DOCUMENT RESUME

ED 223 404 SE 038 774

AUTHOR Olstad, Roger G.; And Others
TITLE Inhibitors to Achievement in Science and Mathematics by Ethnic Minorities.
PUB DATE Mar 81
NOTE 136p.
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC06 Plus Postage.
DESCRIPTORS *Academic Achievement; Counseling; Elementary School Mathematics; Elementary School Science; Elementary Secondary Education; *Ethnic Groups; Inhibition; Mathematics Education; *Minority Groups; Motivation; *Performance Factors; Science Careers; Science Education; *Secondary School Mathematics; *Secondary School Science; Student Attitudes; Student Characteristics; Testing

ABSTRACT

Suggesting that the underrepresentation of ethnic minorities in technical and science-related careers and within academic programs leading to such careers has not resulted primarily from free exercise of choice on their part, but rather has resulted in some measure from barriers to minority group participation, the literature was surveyed to examine factors suspected of inhibiting minority participation in science/mathematics at the pre-college level. Factors examined included: (1) those related to testing procedures (general testing, achievement, other factors such as socio-economic status, performance patterns, and presence of bias); (2) those related to learner characteristics (cognitive style, locus of control, and attitude/motivation); (3) those related to classroom experience (differential exposure of science/mathematics instruction, de facto classroom segregation, classroom psychological environment, teacher expectations, and instructional strategies); and (4) those related to counseling experiences. Programs to encourage minority participation in science/mathematics were also examined. Suggestions based on the literature review include early exposure to experiential science and concrete mathematical materials to develop conceptual understanding, providing instructional strategies accommodating a variety of cognitive styles, rectifying any imbalance in the quality of science/mathematics instruction encountered by minorities, providing career awareness programs and academic role models, and including Asian Americans and minority women in future research studies. (Author/JN)

INHIBITORS TO ACHIEVEMENT IN SCIENCE AND MATHEMATICS BY ETHNIC MINORITIES

Roger G. Olstad
Juan R. Juarez
Linda J. Davenport
David L. Haury

College of Education
University of Washington
Seattle, Washington

March, 1981

Acknowledgments

Though penned by two research assistants, Linda J. Davenport and David L. Haury, this report is a corporate product conceived, directed, and supported by several people associated with the Science and Mathematics for Minorities Project at the University of Washington. Much credit must be given to the Graduate School, Dr. Ronald Geballe, Dean; and the College of Education, Dr. James I. Doi, Dean, for supporting this project at a time when outside funding was not available and the eventual direction of the project remained uncertain.

The preparation of this report has been directed by two members of the College of Education, Dr. Roger G. Olstad, Professor and Associate Dean, and Dr. Juan R. Juarez, Assistant Professor. Their guidance and encouragement is greatly appreciated. In addition, the authors wish to acknowledge and thank Professors Jack L. Beal, Willard E. Bill, Mildred E. Kersh, and James A. Vasquez, Lecturer Virginia M. Warfield, and Research Associate Nancy Cook, each of whom offered valuable consultation as the manuscript was being developed.

Finally, a special thanks is due Dr. Theodore Kaltsounis, Curriculum and Instruction Chairperson of the College of Education at the University of Washington, for his continual support of the project and for expediting the production of this report. We share his desire and the desire of all those associated with the Science and Mathematics for Minorities Project to identify and mitigate the barriers inhibiting achievement in science and mathematics by ethnic minority group members.

TABLE OF CONTENTS

Inhibitors to Achievement in Science and Mathematics by Ethnic Minorities

During the past two decades much time, energy, and money has supported attempts to rid American society of racial and ethnic inequities. A major thrust has been the attempt to provide all people, regardless of ethnic background, an equal opportunity to pursue the career of their choice. Despite recent gains (see Table 1), however, there remain several troublesome imbalances, including an underrepresentation of ethnic minority groups within science and engineering professions. Minorities comprise 22% of the total U.S. population but only 4% of the work force in technical and science-related fields (Slaughter, cited in Williams, 1980). As alarming as this discrepancy might seem, it does not adequately portray the extent of underrepresentation in many instances. Consider the case of a specific minority group--Black Americans. The actual number of Black Americans employed as physicians or graduating as engineers is approximately 10% of the number to be expected if professional representation were to reflect the relative proportion of Black Americans in the U.S. population (see Table 2).

Some progress in rectifying imbalances has been made by educational agencies, but it takes only a cursory glance at Table 3 to notice that certain minority groups remain distressingly underrepresented in the academic pursuit of degrees leading to careers in science and engineering. During the four years of 1973 to 1976, minority group members received only 5.3% of the bio-science doctorates conferred (Vetter, 1978). Clearly, underrepresentation of minorities within technical and science-related careers and within the academic programs leading to such careers is a lingering concern worthy of serious attention. In this report, we are assuming that this underrepresentation has not resulted primarily from free exercise of choice on the part of ethnic group members, but rather has resulted in some measure from barriers to minority group participation.

Table 1
Progress in Increasing Ethnic Minority Participation
In Science and Engineering Professions

Profession	Percent Who Represent Minority Groups	
	1972	1978
Engineers	3.4	5.5
Sciences	7.8	9.2

Note. Adapted from Bureau of the Census, 1979

Table 2
Representation of Black Americans in Three Professions

Profession	Total Number	Expected Black Representation	Actual Black Representation
Physicians	325,000	32,500	3,500
Dentists	110,000	11,000	2,700
Annual Engineer Graduates	40,000	4,000	400

Note: Adapted from Hale, 1978.

Table 3
Percent of Degrees Earned by Minority Groups in Selected Fields During the 1975-76 Academic Year

Field	Black Americans	American Indian	Hispanic Americans	Asian Americans
Biological Sciences				
B.S.	4.1	0.3	1.6	2.2
M.S.	3.1	0.2	0.8	1.9
Ph.D.	1.3	0.1	0.6	2.5
Engineering				
B.S.	2.9	0.3	1.8	2.1
M.S.	1.3	0.2	1.4	3.0
Ph.D.	0.6	0.1	0.6	4.2
Physical Sciences				
B.S.	2.9	0.3	1.3	1.5
M.S.	2.4	0.2	1.0	2.6
Ph.D.	0.9	0.2	0.8	2.5
Percentage of U.S. Population	11.6	0.4	5.6	0.5 [a]

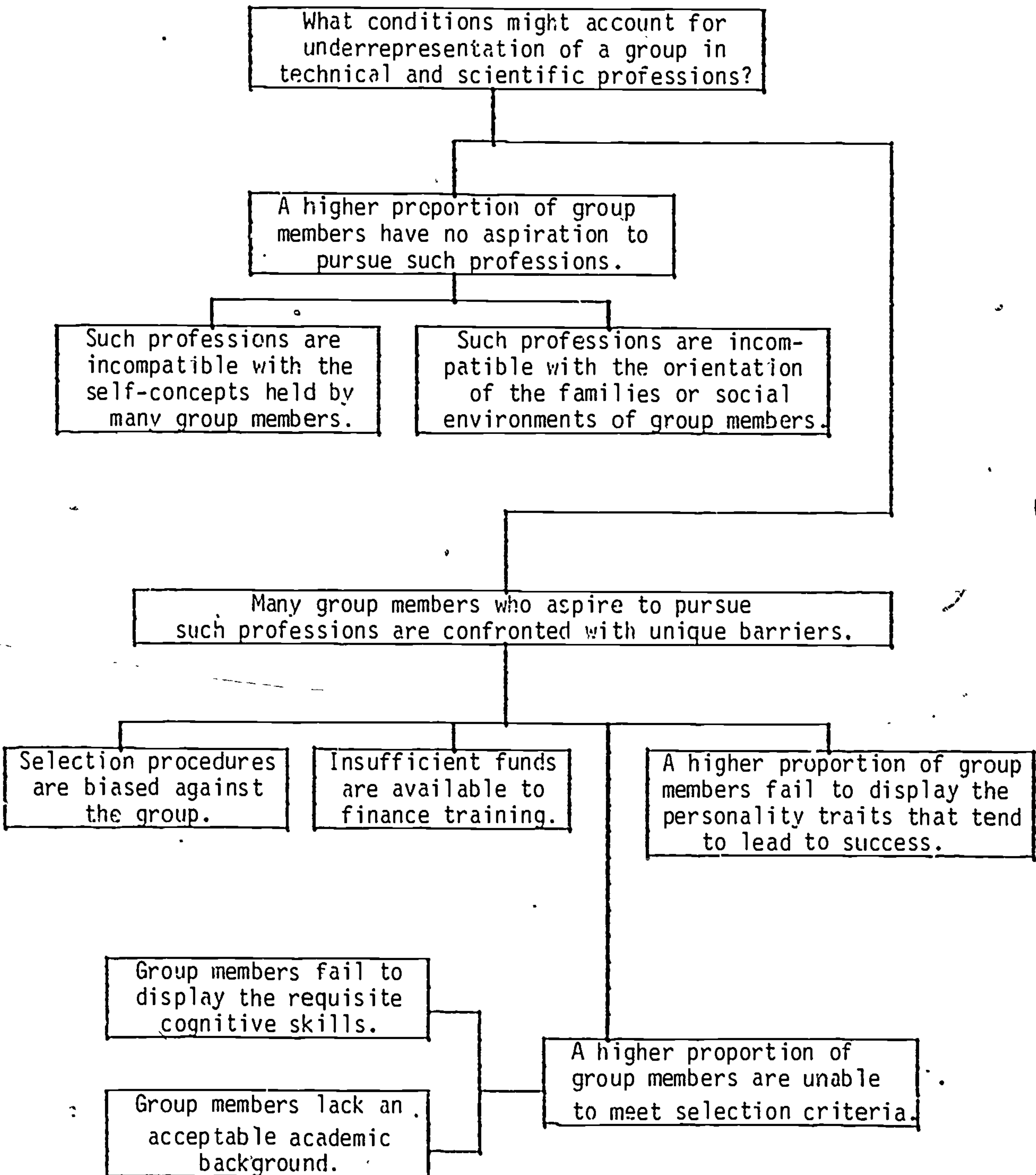
Note. Adapted from Directorate for Science Education, 1980.

[a] The proportion of U.S. citizens that were of Japanese or Chinese descent in 1970 as estimated by the Bureau of the Census, 1979.

What conditions might serve as barriers to minority group participation in technical and scientific professions? How can the conditions be altered? These two questions are simple to formulate but are not simple to answer. It is reasonable to assume that larger proportions of some groups may not aspire to such professions, but why do they not? Perhaps many aspire to such professions, but are thwarted by unique barriers. If so, what are those barriers and why do they persist? We can conceive of several conditions that may account for the acknowledged imbalance, including some that are amenable to educational intervention (see Figure 1 for an example), but how can we be confident that our speculations have some validity? Clearly, what appear to be two simple questions require complex answers, answers substantiated by empirical evidence. To date, however, there seem to be only partial answers and much speculation.

This report represents an initial attempt to survey a widely dispersed body of literature, much of it as yet unpublished, and to begin piecing together the partial answers which have been empirically substantiated to some degree (see Figure 2). It must be stated at the outset that much speculation remains unsubstantiated. Furthermore, a survey of research articles in the leading science and mathematics education journals (such as Journal of Research in Science Teaching, Journal For Research in Mathematics Education, Science Education, and Mathematics Teacher) reveals a paucity of studies having ethnicity either as the focus or as a moderator variable. For instance, fewer than 2% of the research articles presented since 1970 in either Science Education or the Journal of Research in Science Teaching have identified ethnicity as a consideration when interpreting results of empirical studies. Minority groups, it seems, are as underrepresented in the research literature related to science and mathematics education as they are in science-related professions. Surely little progress will be made in rectifying professional underrepresentation until research underrepresentation is eliminated.

Figure 1
Conceptualization of Conditions Possibly Affecting Minority Participation in Technical and Scientific Endeavors



In consolidating the available information, then, no attempt has been made to promote a particular set of factors as being most worthy of educational attention. Rather, this is an attempt to identify what seem to be significant factors affecting professional representation and to identify gaps in the research literature. We have also included a few remarks about programs that have been designed to alter the conditions at the pre-collegiate level that are thought to hinder the entrance of minorities into technical and science-related careers.

Several strategies were used to gain access to the relevant literature: on-line computer searches of selected databases (National Clearinghouse on Bilingual Education, Dissertation Abstracts, ERIC, and Psychological Abstracts), a manual survey of paper indices, a manual survey of the latest volumes of selected research journals, consultation with several University of Washington faculty members, and a review of citations found in research articles and review articles. It must be noted that some of the literature cited in this report does not focus on science or mathematics education specifically, but addresses general school achievement. Furthermore, the literature cited has been restricted for the most part to pre-collegiate education.

For the sake of continuity and clarity, the factors suspected to be hindering minority participation in science and mathematics have been grouped into four categories: (1) factors related to testing procedures, (2) factors related to learner characteristics, (3) factors related to classroom experiences, and (4) factors related to counseling experiences. Within each of these four categories are several factors thought to

Figure 2
A Listing of Some Suspected Barriers to Participation
by Ethnic Minorities in Technical and Science-Related Professions

MATH AVOIDANCE	(Green, 1978; Green, Brown, and Long, 1978)
DIFFERENTIAL TEACHER EXPECTATIONS*	(Dusek, 1975; Gottlieb, 1964; Jackson & Cosca, 1974)
ACADEMICALLY DISADVANTAGED BACKGROUND	(Erlick & LeBold, 1977; Hale, 1978; McDermott, Piternick, & Rosenquist, 1980 b)
INADEQUATE CAREER AWARENESS	(Erlick & LeBold, 1975, 1977)
INSUFFICIENT FINANCES FOR REQUIRED TRAINING	(Brown, Rosen, Hill, & Olivas, 1980; Hale, 1978)
INADEQUATE COUNSELING	(Jay, 1977)
PARENTAL INFLUENCE*	(Eash & Rasher, 1977; Hale, 1978)
LACK OF APPROPRIATE ROLE MODELS	(Epstein as cited in Skypek, Lee, & Cox; Hale, 1978; Jay, 1977)
SELF-CONCEPT	(Hale, 1978; Maestas, 1977; Simpson, 1979)
EDUCATIONAL ENVIRONMENT	(Jay, 1977; Green, 1978)
SOCIOCULTURAL/SOCIALIZATION FACTORS	(Maestas, 1977; Skypek et al.)
INSTRUCTIONAL PROCESS VARIABLES*	(Dallas Independent School District, 1975)
UNATTRACTIVE STEREOTYPES OF SCIENTISTS	(Maestas, 1977; Mead and Metraux, 1957; Simpson, 1979)
LACK OF VERBAL, QUANTITATIVE, AND PROBLEM-SOLVING SKILLS*	(Roueche & Mink, 1976)
LOCUS OF CONTROL	(Rowe, 1973, 1977; Coleman et al., 1966)
COGNITIVE STYLE	(Ramirez, 1974)
LEVEL OF INTELLECTUAL DEVELOPMENT	(Lawson, Nordland, & Kahle, 1975)

* These factors have been declared to affect general achievement

influence the degree of professional representation by minorities. Socioeconomic status (SES) and cultural orientations seem to significantly influence aspects of several factors, and will be discussed as appropriate within each of the categories.

Factors Related to Testing

Testing: General

Our first task in addressing the problem of ethnic minority under-representation in science and mathematics was to examine achievement test data for ethnic group differences in performance. In particular, it seemed important not only to determine whether or not ethnic group differences were revealed in test data, but also to determine what kind of differences these were, and how these differences changed as members of ethnic groups progressed through school. Information of this sort, though readily available through standardized testing of public school students, is very general. Specific information is more difficult to locate. However, national assessments of educational progress have examined science and mathematics achievement in detail, at the different levels of learning as well as in the different content areas.

We also thought it important to examine ethnic group performance in areas other than science and mathematics achievement, such as on intelligence tests, other ability tests, and on Piagetian tasks. It was hoped that group profiles in these areas could be helpful in determining relative strengths and weaknesses, as well as perhaps suggesting abilities associated with success in science and mathematics. Lastly, the problem of test bias was considered in an effort to determine to what extent group differences were artifacts of the tests themselves and of the testing situation.

A comprehensive analysis of achievement with regard to ethnic group performance has been published in the Coleman Report (Coleman, Campbell, Hobson, Partland, Mood, Weinfeld, & York, 1966). Here, achievement in mathematics, as well as a number of other areas, was assessed for large numbers of public school students. Unfortunately, science achievement was not measured. Although this report is dated and has been criticized on methodological grounds, it did provide an extensive breakdown of performance by ethnic group. Median scores were reported for Puerto Ricans, Indian Americans, Mexican Americans, Asians, and Black Americans, with all others included in the category identified as Majority. Test results for these groups were compared with each other using nation-wide median scores for each test at each grade level. As Table 4 indicates, for almost all groups but the Majority, mathematics achievement was below the national median at all grade levels assessed. The performance of the Asian American group at the ninth and twelfth grade levels was the only exception to the general finding. No consistent pattern from grade level to grade level for any of the ethnic groups was indicated in the data, and no specific information with regard to mathematics achievement was provided.

Table 4
Nationwide Median Test Scores for
1st- and 12th-Grade Pupils, Fall 1965

	Racial or Ethnic Group					
Test	Puerto Ricans	Indian Americans	Mexican Americans	Asian Americans	Black Americans	
Majority						
1st Grade:						
Nonverbal	45.8	53.0	50.1	56.60	43.4	54.1
Verbal	44.9	47.8	46.5	51.6	45.4	53.2
12th Grade:						
Nonverbal	43.3	47.1	45.0	51.6	40.9	52.0
Verbal	43.1	43.7	43.8	49.6	40.9	52.1
Reading	42.6	44.3	44.2	48.8	42.2	51.9
Mathematics	43.7	45.9	45.5	51.3	41.8	51.8
General Information	41.7	44.7	43.3	49.0	40.6	52.2
Average of the 5 tests	43.1	45.1	44.4	50.1	41.1	52.0

Note. Taken from Coleman et al., 1966.

Testing: Achievement

Science and mathematics achievement were specifically examined in a series of national assessments which, though procedurally comprehensive, provided only a scanty analysis by ethnic group. Representative samples of nine-year-olds, thirteen-year-olds, seventeen-year-olds including high school drop-outs and early graduates, and adults--totaling over 90,000 individuals--participated in each assessment, which contained items classified by level of cognitive difficulty and by content focus. Some attitudinal items were also included.

Science achievement. There have been three National Assessment of Science by the Education Commission of the United States, administered in 1969-70, 1972-73, and 1976-77. Each assessment has focused on knowledge of fundamental scientific concepts, understanding and application of these concepts in a wide variety of problem situations, and implications of these concepts for society. The overall performance of Anglo Americans, Black Americans, and Hispanic Americans on the most recent national assessment has been summarized in Table 5.

Over the course of these assessments of science achievement, several general tendencies have emerged. On the cognitive items Anglo Americans have consistently outscored Hispanic Americans and Hispanic Americans have consistently outscore Black Americans. In many cases these differences have

Table 5
Selected Deviations from the National Mean for Cognitive Items on the 1976-77 National Assessment of Science

Age	Number of Items	Anglo Americans	Black Americans	Hispanic Americans
All Cognitive Items:				
9	209	+2.5	-12.9	- 8.5
13	284	+2.9	-11.7	-10.3
17	313	+2.6	-15.7	-10.8
Science and Society				
Persistent Societal Problems:				
9	12	+2.2	-10.9	-10.6
13	48	+2.7	-10.6	-10.2
17	56	+2.9	-17.2	-12.3
Science and Self				
9	14	+2.6	-13.1	-9.5
13	22	+3.2	-12.1	-11.8
17	25	+2.3	-13.4	-10.5
Applied Science and Technology				
13	15	+2.8	-10.9	-7.3
17	21	+2.7	-15.9	-11.0

Note. All percents are significantly different from the national average at the 0.05 level of significance.

Adapted from Kahle, 1979.

increased with age. There has been a decreasing performance overall, a portion of which has been attributed to the recent shift of emphasis toward values and attitudes in science education.

In addition to these overall trends, some important changes between assessments can be noted. The achievement of Black American thirteen-year-olds has improved in the physical sciences area between the second and third assessment. Also, the achievement of Black Americans from advantaged urban communities has been near or above the overall performance of their age mates. Results for the Hispanic American population as a group were not assessed until 1971 and consequently no reported changes in achievement are available.

Detailed information regarding Black American relative performance in the 1969-70 assessment is reported in Figures A and B in Appendix A. In this report of science achievement, an attempt is made to adjust some of the data through a process of "balancing" other measured factors. By balancing the data for type of community, parental education, gender, and regional representation, the disproportionate Black representation in these categories was statistically controlled, changing Black American scores from -14.5%, -15.0%, -11.8%, and -15.8% at ages 9, 13, 17, and adult, respectively, to -10.2%, -11.0%, -7.7%, and -10.9% (NAEP no. 7, 1973). Even though median results for Black Americans remained below the national level after balancing, differences in performance were substantially reduced.

Interestingly enough, this report showed no consistent decline in relative Black American performance with increasing age. This was true not only for the balanced data but the unbalanced data as well. Also, the pattern of responses to specific exercises before and after balancing remained generally the same. On the exercises for which Black Americans performed well before balancing, they also performed well after balancing, and the same was true for exercises on which they performed poorly. Exercises of typically high or low Black American performance were addressed in the report (see Tables A, B, and C in Appendix A).

At age nine, Black Americans performed as well as Anglo Americans on exercises that were difficult for the national sample as a whole. The report described these difficult exercises as being often tricky, and even misleading and such exercises did not differentiate well between different groups of respondents. Relatively good Black American performance was achieved on exercises requiring information addressed in most first- and second-grade science curricula--volcanoes and nutrition. Another area of high performance involved a trial-and-error exercise with actual weights. Exercises of a typically low Black American performance generally involved what was described as "relatively remote textbook facts" about astronomy, geology, meteorology, chemistry, electricity, human biology, behavior of animals, and activities of scientists. Often symbols and graphs were involved as well as possibly unfamiliar terms such as "vaccinations" and "fossils." Two exercises involved a detached and abstract "what if" approach toward unusual uses of familiar objects.

For the thirteen-year-old group, Black Americans and Anglo Americans performed equally well on exercises that were generally difficult or had reference to direct experience. These exercises referred to such situations as the use of chemical energy of gasoline burned in a car, the purpose of toothbrushing, the kind of clouds that bring rain, everyday experiences about human biology and about scientists, and a situation in which respondents were asked to time ten swings of a pendulum. Those exercises on which Black Americans performed poorly were characterized as "bookish" and "abstract." Several of these exercises also involved terms possibly unfamiliar or confusing to many Black Americans--"ovules," "Fahrenheit temperature," and "movement and characteristics of air masses." Several other exercises involved the plotting and interpretation of data graphs, determining the appropriate way to balance a beam. The remaining exercises involved selecting an action that would not upset nature's balance, determining why fanning helps campfires, choosing an area most useful in scientific research, solving a hypothetical measurement problem, exploring the difference between "fact" and "opinion," selecting a numerical estimation, and solving a problem in astronomy.

For seventeen-year-olds, the same factors again can be associated with atypically good and atypically poor Black American performance. As before, there were a number of difficult and undifferentiating exercises. Some slight Black American advantage, after balancing, was achieved on the exercise "Whenever scientists carefully measure any quantity many times, they expect that: (a) all of the measurements will be exactly the same; (b) only two of the measurements will be exactly the same; (c) all but one of the measurements wil be exactly the same; (d) most of the measurements will be close but not exactly the same; (e) I don't know," and also exercises involving physical principles in home appliances and why giraffes evolved long necks. On the more poorly performed exercises, again vocabulary factors may account for some results. Successful performance on these exercises required knowledge that "adrenalin stimulates the heart," as well as familiarity with other terms of body chemistry, the association of Darwin's name with the idea of natural selection in a theory of evolution, and again the "movement and characteristics of air masses." Other poorly performed exercises required a graph of data generated from a physical apparatus, the balancing of a weighted pan, measuring weights of objects in hypothetical experiments, and the timing of ten swings of a pendulum. It should be noted that on the pendulum exercise, the relatively poor performance of the 17-year-old group is the result of no Black improvement between the ages of 13 and 17 but sizeable national improvement. Generally, Black American 17-year-olds had difficulty on exercises that involved electromagnetic radiation, the mechanics of springs, the properties of light, the concept of a hypothesis, and various topics in electricity.

The report concluded by identifying a suggestive theme associated with atypical performance at all age levels--that "Black Americans perform best on those science exercises most dependent upon daily experience and common knowledge and poorest on those that involve a detached research attitude toward the objects and phenomena of science." Although the cause of such a pattern of performance was not identified, reference was made to the variety of factors "in the Black American educational, environmental, and cultural situation that might explain such an outcome." Since an analysis of this sort was not available for other ethnic groups, caution must be exercised in drawing general conclusions. For example, the pattern of Black American performance does not seem to apply to the Asian American population.

Mathematics achievement. There have been only two National Assessments of mathematics in 1972-73 and again in 1976-77. Each assessment focused on mathematical knowledge and skills, understanding, and applications in a variety of content areas. Changes in mathematics achievement from the first assessment to the second were reported by NAEP (see Figures C, D, and E in Appendix B), and show a general improvement in ethnic minority performance. In the 9-year-old group, Black Americans showed definite improvement, Anglo Americans showed a decline, and Hispanic Americans achievement remained constant. In the areas of knowledge, skill, and understanding, performance of Black Americans at age 9 improved while that of Anglo Americans either declined or did not change. In the area of applications, 9-year-old Black American achievement remained constant while 9-year-old Anglo American achievement declined. The Hispanic American group, being relatively small, showed little change in either direction. In the 13-year-old group, at all cognitive levels, Anglo Americans and Hispanic Americans showed an overall decline in performance, but 13-year-old Black American performance showed no change. By age 17, the performance of all three groups had declined significantly.

Unfortunately it is difficult to determine, with only two assessments, whether or not these changes in mathematics achievement constitute a trend toward improved ethnic minority performance. Levels of achievement may vary for any number of reasons, some of which may not be related to educational considerations. Furthermore, students bring with them such a range of educational experience that it would be difficult to determine which aspects of that experience contribute to changes in test scores. More detailed information is needed in order to understand how levels of achievement may vary.

Looking at each assessment separately provides some information about areas and levels of Black American and Hispanic American performance. Since results are reported in terms of median differences from national performance, the measures are only relative ones. We are not given information about the nature and the range of responses being made to any given problem. Nonetheless, the reported results are valuable in ascertaining how well these groups of students perform when compared to their peers nationally, and some areas and levels of atypical performance are described by NAEP.

The first assessment compared only Black Americans to Anglo Americans, (see Table D in Appendix B), and indicated that Black Americans were at a disadvantage in all areas compared to Anglo Americans. The disadvantage was more marked at the upper age levels than at the lower age levels. Areas of great difference were measurement, which was also the section in which national median percentages were generally highest, and computation. Some exercises on which atypically poor performance was found for the different age grous were noted in the report. For example, Black American 9-year-olds performed lowest on identifying half-inches marked on a ruler, and drawing hands on a clock to represent a specific time, adding and subtracting with simple regrouping, and solving translation problems. Black American 13-year-olds showed large deficits on exercises about setting a thermometer, identifying three-quarter-inches marked on a ruler, and giving geometric names to common shapes. Black American 17-year-olds also had difficulty giving geometric names to common shapes, and converting feet to yards, figuring square feet, and using map scales. Some of the greatest differences occurred on the complex word problems involving difficult computation and on problems involving renaming and adding of fractions. Black Americans at all age levels had higher percentages of errors with no discernable patterns. Similar differences were found in the consumer mathematics content area.

The second national assessment also provided information on Black Americans and Anglo Americans, and included a small sample of Hispanic American performance. In the areas of mathematical understanding, knowledge, and skills, the average achievement for Anglo Americans was higher than that of Hispanic Americans and Black Americans at all three age levels, with Hispanic American achievement tending to be higher than that of Black Americans (see Tables E, F, G, and H in Appendix B). At age 9, differences between ethnic groups in these content areas appeared greatest on knowledge of place value, knowledge of basic computation acts, and skill at reading graphs and tables. Differences at ages 13 and 17 were greatest on knowledge of place value, computations with decimals and measurement skills. Differences at age 13 were also large for computation with fractions. At age 17, performance of the different groups was also quite disparate on knowledge of number order. In the area of mathematical application, again the same general pattern can be seen (see Tables I, J, and K in Appendix B). It is important to note that for most groups scores improved with age, but for members of ethnic minority groups the deficit increased.

These NAEP results show markedly that Apparently Black American and, to a lesser extent, Hispanic American students are performing relatively poorly at a variety of cognitive levels and in a variety of content areas. Using measurement, map scales, graphs, and tables, as well as translating and solving word problems all involve being able to work with unfamiliar and non-routine mathematics. Such mathematics is rarely taught in the basic and remedial mathematics class where basic drill with number operations is so often stressed, and students placed in classes of this sort may have few opportunities to problem-solve. Differential course enrollment may account for some of the Black American and Hispanic American differences in performance, especially at the higher grade levels. The improvements in performance that have occurred in recent years at the lower grade levels may indicate a trend, at least at the elementary level, toward more effective mathematics education. It is hoped that further testing by NAEP will continue to show such gains in ethnic minority performance. However, much more research is needed to identify and diagnose the error patterns of these students, to investigate their problem-solving strategies, and to find approaches that are helpful in teaching an ethnically diverse student population.

Another study (Breland, 1974) which also examined test performance in mathematics involved 14,828 twelfth-grade students in 1044 schools across the country. In this study the test response patterns of ten mutually exclusive socio-cultural groups--American Indian, Black American, Mexican American, Puerto Rican, other of Spanish origin, Asian American, Northeastern Anglo American, Southern Anglo American, Central Anglo American, and Western Anglo American--were explored. In order to minimize differences between groups due to different course enrollment, the mathematics test contained no items requiring the use of algebraic, geometric, or trigonometric skills. When specific test items were examined it was found that the easiest item for all non-Asian American minorities involved assessing the value of eleven dimes and the most difficult item for these groups involved finding the square root of 9. Given the simplicity of this latter item, the study suggested that "minority groups receive seriously deficient training in the fundamentals of mathematics." This supposition strengthens even further the inference that ethnic minority students perform well on items that are familiar, and poorly on items for which there is no strong experiential base. Furthermore, performance may sometimes be restricted by the use of unfamiliar vocabulary or notation.

Testing: Other Factors

In spite of these generally consistent performance patterns in both science and mathematics, results of standardized tests that are reported by group populations must be interpreted cautiously. A variety of factors can contribute to different levels of achievement and may correlate positively with a high or low test score. For example, NAEP (1979) reports that students residing in the Northeast consistently score above the national average, while those residing in the Southeast consistently score below the national average. Also, students with at least one parent having some post-high-school eduation perform above the national level, while those with parents having no high school or only some high school education perform below the national level. Although more than one factor may be present in a group result, rarely is more than one variable at a time controlled, and it is uncertain how a variety of factors may be interacting to influence levels of achievement. Nonetheless, of such factors, socio-economic status has been shown to consistently have important consequences for achievement.

One study (Okada, Cohen, & Mayeske, 1969) looked at the relationship between socio-economic status (SES) and academic achievement for different ethnic groups in various regions of the country and metropolitan--nonmetropolitan locations. The relationship of SES to growth in academic achievement was also considered. To determine SES, a weighted linear composite was made of father's educational and occupational level, mother's educational level, number of siblings, number of rooms in the home, number of appliances and reading materials in the home, and degree of urbanness of the community in which the students had spent most of their lives. Ethnicity was determined by self-report, using the categories Black American, Anglo American, American Indian, Asian American, Puerto Rican, Mexican American, and Other (which was excluded from the analysis). Three levels of SES and six categories of ethnicity were considered (see Table 6).

Table 6
Number of Students by Race, Grade, and Socio-Economic Status Level for Total, United States

Grade	SES	Black American	Anglo American	American Indian	Asian American	Puerto Rican	Mexican American
6	Low SES	14791	4536	3958	86	1424	1487
	Med SES	18681	5617	6208	90	11396	1628
	High SES	12942	4000	4240	159	12418	2239
9	Low SES	20573	15366	1740	559	2488	3350
	Med SES	13136	3223	920	704	1053	2224
	High SES	3878	29915	290	448	258	715
12	Low SES	14663	11811	988	540	947	1630
	Med SES	7717	25461	455	602	947	1630
	High SES	2626	25388	215	299	173	355

Note. Taken from Okada, Cohen, Mayeske, 1969

The Sequential Test of Educational Progress (STEP) developed by the Educational Testing Service was used to measure mathematics achievement as well as reading comprehension. The College Ability Test Series was used to measure verbal ability. Scores were reported in terms of grade level equivalents (GLE) for sixth-, ninth-, and twelfth-graders.

In the area of mathematics achievement (see Table 7), at the sixth-grade level only high-SES Anglo American and all Asian Americans had attained or surpassed the average GLE. By the ninth grade, high- and medium-SES Anglo Americans as well as all Asian Americans had achieved at least a ninth-grade GLE in mathematics. At the twelfth-grade level, high-SES American Indians, high- and medium-SES Anglo Americans and all Asian Americans attained or surpassed the mathematics GLE for the twelfth grade. It should be noted that in many instances high-SES minority groups achieve at levels similar to or lower than the low-SES Anglo American group. The achievement levels of the Asian American group, and in some cases the American Indian group, are noticeable exceptions to this general finding.

It is difficult to draw any conclusions about rates of achievement because different populations were being tested at each grade level. However, the study described an "interlocking" property of the test which allowed scores to be related on a common scale. From this relation, several observations were made concerning growth in mathematics achievement. Between the sixth and ninth grades, all ethnic groups showed approximately the appropriate grade-level increase regardless of their level of achievement. Between the ninth and twelfth grades, the achievement levels of Black Americans, Puerto Ricans, and to a lesser extent, Mexican

Americans, showed little improvement while the other groups continued to improve. At each grade level, disparities in GLE between low-, medium-, and high-SES levels increase. The report concludes that SES accounts for some but not all of the ethnic differences in mathematics achievement and also plays a role in determining the rate of achievement. It is important to note that even after SES is taken into account, ethnic differences remain.

Table 7
Mathematics Achievement by SES Levels, Reported in Grade Equivalence Levels

	SIX			NINE			TWELVE		
SES	LOW	MED	HIGH	LOW	MED	HIGH	LOW	MED	HIGH
Black Am.	3.7	4.0	4.5	6.3	7.1	7.9	7.1	7.7	8.6
Anglo Am.	5.0	5.5	7.1	8.1	9.6	10.7	10.3	*	*
Am. Indian	4.1	4.2	4.9	6.9	7.8	8.8	8.8	10.1	*
Asian Am.	4.2	4.8	6.1	8.6	10.0	11.1	10.3	12.8	*
Puerto-Rican	3.3	3.4	3.9	6.2	6.6	7.3	7.5	8.1	9.1
Mexican Am.	4.0	4.0	4.7	6.7	7.7	8.5	8.6	8.8	10.2

Asterisk (*) denotes GLE ± 14.0.

Note. Taken from Okada, Cohen, Mayeske, 1969

Testing: Patterns of Performance

It should also be noted that science and mathematics are were not the only areas of lower-than-median performance by non-Asian American minorities. Weaknesses in other areas have also been exhibited in the literature. Coleman et al. (1966) reported ethnic minority scores below the median in the non-verbal, verbal, reading, and general information areas at grades one, three, six, nine, and twelve for almost all non-Asian American minority groups tested. The only exceptions to these general findings were the first-grade non-verbal scores for American Indians and Mexican Americans. Also, Okada et al. (1969) found a similar trend toward underachievement in the areas of verbal ability and reading comprehension, even when SES was controlled. The only non-Asian American minorities to attain or surpass the grade level equivalent were high-SES ninth-grade Mexican Americans and high-SES ninth-and twelfth-grade American Indians. Similar general findings are plentiful among the standardized test data.

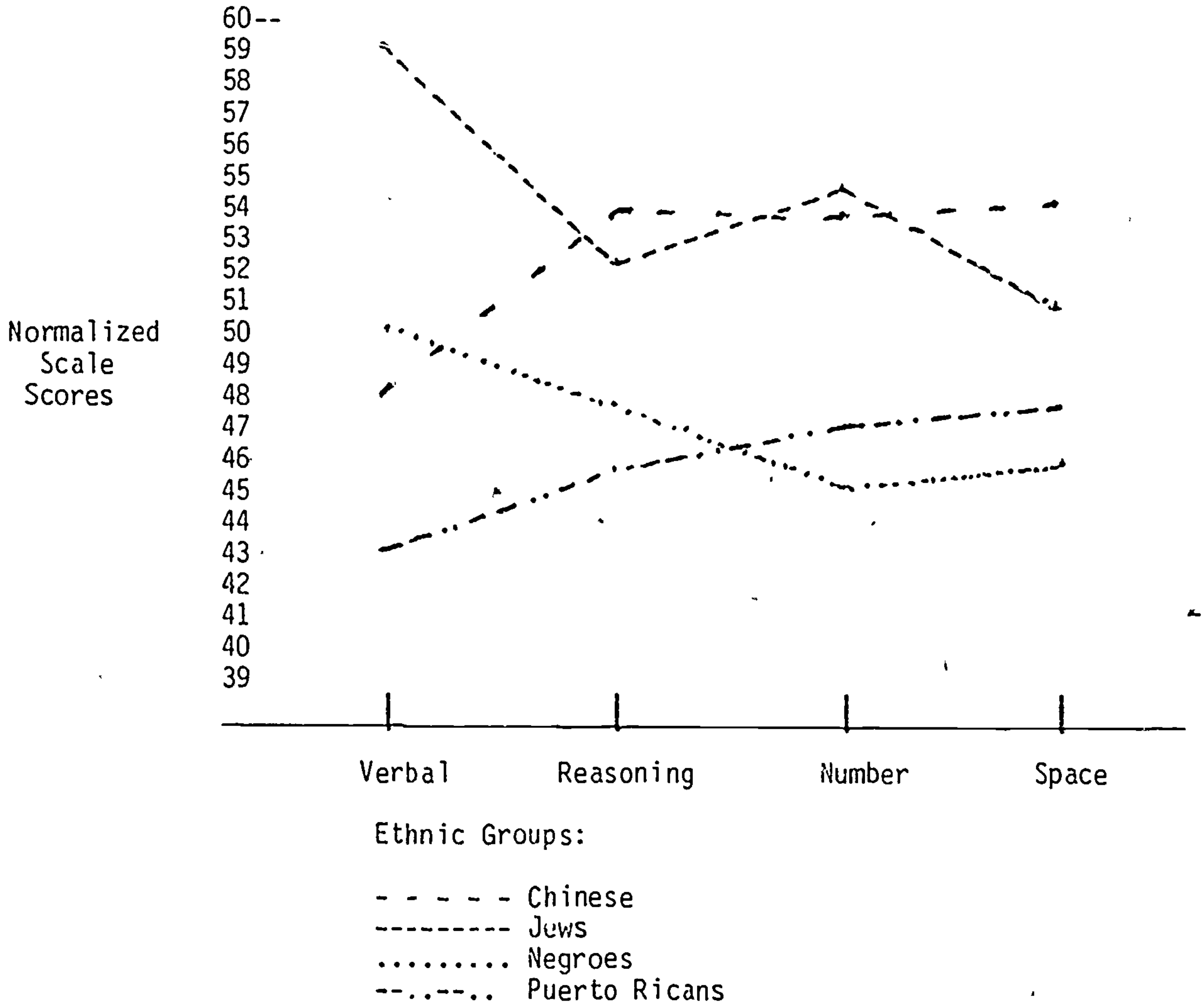
Although standardized test performance has been characteristically poor in all areas, different ethnic groups do exhibit areas of relative strength and weakness (see Table 4). For many of these groups, strengths seem to lie in the quantitative and spatial areas. Coleman et al. (1966) indicated that at the first grade level, all ethnic groups but the Black American group received higher percentile scores on the nonverbal test than on the verbal test. For the Black American group, however, the reverse was true. It is also indicated that at the twelfth-grade level, Puerto Ricans, American Indians and Mexican Americans received their two highest percentile scores in the mathematics and nonverbal areas. Again, the Black American group was the exception, receiving its highest score in reading, followed by mathematics.

A similarly consistent pattern of strong and weak performance has been noted in comparisons of native Spanish-speaking and native English-speaking groups. In one study the Metropolitan Readiness Test was used with 51 primary grade students to provide information about the development of pre-reading and pre-mathematical skills (Coffland & Cuevar, 1977). Even though the native Spanish speakers received consistently lower mean scores on the Language and Quantitative subscales of the test than the native English speakers, they did receive higher mean scores on the Quantitative subscales than on the Language subscales. A School Mathematics Study Group Working Paper (Begle, 1972) cited further studies that indicated this strength in the nonverbal area. On a variety of standardized tests that compared Mexican American and Anglo American performance, Anglo American students scored significantly higher than Mexican American students on tasks involving reading or verbal skills but Anglo American students scored only slightly higher or at the same level as Mexican American students on the nonverbal tests (Anderson & Evans; Christiansen & Livermore; Killian; Spence; Mishra & Ghozeil, as cited in Begle, 1972). Unfortunately the performance of other ethnic groups has not been studied as extensively in this regard.

Although ethnic groups exhibit similarities with regard to overall academic performance, such similarities may be due in part to language differences. Many ethnic groups exhibit distinct ability patterns that may make generalizing from one ethnic group to another somewhat risky. Stodolsky and Lesser (1966) found strong ethnic differences when they tested 320 first-grade Chinese, Jewish, Black American, and Puerto Rican children in verbal ability, reasoning, number facility, and space conceptualization. Ethnicity not only had a significant effect on the level of the four mental abilities, but more importantly on the ability pattern for each ethnic group (see Figure 3). Furthermore, SES had a highly significant effect only on the level of the scores and not on the ability patterns themselves. While Jewish and Black American children displayed strengths in the verbal area, Chinese and Puerto Rican children were strongest in the space and number areas. However, in a replication study using Irish-Catholic first-graders, a characteristic ability pattern was not found.

Neither were ability patterns found in a study that examined the relationship of ethnicity, SES, and gender to ability in twelfth grade students (Backman, 1972). This study involved groups of Jewish White, non-Jewish White, Black American, and Asian American students who were tested on Verbal Knowledge, English, Languages, Mathematics, Visual Reasoning, Perceptual Speed and Accuracy, and Memory. Using ANOVA to compare between-subject variables, this study reported that the relationship of gender to ability comprised 69% of the total variance in test performance, while ethnicity only comprised 13% (9% the shape of the pattern, 4% the level of the pattern). SES comprised 2% of the total variance.

Figure 3
Pattern of Normalized Mental-Ability Scores
For Each Ethnic Group



Note. Taken from Stodolsky, Lesser, 1966.

These results suggest that several mental abilities may be organized in ways that reflect different emphases among different cultural groups. However, stereotyping on the basis of ethnic group membership would certainly be inappropriate since membership in an ethnic group does not necessarily imply cultural distinctiveness. Many students may not exhibit distinct patterns of abilities associated with their ethnic background. It is possible that the longer students stay in school the less culturally distinct they become. Perhaps students who do exhibit culturally distinct patterns of abilities when they begin school drop out of school before reaching the twelfth grade because they are unsatisfied with or unsuccessful in a system that fails to address their special needs. It is also possible that after puberty, gender has an increased influence on ability and tends to mask any cultural differences that may be present. Lastly, the instrument itself may be responsible for the differences reported. A gender bias may be present in the instrument being used to assess ability, and this gender bias may be stronger than any ethnic bias that is present. The presence of test bias may be a problem that threatens the validity of many ethnic group test results.

Testing: Presence of Bias

Most of the discussions of bias in testing have focused on the issue of intelligence testing and, in particular, on the findings that some ethnic minority groups consistently receive lower scores on such tests than do their Anglo American peers. An explanation for this difference was offered by Jensen (1969) who suggested that while all children were more or less equal in the Type I intelligence involving simple associative learning, poor and ethnic minority children were seriously deficient in the Type II intelligence involving more conceptual learning. He concluded that this deficiency was more attributable to a genetic than to an environmental deficiency. Consequently, poor and ethnic minority children would tend to avoid science and mathematics because they lacked the highly conceptual and abstract skills necessary for success. However, there is little evidence to support this genetic deficiency position (Kamin, 1973), and it is generally assumed that intelligence is equally distributed among various ethnic groups.

The results of Piagetian testing lend support to this assertion of equally intelligent populations. Although these tests measure cognitive development they do reflect general intelligence and address abilities important for academic success. Based on tasks described by Piaget, these tests are administered to individual students at different age levels by trained examiners and involve the use of concrete materials. A child is asked to perform a task or draw a conclusion from a performed task and to give a verbal justification or explanation. From this information, a child's level of cognitive development is determined. Many of these tasks are strongly associated with academic performance in science and mathematics. Although the cross-cultural research in this area is not conclusive, there do not appear to be the same strong differences in cognitive development between ethnic groups in the United States as in intelligence test scores.

In one an effort to determine whether cultural differences, including language, affect the cognitive development of ethnic groups in the United States, Zellner (1977) studied 60 middle-income and 60 low-income groups of both Mexican American and Anglo American children. Using eight classification tasks and three seriation tasks the judgments and verbal explanations of each child were recorded and assessed. The Mexican American and Anglo American groups did not differ significantly in performance on either the classification or seriation tasks. Zellner found that the only significant predictors of performance were chronological age, grade level, and verbal ability as measured by the Peabody Picture Vocabulary Test. However, when the lower-middle SES group was compared to the middle SES group, significant differences in task performance were found. The study suggests that factors other than ethnicity influence cognitive development. Results similar to these are desccribed by Demmert (1976), who cited the Piagetian testing of Oggala Sioux Indians by Silk and Voyat. In this case also, the level of cognitive development of this group was similar to that of majority-culture children.

The lack of a consistent ethnic difference. in Piagetian test performance strongly suggests that some of the difference in performance on standardized intelligence tests may be due to other factors than intelligence. Mercer (1977) has suggested that the language components of many of these tests and the cultural bias of much of their content may contribute to minority- majority- culture differences. Even the results of less highly verbal intelligence tests have been equivocal. Feldman and Bock (1970) have suggest that on such intelligence tests a more subtle form of cultural bias may be present. For example, they report that on a spatial test that used directional arrows, one-third of a group of Eskimo subjects did not appear to understand the directions and scored at near-chance levels. Furthermore, Samuda (1973) has suggested that there may be aspects of cultural bias in the test-taking situation itself. As Kleinfeld (1973) explained " . . . Eskimos may find it difficult to view a trivial, pointless task such as copying a design or running through a finger maze as worthy of serious concentration and maximum effort." It has also been suggested that some groups may view such tests as another form of White exploitation and respond in such situations with some hostility. Green, Brown, and Long (1978) reported a strong feeling that American Indian students are largely tested for their deficiencies rather than for their proficiencies, and for their "deviance" in "White cultural terms" rather than for their "normalities" in "Indian terms." Also, such cultural differences as a slow and cautious response style may result in depressed scores on tests typically subject to time constraints. There are many other ways in which individual and cultural differences unassociated with intelligence may have an effect on even non-verbal intelligence test scores.

It is likely that test bias also occurs in tests of science and mathematics achievement. Except for tests that are purely computational, such tests include a great deal of descriptive material. Considering the impact of the language component, the National Advisory Council on Mathematics Education (1975)has suggested that in the mathematics curriculum, the development of a common language of mathematics should be stressed. The same may be said for the development of the language of science. In its report NACOME explained that the cultural background of students determined to a large extent the nature of the concepts they brought with them when they entered school. It also suggested that it was the responsibility of the school to correct and refine these concepts, and to develop the language necessary for expressing them. When test items contain concepts that are developed in the school curriculum, cultural bias is minimal, but when test items involve applications, the cultural differences may affect the understanding of the problem.

In many cases not all students have had equal opportunities to develop the language for expressing scientific and mathematical concepts, which is so heavily relied upon in standardized testing. For example, Weinberg (1977) cites remarks made by Feldman, Lee, and McLean about Eskimo students:

> The curriculum in Eskimo schools seems much lower-powered than is usual in high schools. There are virtually no hard-core academic courses in which a child might acquire technical languages. Many children take no

science at all, and many are distressed because they cannot take mathematics each year. It is clear that there is little opportunity for the child to acquire formal representational systems.

This is especially unfortunate since many Eskimo children in their informal classroom situations have exhibited some highly developed spatial abilities (Demert, 1976).

Another indication of unequal opportunity to learn scientific and mathematical language skills has been the pattern of course enrollment that ethnic minorities exhibit. NAEP (1979) reports important differences between Black American and Anglo American course enrollment in secondary school mathematics. While 75% of the 17-year-old Anglo Americans had taken Algebra I, 35% had taken Geometry, and 38% had taken Algebra II, among the 17-year-old Black Americans only 55%, 31%, and 24%, respectively, had taken these classes. There were similar differences in science course enrollment. It is likely that some other ethnic minority groups not assessed by NAEP would also show similar patterns of course enrollment. Assessments of groups having such disparate mathematical backgrounds are bound to show important differences in performance.

In addition to being used to assess science and mathematics achievement, standardized tests are often used to predict such achievement and to place students in appropriate ability groups or classes. These predictive tests are of questionable validity for ethnic minority groups. Begle

(1972) examined learning correlates for two 7th-grade classes in which a majority of the students had Spanish surnames, and compared results to those of an earlier study involving Anglo American students. Using test scores on a battery of pretests and a posttest, he found that though test reliabilities were about the same for both groups, pretests did not correlate with the posttest for the Mexican American student as they did for the Anglo American. Since the standardized test used in this study was not as good a predictor of mathematics achievement for the Mexican American student as for the Anglo American student, again we see tests having questionable validity being used to compare group levels of performance. More importantly, if such tests are being used to place ethnic minority students in science and mathematics classrooms, such placement may be more inappropriate for them than for other students. Alternate means of evaluation that more accurately assess those abilities associated with succssful learning need to be developed. Until then, more attention must be given to such considerations as teacher recommendation and prior academic record.

These results suggest that ethnic differences on standardized tests of science and mathematics achievement are not due to differences in native ability or level of cognitive development. Rather, such differences may be due to such factors as cultural bias in test materials and procedures, and to differences in opportunities to learn. In short, more is involved in the classroom learning of science and mathematics than is being measured by such standardized tests.

Factors Related to Learner Characteristics

Standardized test scores consistently indicate that there are differences in achievement as it is currently assessed among ethnic groups. Such differences may be attributed in part to differences in learner characteristics, classroom experiences, and counseling experiences. The focus of this portion of the report will be on learner characteristics--characteristics that apparently arise from a complex interaction of environmental and heritable influences.

As stated previously, there exists no conclusive evidence of neurological or genetic differences in cognitive ability among racial or ethnic groups. In fact, when performance on 15 cognitive variables by European-Americans and Asian Americans were compared (DeFries, Vandenberg, McClearn, Kuse, Wilson, Ashton, & Johnson, 1974; DeFires, Ashton, Johnson, Kuse, McClearn, Mi, Rashad, Vandenberg, & Wilson, 1976), no significant difference was found in cognitive structure. Principal component analysis yielded four factors--spatial visualization, verbal ability, perceptual speed and accuracy, and visual memory--for which the loadings of the two ethnic groups were essentially identical. Since environmental factors that differentially affect these cognitive abilities may be identifiable, comparative studies should perhaps be attempted with other ethnic groups.

Recent studies providing evidence of variations in brain lateralization among subjects strongly imply a structural basis for some variations in spatial ability, variations that seem to become manifest as differences in perceptual and cognitive functioning. Such differences have recently been of great interest among mathematics educators, particularly since evidence seems to support the notion of gender differences in spatial ability (McGee, 1979). Could there be a structural basis for variations in cognitive function among cultural groups? Possibly so, and not necessarily as the result of inheritance. There seems to be evidence that peculiarities of the Japanese language have caused brain lateralization among the Japanese-speaking people to follow a pattern different from that among members of Western culture (Sibatani, 1980). It may very well be that in addition to the previously suspected environmental and hereditary factors, a person's first language influences brain organization and function. Perhaps we must consider language a powerful environmental factor.

Recent studies providing evidence of variations in brain lateralization strongly imply a structural source for some variations in spatial abilities. That gender differences have been noted for spatial abilities (McGee, 1979) leaves open the possibility that structural differences may be found among other groups. Since technical and science-related careers often require a high level of spatial ability, any mitigating factors should be identified.

As Scarr-Salapateck (1971) has suggested, unquantified environmental differences among groups preclude many cross-population comparisons of inherent abilities; the disadvantaged of any race or ethnic group suffer the impact of detrimental environmental factors. In considering individual differences, then, there seems little reason to pursue heritable influences until deleterious environmental influences amenable to educational intervention have been elucidated and ameliorated. There are several learner characteristics--cognitive style, locus of control, motivation--that seem to significantly affect achievement, but for which there are no simple structural correlates that can be isolated and compared. Such factors are influenced by the environment and are susceptible to educational intervention or accommodation.

Cognitive Style

One aspect of ethnic difference that has been closely associated with socio-cultural factors is the concept of cognitive style. It has been suggested that ethnic differences found in academic achievement may be due to cognitive, or learning, styles that are culturally unique. Generally, cognitive style refers to a preferred mode of processing information. It is described in the literature by a variety of terms such as a descriptive-analytic, relational-contextual, categorical-inferential tendency, a leveling or sharpening ability, an equivalence range, focal attention, and constricted or flexible control. However, in relation to ethnic group differences, cognitive style is most often described in the literature as a tendency to process information in an analytic or a global fashion, or a tendency to be "field-independent" or "field-dependent."

Field-independence or field-dependence is a bipolar construct that describes the way in which the environment is perceived and categorized. It is usually measured by performance on a tilting-room-tilting-chair test or a rod-frame test in which the vertical direction in a given context is identified. It may also be measured by performance on an embedded figures test in which certain embedded shapes are identified under timed conditions. A relatively successful performance on any of these tests is interpreted as a tendency to be field-independent. Field-dependency is not directly measured but inferred from a less successful performance on these tasks.

As well as describing characteristics of information-processing preferences, cognitive style may describe a general approach to learning. A number of personality characteristics associated with field-dependent and field-independent people, and which have important implications for learning, are described by Castaneda, Ramirez, and Herold (1972) in Figure 4.

Figure 4.
Characteristics of Field-Dependent and Field-Independent People

Field Dependent	Field Independent
1) Perform best on tasks of verbal expressiveness, story telling	1) Do better on tasks requiring arranging pieces together to make a whole, or extricating parts of the whole
2) Better at recalling human faces	2) Do better on tasks requiring the use of common objects in novel ways to solve problems
3) Better at learning material containing human content	3) Better at learning impersonal abstract material
4) Influenced more by opinions of others making decisions--more conforming	4) Decisions not as readily influenced by opinions of others
5) Performance is influenced more by indications of approval and disapproval from authority figures	5) Performance on tasks is influenced less by statements of authority figures

Note. Taken from Castaneda, Ramirez & Herold, 1972

Much of the research on cognitive style seems to indicate a relationship to cultural socialization practices, and particularly to child-rearing practices. However, other variables such as gender, SES, and degree of acculturation are also related to the development of cognitive style, and it should also be noted that there is a range of individual variation within any ethnic group.

Ramirez and Price-Williams (1974) examined groups of 60 Black American, 60 Mexican American, and 60 Anglo American 4th-grade children and found significant ethnic differences in cognitive style, with Mexican American and Black American children scoring in a signficantly more field-dependent direction than their Anglo American peers. Also, Ramirez, Casteneda, and Herold (1974) found that the more acculturated the ethnic group, the more the cognitive style resembled that of the Anglo American mainstream. These ethnic differences in cognitive style may suggest an "incompatability" of learning preference with school practice to explain ethnic group differences in academic performance. This incompatability may be greater in science and mathematics, as they are currently taught, than in other content areas since analytic skills, an abstract and often impersonal orientation, and working independently are more heavily relied upon.

The suggestion that performance in science and mathematics may be more affected by cognitive style than other content areas is supported by the research. Kagan and Zahn (1975) explored school achievement in reading and mathematics and its relation to cognitive style. Their study involved 134 Anglo American and Mexican American children from the second, fourth, and sixth grades of a semi-rural, lower-income elementary school in southern California. Students were tested using a "Man-in-the-Frame" box, adapted from Witkin's rod-and-frame test measure of field-independence, and an average error over four trials was reported. School achievement was measured by the California Achievement Test in terms of grade level equivalents. Results indicated that (1) Mexican Americans performed significantly lower than Anglo Americans in reading and mathematics; (2) Mexican Americans were significantly more field-dependent; (3) field independence was significantly correlated with both reading and mathematics achievement; and (4) the effect of field dependence was greater on mathematics achievement than on reading achievement. Hence, cognitive style seemed to account for differences in mathematics achievement more fully than for differences in reading. Perhaps by including in science and mathematics instruction the use of more global skills, a more personal orientation, and more group work in which positive social interaction can take place, the science and mathematics classroom would become a more comfortable domain for many ethnic minority learners.

The role of the educational institution with regard to ethnic minority education is a crucial one. Castaneda et al. (1974) have suggested that educational institutions have failed in the education of ethnic minorities because they are not sensitive to differences in cognitive style. They have suggested that this insensitivity may lead to alienation, high absenteeism, poor academic performance, and eventually to high drop-out rates for these groups of ethnic minorities. Sigel and Coop (1974) explained this insensitivity in terms of a cue discrepancy. Since cognitive style is significantly involved in information-processing in general, not only in the acquisition of new material but also in the utilization of acquired material, cues selected by the student for processing may be discrepant from those expected by the teacher. As a result of this difference in cue selection and expectation, what is being taught and what is being tested may not be what is being learned. To minimize this discrepancy, more attention must be given to the characteristics of the learners.

The educational implications of cognitive style as it relates to ability to structure and process information are addressed in some detail by Witkin, Moore, Goodenough, and Cox (1977). In a review of characteristics assocated with field-dependence and field-independence, they suggested that in some educational contexts the field-dependent student may be at a disadvantage. They explained how some of the characteristics of field-dependence interact with classroom structure:

> The evidence we have reviewed suggests that their lesser use of structuring as a mediator may handicap field-dependent students in unstructured learning situations. There are probably many classroom situations where, because the material to be learned is not clearly presented, the field-dependent student may be at a disadvantage. Field-dependent students may need more explicit instruction in problem-solving strategies or more exact definitions of performance outcomes than field-independent students, who may even perform better when allowed to develop their own strategies.

Holtzman, Goldsmith, and Barrera (1979) also mentioned the role of structure in relation to cognitive style, noting that field-dependent students seemed to be more affected by an ambiguous social context than field-independent students. A well-stuctured classroom in which teacher clarity and guidance is provided could have positive effects on the performance of field-dependent students, whether ethnic minority or Anglo mainstream.

The role of structure in problem-solving situations has been studied experimentally with ethnic minority students, although without assessing cognitive style. Bernal (1971) examined concept-learning among Anglo American, Black American, and English-speaking Mexican American 8th-grade students, using facilitation strategies and bilingual techniques such as practice with feedback. He found that Black American and Mexican American students benefited significantly from learning the test-marking strategies and the nature of the learning task required.

Similar findings with regard to structure were reported by Kessler and Quinn (1980), who examined science problem-solving abilities of bilingual and monolingual students. Following an intervention involving discussion and evaluation of hypothesis generation, the quality and syntactic complexity of hypotheses posed by bilingual students were significantly greater than those posed by monolinguals. Although Kessler and Quinn characterized the intervention as an attempt to "assist the learner in moving to a higher cognitive level of inquiry," it is possible that the increased structure of the problem-solving situation was beneficial to those students who may have been more field-dependent.

In another study, Ginther (1975) examined the effect of a pre-training treatment on the predictability of a mathematics predictor test for Mexican American and Non-Mexican American students. The treatment involved discussing strategies for test-taking and working sample problems. Results indicated significant improvement of reliability and predictability for

Mexican American students, but only improved reliability for non-Mexican American students. Apparently for members of the Mexican American group, the use of clearly organized, well-structured material and explicit, well-defined instruction was an important educational consideration.

The behavior of the classroom teacher also seems to be an important variable, as research shows that teaching style interacts with the cognitive styles of students. Holtzman et al. (1979) noted differences in the ability of students to tolerate verbal criticism, with field-dependent students responding best to positive feedback and field-independent students responding best if given negative feedback. Ramirez and Castaneda (1974) suggested that teachers tend to rate students with the same cognitive style as themselves more favorably than those with a cognitive style that differed. They also suggested that field-dependent and field-independent teachers tend to be clustered in different areas of instruction, with field-independent teachers tending to be in science and mathematics. If true, cognitive style may help explain the unpleasant image of scientists and mathematicians held by so many ethnic minority students. For example, Green (1978) related the following American Indian impression:

> They believe that math teachers are mean and hard. Only the very smartest people succeed in mathematics, but they are cold, rational, distant beings lacking in sociability and personal warmth. Who would want to be characterized like that?

No doubt these characterizations attributed to scientists and mathematicians have been exaggerated. However, it may be that cognitive style makes an important difference in how such individuals are perceived, thus influencing achievement in the contemporary science and mathematics classroom. It should be noted that cognitive style seems to have little bearing on general achievement.

Witkin et al. (1977) reported that although cognitive style did not show a strong relation to overall achievement measures such as college grade-point average, a relationship did exist between cognitive style and performance in specialized areas at the college level. He explained that as a group, field-independent or field-dependent persons were likely to show an interest and ability in a domain where their cognitive skills were called for. He indicated that:

> It has been observed repeatedly . . . that relatively field-dependent students are not likely to do as well in mathematics and the sciences as the more field-independent students--given the present way of teaching these disciplines.

Although this may be true for college-level students, this same trend is not as clear for younger students at the high-school level. Witkin reported that in only about one-half the studies he reviewed at this age level was the relation between mathematics-science achievement and measure of cognitive style significant, although in the expected direction. It seems that cognitive style becomes more important as subject matter becomes more advanced, which may explain why numbers of ethnic minority students in science and mathematics decrease as academic level increases.

In a study of career choice, Witkin reported that the mathematics-science domain was "clearly favored" by field-independent students and the education domain was "favored' by field-dependent students. He noted that:

> Shifts out of mathematics and science were especially common among the more field-dependent students; the shifts served to bring about a better fit between students' cognitive styles and their career choices.

The situation he described appears to support the view that the relationship between cognitive style and mathematics-science domain is a result of field-independent people choosing this domain, rather than it being a result of experience. The same trend in career choice was reported by Holtzman et al. (1979). This model, if true, might explain why so few of some ethnic minority groups are found in mathematic, scientific, and technological professions.

Unfortunately, in many ways the question of cognitive style seems to generate more questions than it produces answers. There is still a great deal of uncertainty as to what perceptual abilities are being measured by cognitive style tests, and how such perceptual characteristics influence learning preferences. Different tests of cognitive style do not correlate as highly as might be desired, which suggests that perhaps slightly different abilities are being measured by each test. Also, it is possible that such tests measure abilities that are situation-specific and that do not generalize to larger cognitive processes. More careful research in this area is required before it can be considered a valid and vigorous construct for discussing individual and group differences in cognitive functioning. However, until a firm theory base for this construct is developed, it does provide a conventient framework for discussions of ethnic differences in preferred learning strategies and professional goals.

Locus of Control

The locus of control (LC) construct has its origins in the expectancy-reinforcement perspective of Rotter's (1954) Social Learning Theory, and seems to describe a learner characteristic having significant educational implications. Essentially, LC refers to a person's belief regarding the contingency relationship that may or may not exist between one's behavior and the events that follow. If a person tends to perceive positive or negative events as being contingent upon his or her behavior, the person is said to have an internal LC; if a person does not perceive events as being contingent upon his or her own behavior, the person is said to have an external LC. Rotter (1966) made it quite clear that the LC construct describes an aspect of one's belief system and does not rest on whether or not a person actually has any control over the events that follow personal action. He reported evidence that individuals who have a strong belief in their ability to control their own destiny are likely to place great value on skill or achievement reinforcements and take steps to improve their environmental conditions.

Studies elucidating the LC construct have been frequently reviewed (Bar-Tal, 1978; Joe, 1971; Lefcourt, 1966, 1976; Rotter, 1966) and many correlates to LC have been identified (see Figure 5). Some theorists have incorporated the LC construct in a general attribution theory (Bar-Tal, 1978; Weiner, Heckhausen, Meyer, & Cook, 1972), which postulates that beliefs about the causes of success and failure mediate between the perception of an achievement task and actual task performance. In learning situations, then, highly internal students would generally tend to attribute success or failure to personal ability or effort, whereas highly external students would tend to attribute such outcomes to luck, task difficulty, or some other causal element over which they have no control. Internality and externality are thought to represent the extremes of a continuum of beliefs that we will assume to be normally distributed. Of primary concern in this report is whether or not the distribution of beliefs regarding control remain the same across ethnic groups. If LC is as significantly related to academic successes as it appears to be, we would want to identify any differential group effects and attempt to reduce any disadvantages that might obtain as a result.

Figure 5
Locus of Control Correlates

Externality has been shown to be positively correlated with:
- Alienation (Tolor and LeBlanc, 1971)
- Anxiety (Hountras and Scharf, 1970; Joe, 1971; Lefcourt, 1966; Powell and Vega, 1972; Ray and Katahn, 1968; Watson, 1967)
- Learning Problems in Children (Loeb, 1975)

Internality has been shown to be positively correlated with:
- Academic Achievement (Clifford and Cleary, 1972; Coleman et al., 1966; Doane, 1973; McGhee and Crandall, 1968; Nowicki and Roundtree, 1971)
- Constructive Reaction to Frustration (Brisset and Nowicki, 1973; Butterfield, 1964)
- Creativity (DuCette, Wolk, and Friedman, 1972)
- Mental Ability (Powell and Centra, 1972)
- Positive Self-concept (Fish and Karabenick, 1971; Wickersham, 1971)
- Problem-solving Ability (Baugh, 1973)
- Realistic Aspiration Level (Lefcourt, 1966)

Note. Modified from Roueche and Mink, 1976.

Interestingly, the Coleman report (Coleman et al., 1966) provided evidence that a greater proportion of minority group members than Anglo Americans express attitudes consistent with a tendency toward externality (see Table 8). The validity of the Coleman report has been questioned, but as Welsh (1967) suggested, the report should be used as a stimulus to further examination of its implications. A more recent study (Bar-Tal, Kfir, Bar-Zohar, and Chen, 1980) in Israel has corroborated Coleman et al.'s evidence that LC orientation can vary among subcultures and is correlated with academic achievement, level of aspiration, and level of anxiety. Unfortunately, the criteria used to assess SES--number of siblings, father's level of education, and number of books at home--do not include a direct measure of either occupation or economic status, so the effect due to LC orientation must be recognized as being tentative.

Table 8
Percent of 12th-Grade Students Agreeing with Selected Statements

	Black Americans	Mexican Americans	Asian Americans	American Indians	Puerto Ricans	Anglo Americans
"Good Luck is more important for success than is hard work"	12	11	8	11	19	4
"Everytime I get ahead, something or somebody stops me"	22	23	18	27	30	14
"People like me don't have much of a chance to be successful in life"	12	12	9	14	19	6

Note. Taken from Coleman et al., 1966.

There are, however, other studies supporting a relationship between LC orientation and minority group membership. In all of tne studies that Lefcourt (1966) reported, groups whose social position is one of minimal power tended to score higher in externality on LC scales. Joe (1971) interpreted many studies as supporting the notion that individuals who are restricted by environmental barriers and limited material opportunities--conditions familiar to many minority group members--tend to develop an external LC orientation.

More recently, a longitudinal study of Hispanic Americans (Brown et al., 1980) revealed opinions indicative of a LC orientation significantly more external than that of their Anglo American counterparts (see Table 9). When Hispanic American high school seniors were asked what conditions interfered with school work, more than 45% mentioned each of the following: financial concerns, courses are too hard, teachers do not offer enough help, poor teaching, poor study habits, and the courses desired are not offered. Given that "poor study habits" could be interpreted to mean "I am not able to put in as much effort as I should," each of the factors listed seem congruent with a tendency toward externality. What factors could account for the apparent differences in LC orientation among ethnic groups? What are the antecedents to a LC orientation?

It was found early on (Battle & Rotter, 1963; Lefcourt, 1966) that LC orientation is highly correlated with SES, with the interaction of low economic status and minority group membership being strongly associated with externality. Experiences of success also seem to have an effect on LC orientation (Leon, 1974), with the degree of internality increasing as academic success increases. More recently, it has been noted that despite a diversity of LC measures and research procedures, parental supportiveness and encouragement have consistently been found associated with the development of an internal LC orientation (Lefcourt, 1976). In addition to these situational factors related to experience, social status, and the home environment, Fry and Ghosh (1980) have provided evidence that religious and cultural factors influence one's LC orientation. Obviously our LC orientations emerge from a complex interaction of factors moderated by the social milieu, parental influences, cultural perspectives, and personal experiences of success and failure. Developing as it does from such a wide range of factors, should science and mathematics educators be concerned about the LC orientations of their students?

Table 9
Percent of Hispanic Americans and Anglo Americans
Holding Opinions Indicative of an External Locus of Control Orientation

Opinion	Hispanic Americans	Anglo Americans
Good luck is more important than than hard work for success	11.5	7.9
Every time I try to get ahead, something or somebody stops me	20.3	12.6
Planning only makes a person unhappy since plans hardly ever work out anyway	22.2	10.5
People who accept their condition in life are happier than those who try to change things	26.5	18.7

Note. Adapted from Brown et al., 1980, p. 240.

Yes. Success in science and mathematics seems particularly dependent upon LC since perceptions of causal relationships among agents and events is of fundamental importance; scientific epistemology rests on the assumption that cause-effect relationships do exist and can be understood. Rotter (1966) alluded to the relationship that may exist between an individual's LC orientation and other aspects of his or her perception of causality. It may be that a person who fails to perceive a causal relationship between her or his behavior and the presentation of rewards will have difficulty discerning causal relationships of any sort. That causal relationships are not obvious to all students has been demonstrated by the NAEP (see Table 10).

It seems particularly significant that a larger proportion of Black American students than Anglo-American students do not believe there to be logical explanations for natural phenomena (Kahle, 1979). The belief in logical explanations seems essential to the serious study and application of concepts in science and mathematics. Indeed, though there is little correlation between LC and IQ, Rowe (1973) has expressed the opinion that LC may have a great deal to do with the acquisition of information. Students having an internal LC would seem more likely to assume responsibility for discerning relationships and to exhibit more persistence in solving problems. As Table 10 illustrates, the group expressing a stronger belief in logical explanations also tends to exhibit greater persistence when solving problems.

With regard to the tentativeness with which we must accept scientific explanations, Burow (1978) provided evidence that students having a more internal LC orientation tend to understand scientific knowledge as being tentative and to exhibit higher achievement in science. More correlations of this sort are needed; correlations between LC and various scientific process skills and learner characteristics are needed to explicate the relationship between LC and achievement in technical and scientific fields.

Table 10
Percent of Responses of "Always" or "Often" to Selected Questions Demonstrating Locus of Control Orientation

Question	National %		Deviations of Anglo Americans		Deviations of Black-Americans	
	Age 13	Age 17	Age 13	Age 17	Age 13	Age 17
Do you believe that there are logical explanations for the things you see happen?	59.6	68.1	+2.1*	+2.6*	-12.2*	-13.3*
How often do you keep working on a task even if you run into problems that you didn't expect?	52.3	60.9	+1.8*	+2.0*	-9.3*	-8.3*

Note. Adapted from Kahle, 1979.

* = Significant at $p < 0.05$

Moreover, direction is needed in designing instructional strategies that either promote internality or accommodate externality; we need what Lefcourt (1976) has characterized as therapy-relevant research. Feelings of helplessness fostered by an external LC orientation may promote the widespread resignation and benign indifference exibited by unsuccessful science and mathematics students. While investigating Fate Control--a construct incorporating LC orientation--Rowe (1974 a, b) found that a higher sense of Fate Control could seemingly be induced through simply modifying the sanctioning patterns and the questioning procedures (wait-time) employed by teachers. These two instructional devices were altered in such a way as to allow students more time to think about their responses to questions, to provide students with an increased range of acceptable answers to questions, and to demonstrate to students the appropriateness of being uncertain about inferences. Rowe has offered convincing evidence that manipulation of these variables can significantly affect self-confidence, task-persistence, and the quality of student responses to teachers' questions.

DeCharms (as cited in Lefcourt, 1976) provided even more direct evidence that LC orientations can be altered. Black American teachers of low SES, inner-city, Black American students designed classroom experiences that encouraged realistic goal-setting, achievement-motivation, self-confidence, personal responsibility, and increased awareness of personal causation. Over a three-year period of the "personal causation training," the discrepancy between national norms and performance by these students on standardized achievement tests did not increase as it typically does, and indicators of LC orientation imply a shift toward internality among the participating students.

Other studies have focused on accommodating the range of LC orientations rather than promoting internality. In a study involving college students, Parent, Forward, Canter, and Mohling (1975) found that highly internal students performed better when instruction was less structured, whereas highly external students benefitted from high teacher discipline. Analogous results were reported by Brooks and Hounshell (1975) who found that more externally oriented elementary students in nongraded schools scored significantly lower on achievement tests than both more internally oriented students who were exposed to the same environment, and other externally oriented students in graded schools. MacMillan (1980) attempted a study comparing a structured and an individualized instructional strategy, but his results were inconclusive. There was some indication that more internally oriented students preferred personal control while more externally oriented students preferred structured conditions, but the most practical finding was that short, two-week units will not likely yield significant information about the interaction of instructional strategies and student LC orientations.

Despite the general lack of empirical studies elucidating the relationship between student LC orientations and instruction in science and mathematics, some inferences can be made. Student LC orientations emerge from a complex milieu of social, cultural, parental, and experiential factors, and have a significant effect on academic success and self-concept. Differences in student LC orientations can be accommodated to some degree through appropriate instructional strategies, by differentiating the patterns of interactions among students and teachers. Most importantly, however, it seems probable that an appropriate science and mathematics education can enhance internality among students.

Rowe (1974b) has suggested that "probably the single greatest contribution which early education in science can make to a people is the development of . . . a belief based on evidence, that they can to some extent influence the direction and quality of their destiny." That is a bold assertion, but it just may be valid. Notions of causality are central to scientific endeavor, and perceptions regarding personal causation form the core of one's LC orientation. If early experiences with natural phenomena provide a foundation for the abstractions of science, then an early awareness of personal instrumentality may provide a foundation for the emergence of internality.

If experiential learning in the early school years positively affects internality, a strong case could be made for systematically introducing experiential mathematics and science in the earliest years, particularly if school experiences must compensate for the influence of low SES and unsupportive home environments. Studies are critically needed to elucidate both the influence of LC on mathematics and science achievement specifically, and the influence of early science experiences on the development of internality. It may be that disadvantaged students would particularly benefit from early exposure. Program evaluations in the past have focused on gains in academic achievement; perhaps it is time to consider more seriously other learner characteristics, such as personal locus of control orientation.

Attitudes and Motivation

There remains much to be learned regarding the nature of attitudinal barriers and their impact on science career choices. Intuitively, it seems unlikely that students will be highly motivated to achieve in any sphere of study unless the outcome is valued and success seems attainable. Once motivated, the degree of persistence exhibited by individual students will likely be moderated by personal priorities and attitudes toward the task at hand. Any group differences in the degree of persistence exhibited, such as reported in Table 10 (page 52), may reflect priorities and attitudes commmonly held among group members. Of primary interest in this report are the attitudes widely adopted by minority group members and the factors that encourage those attitudes.

Among the factors thought to be influencing attitudes and motivation in the areas of science and mathematics are the following: attitudes toward school work generally, stereotyping, the nature of role models, academic self-concept, the values held, and parental influence. These factors will briefly be discussed individually, but, first, it must be allowed that several factors considered previously in this report presumably have an influence on attitudes. Success on standardized tests, for instance, surely contributes to a positive attitude toward personal abilities.

A positive attitude toward science might be expected to have some correlation with the degree of extracurricular exposure to science; Table 11 reveals some surprising data in this regard. A significant number of respondents to the latest NAEP survey report extra-curricular exposure to science activities, with a higher proportion of Black students indicating that they read science-related material often and talk to friends about science. Though caution is needed while interpreting self-reported tendencies, there appears to be no unique lack of interest in science among Blacks. Why then the apparent lack of motivation to pursue science careers?

A great disparity in students' regard for school generally does not seem to be the answer. The Coleman report (Coleman et al., 1966) provides evidence of differences in academic aspirations (see Table 12), but Black Americans reported the greatest desire to stay in school, to do well in school, and to finish college. Interestingly, a smaller proportion of Anglo Americans than any other group expressed a desire to be the best student in class. It may be argued that these results are out of date and no longer valid, but it must be remembered that the technicians, engineers, and scientists of today were represented in this very report. Their general regard for school does not seem to account for the disparity of representation in science-related careers.

Table 11
Percent of Responses of "Always" or "Often" to Selected Statements About Extracurricular Science Activities

Statement	Anglo Americans Age 13	Anglo Americans Age 17	Black Americans Age 13	Black Americans Age 17
Read science articles in magazines	45.6	47.4	51.7	53.7
Read science articles in newspapers	40.7	47.2	42.6	50.3
Read books on science	42.0	26.2	62.4	45.6
Watch scientific television shows	57.6	63.1	56.8	53.5
Talk to friends about science	40.3	36.5	46.5	38.6
Not required, but did science hobbies	45.4	37.6	45.4	37.1

Note. Adapted from Kahle, 1979.

Scientists have typically been characterized as being of high intellectual ability, persistent in their work, extremely independent, and social isolates (Rossi, 1965). These qualities are not highly esteemed by many groups nor do they correspond to the popular stereotypes of many minority groups, and one would suspect that they do not correspond to the

Table 12
Percent of 12th-Grade Students
Having Selected Attitudes

	Black Americans	Mexican Americans	Asian Americans	American Indians	Puerto Ricans	Anglo Americans
Do anything to stay in school	37	35	36	44	46	45
Desires to be best in class	33	36	38	46	58	33
Desires to finish college	43	43	42	46	46	45
Believes self to be brighter than average	31	37	31	51	40	49
3 or more hours per day study outside of school	22	21	17	42	31	23
Definitely planning to attend college next year	26	26	27	53	34	40
Expect a professional career	18	21	21	43	27	37

Note. Adapted from Coleman et al., 1966.

actual traits of many scientists. But on the basis of such stereotypes people develop attitudes that may function as barriers to certain aspirations. Green, Brown, and Long (1978) have reported, for example, that mathematics and science teachers are characterized by American Indian students as being "hard, tough, unyielding, and difficult." There is commonly a special mystique attached to mathematics as well, and since mathematics majors are considered "brains," most minorities and women have difficulty envisioning themselves as mathematicians. Likewise, Hale (1978) has complained that Blacks are applauded for physical prowess in sports while other groups claim intellectual superiority. There is obviously no place in respectable institutions for such attitudes, but it seems important to elucidate how these stereotypes and psychological barriers have developed.

The lack of science role models among some minority groups seems an obvious factor. As Vasquez (1979) has explained, minority group members are unlikely to pursue professions in which other members of their ethnic group are seldom encountered. There is a certain amount of psychological risk involved in pursuing a profession where there is the double fear of rejection by colleagues on the basis of ethnicity (Maestas, 1977) and obscurity or failure due to a lack of ability.

But many students are likely never confronted with this risk because a lack of academic modeling in the home inhibits professional aspirations. The national assessment in science (NAEP, 1978a) indicated quite clearly that students who have at least one parent with a post high school education tend to perform above the national average in science. When you consider that Coleman et al. (1966) reported a significantly greater proportion of Anglo Americans than any other group of students had mothers who had completed high school (See Table 13), the significance of academic role models in the family seems evident.

Using multiple regression analysis, Eash and Rasher (1977) found home support to be the single best predictor of achievement in school, better than ethnicity or SES. Crandall and Katkovsky (1967) found that supportive, positive relationships among parents and children tend to foster

Table 13
Percent of Students whose Mother Completed a High School Education

	Anglo Americans	Black Americans	Mexican Americans	Puerto Ricans	American Indians	Asian Americans
Elementary	58	40	49	47	50	53
Secondary	48	33	37	34	39	41

Note. Adapted from Coleman et al., 1966.

beliefs in self-achievement. Could it be that, in their modeling, more academically oriented parents tend to provide the sort of supportive environment which promotes success in school? It is reasonable speculation that needs corroboration.

Would an answer to that question be of value to the educational enterprise? Yes, in two ways. A detailed explication of what constitutes a supportive home environment might reveal elements that are amenable to educational intervention, and it may be that some type of "parental awareness" program could be initiated. Through such a program the school could indirectly aid students by offering educational guidance to parents. Some strategy is needed to break the cycle of repeated science and mathematics underachievement among some ethnic groups, and the most effective strategy will likely involve home support.

Academic self-concept is one learner characteristic that may well be the focus of such attempts. Simpson (1979) has alluded to a relationship between self-concept and success in science, and the Dallas Independent School District (1975) found Anglo Americans to exhibit a more positive academic self-concept than members of minority groups, with no sex differential being noted. More detailed studies are needed in order to both adequately define self-concept and to isolate those factors contributing to self-concept that are amenable to educational intervention. One contributing factor that may not be particularly amenable to school intervention is that of cultural perspective.

Maestas (1977) has offered some values and attitudes of many Mexican Americans and American Indians that serve to inhibit aspiration to careers in science:

(1) a general resistence to change,

(2) the belief that it is inappropriate for man to assume mastery over nature (many classroom experiences seem contrary to a perspective of submission to the environment),

(3) perplexity concerning society's esteem for pure science over applied science,

(4) a feeling that the rigorous and systematic pursuit of knowledge which typifies science is incongruent with the chance discovery, serendipity, and trial and error approach of the culture, and

(5) the fear of rejection by majority culture members (adoption of new values does not insure acceptance in majority society).

This last notion seems to be the essence of a cultural dilemma. Even if minority group members succeed academically and pursue an interest in science-related professions, there remains the unquantifiable risk of rejection by colleagues.

The scientific enterprise as it exists today is largely a product of Western culture and incorporates a system of thought that may seem a bit alien to minority group members who maintain strong ties to traditional ethnic values such as those described by Maestas (1977). These values which seem incongruent with scientific endeavor, insufficient academic role models, and the psychological barriers posed by stereotypes all contribute to attitudes and orientations that may hinder achievement in technical, engineering, and scientific fields.

Factors Related to Classroom Experience

Having considered differences in achievement and differences in learner characteristics, the impact of classroom experiences will now be assessed. Again, there is a paucity of firm, reliable data describing the relationships between classroom experience and performance in the areas of mathematics and science, but on the basis of national surveys (Coleman et al., 1966; Kahle, 1979) and selected classroom studies, some inferences regarding influential factors can be made. Among the suspected factors are (1) differential exposure to science and mathematics instruction, (2) de facto classroom segregation, (3) classroom psychological environment, (4) teacher expectations, and (5) instructional strategies.

The Coleman report (Coleman et al., 1966) and the NAEP (Kahle, 1979) both indicated disparities among ethnic groups w th regard to exposure to science experiences. For example, they reported fferences in exposure to each of the following: natural phenomena, informal learning experiences in science, science and mathematics coursework, and study outside the school. Some differences between Black American and Anglo American exposure to natural phenomena are presented in Table 14. Though differences are small, a greater proportion of Anglo Americans report direct experience in all but three cases. A greater proportion of Anglo Americans also report exposure to institutions of informal learning (planetariums, zoos, and museums) It is unfortunate that such data are not available for members of other minority groups. If these disparities are consistently parallel to differences in achievement and interest in science and mathematics across ethnic groups, we would have a basis for offering experiential science and mathematics courses in a systematic manner within school programs.

There are also disparities among ethnic groups in the degree of exposure to formal work in science and mathematics. Coleman et al. (1966) found a significantly higher proportion of Anglo Americans and Asian Americans than other groups enrolled in college prep courses (see Table 15). Similar proportions of all groups reported taking 2-1/2 years or more of science and mathematics. However, a higher proportion of Anglo Americans did report 2½ years or more of such coursework. The quality of exposure to science and mathematics seems more extreme. Ignatz (1975) reported great disparities in the types of science classes Black Americans and Anglo Americans experience in northern Florida (see Table 16). Quite clearly, Black Americans in this instance are underrepresented in the physical science classes that are likely prerequisites for many science programs at the college level.

Table 14
Percent Responding Affirmatively to Questions
Concerning Science Experiences

Question	Anglo Americans			Black Americans		
	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17
Had students seen...						
a sprouting seed?	60.7	73.0	84.7	45.4	54.9	65.5
an egg hatching?	42.5	55.5	58.3	47.5	44.1	43.5
an animal being born?	47.5	61.0	63.1	57.5	56.7	56.7
a fish eating?	82.5	91.5	92.9	73.6	87.4	91.1
ants or bees working?	76.7	90.0	94.2	56.2	78.8	88.8
birds caring for young?	64.2	77.8	81.2	60.7	77.4	81.7
the North Star?	44.3	64.7	78.9	36.3	34.9	44.0
the moon through a telescope?	34.6	52.2	60.3	34.6	32.2	38.4
an animal skeleton?	63.6	86.0	89.6	53.0	75.2	77.5
a fossil?	57.3	89.3	93.1	34.9	65.0	75.0
Have you ever actually visited...						
a planetarium?	32.3	57.5	69.2	30.7	49.8	50.8
a zoo?	87.9	95.2	96.8	79.5	91.4	94.2
a museum?	71.6	94.8	96.6	62.2	85.1	90.9

Note. Adapted from Kahle, 1979.

Table 15
Percent of Students Exposed to Selected Academic Environmental Characteristics in Second Schools

Characteristic	Mexican Americans	Puerto Ricans	American Indians	Asian Americans	Black Americans	Anglo Americans
taking college prep course	36	38	35	41	32	41
2½ years or more of science	36	38	38	38	39	42
2½ years or more of math	47	45	44	47	44	49
One year or less of science	26	25	25	26	26	21
Teacher expects them to be one of the best in class	25	25	24	22	33	22
Three or more hours per day study outside of school (12th-grade students)	22	21	17	42	31	23

Note. Adapted from Coleman et al., 1966.

Another very interesting finding related to exposure to mathematics and science that should be studied further involves the amount of time away from school that is devoted to study. A larger proportion of Asian Americans, by far, report that each day they study three hours or more outside of school. Considering that all groups, including Anglo Americans, are underrepresented in fields of science and mathematics when compared to Asian Americans, this may be a highly significant factor. Does this greater amount of study-time indicate greater motivation, greater home

Table 16
Percent of Students Enrolled in Science Courses of
44 Public High Schools in Northern Florida

Course	Black Americans	Anglo Americans
Biology II	23	77
Chemistry I	9	91
Chemistry II	6	94
Physics I	7	93
Other	29	71

Note. 75.2% of total enrollment are White, 24.89% are Black. Adapted from Ignatz, 1975.

support, different cultural values, or a slower rate of learning? Research in this area may reveal some clues as to why Asian Americans tend to excel in mathematics and the sciences.

Another area needing further study is that of classroom segregation. There is little firm evidence to suggest that segregation necessarily affects achievement in mathematics and science, any such assertion should be demonstrated empirically. In a longitudinal study, Eash and Rasher (1977) found desegregation of one school district to promote academic and social improvement among students. Green (1978) maintained, however, that over 70% of the nation's Black Americans still attend segregated schools.

Given all the recent busing efforts, this estimation is a bit unsettling. Kahle (1979) made a good point that there may also be much segregation by classroom.

As a result of formal or informal procedures, students are often grouped according to achievement level in reading and mathematics. Such practices often result in de facto segregation. Stake and Easley (cited in Kahle, 1979), for instance, reported that over 60% of the students in remedial science classes of a Texas school were Black American males who had been assigned there because of problems assocated with reading, mathematics, discipline, and, last of all, science. In another case, Brown et al. (1980) found in a national longitudinal survey of 1972 high school seniors that a much higher proportion of Hispanic Americans (10.4%) than Anglo Americans (3.0%) had been assigned to particular coursework in high school with no free exercise of choice. Given the disparities among ethnic groups in exposure to natural phenomena, academic role models, loci of control, cognitive styles, and more, de facto segregation may indeed be interfering with a lateral transmission of learner values and characteristics. Such segregation in the elementary classroom carries over into high schools where some courses become "elitist" by default, with students segregating themselves into comfortable niches.

Indeed, the classroom oriented toward achievement may not be a comfortable place for the disadvantaged because of its psychological environment.

Such classes often promote competition and individualism, traits characteristic of Western culture. Several studies have indicated that Anglo-American students are much more competitive, for instance, than Mexican American students (Kagan and Madsen, 1971, 1972; McClintock, 1974). Though Avellar and Kagan (1976) point out that such results are confounded by SES and degree or urbanization, their work with children of 5 to 6 and 7 to 9 years of age confirmed that Anglo American children are more concerned than Mexican American children about personal absolute gains. This cultural difference in degree of concern could not be attributed to SES or completely to urbanization, and the difference increased with age. These are intriguing findings that need to be corroborated at other age levels and with members of other ethnic groups.

It seems particularly important to study the Asian American population in this regard. The implication of such research may be that unnecessarily competitive learning environments are detrimental to some minority group members, and alternative strategies focusing on cooperation would be more beneficial. Particularly during elementary school, it seems, a variety of learning opportunities should be provided if, indeed, consistent differences in orientation can be found. Graham (1980) has stated the situation very well:

> School and community people will have to face squarely whether the school's principal role is to reinforce the advantages with which children are born as a result of their genetic and environmental

circumstances, or whether it is to maximize the talent pool available to the society by differentiating its programs to help those who are not benefiting from it in its present form.

The school and community, it seems, must establish priorities and make programmatic changes congruent with those priorities. Not only should the characteristiacs of students be considered, however, for it is the teachers who set the psychological tone of the classroom. Do teachers have different orientations and expectations with regard to student performance?

Indications are that differential expectations do exist. Several years ago, Gottlieb (1964) surveyed 89 teachers (53 White and 36 Black) to determine their attitudes toward pupils (Black Americans and Anglo Americans) from low income inner-city families. The differences in teacher perspectives were striking, with Black American teachers feeling much more positive about the students than the Anglo American teachers. So, when asked what reasons they might have for feelings of job dissatisfaction, Black-Americans mentioned large classes, poor equipment, inadequate supplies, and lack of proper curricula. Anglo Americans however, mentioned the lack of student ability, poor motivation among students, disciplinary problems, and unconcerned parents. Unfortunately these findings are somewhat questionable since the mean age and years of experience among Black-American teachers were much less than that of the Anglo-American teachers.

But there is evidence that differential teacher attitudes and expectations affect teacher treatment of students. Jackson and Cosca (1974) have some interesting results from a study of Chicano and Anglo students in the Southwest. Observers evaluated the frequency and quality of teacher-student interactions in 494 classrooms representing grades 4, 8, 10, and 12. Significant disparities between Chicano and Anglo students were found with regard to the amount of praise and encouragement received, the amount of acceptance shown by the teacher, and the amount of positive feedback given by the teacher. In all cases, Anglos received more, receiving up to 35% more praise and encouragement. These findings support Rowe's (1977) contention that top rated students are cued to a different reinforcement pattern than are other students.

Dusek (1975) has reviewed the literature regarding teacher-expectancy effects and found abundant evidence to suggest that teachers do tend to treat children differentially on the basis of expectations they acquire. The differential treatment has also been shown, he claimed, to affect achievement. Dusek commented that teachers frequently assume students to be less capable of learning if they are Black Americans or poor. Others as well have found teacher expectations for minority students to be lower than they are for Anglo Americans (Adenika & Berry, 1976; Davidson & Lang, 1960). Rist (1970) suggested that schools really do a poor job of influencing achievement independent of family, social, and cultural background. That is, teacher orientation toward students is determined to a great extent by social and cultural criteria rather than by academic criteria. With regard to science and mathematics for minorities, research is needed to determine the bases upon which expectations are formed and the significance of their effect on student-teacher interactions.

Though differences in teacher expectations and treatment of minorities clearly exists, can achievement be shown to be affected by the differences? Intuitively there seems little doubt, and Rosenthal and Jacobson (1966) seemed to confirm an affirmative answer to the question. Claiborn (1969) was unable to replicate their findings, however, as were Jose and Cody (1971). This indeed seems to be an area in critical need of firm data, particularly with regard to science and mathematics education. Three National Science Foundaton studies reviewed by DeRose, Lockard, and Paldy (1979) illustrate quite convincingly how the success of science programs rests largely on what individual teachers believe, know, and do within their classrooms; there exists limited outside guidance through federal funding of programs, supervisory support, or coordinated curriculum development. Are teachers' expectations highly valued by students of all ethnic groups? Are there ages during which teacher support is more important? By inhibiting a laterial transmission of learner values and characteristics, de facto segregation may be intensifying detrimental effects caused by differential experiences on the part of students and differential expectations of student performance by teachers. Should teachers employ different instructional strategies with different student populations?

With regard to instructional strategies, there is much work to be done. It is clear that the social and cultural backgrounds of students predisposes their response to school instruction to some degree. It is also clear that the social and cultural background of students influence teacher expectations and interactions to some degree. Is it important to modify student orientations to conform to established instructional modes, or are there more effective alternative strategies? Do mathematics content and science content, by their very nature, require particular instructional strategies? Essentially, it is a question of the extent to which classroom experiences must accommodate learner characteristics or to which students must conform to strategies of instruction. These are critically important questions, the answers to which would greatly influence the nature of any strategies for educational intervention.

There have been attempts to render the classroom more student-oriented, but with mixed results. The latest NAEP results (Kahle, 1979), for example, indicated that some students perceive a degree of flexibility within their classes (see Table 17). The surprising result is that Black American students report more freedom to choose topics of interest, sequences of study, the pace of instruction, and the frequency of tests than do Anglo Americans. Such choices are characteristics of student-oriented classrooms, but yet discrepancies in achievement remain. It could be argued that results take time, but perhaps the quality of this more flexible instruction should be questioned. Indeed, a significantly higher

Table 17
Percentages of Students Responding "Always" or "Often" to Selected Questions Concerning Instructional Strategies and Classroom Management

Question Statement: Have you . . .	Anglo Americans		Black Americans	
	Age 13	Age 17	Age 13	Age 17
chosen topics/projects yourself?	15.9	17.9	22.7	26.6
chosen the way you want to learn?	9.4	6.5	19.0	16.1
selected study sequence of topics?	11.7	6.2	22.0	14.5
decided when to take tests?	15.7	6.3	19.2	17.5
gotten to work at your own speed?	43.4	21.1	51.1	42.2
followed exact order of textbook?	43.4	36.5	63.2	52.7

Note. Adapted from Kahle, 1979.

proportion of Black Americans report following the exact order of a textbook (see Table 17). Has personal interaction with a teacher been replaced by a mechanical progression through textbooks? Individualization may be needed, but not at the expense of effective instructional strategies.

A successful collegiate compensatory program offering special science classes to minority students (McDermott, Piternick, & Rosenquist, 1980 a, b, c) has provided some insights regarding instructional strategies. McDermott et al. have identified four general academic weaknesses for which allowances are not generally made in mainstream science courses:

1. a general lack of experience on which to build the abstractions of science,
2. poorly developed mathematical and verbal skills,
3. a lack of self-confidence in using reasoning skills to solve problems, and
4. low personal standards for academic achievement.

If these weaknesses are prevalent among minority group members, the official barriers to success, such as low scores on standardized tests and low grade-point-averages may be secondary manifestations of more basic problems.

In conjunction with their classes, McDermott et al. have explicated a number of specific cognitive difficulties that seem to impede student progress. Their students frequently confuse closely related concepts such as mass and volume, and often fail to discern relationships between reality and representation. Many students have difficulty recognizing logical implications, controlling variables, and reasoning proportionally or by analogy. By emphasizing concept formation along with reasoning development, McDermott et al. have helped students overcome these weaknesses and compete successfully in standard college science courses.

McDermott et al. have structured their program to compensate for the identified weaknesses; a low student-teacher ratio is maintained, tutoring is provided, minority role models participate, encouragement and counseling are provided, and persistence in attendance and homework is required. By being conscious of attitudinal and motivational needs as well as cognitive needs, a powerful combination of instructional strategies has been developed. If such simple techniques foster success among minority college students, perhaps there are manageable techniques that can be employed in elementary and secondary schools.

Kahle, Nordland, and Douglass (1976) reported that a self-paced biology class using audio-tutorial methods promoted significant gains in achievement over traditional approaches. Their results are somewhat questionable, however, since the audio-tutorial group had no time limit within which units had to be completed. In response to an early call (Gallagher, 1974) urging science teachers to take on the multi-dimensional task of working effectively with students from a variety of cultures, more studies are still needed that compare instructional strategies and have ethnicity as a variable. Without such studies, teacher response to differential sociocultural backgrounds and differential learner characteristics will be uncoordinated and ineffective. Effective educational intervention relies on the testing of instructional strategies and identification of any consistent patterns of achievement that may result.

Factors Related to Counseling Experiences

Counselors have the complicated task of assessing learner characteristics, resolving problems related to classroom behavior, monitoring student academic performance, and guiding students in their selection of careers. Performance of these tasks will likely influence student attitudes, motivations, and aspirations. As important as these matters seem, however, few studies relating achievement in science and mathematics to counseling procedures are available. There are, however, some interesting findings about two aspects of counseling, career selection and counselor influence in the classroom, that seem relevant and will be discussed briefly. The discussion will be brief because there is more awareness of problems than understanding of solutions.

Angel (1977) identified career selection as a major problem. Though the Medical College Admission Test is cited as a barrier to minorities interested in medical careers, the rate of admission for minority applicants is 30% while the general rate of admission for all ethnic groups is 33%. This would seem to indicate that there is simply a lower proportion of minorities who attempt the exam. During a nationwide survey of college students, in fact, Erlick and LeBold (1977) found a much smaller proportion of the minority and female populations than Anglo American males to be considering science careers (see Table 18).

Table 18
Science Career Choice, 1975

	Overall	Non-White Minorities
Male	6.6%	3.2%
Female	4.4%	2.3%

Note. Based on 8,621 respondents to Poll #101 of the Purdue Opinion Panel (Erlick and LeBold, 1977.

Of considerable interest is the apparent "double effect" on minority women. Table 18 offers what seems to be very solid evidence that the obstacles to women and the obstacles to minorities interested in science careers are compounded for minority women. Over 25% of those minorities interested in science indicated that they could not pursue science careers for academic reasons, such as lack of prerequisites or poor grades. In the case of Black Americans, Jay (1977) may well be correct in suggesting that high school counselors either counsel Black Americans out of science or fail to motivate them by suggesting goals.

The Coleman report (Coleman et al., 1966), however, did not provide evidence for this charge (see Table 19). Nearly equal proportions of the various ethnic groups report that their teachers and counselors have encouraged them to attend college, and similar proportions desire to finish

Table 19

Percent of Students Having Specific Aspirations Regarding College and a Career

	Mexican Ameri-cans	Puerto Ricans	Ameri-can Indians	Asian Ameri-cans	Black Ameri-cans	Anglo Ameri cans
Secondary Students:						
Teachers or counselors encourage them to go on to college	51	47	48	50	50	51
12th Grade Students:						
desires to finish college	43	43	42	46	46	45
definitely planning to attend college next year	26	26	27	53	34	40
have read college catalog	46	45	50	70	54	61
have consulted college officials	22	25	26	33	25	37
expect a professonal career	18	21	21	43	27	37

Note. Adapted from Coleman et al., 1966.

college. But when it comes to setting goals and actively pursuing those goals, there are great differences among groups. A greater proportion of Asian Americans have definite plans to attend college immediately after graduation, have read a college c talog, and expect to pursue professional careers. A higher proportion of Asians seem to be aware of their interests, aware of the preparation required, and willing to pursue their goal early in their academic career. What are the factors that contribute to such an orientation? Once again, it seems important to examine more closely the culture and personality traits of these successful minorities.

Brooks (1976) reminded us that minority students will likely need more support through counseling because of the many obstacles to overcome in reaching their goals. Counselors may decrease some of the obstacles by extending their influence into the classroom to affect the learning process (Cardell, Cross, and Lutz, 1978). Cardell et al. accomplished this by training peer tutors to develop mathematical skills among American Indian students of the Mescalero Apache Reservation. After an eight-week period of instruction, peer learners demonstrated a significant gain in mathematical concepts and skills over students in a conventional class. After reviewing research on peer and cross-age tutoring, Bloom (1976) regarded such tutoring to be a promising method for providing individualized guidance in the conventional classroom. Bloom suggests the need for more longitudinal studies and research of alternative ways by which children can interact to support each other in the learning process. If mathematics and science classes emphasize experiential understanding of concepts and skills, peer tutoring strategies may well be a technique which would promote the cooperation to which many minorities seem responsive.

The school counselor, then, seemingly can influence minority entrance into engineering and the sciences in many ways. They can encourage early career education and selection, they can indirectly influence the learning process through peer tutors, and they can monitor the academic progress of students for obstacles related to SES or sociocultural factors. As Trachtman (1975) has demonstrated, counselors could make more use of attitudinal correlates of academic success to guide more effective diagnostic, remedial, and tutorial efforts and to plan motivational experiences that promote those learner characteristics and attitudes associated with success. By using measures of dogmatism, locus of control, and attitudes toward authority, Trachtman was able to account for twice as much variance as could be accounted for by cognitive factors alone. Having influence on both individual students and classroom practices, counselors occupy a critical position on the education staff. Mathematics and science educators need desperately to interact more effectively with counselors to both modulate the classroom experience of minority group members and to maximize guidance efforts.

Special Programs

Although many colleges and universities have developed special programs to encourage ethnic minority participation in science and mathematics, few such programs exist at the pre-collegiate level. This is indeed unfortunate since it is at this level that weaknesses in science and mathematics begin to develop. However, a few special programs have been implemented successfully with "low achievers." These programs incorporate such approaches as Science Curriculum Improvement Study (SCIS), Science--A Process Approach (SAPA), and Elementary Science Study (ESS), which emphasize a hands-on, experience-based approach to science education. By the same token, mathematics laboratories have encouraged the use of concrete manipulatives to develop knowledge and understanding. Also, small but regular doses of Computer-Assisted Instruction (CAI) have been used as a supplementary strategy with a great deal of success. One use of CAI was reported by Green et al. (1978) in a description of the All Indian Pueblo Council program. Although the computer was used to teach only particular items such as those dealing with approximation and perception, Pueblo students using the machine reported liking the privacy and individualized pace. Green suggested that perhaps this strategy was able to accommodate students "highly sensitive to the pressures of public achievement and failure," and those who preferred a "silent involvement in learning."

A number of bilingual programs in science and mathematics have been developed for ethnic minority students whose first language is not English.

These programs, though very few in number, have been successful in improving achievement over extended periods of time (Olesini, 1971; Trevino, 1968). Unfortunately, many of these bilingual programs have been for demonstration purposes only and have not been widely implemented. Because of shortages in materials and trained personnel as well as problems with limited funding, such programs have not been widely implemented.

The need for special programs for American Indian students has been discussed by Green (1976) but her remarks are easily extended to include other ethnic minority groups of students as well. She called for an assessment of current practices in science and mathematics classrooms serving American Indian students, and for the development of special programs that incorporate succe‹ ful approaches. Suggestions for such approaches included content that is organized around everyday experience, bilingual science and mathematics instruction, concentrated attention to mathematics deficiencies, incorporation of ethnoscience, taking advantage of working experience, academic and career counseling, and identification of recruitment programs.

One program currently being implemented is the Mathematics, Engineering, and Science Achievement (MESA) program has been developed through the Lawrence Hall of Science, University of California at Berkeley. Though a program designed to increase the numbers of underrepresented minorities in mathematics, engineering, and physical-science-related professions, it deals with a very select minority population. Its target students include

Black Americans, Mexican Americans, Puerto Ricans, and American Indians who have expressed an interest in mathematics- and science-related careers, but such students must be currently enrolled in college-preparatory mathematics and science courses. The MESA program makes no effort to address the needs of other minority students. The program was designed to encourage students from target minority groups to acquire the educational background required of majors in mathematics, engineering, and the physical sciences at university level, while promoting career awareness of professional opportunities.

Educational enrichment activities for the targeted minority students include such services as tutoring; independent study groups; academic, university, and career counseling; field trips to industrial plants, research centers, universities, engineering firms, computer centers, and other sites; summer enrichment and employment programs; and scholarship incentive awards to students who maintain B averages in advanced-level college preparatory mathematics, science, and English courses. These enrichment activities are provided through a wide variety of agencies including universities, industries, school districts, California State Department of education, and engineering and educational professional societies.

The results reported by MESA are impressive. More than 85% of participating MESA students have gone on to study at colleges and universities, and more than two-thirds of these students have chosen majors in technical fields. However, one must bear in mind that only highly qualified minority students are eligible to participate. This program makes no effort to improve the achievement of ethnic minorities who are finding science and mathematics difficult or who are avoiding these content areas entirely. Nor does it seek to identify the sources of these difficulties for such students ineligible to participate. Although this program does seem to effectively increase ethnic minority participation in science and mathematics, its goals are short-ranged, and more and earlier attention must be given to the larger population.

Summary

An attempt has been made in this report to identify the primary pre-collegiate factors influencing the entrance of minority group members into technical and science-related professions. Special attention has been given to those factors which seem amenable to educational intervention; there are undoubtedly other home and cultural factors, economic factors, psychological factors, and social factors that influence career selection.

Figure 6
Currently There is Ongoing Research
in the Following Areas:

1. Factors influencing persistence and achievement in the sciences and health professions by Black high school and college women
2. Research on process models of basic arithmetic skills
3. Effects of processing style on problem solving in mathematics
4. Cognitive developmental approach to mathematics learning difficulties
5. Social influences on the participation of Mexican-American women in science
6. Identifying learning handicaps of college-age Spanish-speaking bilingual students majoring in technical subjects
7. Psychosocial factors affecting the mathematical orientation of Black americans
8. Cognitive development and achievement in secondary school geometry
9. Development of children's concepts of number and numeration in the primary grades

to some degree. But a sufficient number of seemingly major factors have been identified to provide a direction for further research (see Figure 6) and special program development. Studies of test performance differences and learner characteristics substantiate the need for educational intervention. But what is to be the nature of such intervention?

Early exposure to experiential science and concrete mathematical materials in order to develop conceptual understanding seems to be highly desireable. Such exposure is thought to promote an increased awareness of natural phenomena and mathematical relationships, and the construction of a tangible experience base needed for success in science and mathematics. More research is needed however, to elucidate the relationship suspected to exist between experience with concrete materials and the development of specific learner characterstics such as level of cognitive development, motivation, and locus of control. Given the many factors influencing achievement, any search for the relationships between these early experiences and achievement may be unproductive if these intervening learner characteristics are neglected.

Instructional strategies that accommodate the variety of cognitive styles seemingly associated with different minority groups must be encouraged. Allowing greater personal interaction, group activities, and cooperative behavior seems to promote positive attitudes in those students alienated by the more rigorous and abstract aspects of science and mathematics education. Such changes in attitudes may indirectly affect

DOCUMENT RESUME

ED 223 404 SE 038 774

AUTHOR Olstad, Roger G.; And Others
TITLE Inhibitors to Achievement in Science and Mathematics by Ethnic Minorities.
PUB DATE Mar 81
NOTE 136p.
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC06 Plus Postage.
DESCRIPTORS *Academic Achievement; Counseling; Elementary School Mathematics; Elementary School Science; Elementary Secondary Education; *Ethnic Groups; Inhibition; Mathematics Education; *Minority Groups; Motivation; *Performance Factors; Science Careers; Science Education; *Secondary School Mathematics; *Secondary School Science; Student Attitudes; Student Characteristics; Testing

ABSTRACT

Suggesting that the underrepresentation of ethnic minorities in technical and science-related careers and within academic programs leading to such careers has not resulted primarily from free exercise of choice on their part, but rather has resulted in some measure from barriers to minority group participation, the literature was surveyed to examine factors suspected of inhibiting minority participation in science/mathematics at the pre-college level. Factors examined included: (1) those related to testing procedures (general testing, achievement, other factors such as socio-economic status, performance patterns, and presence of bias); (2) those related to learner characteristics (cognitive style, locus of control, and attitude/motivation); (3) those related to classroom experience (differential exposure of science/mathematics instruction, de facto classroom segregation, classroom psychological environment, teacher expectations, and instructional strategies); and (4) those related to counseling experiences. Programs to encourage minority participation in science/mathematics were also examined. Suggestions based on the literature review include early exposure to experiential science and concrete mathematical materials to develop conceptual understanding, providing instructional strategies accommodating a variety of cognitive styles, rectifying any imbalance in the quality of science/mathematics instruction encountered by minorities, providing career awareness programs and academic role models, and including Asian Americans and minority women in future research studies. (Author/JN)

achievement in science and mathematics by influencing choices of coursework. Since much of the research in the area of cognitive style is speculative, more research is necessary in this area. In particular, the relationships among instructional strategies, classroom experiences, learner needs, and desired outcomes needs further examination. Until techniques can be developed to successfully accommodate the diversity of learner characteristics and enhance the achievement of all learners, perhaps the known correlates to success in science and mathematics should be utilized to select candidates for special programs. Such candidates would help meet the immediate need for successful role models in technical and science-related careers.

Any imbalance in the quality of science and mathematics coursework encountered by members of various ethnic minorities must be rectified. The underrepresentation of minorities in science and mathematics begins to occur in high school, not in the job market or college. De facto segregation, which is initiated in elementary school through the practice of ability grouping, seems to divert many minority students away from the mainstream courses that are prerequisites for college programs in science and engineering by not adequately preparing them for success in such courses. Research is needed to elucidate the effects of differential teacher expectations and the seeming inability of some minority group members to decide on career goals early and pursue appropriate programs.

Greater promotion of career awareness also seems necessary. There is a need both to expand professional aspirations among minority group members and to dispel unattractive and inaccurate stereotypes. It is recommended that counselors emphasize early and informed goal-setting and that teachers provide exposure to professional role models during instructional sessions. The teacher should not be the sole representative of science and mathematics professionals encountered by students.

Academic role models are also needed. Guidance in promoting a positive academic self-concept among children should be available to concerned parents. Support from the local community is also important in this regard. At the same time, research is needed to establish more clearly the factors that typically comprise a supportive home environment. Even with supportive classroom environments, supportive home environments are essential.

Finally, it is recommended that the members of two specific groups--Asian Americans and minority women--who have been neglected in many major studies also be included in research efforts. Asian Americans, like all major groups, do not represent a homogeneous population, but their success in the science and mathematics professions cannot be ignored. They comprise 60% of the scientists and engineers who are members of minority groups (Skypek et al.). It is natural to focus attention on the most critical problems, but basic research is needed and should include consideration of successful populations. Perhaps explanations accounting for their success would benefit members of all ethnic groups.

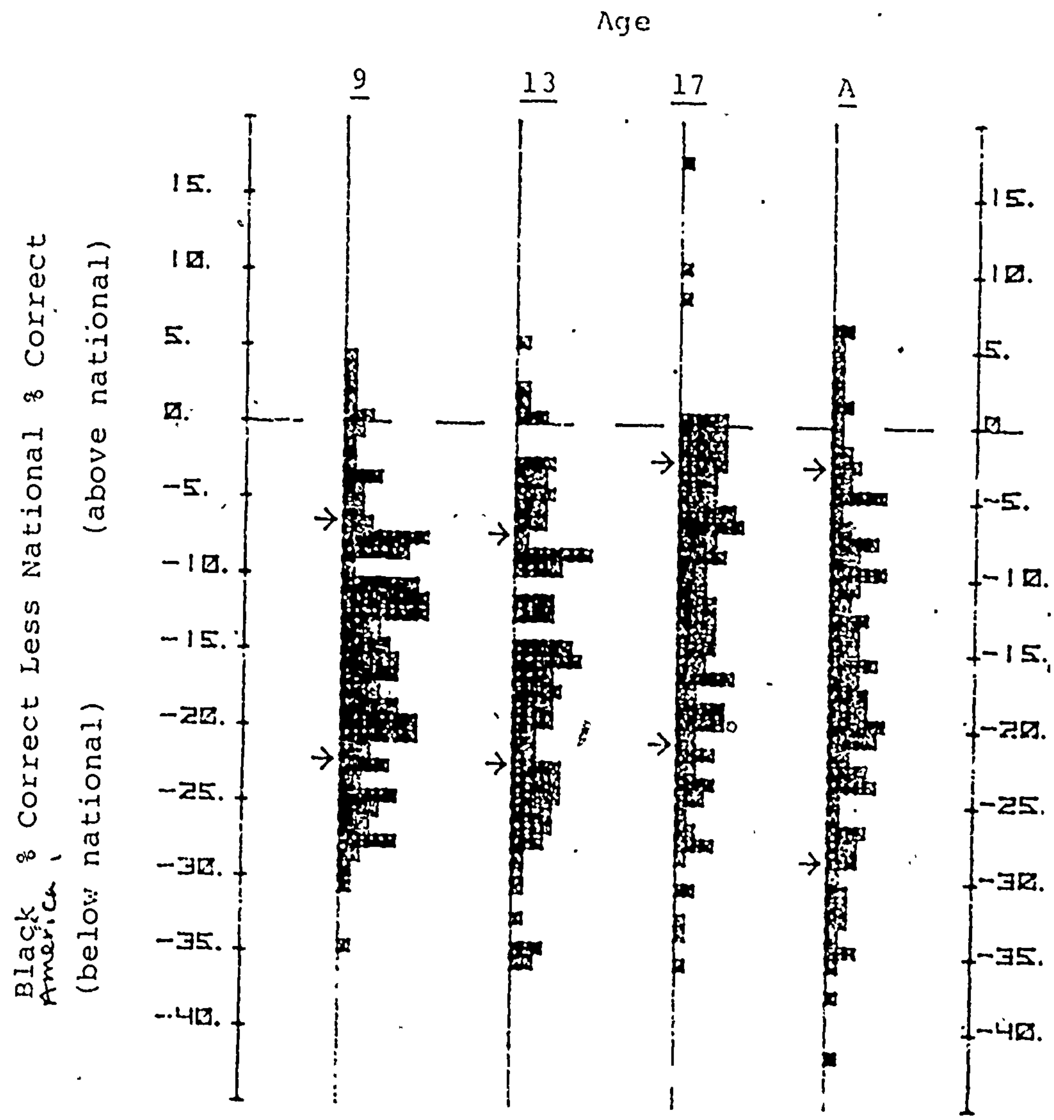
Minority women need special attention because of the compound effects relating to ethnicity and gender. Research is needed in order to differentiate obstacles relating to gender from those relating to ethnicity, and to compensate for them through educational intervention. Do socialization factors, as Rossi (1965) contended, predispose women to fields other than those of science and engineering, or are there other sorts of barriers? The interaction of factors relating to gender and factors relating to ethnicity which affect achievement in mathematics and science is an open field for study.

APPENDIX A

Selected Test Results from the

National Assessment of Education Progress in Science

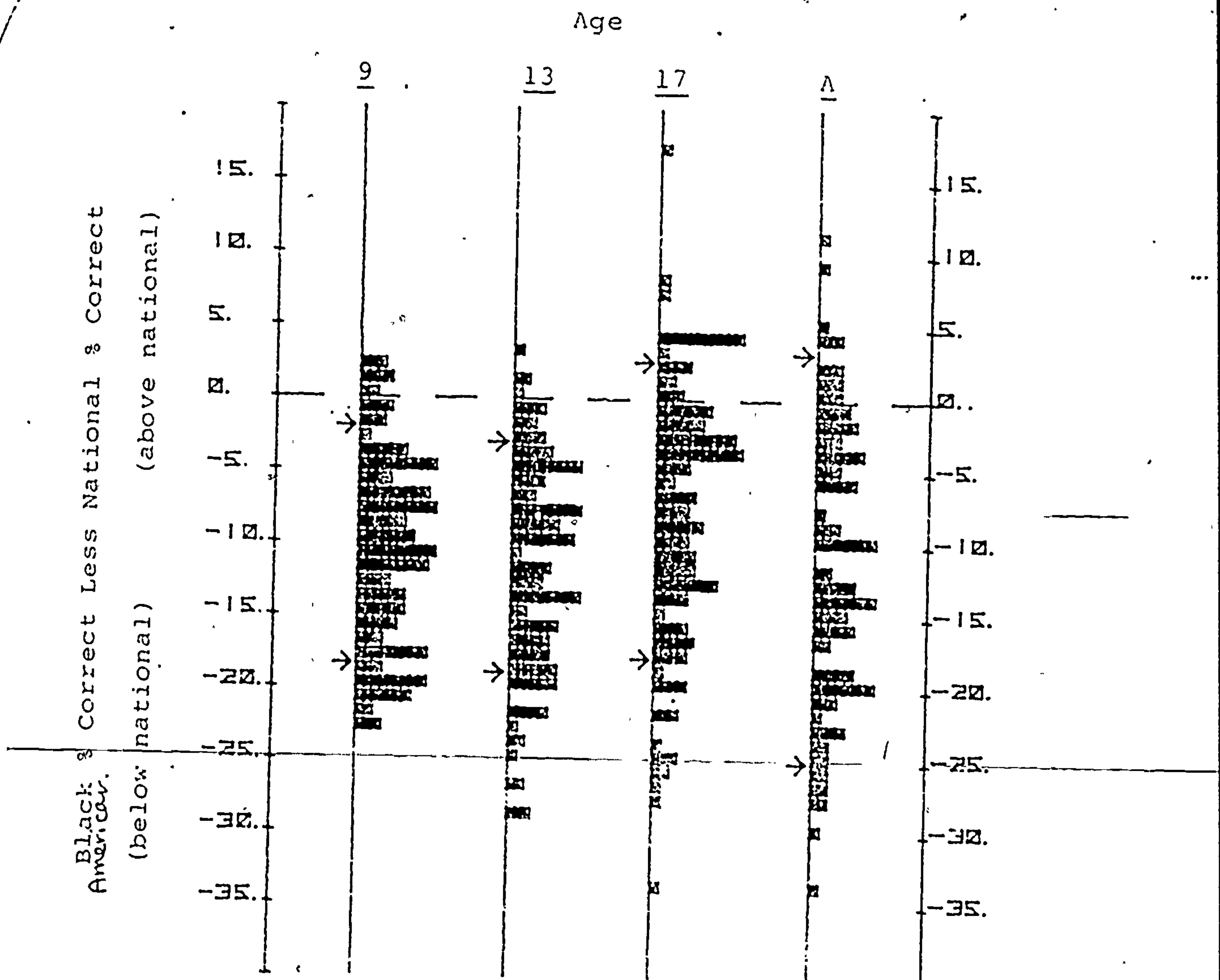
Figure A
Distributions of Relative Performances of Black Americans
for all Science Exercises at Four Ages



	9	13	17	A
No. of Exercises	145	122	124	119
Median	-14.5%	-15.0%	-11.8%	-15.8%

Note. Adapted from NAEP, 1973

Figure B
Distributions of Relative Performances of Blacks, Balanced, for all Science Exercises at Four Ages



	9	13	17	A
No. of Exercises	145	122	124	119
Median	-10.2%	-11.0%	-7.7%	-10.9%

Note. Adapted from NAEP, 1973

Table A
Exercises Showing Atypical Effects, Balanced
for Black Americans, Age 9

Exercise #	% Correct Black	% Correct Nat'l	% Difference	Content
U652*	35	33	2	
R141*	9	7	2	Mixing water of 50° and 70° yields water of 60°
U673*	12	11	1	
U650*	37	36	1	
U655*	15	14	1	
U678*	27	26	1	
U657*	12	11	1	
U621*	76	76	0	
U656*	12	12	0	
R140*	14	14	0	Dead plants form coal
R142*	96	96	0	Balancing a beam with one weight
U617	78	78	0	
U677*	33	33	0	
R158*	22	23	-1	What is a scientific theory
U671	39	31	-1	
U672*	18	19	-1	
U632*	47	66	-19	
U665*	51	70	-19	
R147*	49	68	-19	To test an idea, try it
U624*	54	73	-19	
U629*	50	69	-19	
U675*	56	75	-19	
U633*	46	65	-19	
R120*	53	72	-19	Transfer of momentum between objects
U634*	44	63	-19	
R109	66	86	-20	Rocks on Earth's surface are solid
U618*	57	77	-20	
R152	33	53	-20	Because of vaccinations few people get smallpox
R150*	35	55	-20	From chart--sodium is least common in human body
U667*	43	63	-20	
U616*	60	80	-20	
U661	67	87	-20	
U611*	67	87	-20	
U639*	33	54	-21	
R123*	44	66	-22	What scientists learn from fossils
R116*	57	79	-22	Mushrooms do not have green leaves
U668*	41	63	-22	

*Exercises also identified as atypical before balancing.

Note: The --- line separates atypically high from atypically low exercises.

Adapted from NAEP, 1973

Table B
Exercises Showing Atypical Effects, Balanced
for Black Americans, Age 13

Exercise #	% Correct Black american	% Correct Nat'l	% Difference	Content
R247*	10	7	3	Do you often question things in nature
U774*	20	19	1	
U747*	8	8	0	
U741*	34	34	0	
U775*	5	5	0	
R222*	38	38	0	By natural selection, why giraffes have long necks
U769*	66	66	0	
U767*	89	89	0	
R237*	34	35	-1	Time a pendulum's swings
R243*	67	68	-1	Measurements in science: close not identical
U729*	50	51	-1	
U766	9	11	-2	
R217*	46	48	-2	Burning gasoline in a car creates heat
R202*	96	98	-2	Why brush your teeth
R203*	90	92	-2	Thick, dark clouds bring rain
U709*	61	80	-19	
U750*	60	79	-19	
R241	60	79	-19	Mathematics a useful skill in science
R234*	43	62	-19	Balance beam--weight in pan; weight on hook
U754*	44	63	-19	
R205*	66	85	-19	Comfortable temperature: 70°F
R236*	40	60	-20	From chart--determine dog's food ration
R212*	38	59	-21	Movement of air masses predicts weather
U707*	63	84	-21	
R214*	33	54	-21	Counterbalancing unequal weights on beam
R206*	57	78	-21	Why fan a campfire
U717*	41	63	-22	
U760*	19	42	-23	
U758*	26	49	-23	
U759*	23	47	-24	
U727*	27	53	-26	

Table B (continued)

Table B (continued)

Exercise #	% Correct Black American	Nat'l	% Difference	Content
U753*	43	69	-26	
R213*	30	57	-27	Radio waves least upset plant and animal life
R233*	43	70	-27	From chart--compare guinea pig weights
R215*	24	52	-28	Flower seeds develop from ovules

*Exercises also identified as atypical before balancing.

Note: The - - -line separates atypically high from atypically low exercises.

Note. Adapted from NAEP, 1973

Table C
Exercises Showing Atypical Effects, Balanced,
for Black Americans, Age 17

Exercise #	% Correct Black American	% Correct Nat'l	% Difference	Content
U341*	36	19	17	
R322*	56	48	8	Efficient use of food can cause overweight
U835*	33	26	7	
R332*	24	20	4	How scientists determine rock age
U843*	18	15	3	
U856*	42	60	-18	
U855*	43	62	-19	
U813*	48	67	-19	
U811*	52	71	-19	
R312*	40	59	-19	Unaided eye detects certain wavelengths of light
U809*	51	72	-21	
U816*	37	60	-23	
R316*	29	53	-24	Adrenalin is a stimulant to the heart
R309*	41	65	-24	Who proposed natural selection in evolution
R305*	52	76	-24	Movement of air masses predicts weather
R344*	30	55	-25	Time a pendulum's swings
R340*	54	79	-25	Which weight experiment gives strongest evidence
R341*	49	74	-25	Balance beam--weight in pan; weight on hook
U820*	29	56	-27	
U852*	40	73	-33	

*Exercises also identified as atypical before balancing.

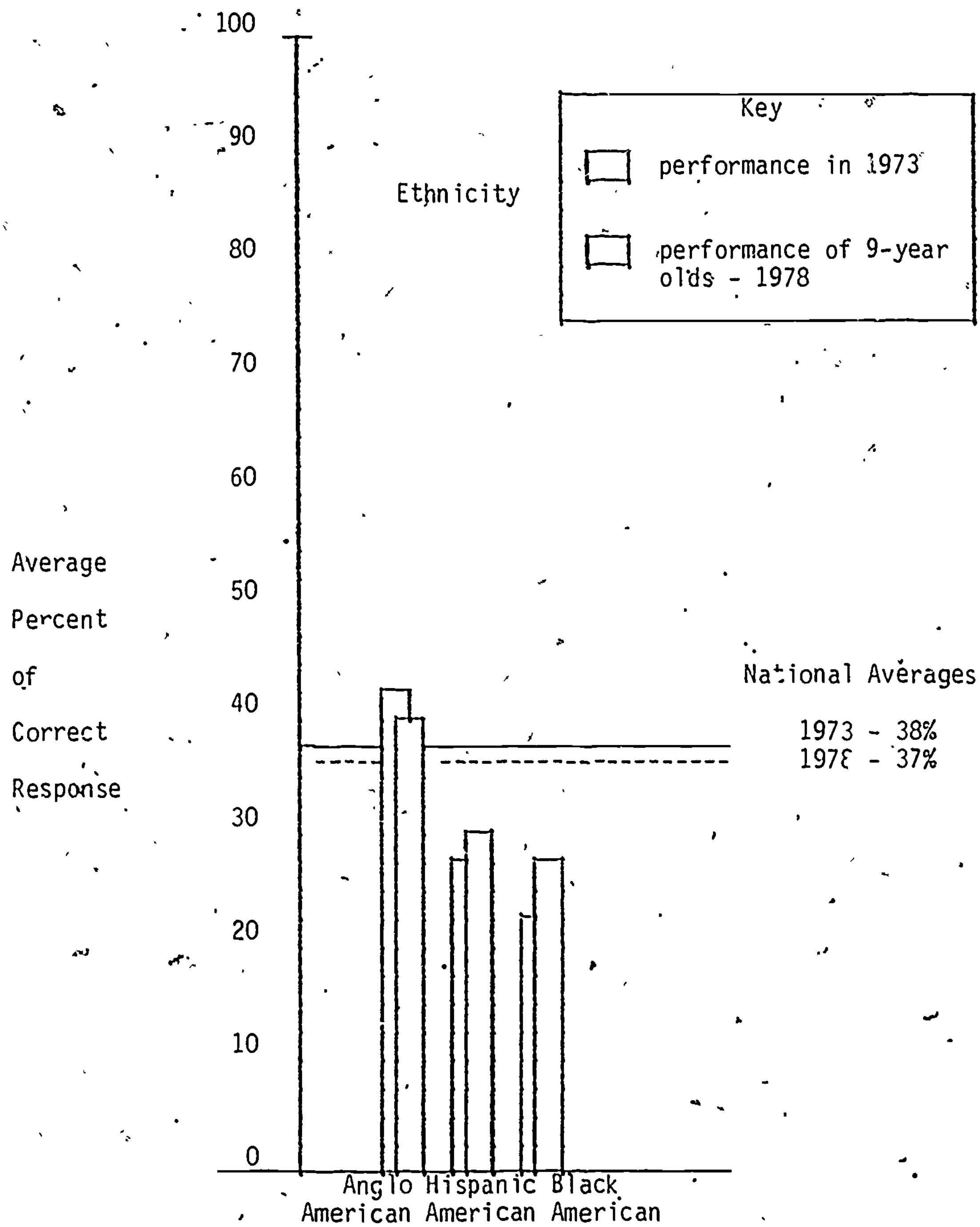
Note: The - - -line separates atypically high from atypically low exercises.

Note. Adapted from NAEP, 1973

APPENDIX B

Selected Test Results from the National Assessments of Educational Progress in Mathematics

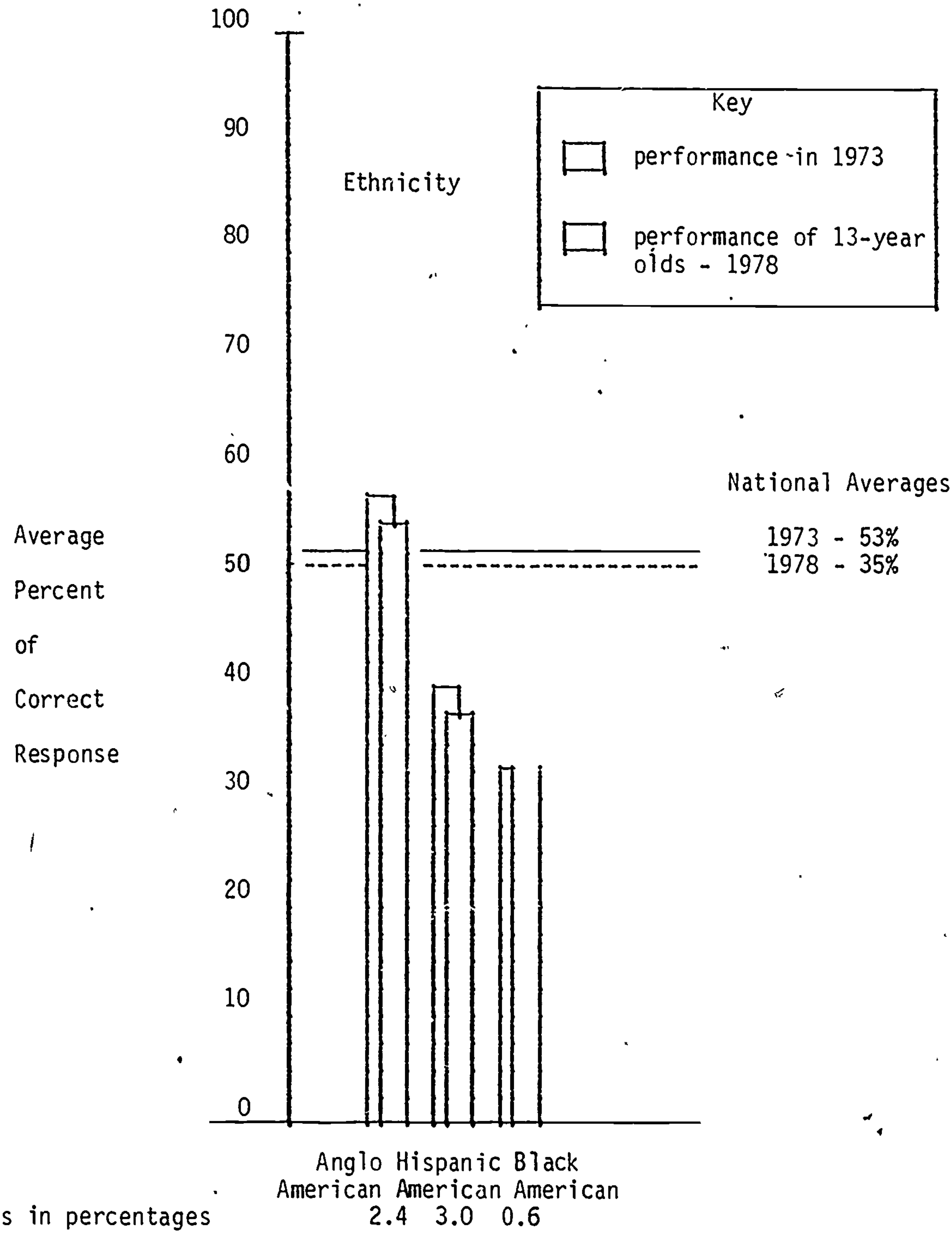
Figure C
Average Percentages of Correct Responses for
Selected Reporting Groups on Mathematics Items--1973 and 1978, Age 9



Changes in percentages 2.0 0.6 2.9

Note. Adapted from NAEP, 1979

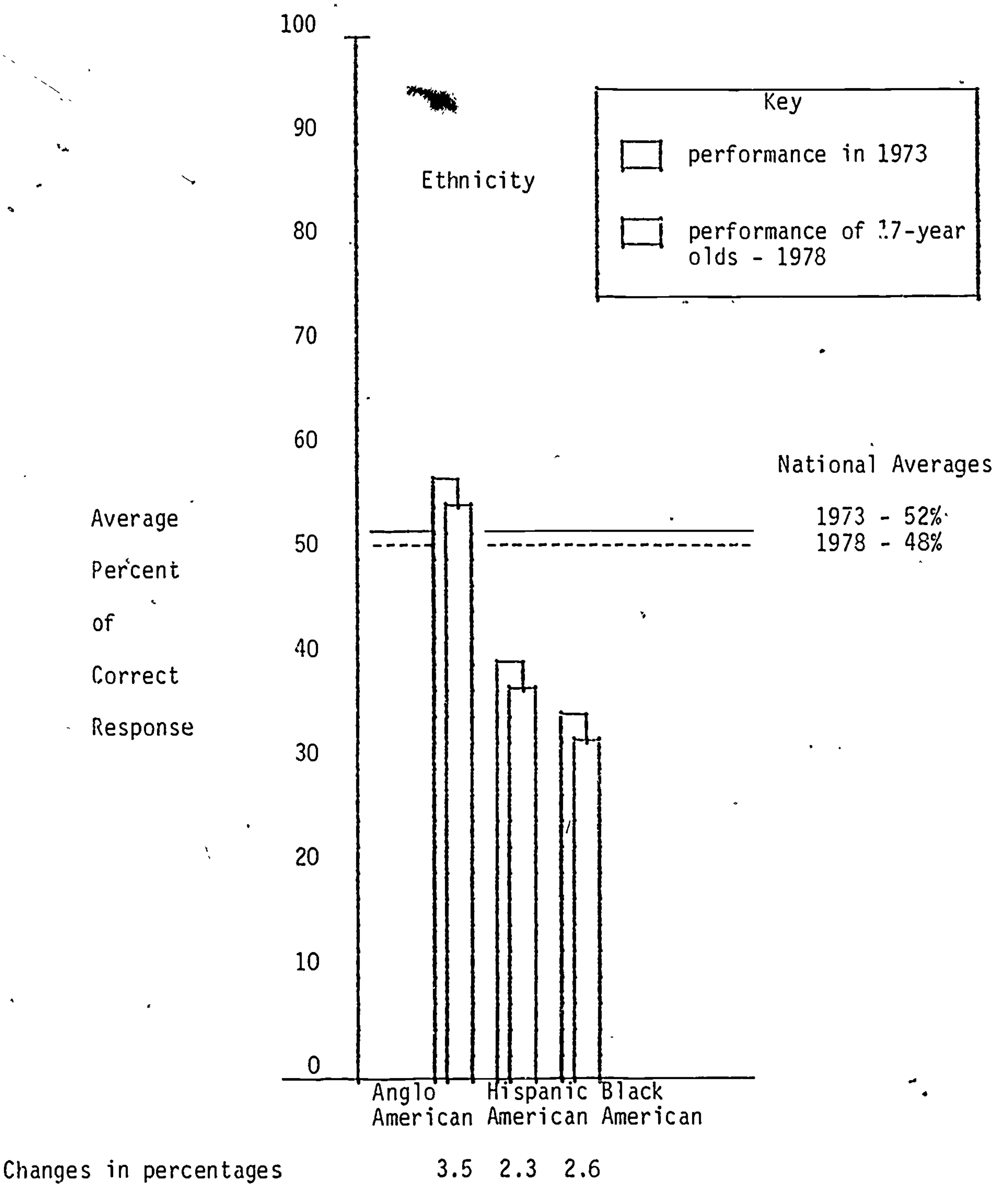
Figure D
Average Percentages of Correct Responses for
Selected Reporting Groups on Mathematics Items--1973 and 1978, Age 13



Changes in percentages 2.4 3.0 0.6

Note. Adapted from NAEP, 1979.

Figure E
Average Percentages of Correct Responses for
Selected Reporting Groups on Mathematics Items--1973 and 1978, Age 17



Note. Adapted from NAEP, 1979

Table D
Black American and Anglo American Median Differences from National Performance by Content Area

	Age 9	Age 13	Age 17	Adult
Overall				
Black American	-12.9	-18.5	-21.0	-24.5
Anglo American	2.9	3.9	4.0	3.9
Number of exercises summarized	(163)	(211)	(245)	(179)
Numbers & numeration				
Black American	-14.9	-17.9	-20.8	-22.8
Anglo American	3.3	3.7	4.3	3.2
Number of exercises summarized	(74)	(86)	(74)	(44)
Measurement				
Black American	-17.0	-22.2	-24.3	-25.4
Anglo American	3.6	4.1	4.9	4.3
Number of exercises summarized	(35)	(35)	(29	(29)
Geometry				
Black American	-5.6	-19.8	-22.6	-23.7
Anglo American	1.3	3.9	4.0	4.0
Number of exercises summarized	(39)	(37)	(37)	(29)
Variables & relationships				
Black American	*	-18.3	-17.5	-22.6
Anglo American		4.0	3.4	3.4
Number of exercises summarized		(28)	(50)	(21)
Probability & statistics				
Black American	*	*	-12.7	-16.5
Anglo American			2.4	2.7
Number of exercises summarized			(17)	(21)
Consumer math	*	-21.0	-22.3	-25.6
Black American		5.2	4.0	4.2
Anglo American		(14)	(34)	(41)
Number of exercises summarized				

* There were not enough exercises in this content area for a meaningful summary.

Note. Adapted from NAEP, 1975

Table E
Group Differences from the Nation on
Mathematical Understanding of Items

Average Group Differences from the Nation for Understanding Items--Ages 9, 13, & 17

	Age 9	Age 13	Age 17
Number of items	44	108	105
National percentage	39.6	51.7	58.0
Ethnicity			
Anglo American	2.3*	3.0*	3.0*
Black American	-10.3*	-14.8*	-17.4*
Hispanic American	-8.2*	-11.8*	-13.8*

Note. Adapted from NAEP, 1979.

Table F
Group Differences from the Nation for Various Sets of Mathematical Knowledge and Skills Items, Age 9

	All Know-ledge Items	All Skills Items	Compu-tation Items	Measure-Ment Items	Read Graphs Tables Items	Geo-metric Manipu-lation Items	Alge-braic Manipu-lation Items
Number of Items	161	137	48	30	16	15	19
National Percentage	65.9	43.3	35.4	52.9	58.9	44.4	39.4
Ethnicity							
Anglo American	2.4*	2.3*	1.9*	2.5*	3.3*	2.3*	2.4*
Black American	-11.0*	-10.8*	-8.8*	-11.3*	-15.2*	-10.8*	-11.8*
Hispanic American	-9.2*	-7.9*	-6.1*	-9.6*	-11.4*	-7.3*	-7.4*

Note. Adapted from NAEP, 1979

Table G
Group Differences from the Nation for Various Sets of Mathematical Knowledge and Skills Items, Age 13

	All Knowledge Items	All Skills Items	Computation Items	Measurement Items	Read Graphs Tables Items	Geometric Manipulation Items	Algebraic Manipulation Items	Estimation Items
Number of Items	147	272	129	32	27	19	43	22
National Percentage	66.9	51.9	51.7	54.8	68.8	45.8	52.2	32.8
Ethnicity								
Anglo American	2.9*	3.3*	3.3*	4.1*	3.3*	2.4*	3.8*	2.4*
Black American	-14.0*	-16.8*	-16.4*	-21.2*	-16.6*	-12.4*	-18.6*	-12.9*
Hispanic American	-10.9*	-12.0*	-12.5*	-13.2*	-11.4*	-6.4*	-14.0*	-8.2*

Note. Adapted from NAEP, 1979.

Table H
Group Differences from the Nation for Various Sets of Mathematical Knowledge and Skills Items, Age 17

	All Knowledge Items	All Skills Items	Computation Items	Measurement Items	Read Graphs Tables Items	Geometric Manipulation Items	Algebraic Manipulation Items	Estimation Items
Number of Items	140	273	127	21	29	15	59	22
National Percentage	71.7	59.0	67.2	56.7	72.6	54.8	40.0	49.6
Ethnicity								
Anglo American	2.6*	2.9*	2.9*	3.7*	2.9*	3.1*	2.5*	3.3*
Black American	-15.5*	-17.6*	-17.6*	-23.5*	-16.6*	-18.9*	-14.9*	-19.5*
Hispanic American	-11.8*	-12.0*	-12.3*	-13.2*	-10.8*	-13.0*	-11.5*	-11.6*

Note. Adapted from NAEP, 1979

Table I
Group Differences from the Nation for Various Sets of Mathematics Application Items, Age 9

	All Application Items	One-Step Word Problems	Consumer Problems
Number of items	44	18	7
National percentage	37.7	44.4	32.7
Ethnicity			
Anglo American	2.4*	3.0*	1.9*
Black American	-10.7*	-14.3*	-9.8*
Hispanic American	-8.2*	- 8.8*	-5.9*

Note. Adapted from NAEP, 1979.

Table J
Group Differences from the Nation for Various Sets of Mathematical Application Items, Age 13

	All Application Items	One-Step Word Problems	Consumer Problems	Multi-Step Problems	Graph Table Problems	Geometry Problems	Probability & Statistics problems	Reasoning & Judgment Problems
Number of Items	106	27	20	13	13	13	11	13
National Percentage	43.3	52.1	44.5	36.8	55.3	25.9	32.5	61.2
Ethnicity								
Anglo American	2.8*	3.6*	3.1*	2.7*	3.9*	1.2*	2.4*	2.4*
Black American	-13.7*	-18.4*	-14.9*	-12.6*	-19.6*	- 6.3*	-10.8*	-11.0*
Hispanic American	-10.5*	-12.6*	-12.2*	-11.6*	-13.5*	-3.8*	-11.0*	-9.9*

Note. Adapted from NAEP, 1979.

Table L
Group Differences from the Nation for Various Sets of Mathematical Application Items, Age 17

	All Application Items	One-Step Word Problems	Consumer Problems	Multi-Step Problems	Graph & Table Problems	Geometry Problems
Number of Items	136	20	33	30	15	18
National Percentage	43.5	57.1	37.0	35.1	63.2	36.8
Ethnicity						
Anglo American	3.0*	3.6*	2.9*	3.2*	3.9*	2.5*
Black American	-17.8*	-21.7*	-17.7*	-19.2*	-22.3*	-15.9*
Hispani American	-12.1*	-13.2*	-11.0*	-12.6*	-16.9*	-11.5*

	Measurement Problems	Perimeter Area Volume Problems	Probability and Statistics Problems	Reasoning & Judgment Problems	Non-Routine Problems
Number of Items	13	9	13	12	10
National Percentage	33.1	26.2	25.5	64.4	40.5
Ethnicity					
Anglo American	3.2	2.8	2.0	2.1	2.9
Black American	-19.7*	-17.4*	-12.0*	-11.8*	-17.1*
Hispanic American	-12.2*	-12.5*	-6.9*	-9.7*	-12.5*

Note. Adapted from NAEP, 1979

References

Adenike, T. J., & Berry, G. L. Teachers' attitudes toward the education of the Black child. Education, 1976, 97, 102-114.

Angel, J. L. The new Medical College Admission Test: New dimensions in assessment. In V. L. Melnick & F. D. Hamilton (Eds.), Minorities in science: The challenge for change in biomedicine. New York: Plenum Press, 1977.

Avellar, J., & Kagan, S. Development of competitive behaviors in Anglo American and Mexican American children. Psychological Reports, 1976, 39, 191-198.

Bar-Tal, D. Attributional analysis of achievement-related behavior. Review of Educational Research, 1978, 48, 259-271.

Bar-Tal, D., Kfir, D., Bar-Zohar, Y., & Chen, M. The relationship between locus of control and academic achievement, anxiety, and level of aspiration. British Journal of Educational Psychology, 1980, 50, 53-60.

Battle, E. S., & Rotter, J. B. Children's feelings of personal control as related to social class and ethnic group. Journal of Personality, 1963, 31, 482-490.

Baugh, L. J. Locus of control and problem solving. Dissertation Abstracts International, 1973, 33, 4499B.

Backman, M. E. Patterns of mental abilities: Ethnic, socio-economic and sex differences. American Educational Research Journal, 1972, 9, No. 1, 1-12.

Begle, E. G. Learning correlates for Mexican American students. Dept. of H.E.W., SMSG Research and Analysis Section, 1972.

Beilin, H., & Golkin, L. G. Psychological issues in the development of mathematics curricula for socially disadvantaged children. SMSG, 1969.

Bernal, E. M. Concept learning among Anglo, Black, and Mexican American children using facilitation strategies and bilingual techniques. (Doctoral dissertation, University of Texas at Austin, 1971). Dissertation Abstracts International, 1971, 32, 6180A.

Bloom, B. S. (Ed.). Taxonomy of educational objectives: The classification of educational goals: Handbook I: Cognitive Domain. New York: David McKay Co., Inc., 1956.

Bloom, S. Peer and cross-age tutoring in the schools: An individualized supplement to group instruction. Washington, D.C.: National Institute of Education, 1976.

Breland, H. et al. Cross-cultural stability mental test items: An investigation of response patterns for 10 socio-economic groups, Final Report. Educational Testing Service, Princeton, N.J., 1974.

Brisset, T. M., & Nowicki, S. Internal versus external control of reinforcement and reaction to frustration. Journal of Personality and Social Psychology, 1973, 25, 35-44.

Brooks, L. Developing communication skills and program strategies in career guidance for ethnic minorities. University of Michigan, 1976. (ERIC Document Reproduction Service No. ED 140 204)

Brooks, S. M., & Hounshell, P. B. A study of locus of control and science achievement. Journal of Research in Science Teaching, 1975, 12, 175-181.

Brown, G. H., Rosen, N. L., Hill, S. T., & Olivas, M. A. The condition of education for Hispanic Americans. Washington, D.C.: National Center for Educatinal statistics, 1980. (ERIC Document Reproduction Service No. ED 188 853).

Bureau of the Census. Statistical Abstract of the United States. Washington, D.C.: U.S. Department of Commerce, 1979.

Burow, E. D. The relationship among secondary science students' locus of control, views of the tentativeness of science, attitudes, perceptions of teaching strategies, and achievements. (Doctoral Dissertation, University of Southern Mississippi, 1978). Dissertation Abstracts International, 1978, 39, 2165A.

Butterfield, E. C. Locus of control, test anxiety, reactions to frustration, and achievement attitude. Journal of Personality, 1964, 32, 355-370.

Cardell, G. W., Cross, W. C., & Lutz, W. J. Extending counselor influence into the classroom. Journal of American Indian Education, January, 1978, 17(2), 7-12.

Carpenter, T. P., Coburn, T. G., Reys, R. E., & Wilson, J. W. Results and implications of the NAEP mathematics assessment: Secondary school. Mathematics Teacher, October 1975, 453-470.

Castaneda, A., Ramirez, M. III, & Herold, P. Culturally democratic learning environments: A cognitive styles approach. Multi-lingual Assessment Project. Riverside, California: Systems and Evaluations in Education, 1972.

Claiborn, W. L. Expectancy effects in the classroom: A failure to replicate. Journal of Educational Psychology, 1969, 60, 377-383.

Clifford, M. M., & Cleary, T. A. The relationship between children's academic performance and achievement accountability. Child Development, 1972, 43, 647-655.

Coffland, J. A., & Cuevar, G. J. Math concept learning by Spanish-speaking children: Progress Report no. 1. National Institute of Education, Washington D.C., 1977.

Coleman, J. S., Campbell, E. Q., Hobson, C. J., Partland, J., Mood, A. M., Weinfeld, F. P., & York, R. L. Equality of Educational Opportunity. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1966.

Crandall, V. C., & Katkovsky, W. Parental antecedents of one motivational determinant of intellectual achievement behavior. Washington, D.C.: U.S. Department of Health, Education, and Welfare, 1967. (ERIC Document Reproduction Service No. ED 020 223).

Dallas Independent School District. Abstracts of research and evaluation reports, 1974-1975. Dallas, Texas: Department of Research, Evaluation, and Information Systems, December 1975.

Davidson, H. H., & Lang, G. Children's perceptions of their teachers' feelings toward them related to self-perception, school achievement and behavior. Journal of Experimental Education, 1960, 29, 107-118.

DeFries, J. C., Vandenberg, S. G., McClearn, G. E., Kuse, A. R., Wilson, J. R., Ashton, G. C., & Johnson, R. C. Near identity of cognitive structure in two ethnic groups. Science, 1974, 183, 338-339.

DeFries, J. C., Ashton, G. C., Johnson, R. C., Kuse, A. R., McClearn, G. E., MI, M. P., Rashad, M. N., Vandenberg, S. G., & Wilson, J. R. Parent-offspring resemblance for specific cognitive abilities in two ethnic groups. Nature, 1976, 261, 131-133.

Demmert, William G., Jr. Young Native Americans and their families: Educational needs assessment and recommendations. United States Bureau of Indian Affairs, 1976.

DeRose, J. V., Lockard, J. D., & Paldy, L. G. The teacher is key: A report on three NSF studies. Science and Children, 1979, 17(7), 35-41.

Directorate for science education. Science education databook. Washington, D.C.: National Science Foundation, 1980.

Doane, B. S. The effects of homework and locus of control on arithmetic skills achievement in fourth grade students. Dissertation Abstracts International, 1973, 33, 5548A.

DuCette, J., Wolk, S., & Friedman, S. Locus of control and creativity in black and white children. Journal of Social Psychology, 1972, 88, 297-298.

Dusek, J. B. Do teachers bias children's learning? Review of Educational Research, 1975, 45, 661-684.

Eash, M. J., & Rasher, S. P. Mandated desegregation and improved achievement: A longitudinal study. Phi Delta Kappan, 1977, 58, 394-397.

Erlick, A. C. & LeBold, W. K. Factors influencing the science career plans of women and minorities (supplementary report of poll no. 101 of the Purdue Opinion Panel). West Lafayette, Indiana: Purdue University, April 1977. (ERIC Document Reproduction Service No. ED 180 747)

Fish, B., & Karabenick, S. A. Relationship between self-esteem and locus of control. Psychological Reports, 1971, 29, 784.

Fry, P. S., & Ghosh, R. Attributions of success and failure. Comparison of cultural differences between Asian and Caucasian children. Journal of Cross Cultural Psychology, 1980, 11, 343-363.

Gallagher, J. J. Secondary science teacher education: Where are we going? Science Education, 1974, 58, 223-229.

Ginther, J. R. Pretraining Chicano students before administration of a mathematics predictor test. Journal for Research in Mathematics Education, 1972, 9, no. 2, 118-125.

Gottlieb, D. Teaching and students: The views of Negro and White teachers. Sociology of Education, 1964, 37, 345-353.

Graham, P. A. Whither equality of educational opportunity? Daedalus, 1980, 109, 115-132.

Green, R. Recommendations for the improvement of science and mathematics education for American Indians. Unpublished paper, December, 1976.

Green, R. L. Poverty, race, and the pursuit of excellence. Phi Delta Kappan, 1978, 60, 198S-200S.

Green, R., Brown, J. W., & Long, R. Report and recommendations: Conference on Mathematics in American Indian Education (A report of the Project on Native Americans in Science). American Association for the Advancement of Science Office of Opportunities in Science, February 1978.

Hale, F. W., Jr. An agenda for excellence: You can make the difference. Phi Delta Kappan, 1978, 60, 204S-206S.

Holtzman, E., Goldsmith, R., & Barrera, C. Field-dependence and field-independence: Educational implications for bilingual education, Dissemination and Assessment Center for Bilingual Education, 1979.

Hountras, P. T. & Scharf, M. C. Manifest anxiety and locus of control of low-achieving college males. Journal of Psychology, 1970, 74, 95-100.

Ignatz, M. G. Low Black enrollment in chemistry and physics courses. Science Education, 1975, 4, 571-573.

Jackson, G., & Cosca, C. The inequality of educational opportunity in the Southwest: An observational study of ethnically mixed classrooms. American Educational Research Journal, 1974, 11, 219-229.

Jay, J. Black Americans in the sciences. In V. L. Melnick, & F. D. Hamilton (Eds.), Minorities in science: The challenge for change in biomedicine. New York: Plenum Press, 1977.

Jensen, A. R., How much can we boost IQ and scholastic achievement?" Harvard American Educational Research Journal, 1968, 5, 23.

Joe, V. C. Review of the internal-external control construct as a personality variable. Psychological Reports, 1971, 28, 619-640.

Jose, J., & Cody, J. J. Teacher-pupil interaction as it relates to attempted changes in teacher expectancy of academic ability and achievement. American Educational Research Journal, 1971, 8, 39-49.

Kagan, S., & Madsen, M.C. Cooperation and competition of Mexican, Mexican-American, and Anglo-American children of two ages under four instructional sets. Developmental Psychology, 1971, 5, 32-39.

Kagan, S., & Madsen, M. C. Experimental analyses of cooperation and competition of Anglo-American and Mexican children. Developmental Psychology, 1972, 6, 49-59

Kagan, S., and Zahn, G. L. Field dependence and the school achievement gap between Anglo-American and Mexican-American children. Journal of Educational Psychology, 1975, 67, no. 5, 643-650.

Kahle, J. B. An analysis of minority attitudes toward science from the 1976-77 National Assessment of Science results. In National assessment of educational progress. Attitudes toward science: A summary of results from the 1976-77 National Assessment of Science (Report No. 08-S-02). Denver: Education Commission of the States, October 1979.

Kahle, J. B., Nordland, F. H., & Douglass, C. B. An analysis of an alternative instructional model for disadvantaged students. Science Education, 1976, 60, 237-243.

Kamin, L. Presentation denying that proof exists that IQ test scores are hereditary - Transcripts from the Southern-Regional Council's Symposium on Human Intelligence, Social Science, and Social Policy. South Today, 1973, 4, nos. 8 & 9.

Kleinfeld, J. Intellectual strengths in culturally different groups: an Eskimo illustration. Review of Educational Research, 1973, 43, no. 3. 341-360.

Lawson, A. E., Nordland, F.H., & Kahle, J. B. Levels of intellectual development and reading ability in disadvantaged students and the teaching of science. Science Education, 1975, 59, 113-125.

Lefcourt, H. M. Internal versus external control of reinforcement: A review. Psychological Bulletin, 1966, 65, 206-220.

Lefcourt, H. M. Locus of control: Current trends in theory and research. Hillsdale, N.J.: Lawrence Erlbaum Associates, Publishers, 1976.

Leon, G. R. Personality change in the specially admitted disadvantaged student after one year in college. Journal of Clinical Psychology, 1974, 30, 522-528.

Loeb, R. C. Concomitants of boy's locus of control examined in parent child interactions. Developmental Psychology, 1975, 11, 353-358.

Maestas, S. Sociocultural factors as a deterrent to students' pursuit of the sciences. In V. L. Melnick, & F. D. Hamilton (Eds.), Minorities in science: The challenge for change in biomedicine. New York: Plenum Press, 1977.

Martinez, J. V. Spanish-surnamed Americans in science: Availability and barriers. In V .L. Melnick, & F. D. Hamilton (Eds.), Minorities in science: The challenge for change in biomedicine. New York: Plenum Press, 1977.

McClintock, C. G Development of social motives in Anglo-American and Mexican-American children. Journal of Personality and Social Psychology, 1974, 29, 348-354.

McDermott, L. C., Piternick, L. K., & Rosenquist, M. L. Helping minority students succeed in science. Development of a curriculum in physics and biology. Journal of College Science Teaching, 1980, 9, 135-140. (a)

McDermott, L. C., Piternick, L. K., & Rosenquist, M. L. Helping minority students succeed in science. Implementation of a curriculum in physics and biology. Journal of College Science Teaching, 1980, 9, 201-205. (b)

McDermott, L. C., Piternick, L. K., & Rosenquist, M. L. Helping minority students succeed in science III. Requirements for the operation of an academic program in physics and biology. Journal of College Science Teaching, 1980, 9, 261-265. (c)

McGee, M. Human spatial abilities: Psychometric studies and environmental, genetic, hormonal, and neurological influences. Psychological Bulletin, 1979, 86, 889-918.

McGhee, P. E., & Crandall, V. C. Beliefs in internal-external control of reinforcements and academic performance. Child development, 1968, 39, 91-102.

McMillan, J. H. Effect of instructional procedure and pupil locus of control on achievement and attitudes. Psychology in the Schools, 1980, 17, 123-127.

Mead, M. & Metraux, R. Image of the scientist among high-school students. Science, 1957, 126, 384-390.

Mercer, J. R. Implications of current assessment procedures for Mexican-American children. Bilingual Education Paper Series, National Dissemination and Assessment Center, 1, No. 1, August 1977.

National Advisory Committee on Mathematical Education. Overview and Analysis of School Mathematics Grades K-12. Conference Board of the Mathematical Sciences, 1975.

National Assessment of Educational Progress. The first national assessment of mathematics: An overview. Education Commission of the States, 1975, Report no. 04-MA-00.

National Assessment of Educational Progress. Math Fundamentals: Selection results from the first national assessment of mathematics' Education Commission of the States, 1975, Report no. 04-MA-01.

National Assessment of Educational Progress. Three National assessments of science: changes in achievement, 1969-1977. Selected results from the third national assessment of science (Science Report No. 08-s-00). Denver, Colorado: Education Commission of the States, June, 1978. (a) (ERIC Document Reproduction Service No. ED 159 026)

National Assessment of Educational Programs. Science group and balanced group results for color, parental education, size, and type of community, 1973, Report No. 7.

National Assessment of Educational Progress. Science achievement in the schools: A summary of results from the 1976-77 national assessment of science (Science Report No. 08-s-01). Denver, Colorado: Education Commission of the States, December 1978. (b) (ERIC Document Reproduction Service No. ED 164 337)

National Assessment of Educational Progress. Changes in mathematical achievement, 1973-78: Results from the second assessment of mathematics. Education Commission of the States, 1979 Report no 09-MA-0 (a)

National Assessment of Educational Progress. Mathematical knowledge and skills: Selected results from the second assessment of mathematics. Education Commission of the States, 1979, Report no 09-MA02. (b)

National Assessment of Educational Progress. Mathematical application selected results from the second assessment of mathematics. Education Commission of the States, 1979, Report no. 09-MA-03. (c)

National Assessment of Educational Progress. Mathematical understanding selected results from the second assessment of mathematics. Education Commission of the States, 1979, Report no. 09-MA-02. (d)

National Council of Teachers of Mathematics. The slow learner in mathematics: Thirty-fifth yearbook. National Council of Teachers of Mathematics, 1972.

Nowicki, S., Jr., & Roundtree, J. Correlates of locus of control in a secondary school population. Developmental Psychology, 1971, 4, 477-478.

Okada, T., Cohen, W. M., & Mayeske, G. W. Growth in achievement for different racial, regional and socioeconomic groupings of students. Office of Education, U.S. Department of Health, Education, and Welfare, 1969, Technical Paper no. 1.

Olesini, J. The effect of bilingual instruction on the achievement of elementary pupils. (Doctoral dissertation, East Texas State University, Dissertation Abstracts International, 1971, 32, 4844A.

Parent, J., Forward, J., Canter, R., & Mohling, J. Interactive effects of teaching strategy and personal locus of control on student performance and satisfaction. Journal of Educational Psychology, 1975, 67, 764-769.

Powell, A., & Vega, M. Correlates of adult locus of control. Psychological Reports, 1972, 30, 455-460.

Powell, A., & Centa, D. Adult locus of control and mental ability. Psychological Reports, 1972, 30, 829-830.

Ramirez, M., III, & Price-Williams, D. Cognitive styles of children of three ethnic groups in the United States. Journal of Cross-Cultural Psychology, 1974, 5, 212-219.

Ramirez, M. III, Castaneda, A., & Herold, P. The relationship of acculturation to cognitive style among Mexican-Americans. Journal of Cross-Cultural Psychology, 1974, 5, No. 4, 424-433.

Ray, W. J., & Katahn, M. Relation of anxiety to locus of control. Psychological Reports, 1968, 23, 1196.

Rist, R. C. Student social class and teacher expectations: The self-fulfilling prophecy in ghetto education. Harvard Educational Review, 1970, 40, 411-451.

Rosenthal, R. S., & Jacobson, L. Teachers' expectancies: Determinants of pupils' IQ gains. Psychological Reports, 1966, 19, 115-118.

Rossi, A. Women in science: Why so few? Science, 1965, 148, 1196-1202.

Rotter, J. B. Social learning and clinical psychology. New York: Prentice-Hall, Inc., 1954.

Rotter, J. B. Generalized expectations for internal versus external control of reinforcement. Psychological Monographs, 1966, 80 (1, Whole No. 609).

Roueche, J. E., & Mink, O. G. Impact of instruction and counseling on high risk youth. Austin, Texas: The University of Texas at Austin, 1976. (ERIC Document Reproduction Service No. ED 133 000)

Rowe, M.B. Teaching science as continuous inquiry. New York: McGraw-Hill, 1973.

Rowe, M. B. Wait-time and rewards as instructional variables, their influence on language, logic, and fate control: Part one--wait-time. Journal of Research in Science Teacher, 1974, 11, 81-94 (a).

Rowe, M. B. Relation of wait-time and rewards to the development of language, logic, and fate control: Part II--Rewards. Journal of Research in Science Teaching, 1974, 11, 291-308 (b).

Rowe, M. B. Why don't Blacks pick science? The Science Teacher, 1977, 44, 34-35.

Samuda, R. J. Racial discrimination through mental testing: A social critic's point of view. IRCD Bulletin, 1973, no. 42, 1-17.

Scarr-Salapatek, S. Race, social class, and I.Q. Science, 1971, 174, 1285-1295.

Schnur J. O. A study of the possible improvement of problem solving ability in migrant children. School Science and Mathematics, 1969, 69, no. 9, 821-826.

Sigel, I., & Coop, R. Cognitive style and classroom practice. In R. H. Coop, & K. White (Eds.), Psychological Concepts in the Classroom. New York: Harper & Row, 1974, 250-275.

Sibatani, A. The Japanese brain. Science 80, 1980, 1 (8), 22-26.

Simpson, R. D. Breeding success in science. The Science Teacher, 1979, 46(8), 24-26.

Skypek, D. H. B., Lee, E. C., & Cox, M. K. A study of factors that influence women and Blacks in science career choice and stability. Atlanta, Georgia: Emory University, Division of Educational Studies. (An unpublished paper).

Stanford Mathematics Education Study Group. Test factor, institution programs, and socio-économic factors related to mathematics achievement of Chicano students: a review. Stanford University, California, 1975.

Stodolsky, S. S., & Lesser, G. S. Learning Patterns in the disadvantaged. Harvard Educational Review, Fall 1967, 37, no. 4, 546-5 ..

Tolor, A., & LeBlanc, R. F. Personality correlates of alienation. Journal of Consulting and Clinical Psychology, 1971, 37, 444.

Trachtman, J. P. Cognitive and motivational variables as predictors of academic performance among disadvantaged college students. Journal of Counseling Psychology, 1975, 22, 324-328.

Trevino, A. G: An analysis of the effectiveness of a bilingual program in the teaching of mathematics in the primary grades. Ph.D. disser tation, University of Texas at Austin. Dissertation Abstracts International,

1968.

Vasquez, J .A. Motivation and Chicano students. Bilingual Resources, 1979, 2(2), 2-5.

Vetter, B. New data show uneven progress for women and minorities in science. Science, 1978, 202, 507-508.

Watson, D. Relationship between locus of control and anxiety. Journal of Personality and Social Psychology, 1967, 6, 91-92.

Weinberg, Meyer. Minority students: A research appraisal. U.S. Department 1977.

Weiner, B., Heckhausen, H., Meyer, W., & Cook, R. E. Causal ascriptions and achievement behavior: A conceptual analysis of effort and reanalysis of locus control. Journal of Personality and Social Psychology, 1972, 21, 239-248.

Welsh, J. F. The Coleman report. Educational Research, 1967, July, 8-9.

Wickersham, P. H. Classroom interaction patterns: Differential effects and relationships between sixth grade children's self-concepts and locus of control of reinforcements. Dissertation Abstracts International, 1971, 32, 804A.

Witkin, H., Moore, C., Goodenough, D., & Cox, P. Field-dependent and field-independent cognitive styles and their educational implications. Review of Educational Research, Winter, 1977, 1-64.

Williams, H. Science-prep class helps minority students over big hurdle. The Seattle Times, December 21, 1980, p. B16.

Zellner, R. D., & Wisner, R. H. A comparison of Anglo-American and Mexican-American student performances on measures of classification and transitivity. Paper presented at Annual Meeting of the American Educational Research Association, 1977.