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ABSTRACT

Although minority students have experienced substantial increases in science performance on standardized tests, there is still a large disparity between minority and majority students on science achievement tests for males and females. This study examined science achievement for similarities and differences by gender and race/ethnicity. Using the National Assessment of Educational Progress (NAEP) science proficiency data for 1990, the study focused on average proficiency scores in four science content areas of nationally representative samples of 9-, 13-, and 17-year-old African-American, Hispanic, and White students. The early male advantage in physical science and in earth and space sciences became more substantial with age. Females were favored in the science of nature across all age groups. White students outperformed Hispanic Americans across content area and age group, but the largest gap in mean proficiency scores was between White and African American students, at nearly 55 points at age 17. A more in-depth look at the factors that cause these differences needs to be undertaken. An appendix presents three tables of study findings. (Contains 8 references.) (SLD)

GENDER AND ETHNIC DIFFERENCES IN SCIENCE ACHIEVEMENT OF NINE-, THIRTEEN-, AND SEVENTEEN-YEAR-OLD STUDENTS

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Gender and Ethnic Differences in the Science Achievement of Nine-, Thirteen-, and Seventeen-Year Old Students

Abstract

Low achievement in science is evidenced by poor performance on standardized assessments particularly by minority students. Although minority students have experienced substantial increases in science performance, there is still a large disparity between minority and majority students on science achievement tests. This is true for females as well. This study examines science achievement for similarities and differences by gender and race/ethnicity. Using the National Assessment of Education Progress (NAEP) science proficiency data for 1990, this study focused on students' average proficiency scores in four science content areas. The assessments involved nationally representative samples of nine-, 13-, and 17-year-old African-American, Hispanic, and White students. When comparing across age groups, gender differences became more apparent. Nine-year-old males outperformed females in Physical Sciences and Earth & Space Sciences. The male advantage widened by age 13 and was even more substantial yet by age 17. Females were favored in Nature of Sciences across age groups. By race there were differences between and among the three racial groups studied. White students outperformed Hispanic students across content areas and age groups by between 28 and 36 points. The largest gap in mean proficiency scores was evidenced between White and African-American students, widening to the highest--nearly 55 point--difference across areas by age 17. When examining race by gender, females who tended to perform better than males at age nine in certain areas, maintain or lost their advantage by ages 13 and/or 17. Males who had an advantage in certain areas tended to gain or widen their advantage by ages 13 and 17. A more in-depth look at science curriculum and the methods and more research to identify the instructional approaches and other facilitative factors that impact on minorities and females need to be undertaken.

GENDER AND ETHNIC DIFFERENCES IN THE SCIENCE ACHIEVEMENT OF NINE-, THIRTEEN-, AND SEVENTEEN-YEAR-OLD STUDENTS

Introduction and Purpose

Students from the United States performed well below the mean in a 1988 international assessment of mathematics and science achievement (Lapointe, Mead, & Phillips, 1989). This poor performance resulted in a growing national concern that is reflected in the national reforms in 1989 when six national education goals were adopted by the President and the nation's governors. Goal four strives to make our students first in the world in math and science achievement. More recent results from the second international assessment in mathematics and science (Lapointe, Askew, & Mead, 1992) showed that students of the United States had improved by performing at the average. The concern continues over the preparedness of our students to advance to meet this national goal. And this concern is intensified for minority students including females.

There has been research that indicates that minority and female performance has shown improvement. Yet there is still a large disparity between minority and majority students on science achievement tests. This is true for females as well. Women, particularly African-American, Hispanic, and American Indian women, are severely underrepresented in the ranks of our nation's mathematicians, scientists, and engineers (National Science Foundation, 1990). And by examining differential performance by mean proficiency the disparities by content areas are overlooked. Additionally, there is a need to look beyond the overall mean scores separately for minority and majority and/or gender groups and report results by race/ethnicity and gender.

Much of the available data have been drawn from separate studies on gender or race/ethnicity (Clewell & Anderson, 1991). Until recently studies (Anderson & Bruschi, 1992) and reports from large scale assessments of mathematics and science achievement have not considered race/ethnicity by gender. In fact, large scale assessments have just begun (NAEP, 1992) to report although minimally on gender by race breakdowns.

The need to examine the interactions of race/ethnicity and gender in science coupled with the need for a more in-depth, practical examination of science assessments are the bases for this paper that takes a closer look at science content areas to discuss how achievement by gender are similar and different for three racial/ethnic groups. This is seen as a way to identify specific areas where minority groups and females are experiencing difficulties.

Data Source and Sample

The National Assessment of Education Progress (NAEP) conducts continuing assessments of what American students know and can do in science content areas. Mean proficiency scores were examined for 1990 in science content areas by gender, race, and race/ethnicity by gender. Aggregate data were reported by gender separately so additional analyses were conducted to examine the national science data bases and provide a snapshot of the status of nine-, 13-, and 17-year-old students in 1990, and science achievement of these three age groups by race/ethnicity and gender.

Data Analysis

Descriptive statistics were used to analyze the data. The means for gender subgroups were compared by race to look at how nine-, thirteen-, and seventeen-year-old students

performed in science by four content areas (Areas are described briefly below. For more detailed descriptions see Appendix A, Attachment to Table 1.) Comparisons were made between gender groups and race/ethnicity separately and for race/ethnicity by gender.

Life Sciences

This area ranges from topic-specific knowledge and understandings some of which may be gained through life experiences and include questions such as asking students to classify plants and animals. Items for older students--for example, questions dealing with energy transformations or genetics--require integration of knowledge from several disciplines.

Physical Sciences

The physical sciences deal with the fundamental components of the natural universe--space, time, matter, and energy.

Earth & Space Sciences

Knowledge and understanding of key concepts in this area provides students with a more informed view of their place on Earth and the Earth's place within the universe.

Nature of Science

The three aspects included were processes, principles, and knowledge. The first focuses on the scientific process. Values and principles include questioning, verification, and logic. Knowledge was defined according to five tenets: It is tentative, public, empirically based, based on replicable observations, and cumulative.

Findings

By Gender (Table 1):

Nine-Year-Olds

- Females and males performed the same in Life Sciences and Physical Sciences. Males outperformed their female counterparts in the Earth & Space Sciences by 7 points. Females had a 5-point advantage over males in mean proficiency in the Nature of Sciences area.

Thirteen-Year-Olds

- Males gained the advantage (by 5 points) in Physical Sciences. The largest between-gender disparity was in Earth & Space Sciences with an 11-point gap favoring males in that content area. There was similar performance by males and females in Life Sciences.

- Females in this age group widened their advantage somewhat in the Nature of Sciences area outperforming their male counterparts by 7 points.

Seventeen-Year-Olds

- Males gained or widened their mean point advantage in all but one content area for this age group. Males outperformed females in Life Sciences by 6 points; in Physical Sciences by 15 points; and in Earth & Space Sciences by 17 points.
- The female advantage in Nature of Sciences was maintained, but the point difference lessened to 5 points in their favor.

By Race (Table 2):

Nine-Year-Olds

- There were differences between and among the three racial groups studied. White students outperformed Hispanic students across content areas. The differences in mean scores were substantial and ranged between 28 and 32 points across areas (28 points in Nature of Sciences and 32 points in Physical Science).

- Hispanic and African-American students performed similarly in Life Sciences; 5 point difference in Physical Sciences; and the highest 9-point difference in Earth & Space Sciences. Both Hispanic and African-American students performed similarly (with less than 1-point difference favoring Hispanic students) in Nature of Sciences.

- The largest gap in science mean proficiency scores was between White and African-American students. White students were favored with a 28-point difference in Nature of Sciences to a 33-point or more difference in each of the other three content areas.

Thirteen-Year-Olds

- The gap widened across content areas in this age group between and among racial groups studied. White students outperformed their minority peers. Mean proficiency scores in science content areas for Hispanics were about 30 or more points lower than those of their White counterparts with the greatest gap evidenced (about 36 points) in Natures of Sciences, followed by Earth & Space Sciences (35 points), Physical Sciences (32 points), and Life Sciences (30 points).

- Hispanic students maintained their advantage over African-American students in the four content areas with the largest difference--about 13 points--evidenced in Earth & Space Sciences; 10 points in Life Sciences; 8 points in Physical Sciences; and about 6 points in Nature of Sciences favoring Hispanic students.

- The gap between White and African-American students widened across content areas from 40 points difference in mean score in Life Sciences to nearly 48 points difference in Earth & Space Sciences favoring the White students.

Seventeen-Year-Olds

- Differences in mean proficiency scores for science content areas between and among racial groups were maintained.

- The gap widened between Hispanic and African-American students mean scores with differences in mean scores ranging from 13 points favoring Hispanic students in Life Sciences to 26 points favoring the same group for Earth & Space Sciences. In Nature of Sciences there was a 14 point difference and in Physical Sciences a 22 point difference favoring Hispanic students.

- The mean point difference lessened somewhat between White and Hispanic students with the largest difference evidenced in Earth & Space Sciences (29 points) favoring the White students. In the other areas, White students were favored by 27 points in the Nature of Sciences and by 26 points each in the areas of Life Sciences and Physical Sciences.

- The gap widened also between the White and African-American students with the largest point difference--55 points--in Earth & Space Sciences, followed by Physical Science (48) , Life Sciences (43), and Nature of Sciences (41) favoring White students.

By Gender Within Racial Subgroup (Table 3):

Nine-Year-Olds

- In general, females and males in all three racial groups performed similarly (less than a 5 point difference) in Life Sciences and Physical Sciences. African-American and Hispanic females and males also performed similarly in Earth & Space Sciences (within 3 points for African-American students and 4 points for Hispanic students).

- All females outperformed males in Nature of Sciences (with an 8-point advantage for African-American and Hispanic females; a 7-point advantage for White females in this content area).

- White males had a 5-point advantage in mean score over their female counterparts in Earth & Space Sciences.

Thirteen-Year-Olds

- Females and males within racial groups performed similarly (within 0- to 3-point difference) in Life Sciences and Physical Sciences.

- Males across groups outperformed females in Earth & Space Sciences by 8 points for African-American males; 12 points for Hispanic males; and 9 points for White males.

- Females across groups outperformed their male peers in each group in Nature of Sciences--11 points for African-American females over males; 8-points for Hispanic females; and 9-points for White females.

Seventeen-Year-Olds

- African-American females outperformed male peers in Nature of Science by 6 points. African-American females and males performed similarly in Life Sciences. African-American males outperformed the females in each of the two remaining areas--Physical Sciences and Earth & Space Sciences (by 10 and 16 respectively).

- Hispanic females had a 6-point advantage over their male peers in Nature of Science. Males and females in this racial/ethnic group performed similarly in Life Sciences. Males in this group outperformed females by 19 points in Earth & Space Sciences and 10 points in Physical Sciences.

- White females had a 7-point advantage over their male peers in Nature of Sciences; males in this group had a 14-point advantage in Earth & Space sciences; 5-points in Life Science, and 13 points in Physical Science.

Summary and Implications

Across age groups, gender differences became more apparent. Nine-year-old females and males performed similarly in Life Sciences and Physical Sciences. Males in this age group outperformed females in Earth & Space Sciences. By age 13, males also gained the advantage in Physical Sciences. And this male advantage widened by even more substantially in these two areas by age 17. Females were favored in Nature of Sciences across age groups.

By race there were differences between and among the three racial groups studied. White students outperformed Hispanic students across content areas with mean proficiency scores that ranged between 28 and 36 points across areas and across age groups. Hispanic students evidenced a more moderate advantage over African-American students. The largest gap in mean proficiency scores was evidenced between White and African-American students, widening to the highest--55 point--difference across content areas by age 17.

This research examined some existing data and reanalyzed the data to include the third manipulation of racial subgroups by gender. Interestingly, females who performed similar to male peers at age nine in Life Sciences and Physical Sciences, and in the case of Hispanic and African-American females also in Earth & Space Sciences, tended to maintain or lose their advantage by ages 13 and/or 17. Males on the other hand tended to gain or widen their advantage particularly in Physical and Earth & Space Sciences by ages 13 and 17. And females maintain their advantage in the Nature of Sciences area although it lessens from age 13 to 17. Because females and males do perform similarly in certain content areas at age nine this suggests that perhaps gender equity is more likely to be found in the earlier grades. A second

possibility suggested by this research may be that the content areas in which females tended to outperform males particularly at a early age may be due to the concepts required of that area. However, for the concepts and knowledge required of older students particularly in the Physical and Earth & Space Sciences apparently 13- and 17-year-old females found these questions more difficult. Likewise, minorities fell far below the performance of the majority students, suggesting a need to pay close attention to both equity and diversity in science education.

A more in-depth look at science curriculum and the methods and approaches used that may impact negatively on females and minorities needs to be undertaken. And more research is needed to identify the instructional approaches and other facilitative factors that impact on minorities and females particularly as they reach middle school and continue into high school. In a study (Anderson, Bruschi, & Pearson, 1993) using data taken from the Student Descriptive Questionnaire (College Board, 1990), it was reported that in general, females across ethnic groups tended not to select science and/or mathmatics courses. And, when looking at the science courses taken by college-bound females, only slightly more than one-quarter to less than one-half take Geology/Earth Science and Physics. Minorities' and females' tendency not to take advanced courses may account for the low proficiency overall in specific content areas. It is imperative to reemphasize the need to foster gender and racial equity in science achievement.

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APPENDIX A: Tables

TABLE 1
Mean Proficiency in Science Content Areas by Gender for
Nine-, Thirteen-, and Seventeen-Year Old Students*, 1990

CONTENT AREAS	LIFE SCIENCES	PHYSICAL SCIENCES	EARTH & SPACE SCIENCES	NATURE OF SCIENCES
9-YEAR-OLDS				
Male	229 (1.2)	237 (1.3)	237 (1.2)	231 (1.1)
Female	229 (1.2)	234 (1.1)	230 (1.1)	236 (1.1)
13-YEAR-OLDS				
Male	264 (1.7)	265 (1.6)	270 (1.6)	257 (1.7)
Female	263 (1.2)	260 (1.4)	259 (1.5)	264 (1.5)
17-YEAR-OLDS				
Male	299 (1.5)	299 (2.1)	300 (1.5)	296 (1.7)
Female	293 (1.1)	284 (1.3)	283 (1.4)	301 (1.5)

* Includes Asian/Pacific Islander and American Indian.

Notes: Taken from The 1990 Science Report Card. See attachment for Description of Content Areas.

Standard errors of the mean are in parentheses.

Description of Science Content Areas

THE SCIENCES

Concepts in the life sciences can be placed along a continuum, ranging from the topic-specific to the highly integrated and interdisciplinary. Most students gain some topic-specific knowledge and understandings in this content area through life experiences; thus, some topic-specific questions, such as asking students to classify plants and animals, are most appropriate at the earlier grade levels. In contrast, items for older students — for example, questions dealing with energy transformations or genetics — require integration of knowledge from several disciplines, as these students are assumed to have mastered a detailed knowledge of the simpler (i.e., topic-specific) categories. The major categories of topics in the life sciences included in the 1990 assessment include cellular and molecular biology, energy transformations, genetic continuity and development, evolution, diversity and systematics, structure and function of organisms, behavior, and ecology.

PHYSICAL SCIENCES

The physical sciences deal with the fundamental components of the natural universe — space, time, matter, and energy. Students should understand the properties of matter and how the elements are organized in the periodic table. Students should also understand that the universe is not static; rather, matter and energy are continually being transformed in space and time, producing chemical and physical changes. A grasp of the laws of mechanics, and the interaction of light and matter, provides a way of understanding that among all of nature's transformations. a few invariable (conserved) quantities are known to exist, including mass-energy, electrical charge, and linear and angular momentum. In addition, an understanding of energy — more specifically, the laws of thermodynamics — permits one to predict if and in what manner a change will occur. The six sets of topics included in the 1990 science assessment are motion, conserved quantities, waves, particulate nature of matter, properties of matter, and changes.

EARTH AND SPACE SCIENCES

Knowledge and understanding of key concepts in the earth and space sciences provides students with a more informed view of their place on Earth, and of Earth's place within the universe. These concepts, in turn, build students' capacity to participate in public decisions, particularly those concerning environmental issues. Earth's place within the universe, plate tectonics, water and rock cycles, and the Earth's history constitute the earth and space science topics included in the 1990 assessment.

THE NATURE OF SCIENCE

Three aspects of the nature of science were included in the 1990 assessment — processes, principles, and knowledge. The processes of science encompass observing, classifying, and inferring; interpreting data; formulating hypotheses; designing experiments; and conducting inquiries. The nature of values and principles underlying scientific work include: knowledge is valued, questioning is essential, data are fundamental, verification is essential, and logic is respected. The nature of scientific knowledge was defined according to five major tenets: scientific knowledge is 1) tentative, 2) public, 3) empirically based, 4) based on replicable observations, and 5) cumulative.

TABLE 2
Mean Proficiency in Science Content Areas by Race for
Nine-, Thirteen-, and Seventeen-Year-Old Students, 1990

CONTENT AREAS	LIFE SCIENCES	PHYSICAL SCIENCES	EARTH & SPACE SCIENCES	NATURE OF SCIENCES
9-YEAR-OLDS				
African-American (N = 1713)	196.9 (1.2)	199.6 (1.3)	198.1 (1.2)	204.8 (1.2)
Hispanic (N = 858)	199.5 (1.9)	205.0 (2.2)	207.0 (2.1)	205.0 (2.0
White (N = 5529)	230.6 (0.7)	237.3 (0.8)	236.3 (0.7)	233.2 (0.7)
13-YEAR-OLDS				
African-American (N = 1379)	226.2 (1.8)	224.3 (1.7)	221.0 (1.9)	221.7 (1.9)
Hispanic (N = 1048)	236.1 (2.2)	232.5 (2.0)	233.9 (2.1)	227.5 (2.3)
White (N = 5876)	266.3 (0.8)	264.5 (0.9)	268.6 (0.8)	263.2 (1.0)
17-YEAR-OLDS				
African-American (N = 1294)	257.7 (1.7)	247.7 (1.9)	243.3 (1.9)	259.7 (2.1)
Hispanic (N = 736)	274.8 (2.1)	269.9 (2.5)	269.1 (2.5)	273.8 (2.7)
White (N = 6017)	300.6 (0.8)	295.7 (0.9)	298.1 (1.0)	301.3 (0.9)

Note: Standard errors of the mean are in parentheses.

TABLE 3
Mean Proficiency in Science Content Areas Race by Gender for
Nine-, Thirteen-, and Seventeen-Year-Old Students, 1990

CONTENT AREAS	LIFE SCIENCES	PHYSICAL SCIENCES	EARTH & SPACE SCIENCES	NATURE OF SCIENCES
9-YEAR-OLDS				
AFRICAN AMERICAN: Female	198 (1.8)	201 (2.0)	197 (1.7)	209 (1.8)
Male	196 (1.6)	199 (1.8)	200 (1.6)	201 (1.7)
HISPANIC: Female	200 (3.1)	204 (3.3)	205 (3.4)	209 (2.9)
Male	199 (2.4)	206 (2.7)	209 (2.5)	201 (2.4)
WHITE: Female	232 (1.0)	237 (1.1)	234 (1.1)	237 (1.0)
Male	229 (0.9)	238 (1.1)	239 (1.0)	230 (1.0)
13-YEAR-OLDS				
AFRICAN AMERICAN: Female	228 (2.3)	224 (2.3)	217 (2.3)	227 (2.7)
Male	225 (2.6)	224 (2.5)	225 (3.0)	216 (2.7)
HISPANIC: Female	236 (2.8)	231 (3.0)	228 (3.0)	232 (3.2)
Male	236 (2.8)	234 (3.0)	240 (2.8)	224 (3.1)
WHITE: Female	267 (1.1)	264 (1.3)	264 (1.2)	268 (1.3)
Male	265 (1.2)	265 (1.2)	273 (1.2)	259 (1.4)
17-YEAR-OLDS				
AFRICAN AMERICAN: Female	256 (2.3)	243 (2.8)	236 (2.6)	263 (2.8)
Male	260 (2.3)	253 (2.7)	252 (2.6)	257 (3.0)
HISPANIC: Female	273 (2.8)	265 (3.6)	260 (3.4)	277 (4.2)
Male	276 (3.1)	275 (3.6)	279 (3.4)	271 (3.6)
WHITE: Female	298 (1.1)	289 (1.2)	291 (1.3)	305 (1.3)
Male	303 (1.2)	302 (1.4)	305 (1.3)	298 (1.3)

Note: Standard errors of the mean are in parentheses.