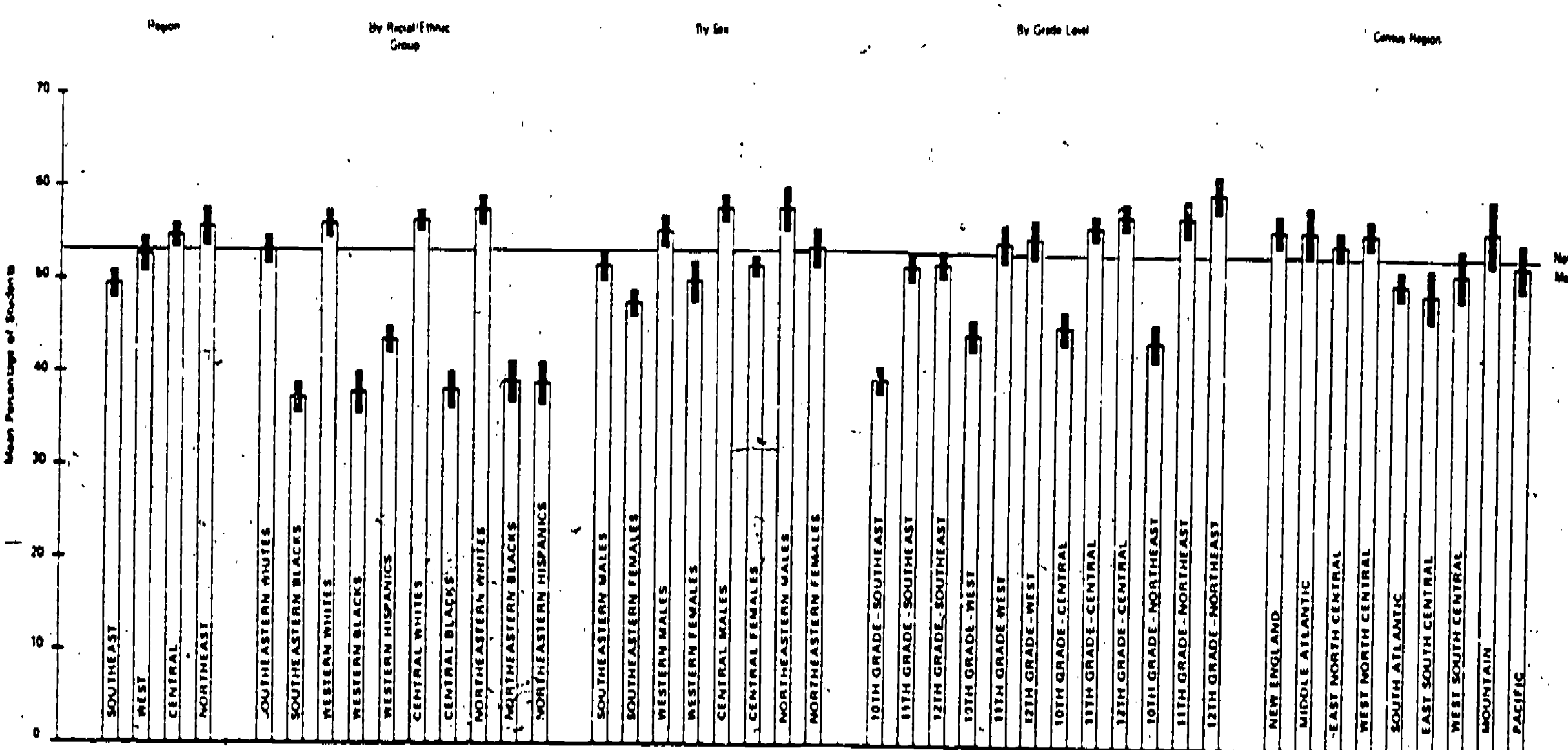
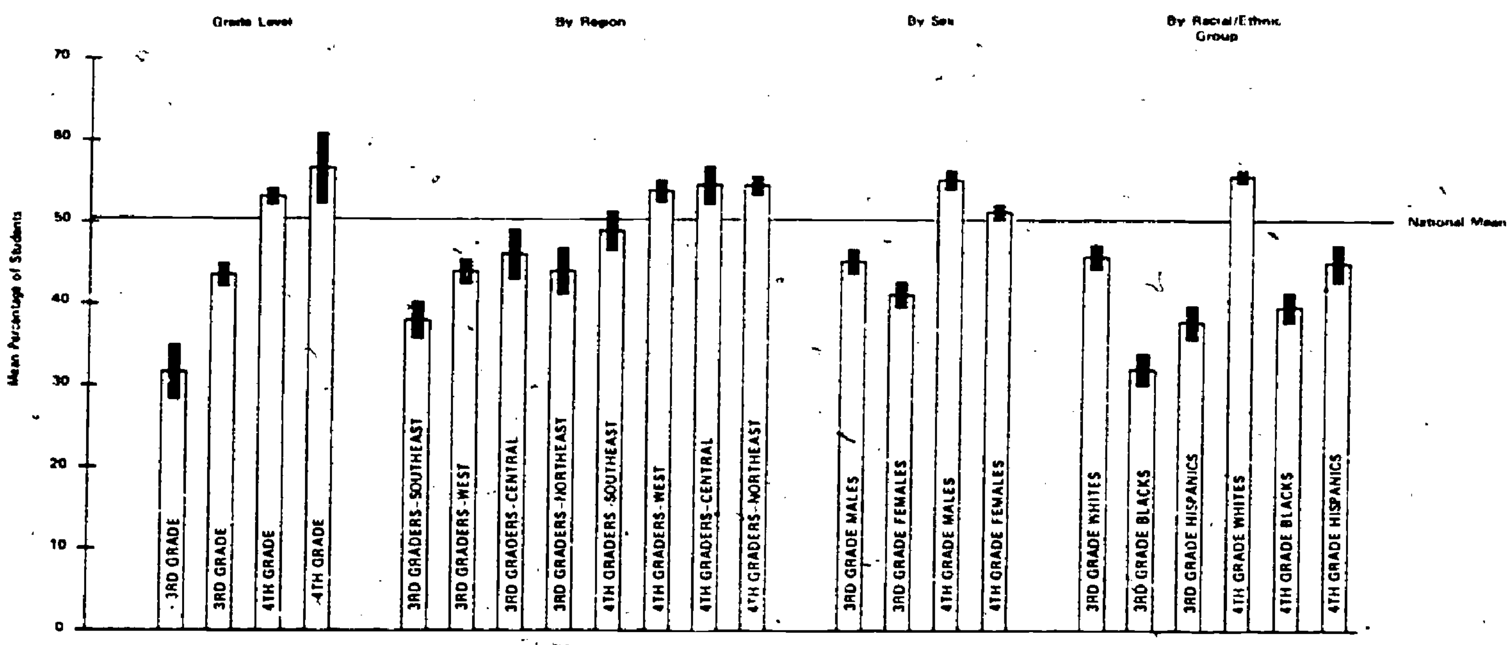


EXHIBIT 13. Mean Percentages of Selected Groups of 3rd and 4th Graders Answering Science Questions Correctly, Age 9



school. The grade in which a student was enrolled may be the result of school policy on enrollment, academic progress of the student, parental attitudes, student health or other factors. Nevertheless, one would expect that achievement would improve with a greater amount of schooling. The data in Exhibits 13 through 15 support this expectation for all the groups that National Assessment describes. Fourth graders in a given group consistently achieved higher than 3rd graders in that group; the same pattern holds true at 7th and 8th grades and for 10th, 11th and 12th grades. The data suggest that amount of schooling is positively related to learning for all groups. However, these data also point to disturbing differences between groups. White 3rd graders performed at the same level as Hispanic 4th graders and above the level of black 4th graders. White 7th graders outperformed black and Hispanic 8th graders. White 10th graders performed as well as Hispanic 12th graders and above the level of black 12th graders.

Exhibits 16, 17 and 18 display the relationship between achievement and socioeconomic status (SES). Most studies of student achievement show a high association between indicators of socioeconomic status and achievement. The National Assessment science results corroborate these findings. Three broad measures of SES are described in these exhibits:

- The reported level of parental education is a measure of social status in the community.

- The types of reading matter in the home are a measure of the attitude of the family toward intellectual activities.

- The type of community is a broad indicator of family income. High and low metropolitan are defined by an occupational profile of the area served by the school as well as the size of the community.

The data support the findings of other studies showing that the various measures of socioeconomic status are all highly related to achievement. Students whose parents have a post high school education, who have at least

EXHIBIT 14. Mean Percentages of Selected Groups of 7th and 8th Graders Answering Science Questions Correctly, Age 13

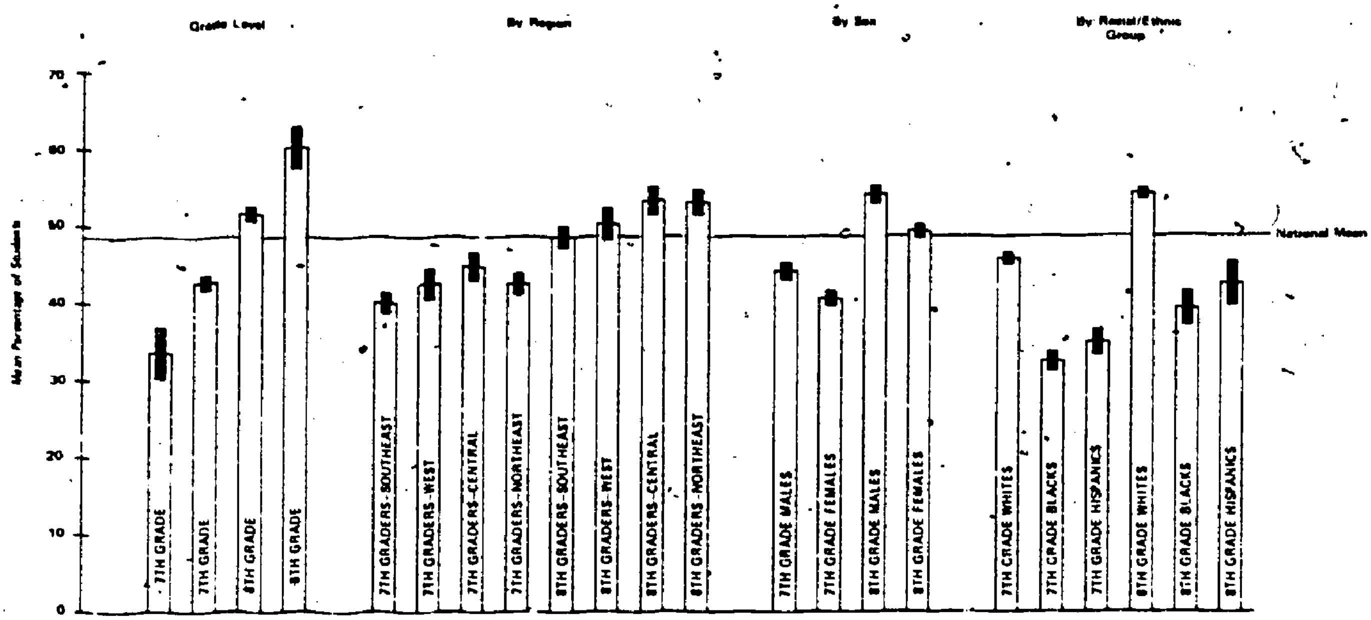


EXHIBIT 15. Mean Percentages of Selected Groups of 10th, 11th and 12th Graders Answering Science Questions Correctly, Age 17

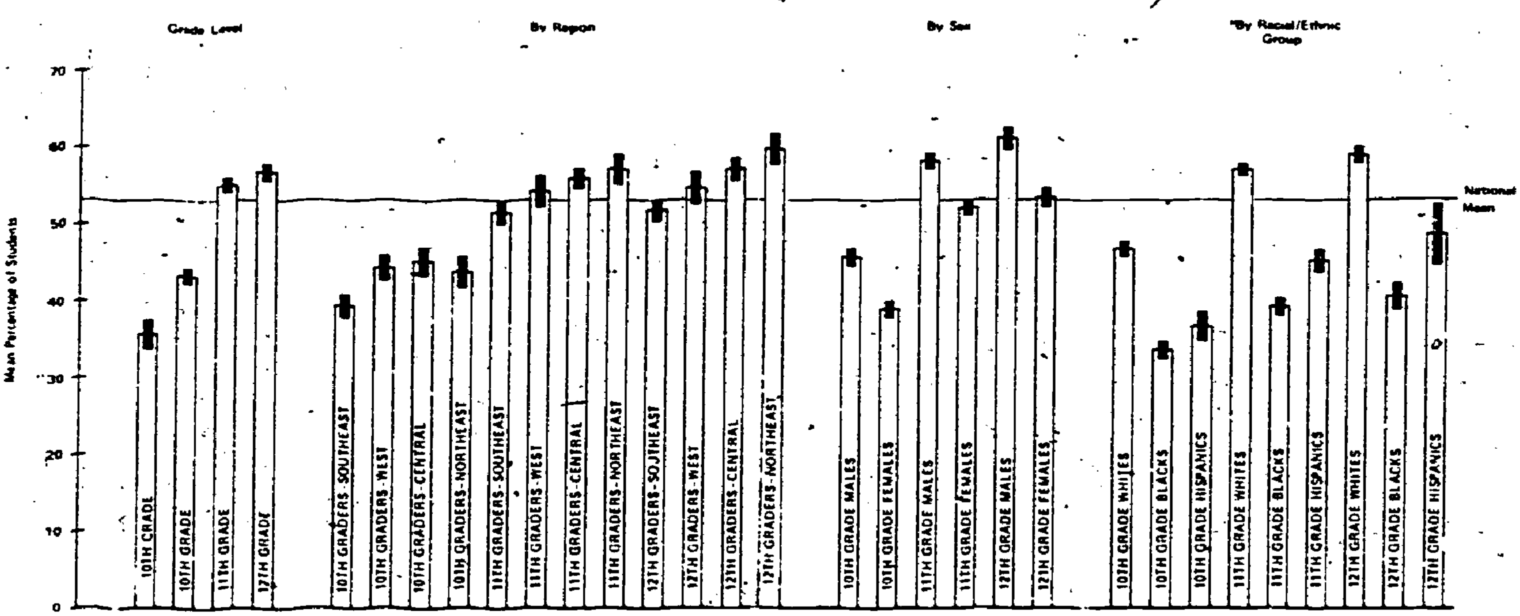


EXHIBIT 16. Mean Percentages of Students in Selected Socioeconomic Groups Answering Science Questions Correctly, Age 9

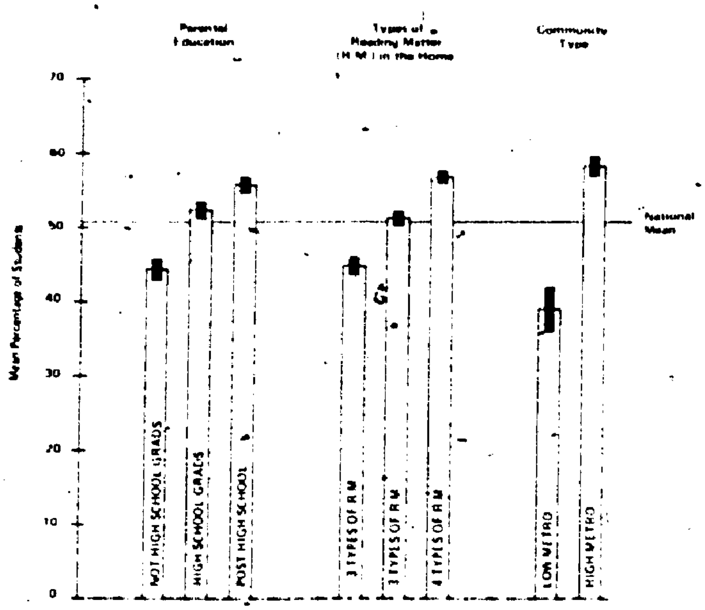


EXHIBIT 17. Mean Percentages of Students in Selected Socioeconomic Groups Answering Science Questions Correctly, Age 13

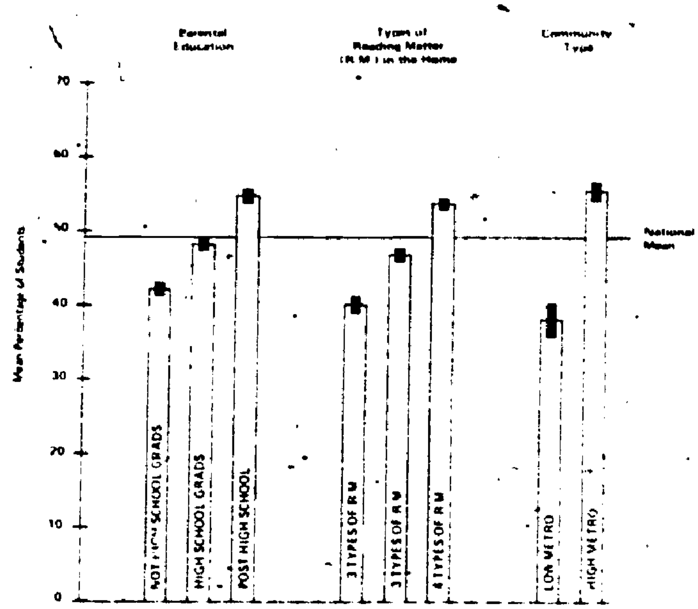
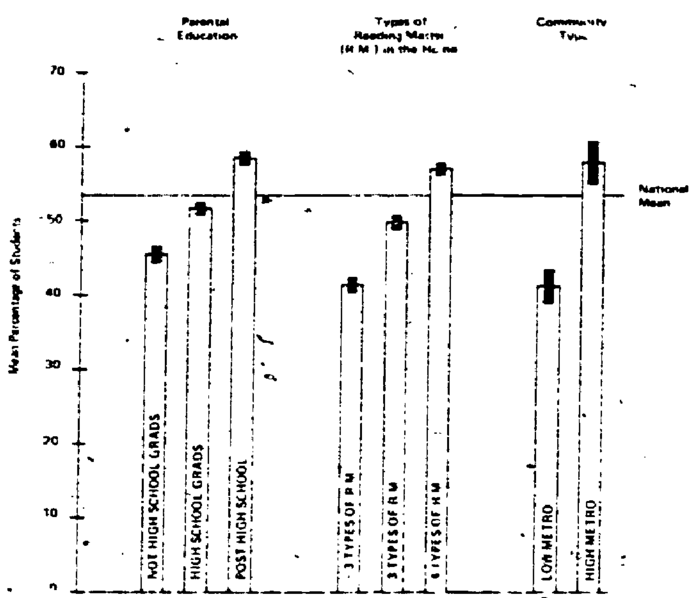


EXHIBIT 18. Mean Percentages of Students in Selected Socioeconomic Groups Answering Science Questions Correctly, Age 17



four types of reading matter in the home or who live in urban communities with a high proportion of professional or managerial residents (high metro) all achieved well above the national level for their age. Conversely, students whose parents have not graduated from high school, who have less than three types of reading matter in the home or who live in urban communities where a high percentage of residents are on welfare or not regularly employed (low metro) all achieved well below the national average for their age. These patterns are consistent at all three ages.

Exhibits 19, 20 and 21 display the relationship between science achievement and the size of communities in which students attend school. The difference between the performance of students attending schools within the city limits of large metropolitan areas (big cities) and that of students attending school outside the city limits (fringes around big cities) is particularly noteworthy.

EXHIBIT 19. Mean Percentages of Students in Communities of Various Sizes Answering Science Questions Correctly, Age 9

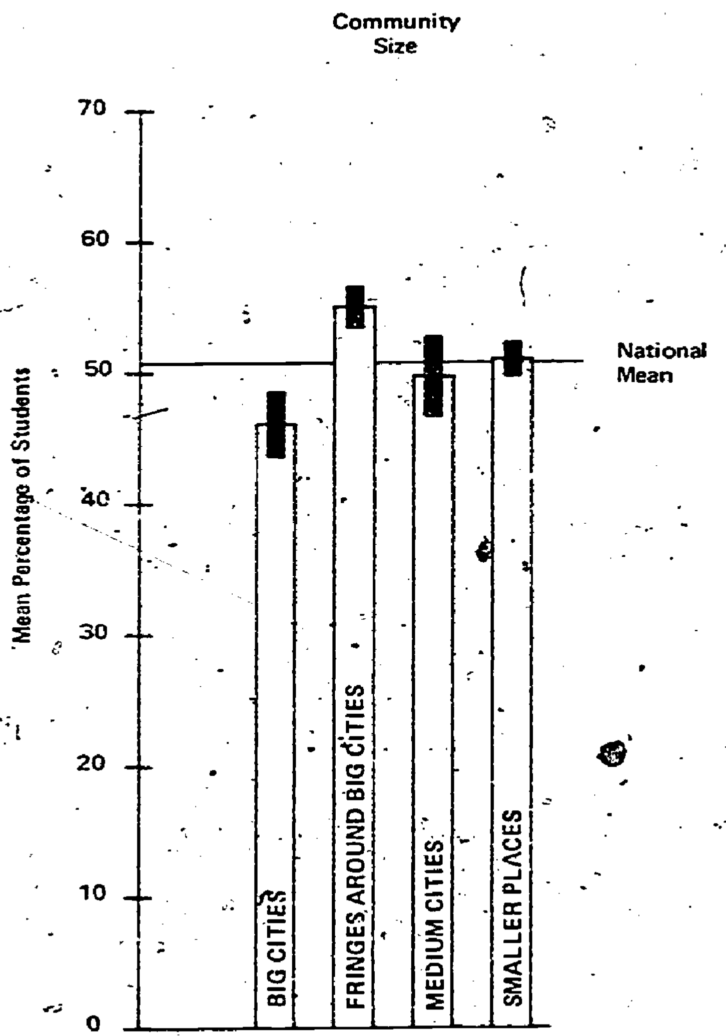
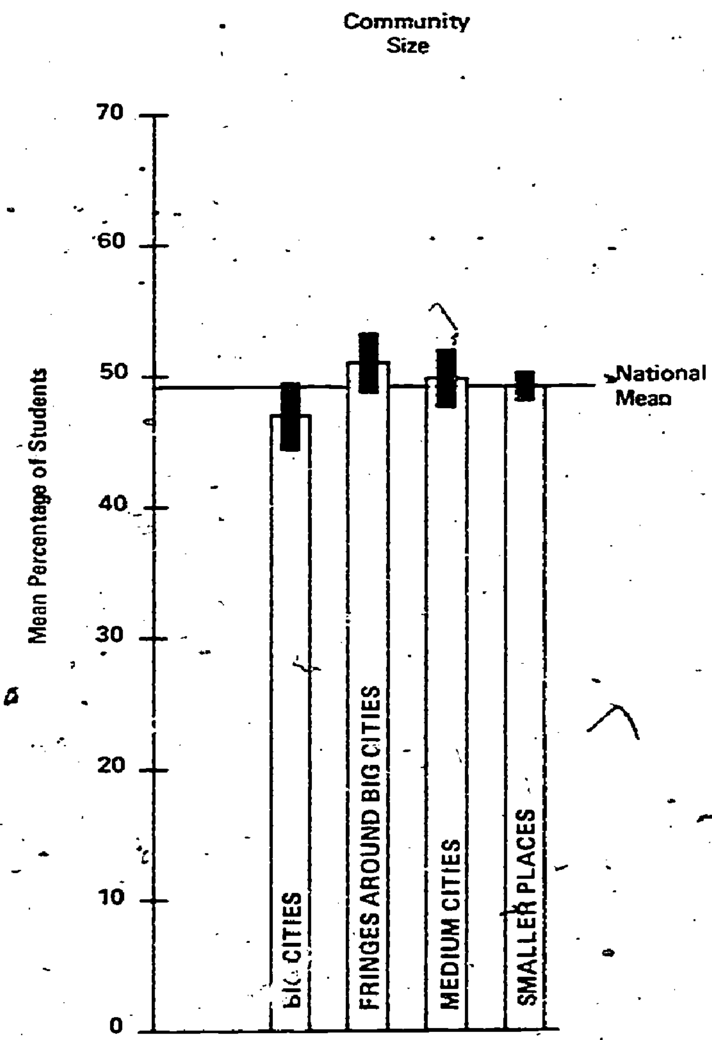


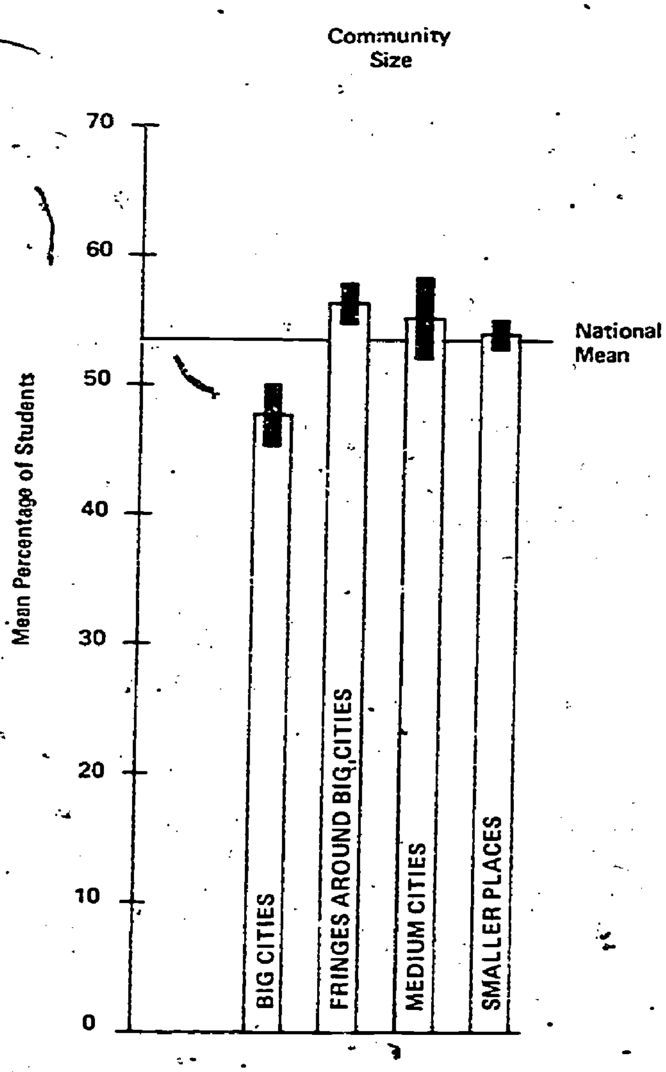
EXHIBIT 20. Mean Percentages of Students in Communities of Various Sizes Answering Science Questions Correctly, Age 13



Comparisons of Performance Between Ages

Many of the questions administered in the 1976—77 science assessment were asked at two age levels — 66 identical questions were asked at ages 9 and 13; 197 identical questions were asked at ages 13 and 17. As might be expected, performance dramatically improved between ages 9 and 13 and 13 and 17. Thirteen-year-olds had a 21 percentage-point advantage over 9-year-olds; the advantage of 17-year-olds over 13-year-olds was 14 percentage points.[2]

EXHIBIT 21. Mean Percentages of Students in Communities of Various Sizes Answering Science Questions Correctly, Age 17



Among the findings for the various groups are:

- A higher percentage of 13-year-old whites answered science questions correctly than did 17-year-old blacks.
- Thirteen-year-olds in the 8th grade performed at the same level as 17-year-olds in the 10th grade.
- Thirteen-year-olds whose parents have post high school education performed at the same level as 17-year-olds whose parents did not graduate from high school.
- Thirteen-year-olds in advantaged-urban communities (high metro) outperformed 17-year-olds in disadvantaged-urban communities (low metro).

A comparison of the relative performance of the various groups on these identical sets of questions suggests that most groups maintain the same relative advantage or disadvantage from age to age. For example, the percentage of students in the Northeast that answered these science questions correctly is approximately 2 percentage points higher than their age mates' nationally at ages 9 and 13. On questions asked of 13- and 17-year-olds, Hispanic students performed approximately 10 percentage points below the national average. However, some notable exceptions do exist.

Between Ages 9 and 13

- The disadvantage of Hispanic students

[2] See Appendix B for the relative performance of the major National Assessment reporting groups on identical questions.

increased by 5 percentage points.

- The advantage of students in affluent-urban communities (high metro) decreased by almost 3 percentage points.

- The disadvantage of students in big cities decreased by approximately 2 percentage points.

Between Ages 13 and 17

- The disadvantage of black students increased almost 6 percentage points.

- The disadvantage of inner-city students (low metro) increased by more than 3 percentage points.

- The advantage of students in affluent-urban communities decreased by over 2 percentage points.

- The disadvantage of students in big cities increased by over 4 percentage points.

These findings suggest that the achievement levels of racial/ethnic minorities and economically disadvantaged students in this country are not improving, and may even be getting worse as the students get older.

Variations in the Overall Patterns of Group Performance

The relative performance of each group tended to be consistent across all content areas and taxonomic levels described in the science assessment (refer to Chapter 1). That is to say, if a group's performance overall was 4 percentage points below the national level of achievement at a certain age, that 4-point disadvantage tended to be consistent across each of the specific content areas and taxonomic levels. Conversely, groups with overall achievement advantages tended to maintain those advantages in each content area and at each taxonomic level. Nevertheless, within this broadly consistent pattern of achievement, several noteworthy differences are evident.[3]

- The disadvantage of Southeastern students at each age was greater on analysis/synthesis and process-methods questions than their overall 3 to 4 percentage-point disadvantage.

- Among disadvantaged socioeconomic groups — i.e., students whose parents did not graduate high school, those attending schools in low-metro communities, and black and Hispanic students — deficits in science achievement tended to be greatest at the higher taxonomic levels (application, analysis/synthesis) and for the process-methods and decision-making areas.

Differences in the performance levels of male and female students were particularly noteworthy for several of the areas described in the science assessment. Exhibit 22 displays the relative advantages of males and females for each content area of science. Although males had an advantage in almost every area described in the assessment, that was not the case in the decision-making and science-and-self areas. In the areas of physical and earth sciences, the male advantage is particularly large.

Exhibit 23 graphically displays the relative advantage of males for each taxonomic level of the matrix. Although males had an advantage at each level, the advantage became progressively smaller at each higher level.

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[3] See Appendix C for the relative performance of the major National Assessment reporting groups in each content area and taxonomic level of the science assessment.

EXHIBIT 22. Relative Advantages of Males and Females for Each Content Area of Science, Ages 9, 13 and 17

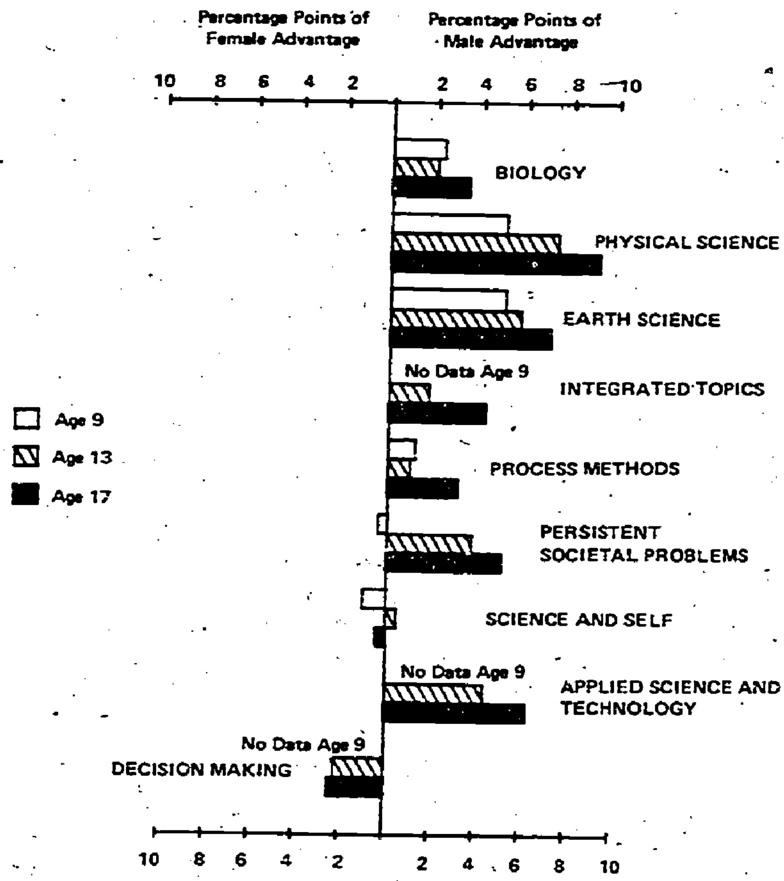
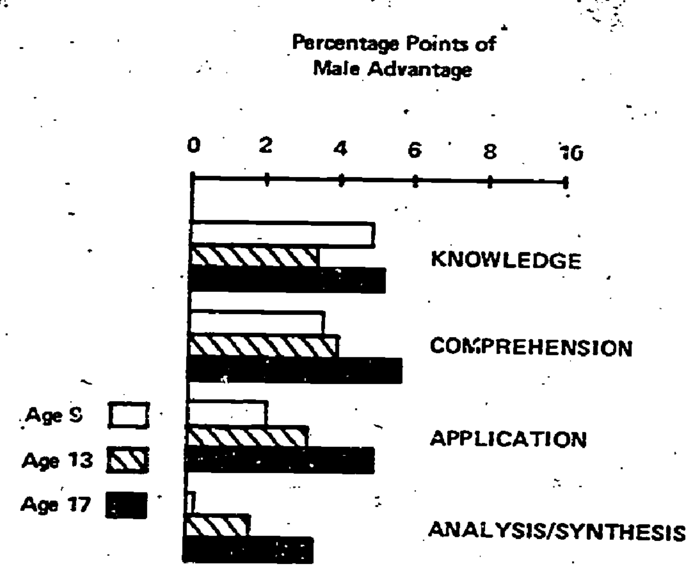


EXHIBIT 23. Relative Advantage of Males for Each Taxonomic Level of Science, Ages 9, 13 and 17



CHAPTER 3

A COMMENTARY

In the following commentary on **Science Achievement in the Schools,** *Lester G. Paldy discusses some of the social implications of the findings and suggests policy directions for the future of science education. Professor Paldy is university-wide dean of Continuing and Developing Education at the State University of New York at Stony Brook, where he also serves as associate professor of Technology & Society and adjunct associate professor of Physics. He currently is serving as editor of the* **Journal of College Science Teaching** *for which he writes a column on science policy developments and is consulting editor of* **The Physics Teacher.**

WILL OUR CHILDREN BE READY FOR THE 21st CENTURY?
A Commentary on Science Achievement in the Schools

Lester G. Paldy

State University of New York at Stony Brook

Even as readers acknowledge the scope and utility of this National Assessment science report, many will be disturbed by the jarring reminder of what differences in socioeconomic status and sex mean to many young Americans in terms of science achievement. The fact that blacks, poor whites, Hispanics and females tend to perform consistently below national averages at the three levels tested, and that differences in performance levels within these broad groups are often related to socioeconomic status, grates on the sensibilities of those who believe that equality of opportunity is the wellspring of American democracy. The report reminds us over and over again of the disparities within the system. Black and white students living in advantaged-urban communities perform significantly higher on science questions than their peers living in disadvantaged-urban communities. The severe educational disadvantage in science associated with low socioeconomic status, and the distance that remains to be traveled if the gap is to be closed, cannot be overlooked in a society that makes increasing technological demands upon its citizens.

The implications of our failure to make more rapid progress toward the elimination of poverty and sharp distinctions in socioeconomic status are nowhere more serious than in the assessment of differences in school achievement. Science achievement, in particular, is important for those seeking to break out of the cycle that traps disadvantaged generations. Leaders in all sectors of American society are increasingly being drawn from the ranks of those possessing scientific and technological abilities. To the extent that young men and women lack these abilities, they will be underrepresented at all leadership levels in the public and private sectors. Without adequate indigenous leadership, efforts to improve the condition and status of the disadvantaged and women in the United States will inevitably be slowed. Young persons with poor science training, even if they do not aspire to positions of leadership, are likely to be seriously handicapped as they seek employment in a post-industrial society's service organizations that are technology-intensive. Real unemployment is already unacceptably high among minority youth in urban settings, and the disparity in the science achievement of poor urban youth and women reported by National Assessment should be regarded as a harbinger of worse times to come by those concerned with social, economic and educational development in the United States.

I do not believe that the schools alone will be able to solve this problem. Wide-ranging needs assessments supported by the National Science Foundation during 1977 have surveyed the literature and practices of science education and developed case studies of representative American schools.[1,2,3,4] One inference that can reasonably be made from these studies is that while schools have managed to maintain the quality of science instruction for that small group of students who often go on to college and elect scientific or science-related careers, schools are not successful, in general, in meeting the needs of children who come to school with educational disadvantages. This inference is corroborated by the National Assessment findings. Even teachers who are intellectually committed to egalitarian social policies find themselves increasingly frustrated by their inability to deal with heterogeneously grouped students exhibiting wide differences in skills and motivation. At a time when school resource allocations are likely to suffer as a result of declining enrollments, and with schools coming under severe attack from external forces even as they are beset by internal strains, it is not reasonable to expect that schools possess the organizational resources required to attack the achievement problem alone. Accordingly, any plan to address the problem must draw upon many resources if it is to stand a chance of success.

We might be tempted to believe that minorities and women have made significant progress during the past decade in achieving equality of educational opportunity as evidenced by a variety of indicators. Unfortunately, a recent report of the U.S. Commission on Civil Rights makes clear that the situation has, in fact, worsened. The Commission report, *Social Indicators of Equality for Minorities and Women*,[5] reveals that educational inequality has increased slightly since 1970, with twice as many minorities and women as majority males two years or more behind the average school grade for their age. The high school dropout rate has not improved significantly for 15- to 17-year-old minority group members; some minorities are twice as likely as whites to drop out. Minorities lag 35% behind in the probability of completing college, and a much higher percentage of minorities and women continue to fill jobs requiring less than a high school education. A similar situation exists in jobs requiring less than a college education.

The complexity of the education problems posed by socioeconomic status differences and their implications for science achievement is such that policy makers have few choices: We can treat these problems with "benign neglect" and hope that improving economic conditions will eventually pull science

[1] *The Status of Pre-College Science, Mathematics and Social Science Education: 1955—75*, 3 vols. (Washington, D.C.: U.S. Government Printing Office).

[2] *Case Studies in Science Education: Design, Overview and General Findings* (Washington, D.C.: U.S. Government Printing Office).

[3] *Case Studies in Science Education: The Case Reports* (Washington, D.C.: U.S. Government Printing Office).

[4] Report of the 1977 National Survey of Science, Mathematics and Social Studies Education (Washington, D.C.: U.S. Government Printing Office).

[5] *Social Indicators of Equality for Minorities and Women* (Washington, D.C.: U.S. Commission on Civil Rights).

achievement up, or we can try to design a comprehensive plan involving individual citizens as well as public and private sector organizations in an attempt to enhance the science achievement of those children and youth whose socioeconomic status, sex or race place them at a disadvantage. Any comprehensive plan to increase school science achievement of the disadvantaged must call for the participation of parents, schools, community organizations, institutions of higher education, the national media and state and federal agencies.

What Can Be Done?

Since this report reveals that some science achievement differences increase with age, it is reasonable to conclude that early intervention is essential. The parents of children in elementary school can, by creating a positive home environment, influence the overall school achievement of their children. Unfortunately, it is the parents of the disadvantaged who are least likely to have either the training, resources or time needed to create the kind of environment that the data seem to suggest is beneficial. Without special assistance it is unlikely that these parents can provide adequate reading material or encourage materials exploration with things such as science toys and games. Many parents of disadvantaged children find it difficult to take young children on trips to zoos and aquariums or participate in other science-related activities that can play a large part in the early development of interest in science. Nor are such parents likely to be able to serve as role models in fields related to science and technology. Community organizations must take the lead in working closely with schools to develop parent-effectiveness training programs designed to demonstrate to disadvantaged parents how they can help at home, if only by monitoring their children's television-watching time while attempting to provide even modest assortments of appropriate reading material.

With support and leadership, schools, community organizations and parents themselves can play important parts in breaking the cycle that often condemns children to low achievement levels in science. One possible alternative is the development of groups like 4H clubs in urban areas, which can begin to stimulate interests in science and technology early in children's development. Furthermore, schools working closely with community organizations must attempt to organize trips to field sites where children would be exposed to scientific or technological environments and role models. Special attempts must be made to utilize "out-of-school" resources more systematically, with assistance being provided to teachers who design the appropriate curriculum activities.

Just as the government now recognizes the need to provide nutritional assistance to poor Americans, so it must provide individual education assistance to disadvantaged families seeking to improve the home environments of their children. A book-stamp program, which would enable families whose incomes were below a certain level to obtain a small quantity of books and magazines each month, could have significant impact on the lives of children. The U.S. Office of Education already supports the Inexpensive Book Distribution Program, which provides matching funds for local efforts to purchase paperbacks for children ages three through high school.[6] Staffed and operated by local volunteers, these programs provide a mechanism for schools and community organizations to increase the amount of reading material available to children in areas that they serve.

As children proceed through the elementary grades, it is important that they be provided with a science curriculum that encourages the manipulation of materials, the direct observations of phenomena and the recording of experimental results. State and

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[6]Inexpensive Book Distribution Program, U.S. Office of Education, administered by Reading Is Fundamental, Inc., Smithsonian Institution, Washington, D.C. 20560.

city governments must assign high priority to the development of science materials and programs in the elementary school grades. Particular attention should be accorded efforts to fabricate kits and other materials from locally available resources, using materials purchased in the community and assembled by local workers. Federal support should continue for summer and inservice institutes for elementary school teachers to familiarize them with the use of simple laboratory materials in school settings. In addition, researchers in schools and institutions of higher education must be encouraged to continue to investigate ways in which disadvantaged children can be helped to learn more effectively. Groups seeking to develop media and community-based science programs for elementary school use — including television broadcasts, museum programs and mobile science displays — should be encouraged with increased funding as well.

Special attempts need to be made in grades four through six to identify gifted and talented children in disadvantaged settings so that special encouragement and support can be provided to them and their parents. At the same time, more curriculum development efforts are needed to ensure that the elementary school curriculum of the majority of children in these grade levels devotes adequate time to health, nutrition and consumer product safety. It is here that institutions of higher education have important roles to play in teacher training at both the preservice and inservice levels. These institutions can also work with schools and community organizations to ensure that older elementary school children, in particular, are exposed to positive role models; urban institutions with minority and women science students should establish visit programs that place these science students in direct contact with elementary school children. Colleges and universities can also collaborate with schools and community organizations in the planning of curriculum materials to be used in parent-effectiveness training programs.

University researchers and curriculum developers can work with national media organizations to prepare study guides and other program materials needed to enable elementary school teachers to take greater advantage of science-related programming on education or commercial network television. Since it is well known that children spend much time watching television at home, schools must create policies that encourage teachers to use media viewing at home to reinforce school experiences. If more television study guides, such as those provided by "Prime Time School Television,"[7] were routinely available, teachers could make more effective use of media programs with science content. Television networks should be asked to reexamine their fair-use copyright policies to ensure that they are sensitive to the needs of urban schools that are not likely to be able to pay substantial fees for the privilege of recording television broadcasts for closed circuit use.

State and federal agencies concerned with education need to review policies and procedures bearing on such things as television broadcast content and coverage so that children's programming is not unreasonably glutted with advertising and contains an adequate amount of educational content. Tax policies must be reviewed to determine whether there are adequate incentives for individuals and media organizations to invest venture capital in the development of innovative science education materials. Tax incentives can exert powerful leverage if they are carefully shaped, and may be of particular interest to large corporations that are in pivotal positions of influence.

All of the suggestions described above are applicable with some adaptations to student needs in secondary school science education as well. It is in the secondary schools, however, that the need for positive role models becomes most intense. Again, visit programs to technical schools, institutions of

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[7] Prime Time School Television, 120 South LaSalle Street, Chicago, Ill. 60603.

higher education and museums should be made available for students and parents even if the parents attend at separate times. There should also be intensified use of out-of-school resources, building on the development of adolescent interest patterns. Similarly, the science curriculum for the majority of children in grades 7—12 should emphasize science literacy, technology assessment, environmental issues, nutrition, health and sex education. Children who have been identified as gifted in the fields of science and mathematics need to be given special opportunities, ranging from invitations to attend special "magnet schools" where their talents can be extended, to participation in special programs organized by local colleges and universities.

More efforts need to be made to establish apprentice programs in fields with technological or scientific content for students in the older age groups. Work-study programs with technical content need to be established to make it possible for students to "stop out" rather than "drop out," and increase their options rather than limit them.

Colleges and universities can establish summer and Saturday-morning science and technology programs for high-ability students designed to provide them with training and motivational experiences that hard-pressed secondary school teachers may not be able to offer. Since many graduates of inner-city secondary schools must attend urban institutions to which they can commute, college and university science departments should establish close liaison with secondary school science teachers, councils and related groups to ensure that adequate curriculum continuity exists.

To remedy the inequalities in science achievement documented in the National Assessment report, and to prepare disadvantaged and inadequately represented members of society to assume positions requiring technical and scientific competence, requires a comprehensive plan of action that links all elements of American society. The 9-year-olds discussed in the NAEP report will become our leaders in the first half of the 21st century. If their ranks are to include adequate representations of minority members and women, we must begin as soon as possible. We now command the resources and possess the technological capacity to educate people in their homes and to share information at a rate and scale that staggers the intellect. If our children are to be ready for the 21st century, we must begin to prepare them now.

APPENDIX A

THE NATIONAL SAMPLE OF 9-, 13 AND 17-YEAR-OLDS IN EACH GROUP

TABLE A-1. Percentages of the National Sample of 9-, 13- and 17-Year-Olds in Each Reporting Group

Group	Percentage of National Sample at Each Age		
	Age 9	Age 13	Age 17
Racial/ethnic background			
White	81.3	79.0	83.9
Black	12.7	15.8	11.4
Hispanic	4.6	3.9	3.4
Other	1.3	1.3	1.3
Sex			
Male	50.6	49.8	49.4
Female	49.4	50.2	50.6
Region			
Southeast	20.9	20.9	18.3
West	24.4	24.8	23.8
Central	29.5	27.8	33.4
Northeast	25.2	26.5	24.6
Grade			
Age 9 Age 13 Age 17			
<3 <7 <10	0.7	2.1	1.4
3 7 10	23.5	25.3	12.7
4 8 11	74.7	71.4	75.5
>4 >8 12	0.7	1.1	10.4
Parental education			
Not graduated high school	9.0	12.6	15.1
Graduated high school	26.9	33.1	33.3
Post high school	30.5	41.1	47.3
Unknown	33.6	13.2	4.2
Types of reading matter			
<3	34.6	19.6	11.8
3	35.2	27.8	23.6
4	30.2	52.6	64.6

Group	Percentage of National Sample at Each Age		
	Age 9	Age 13	Age 17
Community type			
Low metro	6.8	6.8	7.5
High metro	9.4	11.4	11.1
Community size			
Big cities	18.2	21.0	18.7
Fringes around big cities	20.0	18.8	23.0
Medium cities	14.4	11.3	13.0
Smaller places	47.4	48.9	45.3
Racial/ethnic background by sex			
White male	41.5	39.7	41.5
White female	39.8	39.3	42.4
Black male	6.2	7.5	5.3
Black female	6.5	8.3	6.2
Racial/ethnic background by region			
Southeastern white	15.1	15.8	13.8
Western white	18.6	18.3	18.1
Central white	26.1	23.6	30.2
Northeastern white	21.5	21.3	21.8
Southeastern black	5.7	5.0	4.4
Western black	2.0	2.8	2.4
Central black	2.7	3.5	2.8
Northeastern black	2.3	4.5	1.3
Western Hispanic	2.7	2.7	2.3
Northeastern Hispanic	1.4	0.7	0.7
Racial/ethnic background by region by percentage white in schools			
Southeastern white in 0—59% white schools	1.7	1.8	1.2
Southeastern white in 60—100% white schools	13.4	14.1	12.5
Rest of nation, 0—59% white schools	4.5	5.0	3.3
Rest of nation, 60—100% white schools	61.8	58.2	66.8
Southeastern black in 0—59% white schools	3.9	3.1	2.4
Southeastern black in 60—100% white schools	1.8	1.9	2.1
Rest of nation, 0—59% white schools	5.0	8.6	5.0
Rest of nation, 60—100% white schools	2.0	2.3	2.1
Racial/ethnic background by grade			
Modal grade-1 white (grades 3, 7 or 10)	18.9	19.0	9.0
Modal grade white (grades 4, 8 or 11)	61.2	57.8	65.4
Modal grade-1 black (grades 3, 7 or 10)	2.8	4.5	2.6
Modal grade black (grades 4, 8 or 11)	9.5	10.6	7.2
Modal grade-1 Hispanic (grades 3, 7 or 10)	1.6	1.4	0.9
Modal grade Hispanic (grades 4, 8 or 11)	3.0	2.2	2.0
Racial/ethnic background by community type			
Low-metro white	2.5	2.1	2.4
High-metro white	8.3	10.6	10.1
Low-metro black	3.5	3.8	3.9
High-metro black	0.8	0.4	0.7

Group	Percentage of National Sample at Each Age		
	Age 9	Age 13	Age 17
Racial/ethnic background by type of reading matter			
White <3 types	25.1	12.0	7.4
3 types	29.4	21.3	18.5
4 types	26.8	45.7	58.0
Black <3 types	6.2	5.5	3.1
3 types	3.9	4.9	3.7
4 types	2.5	5.4	4.7
Sex by region			
Southeastern male	10.2	10.4	8.7
Western male	12.5	12.3	12.0
Central male	15.2	14.1	16.2
Northeastern male	12.7	13.0	12.0
Southeastern female	10.7	10.5	9.6
Western female	11.9	12.5	11.8
Central female	14.3	13.7	16.7
Southeastern female	12.5	13.5	12.6
Sex by parental education			
Not-graduated-high-school male	4.7	5.6	6.8
Graduated-high-school male	13.9	16.2	16.6
Post-high-school male	15.9	21.1	23.4
Not-graduated-high-school female	4.3	6.9	8.3
Graduated-high-school female	13.0	16.9	16.7
Post-high-school female	14.6	20.1	23.8
Sex by grade			
Modal grade-1 male (grades 3, 7 or 10)	13.9	14.4	8.1
Modal grade male (grades 4, 8 or 11)	35.9	33.4	36.0
Modal grade-1 female (grades 3, 7 or 10)	9.7	11.0	4.6
Modal grade female (grades 4, 8 or 11)	38.8	37.9	39.6
Region by grade			
Modal grade-1 by Southeast	4.3	5.4	2.7
Modal grade by Southeast	16.0	14.8	13.2
Modal grade-1 by West	6.4	7.6	3.4
Modal grade by West	17.7	16.4	18.3
Modal grade-1 by Central	7.9	7.6	3.8
Modal grade by Central	21.2	19.4	26.7
Modal grade-1 by Northeast	5.0	4.8	2.8
Modal grade by Northeast	19.7	20.8	17.3
Census region			
Northeast	5.1	5.0	5.0
Mid-Atlantic	13.5	19.2	18.2
East North Central	19.9	18.9	24.4
West North Central	9.6	8.8	9.0
South Atlantic	12.4	13.7	11.2
East South Central	8.9	8.4	7.8
West South Central	12.0	12.2	10.9
Mountain	3.6	3.5	3.4
Pacific	10.0	10.1	10.3

APPENDIX B

GROUP DIFFERENCES ON IDENTICAL QUESTIONS

TABLE B-1. Relative Group Differences From the Nation on Identical Questions, Ages 9 and 13 and 13 and 17

	Regional Differences				Male/Female Differences		Racial/Ethnic Differences			Parental Education Differences		
IDENTICAL QUESTIONS (66) — Ages 9 and 13												
	SE	C	W	NE	M	F	W	B	H	NHSG	HSG	PHS
Age 9	-3.9*	1.4	0.1	1.6*	1.5	-1.5*	2.3*	-12.2*	-7.2*	-6.4*	1.4*	4.8*
Age 13	-3.4*	1.9*	-1.2	1.8*	1.9	-1.9*	3.3*	-12.9*	-11.2*	-6.9*	-0.3	5.2*
IDENTICAL QUESTIONS (197) — Ages 13 and 17												
Age 13	-3.1*	1.5*	-1.5	2.2*	1.9*	-1.9*	2.8*	-11.4*	-10.3*	-6.9*	-1.2*	5.9*
Age 17	-4.4*	1.4*	-0.6	2.0*	2.8*	-2.8*	2.9*	-17.2*	-11.4*	-8.6*	-1.6*	5.3*

	Type of Community Differences		Size of Community Differences				Grade Level Differences	
IDENTICAL QUESTIONS (66) — Ages 9 and 13								
	LM	HM	BC	FABC	MC	SP	M—1‡	M§
Age 9	-11.4*	8.4*	-4.0*	4.2	-1.2	0.1	-6.9*	2.3*
Age 13	-12.2*	5.8*	-2.5*	2.0	1.0	0.0	-6.2*	2.5*
IDENTICAL QUESTIONS (197) — Ages 13 and 17								
Age 13	-10.6*	6.5*	-2.1*	2.0*	0.7	-0.1	-6.5*	2.5*
Age 17	-13.9*	4.2*	-6.4*	3.3*	1.9	0.6	-10.5*	1.6*

**Indicates mean percentages significantly different from the nation at the .05 level.*
‡M—1 = One grade below the modal grade (3rd, 7th and 10th grades).
§M = Modal grade (4th, 8th and 11th grades).

APPENDIX C

GROUP DIFFERENCES FROM THE NATION BY TAXONOMIC LEVEL AND CONTENT AREA

TABLE C-1. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 9

	No. of Items	Regional Differences				Male/Female Differences		Racial/Ethnic Differences		
		SE	C	W	NE	M	F	W	B	H
All items	206	-4.2	1.3	0.3	1.6	1.5	-1.6	2.5	-12.9	-8.5
Taxonomy										
Knowledge	26	-4.0*	0.5	1.3	1.4	2.2*	-2.2*	2.3*	-12.9*	-5.9*
Comprehension	119	-4.3*	1.5	0.4	1.5	1.8*	-1.8*	2.4*	-12.5*	-8.5*
Application	51	-3.3*	1.3	-0.4	1.6	1.0*	-1.1*	2.5*	-12.8*	-8.4*
Analysis and synthesis	10	-7.5*	2.6	-0.3	3.3*	0.1	-0.1	3.3*	-17.0*	-13.6*
Content										
Biology	66	-4.0*	1.5	-0.6	0.9	1.1*	-1.2*	2.5*	-13.0*	-7.9*
Physical science	71	-3.5*	0.9	0.7	1.3	2.5*	-2.6*	2.0*	-10.8*	-7.0*
Earth science	27	-3.4*	1.0	0.5	1.2	2.5*	-2.6*	1.9*	-11.2*	-4.9*
Integrated topics	2	...	...	...	...	...	...	...	...	...
Process methods	41	-5.9*	2.1	-0.7	3.2*	0.6	-0.6	3.4*	-17.1*	-12.9*
Persistent societal problems	12	-2.3	1.4	-0.2	0.5	-0.2	0.2	2.2*	-10.9*	-10.6*
Science and self	14	-3.8*	1.2	0.9	0.9	0.5	-0.5	2.6*	-13.1*	-9.5*
Applied science and technology	1	...	...	...	...	...	...	...	...	...
Decision making	1	...	...	...	...	...	...	...	...	...

Indicates mean percentages significantly different from the nation at the .05 level.

TABLE C-1 *(Continued)*. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 9

	No. of Items	Parental Education Differences			Type of Community Differences		Size of Community Differences			
		NHSG	HSG	PHS	LM	HM	BC	FABC	MC	SP
All items	206	-6.4	1.7	5.1	-11.7	7.6	-4.7	4.3	-1.0	0.3
Taxonomy										
Knowledge	26	-6.2*	1.7	4.8*	-11.3*	6.0*	-3.6*	3.7*	-1.0	0.0
Comprehension	119	-6.5*	1.8*	5.2*	-11.5*	8.0*	-4.6*	4.6*	-1.0	0.1
Application	51	-5.8*	1.2*	5.0*	-11.4*	6.7*	-4.9*	3.4*	-1.1	0.7
Analysis and synthesis	10	-7.9*	2.0	5.0*	-16.0*	11.8*	-5.9*	6.1*	-1.2	0.1
Content										
Biology	66	-6.5*	1.6*	5.1*	-11.7*	6.5*	-4.6*	4.0*	-1.5*	0.5
Physical science	71	-4.8*	1.5*	4.2*	- 8.9*	6.5*	-3.7*	3.5*	-0.7	0.1
Earth science	27	-6.5*	2.2*	5.2*	-10.3*	6.8*	-4.3*	4.8*	-0.4	-0.3
Integrated topics	2	...	...	...	...	...	...	...	...	...
Process methods	41	-9.1*	1.6*	6.2*	-15.9*	10.9*	-6.4	5.6	-1.0	0.3
Persistent societal problems	12	-4.9*	1.8	5.3*	-11.9*	7.1*	-4.4*	4.2*	-0.4	0.1
Science and self	14	-4.1*	1.9*	4.9*	-12.7*	6.6*	-3.4*	4.4*	-1.7	0.0
Applied science and technology	1	...	...	...	...	...	...	...	...	...
Decision making	1	...	...	...	...	...	...	...	...	...

**Indicates mean percentages significantly different from the nation at the .05 level.*

TABLE C-2. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 13

	No. of Items	Regional Differences				Male/Female Differences		Racial/Ethnic Differences		
		SE	C	W	NE	M	F	W	B	H
All items	284	-3.0	1.6	-1.5	2.1	1.8	-1.7	2.9	-11.7	-10.3
Taxonomy										
Knowledge	29	-2.5*	0.6	-0.5	1.9	1.7*	-1.7*	2.7*	-10.8*	-9.9*
Comprehension	139	-2.3*	1.3	-1.6	2.0	2.0*	-2.0*	2.8*	-11.0*	-9.9*
Application	68	-3.9*	2.2	-1.7*	2.4	1.6*	-1.6*	3.2*	-12.6*	-10.9*
Analysis and synthesis	28	-4.6*	2.1	-0.9	2.0	0.9*	-0.8*	3.2*	-12.9*	-10.4*
Content										
Biology	77	-2.4*	1.3	-0.9	1.5	1.0*	-1.0*	2.8*	-10.8	-9.4*
Physical science	66	-3.2*	1.9	-1.7	2.1	3.7*	-3.7*	2.8*	-11.4*	-9.7*
Earth science	43	-3.2*	1.9	-1.6	1.9	2.8*	-2.8*	2.8*	-12.2*	-10.2*
Integrated topics	14	-3.5*	1.5	-1.2	2.5	0.9	-0.9	2.4*	-10.1*	-9.7*
Process methods	58	-4.1*	2.5	-2.4	2.9	0.5	-0.5	3.4*	-13.2*	-11.7*
Persistent societal problems	48	-1.9	0.7	-1.2	1.8	1.9*	-1.9*	2.7*	-10.6*	-10.2*
Science and self	22	-3.8*	1.5	-0.6	2.0	0.2	-0.3	3.2*	-12.1*	-11.8*
Applied science and technology	15	-2.2	-0.0	-1.1	2.5	2.2*	-2.2*	2.8*	-10.9*	-7.3*
Decision making	11	-2.9*	0.6	-1.6	3.0	-1	1.1*	3.3*	-13.8*	-12.8*

**Indicates mean percentages significantly different from the nation at the .05 level.*

TABLE C-2 *(Continued)*. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 13

	No. of Items	Parental Education Differences			Type of Community Differences		Size of Community Differences			
		NHSG	HSG	PHS	LM	HM	BC	FABC	MC	SP
All items	284	-6.9	-0.9	5.7	-11.1	6.3	-2.2	1.9	0.6	0.0
Taxonomy										
Knowledge	29	-5.8*	-1.1*	5.2*	-10.5*	4.3*	-2.4	1.6*	1.7*	-0.1
Comprehension	139	-6.8*	-0.9	5.6*	-10.7*	6.3*	-1.9	1.4	0.3*	0.1
Application	88	-7.2*	-0.6	5.7*	-11.1*	7.0*	-2.6	2.6	0.8*	-0.1
Analysis and synthesis	28	-8.0*	-1.2	6.6*	-13.4*	6.6*	-2.2	2.1	0.7	-0.1
Content										
Biology	77	-6.7*	-1.0*	5.6*	-10.7*	5.6*	-1.8	2.0	1.0	-0.3
Physical science	66	-6.9*	-0.4	5.0*	-10.0*	6.7*	-2.3	2.0	0.2	0.1
Earth science	43	-7.4*	-0.9	5.6*	-11.0*	7.3*	-1.9	1.7	0.0	0.0
Integrated topics	14	-7.1*	-1.3	5.3*	-9.2*	4.2*	-1.3	0.7	1.8	-0.2
Process methods	58	-7.4*	-0.6	6.3*	-13.4*	6.8*	-2.4	1.9	0.7	0.1
Persistent societal problems	48	-6.4*	-1.4*	6.1*	-10.2*	5.4*	-2.8	1.0	1.3	0.4
Science and self	22	-6.0*	-0.7	5.1*	-10.3*	4.6*	-2.7	1.5	2.0	0.1
Applied science and technology	15	-7.5*	-1.6	7.3*	-10.9*	8.5*	-1.1	3.0	-0.3	-0.8
Decision making	11	-9.8*	-1.4	7.4*	-12.5*	7.2*	-1.7	1.8	-0.2	0.2

**Indicates mean percentages significantly different from the nation at the .05 level.*

TABLE C-3. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 17

	No. of Items	Regional Differences				Male/Female Differences		Racial/Ethnic Differences		
		SE	C	W	NE	M	F	W	B	H
All items	313	-4.1	1.2	-0.8	2.2	2.6	-2.5	2.6	-15.7	-10.8
Taxonomy										
Knowledge	32	-2.9	0.4	-0.9	2.5	2.7*	-2.6*	2.2*	-13.4*	-9.5*
Comprehension	140	-3.4*	1.1	-0.8	1.8	2.9*	-2.8*	2.4*	-14.4*	-10.2*
Application	110	-4.8*	1.5	-0.9	2.5	2.5*	-2.5*	2.8*	-17.0*	-11.5*
Analysis and synthesis	31	-5.7*	1.7	-0.5	2.5	1.7	-1.7	3.3*	-19.6*	-12.3*
Content										
Biology	74	-3.8*	0.8	-0.8	2.5	1.7*	-1.7*	2.4*	-14.5*	-9.4*
Physical science	82	-3.7*	0.9	-1.0	2.6*	4.7*	-4.5*	2.3*	-13.9*	-9.1*
Earth science	43	-4.4*	1.2	-0.1	1.8	3.6*	-3.5*	2.3*	-15.9*	-9.6*
Integrated topics	19	-5.6*	2.0	-0.2	1.7	2.2*	-2.1*	2.7*	-16.7*	-10.5*
Process methods	62	-5.6*	2.0	-1.1	2.7	1.6	-1.5	3.2*	-19.1*	-14.2*
Persistent societal problems	56	-3.7*	1.7	-0.6	0.9	2.6	-2.5	2.9*	-17.2*	-12.3*
Science and self	25	-2.8*	1.1	-1.0	1.5	-0.2	0.2	2.3*	-13.4*	-10.5*
Applied science and technology	21	-4.4*	1.6	-0.5	1.7	3.2*	-3.1*	2.7*	-15.9*	-11.0*
Decision making	16	-2.9	1.7	-1.4	1.3	-1.2	1.2	2.8*	-16.9*	-12.4*

**Indicates mean percentages significantly different from the nation at the .05 level.*

TABLE C-3 *(Continued)*. Relative Group Differences From the Nation by Taxonomic Level and Content Area of Science, Age 17

	No. of Items	Parental Education Differences			Type of Community Differences		Size of Community Differences			
		NHSG	HSG	PHS	LM	HM	BC	FABC	MC	SP
All items	313	-8.0	-1.8	5.1	-12.3	4.4	-5.8	2.8	1.7	0.5
Taxonomy										
Knowledge	32	-7.4*	-1.7	4.6*	-11.8*	4.6*	-5.1*	2.5*	0.9	0.6
Comprehension	140	-7.3*	-1.8	4.9*	-11.3*	4.4*	-5.4*	2.6*	1.5	0.5
Application	110	-8.7*	-1.7	5.3*	-13.0*	4.2*	-6.2*	3.2*	1.8	0.4
Analysis and synthesis	31	-9.4*	-1.9	5.7*	-14.7*	5.5*	-6.8*	3.2*	3.1	0.4
Content										
Biology	74	-7.6*	-1.7	4.8*	-10.7*	4.7*	-5.0*	2.9*	1.7	0.2
Physical science	82	-7.8*	-1.9	5.0*	-10.3*	4.4*	-4.9*	2.5*	1.4	0.3
Earth science	43	-7.2*	-2.1	4.9*	-12.7*	3.3	-6.4*	2.6*	1.4	1.0
Integrated topics	19	-8.7*	-2.0	5.5*	-13.9*	5.5*	-6.5*	4.1*	2.7	-0.2
Process methods	62	-9.9*	-1.7	5.8*	-15.4*	5.6*	-6.4*	3.3*	2.6	0.2
Persistent societal problems	56	-7.8*	-1.5	4.9*	-13.7*	4.0	-7.3*	2.8*	1.5	1.2
Science and self	25	-5.9*	-1.1	3.8*	-12.8*	3.6*	-4.9*	2.2	0.7	0.9
Applied science and technology	21	-8.0*	-2.3*	5.4*	-10.4*	3.6	-6.6*	2.8*	3.3	0.6
Decision making	16	-8.3*	-1.7	5.3*	-14.3*	5.2*	-6.5*	3.2*	0.7	0.6

**Indicates mean percentages significantly different from the nation at the .05 level.*

APPENDIX D

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