DOCUMENT RESUME

ED 451 199 TM 032 424

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TITLE	Long-Term Trends in Student Reading Performance [and] Long-Term Trends in Student Mathematics Performance [and] Long-Term Trends in Student Science Performance [and] Long-Term Trends in Student Writing Performance.
INSTITUTION	National Center for Education Statistics (ED), Washington, DC.
REPORT NO	NCES-98-464; NCES-98-462; NCES-98-468; NCES-98-465
PUB DATE	1998-00-00
NOTE	18p.; Sheida White co-authored Volume 3, Number 1.
AVAILABLE FROM	National Center for Education Statistics, U.S. Department of Education, Washington, DC 20208-5653. For full text: http://nces.ed.gov/NAEP.
PUB TYPE	Collected Works - Serials (022) -- Reports - Descriptive (141)
JOURNAL CIT	NAEPfacts; v3 n1-4 1998
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Achievement Gains; Age Differences; Educational Trends; Elementary Secondary Education; *Mathematics Achievement; Mathematics Tests; *National Competency Tests; National Surveys; Racial Differences; *Science Achievement; Science Tests; *Standardized Tests; *Writing Achievement; Writing Tests
IDENTIFIERS	Fact Sheets; *National Assessment of Educational Progress

ABSTRACT

This document contains four issues of "NAEPfacts," a report series about the National Assessment of Educational Progress (NAEP). Issue 1 discusses data from the NAEP 1996 Long-Term Reading Assessment, which shows that overall student reading performance has increased for both 9- and 13-year-olds. Issue 2 reports that data from the NAEP 1996 Long-Term Mathematics Assessment show a positive linear trend for all three age groups studied since the first assessment in 1973, indicating improving scores over time. All subgroups, including Blacks and Hispanics, showed positive linear trends as well, at all three age groups. Issue 3, "Long-Term Trends in Student Science Performance," reports that data from the NAEP 1996 Long-Term Trend Science Assessment show mixed results since the first assessment. Scores for all three age groups studied fell and then rose. Both 9- and 11-year-olds showed an overall increase, but 17-year-olds showed an overall decline. Scores for Whites were higher than scores for Blacks and Hispanics for all three age groups, although scores for 9- and 13-year-old black students did improve, both absolutely and in comparison with white students. Males aged 13 and 17 had higher scores that female students. The focus of issue 4, "Long-Term Trends in Student Writing Performance," is on data from the 1996 Long-Term Trend Writing Assessment that show a decline in scores for grade 11 students over the period from 1984 to 1996. Scores for students in grades 4 and 8 remained unchanged. White students continued to have higher scores than both Blacks and Hispanic students in all three grades, and female students continued to have higher scores than males at all three grades. (SLD)

Long-Term Trends in Student Reading Performance [and] Long-Term Trends in Student Mathematics Performance [and] Long-Term Trends in Student Science Performance [and] Long-Term Trends in Student Writing Performance.

Alan Vanneman

NAEPfacts, 1998, Volume 3, Numbers 1-4

NATIONAL ASSESSMENT OF EDUCATION PROGRESS

THE NATION'S REPORT CARD

NAEPFACTS

Vol. 3 No. 1

January 1998

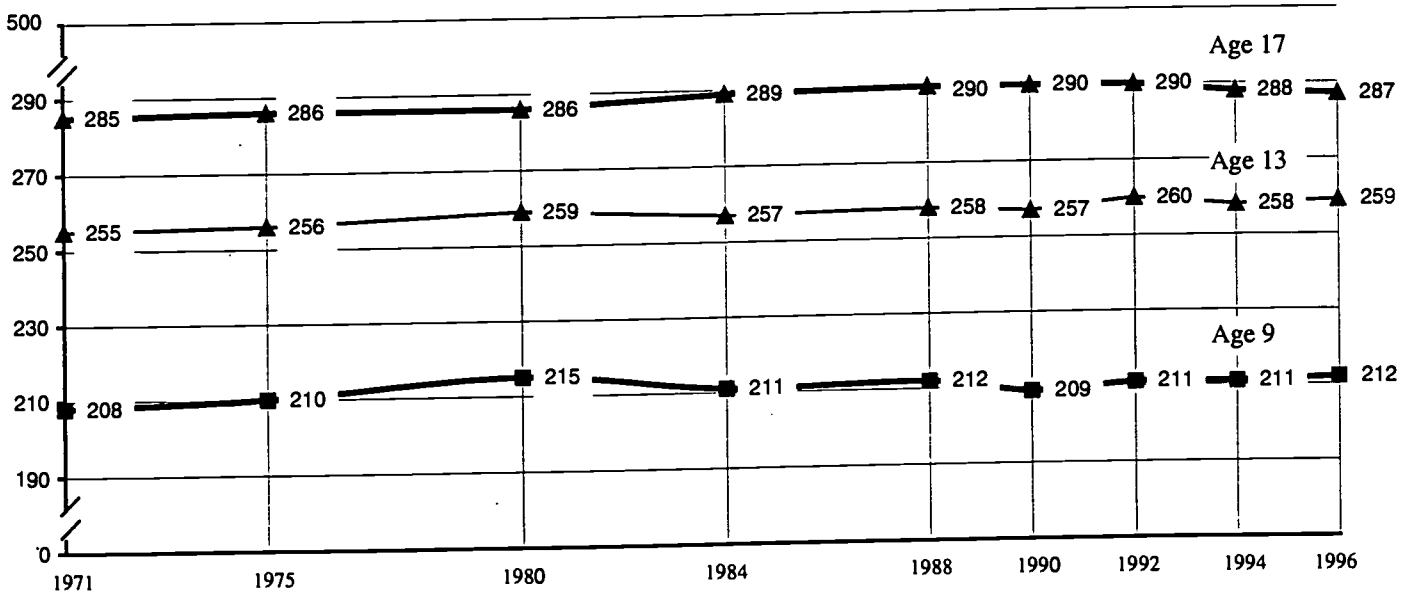
Long-Term Trends in Student Reading Performance

Summary: Data from the NAEP 1996 Long-Term Reading Assessment show that overall student reading performance, as tested at age levels 9,13, and 17, has increased for both 9- and 13-year-olds since the first assessment in 1971. Scores for 9- and 13-year-olds in most racial/ethnic and gender subgroups reflected the overall increase. Black 17-year-olds were the only members of that age group to achieve an increase, and they did so while black dropout rates were declining.

The National Assessment of Educational Progress (NAEP) continuously monitors the knowledge, skills, and performance of the nation's children and youth in a variety of academic subjects. The data collected are available in major reports. The *NAEPfacts* series takes selected data from these reports and uses them to highlight specific issues of particular interest to teachers, researchers, policymakers, and other individuals with an interest in education.

The assessments used by NAEP to evaluate long-term trends in student performance began in the early 1970s. The first assessments were given in three subject areas—science, mathematics, and reading. Students were assessed at ages 9, 13, and 17. In 1984 a fourth subject, writing, was added. Long-term trend data can be analyzed in a number of ways. Student scores for given years can be compared for statistically significant differ-

Figure 1—NAEP Reading Average Scale Scores for the Nation



▲ Positive linear trend (scores have increased) ■ No linear trend

Red lines indicate negative quadratic trend (scores rose and then fell or flattened out).

Black lines indicate no quadratic trend.

Red numbers indicate 1996 scores were significantly higher than 1971 scores, at a 5 percent combined significance level per set of comparisons.

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress, 1996 Long-Term Trend Assessments

ences. Often, scores for student groups or subgroups from the first assessment are compared with the results from the most recent assessment.

It is also possible to analyze a series of scores for overall trends, rather than simple year-to-year variations. Specifically, a series of scores can be analyzed for "linear" and "quadratic" trends. Linear trends can be represented as straight lines. A positive linear trend indicates that overall the average scores for a given student group form a gradually rising line, while a negative linear trend indicates a gradually declining one. A series of scores can show a linear trend despite wide variation among individual scores, as long as the overall pattern is either up or down.[1]

Table1.—Average Scale Scores in Reading by Race/Ethnicity and Gender

	Age 9			Age 13			Age 17		
	1971†	1996	Trend	1971†	1996	Trend	1971†	1996	Trend
Nation	208*	212	q	255*	259	L	285	287	Lq
White	214*	220	L	261*	267	L	291	294	L
Black	170*	190	Lq	222*	236	Lq	239*	265	Lq
Hispanic	183*	194		233	240		252	265	Lq
Male	201*	207	Lq	250	253		279	280	q
Female	214*	218		261*	265	L	291	294	L

† NOTE: For Hispanic students, the differences are calculated between 1975 and 1996.
*Statistically significant difference from 1996, at a 5 percent combined significance level per set of comparisons.
L=Positive Linear Trend l=Negative Linear Trend
Q=Positive Quadratic Trend q=Negative Quadratic Trend

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment.

Quadratic trends can be represented as simple curves, and can be represented mathematically by quadratic equations.[2] A positive quadratic trend indicates that scores form a simple curve with one or both ends higher than its center—scores sagged, and then either leveled off or rose, or were flat and then rose. A negative quadratic trend indicates a simple curve whose center is higher than one or both ends—scores rose, and then either leveled off or declined, or were flat and then declined.

It is possible for scores to display both a linear and a quadratic trend. For example, if scores rose sharply and then flattened out, this would constitute a negative quadratic trend. However, if the pattern of the scores still showed an increase for the entire time period, the scores would also display a positive linear trend.

Overall Performance

Scores for 9- and 13-year-olds on the 1996 assessment are significantly higher than scores for the first assessment, given in 1971 (see figure 1). Scores for 9-year-olds showed a negative quadratic trend—rising and then falling—and no linear trend. Scores for 13-year-olds showed a positive linear trend and no quadratic trend, that is, a relatively straight-line increase. Scores for 17-year-olds showed a positive linear trend and a negative quadratic trend, because they rose and then fell, but with an overall upward trend.

Race/Ethnicity and Gender

Analysis of scores by race/ethnicity and gender shows higher scores in 1996 for most groups as compared to 1971. (Separate data for Hispanics only goes as far back as 1975.) Notably, scores for black students improved for all three age groups. (See table 1.) Whites and females recorded increases for both 9- and 13-year-olds, while Hispanics and males recorded increases for 9-year-olds only.

For the period 1971-1996 scores for white students in all three age groups showed a positive linear trend and no quadratic trend, a relatively straight-line increase. Scores for blacks in all three age groups showed both a positive linear trend and a negative quadratic trend, because scores increased overall between 1971 and 1996 but reached their high point prior to 1996 and then flattened out or declined. Scores for 17-year-old Hispanics showed the same trends. Scores for 13- and 9-year-old Hispanics showed no trends.

Scores for male 17-year-olds showed a negative quadratic trend, rising and then falling, while scores for male 9-year-olds showed a negative quadratic trend and a positive linear trend, rising and then falling, but showing an overall pattern of increase. Scores for female 17- and 13-year-olds showed a positive linear trend—a relatively straight-line increase.

The increase in reading scores for black 17-year-old students over the 1971–1996 period occurred despite the fact that dropout rates for this group fell significantly over the same period. Data from the Census Bureau's Current Population Survey indicate that in 1972 the overall dropout rate (known as the "status" dropout rate) for 16-to-24-year-olds was 14.6 percent, while the black dropout rate for this age group was 21.3 percent.[3] By

1995, the overall dropout rate had fallen to 12 percent, while the black dropout rate had fallen to 12.1 percent. (In 1995 the white dropout rate was 8.6 percent, while the Hispanic dropout rate was 30 percent.)

While the black dropout rate was dropping, the average scale scores for blacks were increasing. The reading score for black 17-year-old students was 265 in 1996, higher than the 1971 average of 239.

It is likely that a decreasing dropout rate increases the proportion of poorer-performing students in a school population.[4] Thus, it appears that the reading scores of black 17-year-old students increased even though the proportion of poorer-performing students in the overall population of black 17-year-old students was also increasing.

Performance Differences

As in the past, the 1996 Long-Term Trend Reading Assessment found significant differences in the performance of different racial/ethnic subgroups and between male and female students. Table 2 displays the differences in average reading scale scores and the trends in those differences since 1971 (in the case of Hispanics, since 1975).

White students in all three age groups outperformed their black and Hispanic peers. The difference between average scale scores for white and black students declined significantly from 1971 to 1996 for both 9- and 17-year-olds, but not for 13-year-olds. The differences in performance for all three age groups show a negative linear trend, that is, a relatively straight-line decline, due to improving scores for black students.

Differences for both the 13- and 17-year-old age groups show a positive quadratic trend as well, a decrease followed by an increase or a flattening out. In the late 1980s the differences between white and black scores for these two age groups were narrowing. For example, in 1988, scores for 17-year-old black students were 20 points lower than scores for their white peers. In 1971 the difference had been 53 points. However, the trend did not maintain itself. In 1996, the difference between scores for black and white 17-year-old students was 29 points.

Average scale score differences between white and Hispanic students did not change significantly over the years 1975–1996. Differences in scores for 17-year-old Hispanics did show a positive quadratic trend. Scores for 17-year-old Hispanics improved, narrowing the gap with whites, but then the gap widened somewhat.

Female students continued to outperform male students by a significant margin, at all three age levels. Differences in performance did not change significantly for any of the three age groups. Scores for 17- and 13-year-olds showed a negative quadratic trend, indicating that tendencies toward reduced differences in performance failed to maintain themselves. For example, in 1988, 17-year-old males scored 7 points lower than 17-year-old females, compared to 12 points lower on the first assessment in 1971. However, in 1996 the difference stood at 15 points. For the most part, minor gains in male students' performance were offset by improved scores by female students.

Table 2.—Trends in Differences in Average Reading Scale Scores by Race/Ethnicity and Gender

	1971†	1996	Trends
White vs. Black Students (white minus black)			
Age 17	53*	29	lQ
Age 13	39	31	lQ
Age 9	44*	30	l
White vs. Hispanic Students (white minus Hispanic)			
Age 17	41	30	Q
Age 13	30	27	
Age 9	34	26	
Male vs. Female Students (male minus female)			
Age 17	-12	-15	q
Age 13	-11	-13	q
Age 9	-13	-11	

† NOTE: For Hispanic students, the differences are calculated between 1975 and 1996.

*Significantly higher than 1996, at a 5 percent combined significance level per set of comparisons.

L=Positive Linear Trend l=Negative Linear Trend
Q=Positive Quadratic Trend q=Negative Quadratic Trend

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment.

Conclusion

Average reading scale scores for 9- and 13-year-old students were higher in 1996 than in 1971. Scores for both 13- and 17-year-old students showed a positive linear trend, indicating a gradual rise in scores for the period 1971–1996. Scores for both 9- and 17-year-old students showed a negative quadratic trend, indicating that scores had increased, but then either declined or flattened out.

Reading scores for most but not all student subgroups were higher in 1996 than in 1971, particularly in the 13-

and 9-year-old age groups. Black students recorded increases at all three age levels. However, scores for many subgroups showed a pattern of increase in the 1980s, followed by a decline or a flattening out in the 1990s. Reading scores for 17-year-old black students have increased even as dropout rates have been falling.

Notes

[1]A series of scores may show a linear trend, either positive or negative, even though a comparison of the first and last scores does not show a statistically significant difference. The reverse is true as well.

[2]Quadratic equations, familiar from elementary algebra, involve variables with a power no greater than 2. For example, the equation $y^2=R^2- x^2$ (or $y = \sqrt{R^2 - x^2}$) is a quadratic equation, in particular, the equation used for graphing a circle. For purposes of trend analysis, this equation could be used to represent either a positive quadratic trend in which scores first fell and then rose to their original starting point, or a negative quadratic trend in which scores first rose and then fell to their original starting point.

[3]See McMillen, M. & Kaufman, P., *Dropout Rates in the United States: 1995,* Chapter 1 (National Center for Education Statistics, U.S. Department of Education, U.S. Printing Office) ***http://nces.ed.gov/pubs/dp95/index.html***.

[4]The dropout population is likely to contain a larger percentage of poorer-performing students than the student population as a whole. See Natriello, G., ed., *School Dropouts: Patterns and Policies*, 1987, Teachers College Press, New York, NY and Schwartz, W., "School Dropouts: New Information About an Old Problem," ERIC Clearinghouse on Urban Education Digest, No. 109, Aug. 1995.

For Further Information

NAEP 1996 Trends in Academic Progress, the complete report. Single copies are available free from the National Center for Education Statistics, U.S. Department of Education, Washington, DC 20208-5653. Copies may also be obtained over the World Wide Web at ***http://nces.ed.gov/NAEP/96report/97986.shtml***.

NAEPfacts briefly summarize findings from the National Assessment of Educational Progress (NAEP). The series is a product of the National Center for Education Statistics, Pascal D. Forgione, Jr., Commissioner, and Gary W. Phillips, Associate Commissioner for Education Assessment. This issue of *NAEPfacts* was written by Alan Vanneman, of the Education Statistics Services Institute, in support of the National Center for Education Statistics, and Sheida White of NCES. To order other NAEP publications, call Bob Clemons at 202-219-1690, or e-mail bob_clemons@ed.gov.

The NCES World Wide Web Home Page is ***http://nces.ed.gov/***.

NATIONAL CENTER FOR EDUCATION STATISTICS

THE NATION'S REPORT CARD

NAEPFACTS

Vol. 3, No. 2 September 1998

Long-Term Trends in Student Mathematics Performance

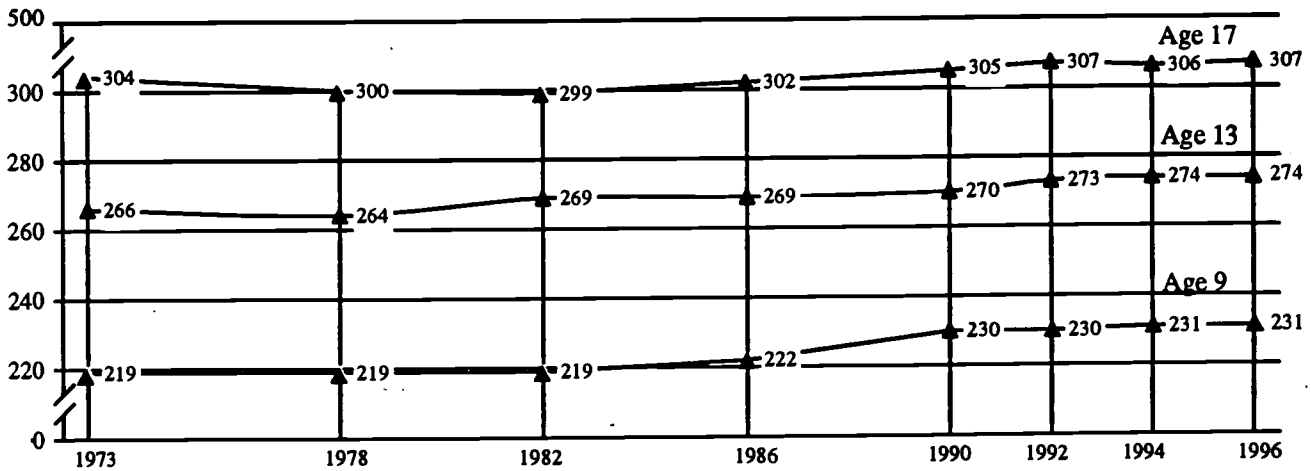
Summary: Data from the NAEP 1996 Long-Term Mathematics Assessment show a positive linear trend for all three age groups since the first assessment in 1973, indicating improving scores over time. All subgroups, including blacks and Hispanics, showed positive linear trends as well, at all three age levels.

The National Assessment of Educational Progress (NAEP) continuously monitors the knowledge, skills, and performance of the nation's children and youth in a variety of academic subjects. The data collected are available in major reports. The *NAEPfacts* series takes selected data from these reports and uses them to highlight specific issues of particular interest to teachers, researchers, policymakers, and other individuals in the general public who have an interest in education.

The assessments used by NAEP to evaluate long-term trends in student performance began in the early 1970s. Three long-term assessment series—in science, mathematics, and reading—date from that time. Students were assessed at ages 9, 13, and 17. In 1984 a fourth subject, writing, was added.

Over the past 25 years, NAEP has administered eight long-term trend assessments to monitor progress in the mathematics performance of 9-, 13-, and 17-year-old students. NAEP has used the same administration procedures and assessment content in each assessment, in order to measure trends in mathematics achievement over time.

Figure 1.—NAEP Mathematics Average Scale Scores for the Nation



Triangular data markers indicate a positive linear trend (scores show an overall increase).

Red data markers indicate a positive quadratic trend (scores fell or remained flat and then rose).

Red numbers indicate 1996 scores were significantly higher than 1973 scores, at a 5 percent combined significance level per set of comparisons.

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment.

U.S. Department of Education
of Educational Research and Improvement

NCES 98–462

Analyzing Long-Term Trend Data

Long-term trend data can be analyzed in a number of ways. Student scores for given years can be compared for statistically significant differences. Often, scores for student groups or subgroups from the first assessment are compared with the results from the most recent assessment. Scores are described as "higher" or "lower" only if the difference is statistically significant—that is, unlikely to be the result of the chance factors associated with the sampling and measurement errors inherent in any large-scale sample survey effort like NAEP.

Table 1.—Average Scale Scores in Mathematics by Race/Ethnicity and Gender

	Age 9			Age 13			Age 17		
	1973	1996	Trend	1973	1996	Trend	1973	1996	Trend
Nation	**219***	**231**	**LQ**	**266***	**274**	**L**	**304**	**307**	**LQ**
White	225*	237	LQ	274*	281	LQ	310	313	LQ
Black	190*	212	L	228*	252	Lq	270*	286	L
Hispanic	202*	215	L	239*	256	Lq	277*	292	LQ
Male	218*	233	LQ	265*	276	L	309	310	LQ
Female	220*	229	LQ	267*	272	L	301	305	LQ

*Statistically significant difference from 1996, at a 5 percent combined significance level per set of comparisons.

L=Positive Linear Trend l=Negative Linear Trend

Q=Positive Quadratic Trend q=Negative Quadratic Trend

SOURCE: National Center for Education Statistics. National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment. Consult this publication for graphs and complete scale score data for all subgroups for each assessment.

It is also possible to analyze a series of scores for overall trends, rather than year-to-year variations. Specifically, a series of scores can be analyzed for "linear" and "quadratic" trends. Linear trends can be represented as straight lines. A positive linear trend indicates that overall the average scores for a given student group form a rising line, while a negative linear trend indicates a declining one. A series of scores can show a linear trend despite wide variation among individual scores, as long as the overall pattern is either up or down.[1]

Quadratic trends can be represented as simple curves, and can be represented mathematically by quadratic equations.[2] A positive quadratic trend indicates that scores form a simple curve with one or both ends higher than its center—scores sagged, and then either leveled off or rose, or were flat and then rose. A negative quadratic trend indicates a simple curve whose center is higher than one or both ends—scores rose, and then either leveled off or declined, or were flat and then declined.

It is possible for scores to display both a linear and a quadratic trend. For example, if scores rose sharply and then flattened out, this would constitute a negative quadratic trend. However, if the pattern of the scores still showed an increase for the entire time period, the scores would also display a positive linear trend.

Overall Performance

Scores for all three age groups showed a positive linear trend—an overall increase from 1973 to 1996. (See figure 1.) Scores for 9- and 13-year-old students were significantly higher in 1996 than in 1973, but this was not true for 17-year-olds. Scores for both 9- and 17-year-olds showed a positive quadratic curve as well, because scores first fell or remained flat for several assessments before rising.

Race/Ethnicity and Gender

Scores for every subgroup as defined by race/ethnicity or gender showed a positive linear trend for the period 1973–1996. (See table 1.) Furthermore, every subgroup at the 9- and 13-year-old age levels showed an increase in the 1996 score as compared to the 1973 score. However, among 17-year-olds, only scores for black and Hispanic students increased.

White students showed both a positive linear trend and a positive quadratic trend at all three age levels, because initially scores either fell or were flat, and then rose. Black students aged 9 and 17 showed a positive linear trend only, while black 13-year-olds showed a positive linear trend and a negative quadratic trend, because scores first increased and then leveled off.

Hispanics showed a positive linear trend at all three levels. Nine-year-olds had a linear trend only, while 13-year-olds also had a negative quadratic trend, because scores rose sharply and then leveled off, and 17-year-olds also had a positive quadratic trend, because scores first were flat and then rose.

Scores for male and female students followed the same patterns observable for students overall, at all three age levels. Thirteen-year-olds showed a positive linear trend only, while both 9- and 17-year-olds showed a positive linear trend and a positive quadratic trend, indicating that scores first fell or remained flat, and then rose.

The increase in mathematics scores for black 17-year-old students over the 1973–1996 period occurred despite the fact that dropout rates for this group fell significantly over the same period. Data from the Census Bureau's Current

Population Survey indicate that in 1972 the overall dropout rate (known as the "status" dropout rate) for 16-to-24-year-olds was 14.6 percent, while the black dropout rate for this age group was 21.3 percent.[3] By 1996, the overall dropout rate had fallen to 11.1 percent, while the black dropout rate had fallen to 13 percent. (In 1996 the white dropout rate was 7.3 percent, while the Hispanic dropout rate was 29.4 percent.)

While the black dropout rate was dropping, the average scale scores for black 17-year-olds in mathematics were increasing, from 270 in 1973 to 286 in 1996.

It is likely that a decreasing dropout rate increases the proportion of poorer-performing students in a school population.[4] Thus, it appears that the mathematics scores of black 17-year-old students increased even though the proportion of poorer-performing students in the overall population of black 17-year-old students was also increasing.

Scores for 17-year-old Hispanic students also improved in 1996 as compared to 1973 (292 as compared to 277). However, the Hispanic dropout rate did not declined during this time period.

Performance Differences

As in the past, the 1996 Long-Term Trend Mathematics Assessment found some differences in the performance of different racial/ethnic subgroups and between male and female students. Table 2 displays the differences in average scale scores between 1973 and 1996, as well as the trends in those differences over all the assessments between 1973 and 1996.

White students in all three age groups outperformed their black and Hispanic peers. The difference between average scale scores for white and black students declined significantly from 1973 to 1996 for all three age groups. For all three age groups, the difference in scores showed a negative linear trend, that is, the size of the difference declined overall. For 17- and 13-year-olds, the size of the differences showed a positive quadratic trend as well, first declining and then either rising or flattening out.

The difference between average scale scores for white and Hispanic students declined significantly from 1973 to 1996 for 17- and 13-year-olds, but not for 9-year-olds. The size of the differences for 17- and 13-year-olds also showed a negative linear trend. The difference in scores for 13-year-olds showed a positive quadratic trend as well, the difference first declining sharply and then leveling off.

In most of the assessments since 1973, the difference between average scale scores for male and female students has not been significant, in any of the three age groups a are not shown). However, the differences for both 9- and 13-year-olds showed changes over time (1973–1996) in favor of male students.

Table 2.—Trends in Differences in Average Mathematics Scale Scores by Race/Ethnicity and Gender

	1973	1996	Trends
White vs. Black Students (white minus black)			
Age 17	40*	27	lQ
Age 13	46*	29	lQ
Age 9	35*	25	l
White vs. Hispanic Students (white minus Hispanic)			
Age 17	33*	21	l
Age 13	35*	26	lQ
Age 9	23	22	
Male vs. Female Students (male minus female)			
Age 17	8	5	l
Age 13	-2*	4	L
Age 9	-3*	4	L

*Differences in scores show significant change when compared to 1996, at a 5 percent combined significance level per set of comparisons.

L=Positive Linear Trend l=Negative Linear Trend
Q=Positive Quadratic Trend q=Negative Quadratic Trend

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment. Consult this publication for graphs and complete scale score data for all subgroups for each assessment.

In addition, the differences for all three age groups show a linear trend. For 9- and 13-year-old males, the differences in scores show a positive linear trend. Over the period 1973–1996, average scale scores for male students in these age groups have risen above the scores of their female peers.

The difference in scores for 17-year-old male and female students show a negative linear trend. In 1973, 17-year-old males scored above females, by an 8-point margin. This advantage has gradually declined, to a 5-point margin.

Conclusion

The NAEP long-term mathematics assessments show a positive linear trend in scores over the period 1973–1996 for all students, and for all subgroups of students. For 9-year-old and 13-year-old students, but not for 17-year-old students, 1996 scores were higher than 1973 scores.

Black students showed consistent improvement for all three age groups, and also improved their scores in comparison to white students, although their scores remain

below those of white students. Black 17-year-old students showed increased scores even as dropout rates declined. Scores for Hispanic students also improved. Male students aged 9 and 13 improved in comparison to their female peers.

Notes

[1]A series of scores may show a linear trend, either positive or negative, even though a comparison of the first and last scores does not show a statistically significant difference. The reverse is true as well.

[2]Quadratic equations, familiar from elementary algebra, involve variables with a power no greater than 2. For example, the equation $y^2=R^2- x^2$ (or $y = \sqrt{R^2 - x^2}$) is a quadratic equation, in particular, the equation used for graphing a circle. For purposes of trend analysis, this equation could be used to represent either a positive quadratic trend in which scores first fell and then rose to their original starting point, or a negative quadratic trend in which scores first rose and then fell to their original starting point.

[3]See McMillen, M. & Kaufman, P., *Dropout Rates in the United States: 1996*, Chapter 1 (National Center for Education Statistics, U.S. Department of Education, U.S. Printing Office) **http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=98250XXXXX**.

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NAEPFACTS

Vol. 3, No. 3

September 1998

Long-Term Trends in Student Science Performance

Summary: Data from the NAEP 1996 Long-Term Trend Science Assessment show mixed results since the first assessment. Scores for all three age groups fell and then rose. Both 9- and 13-year-olds showed an overall increase, but 17-year-olds showed an overall decline. Scores for white students were higher than for blacks and Hispanics for all three age groups, although scores for 9- and 13-year-old black students did improve, both absolutely and in comparison with white students. Thirteen-year-old and 17-year-old male students had higher scores than female students.

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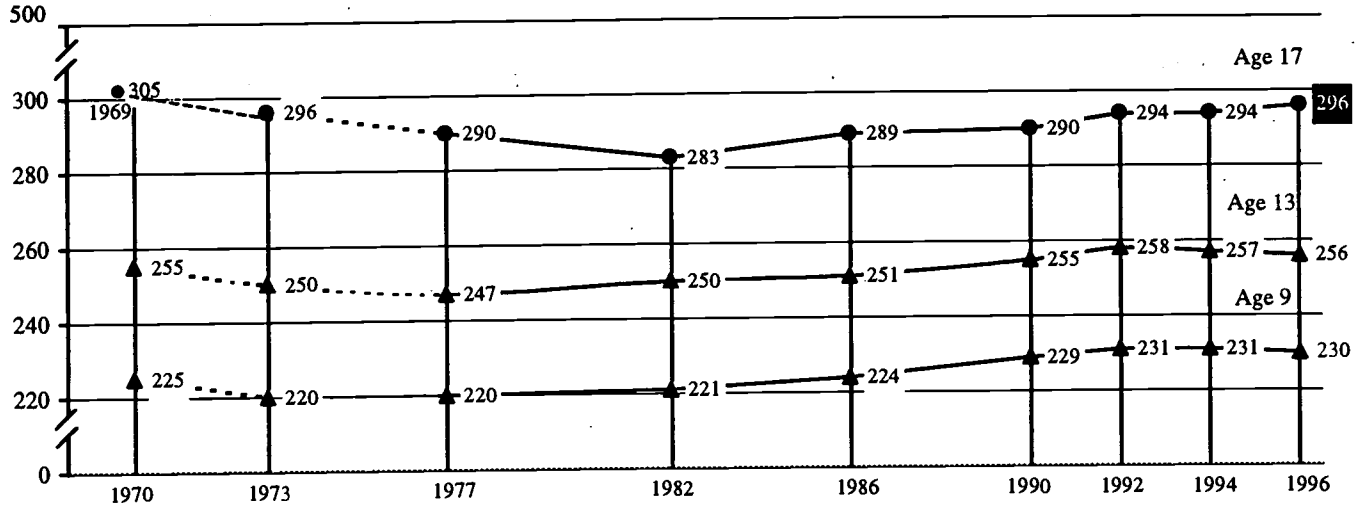
Figure 1.— NAEP Science Average Scale Scores for the Nation



Triangular data markers indicate a positive linear trend (scores show an overall increase).

Round data markers indicate a negative linear trend (scores show an overall decrease).

Red data markers indicate a positive quadratic trend (scores fell or remained flat and then rose).

Red numbers indicate 1996 scores were significantly higher than 1970 scores, at a 5 percent combined significance level per set of comparisons.

White numbers on a red background indicate 1996 scores were significantly lower than 1969 scores, at a 5 percent combined significance level per set of comparisons.

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment.

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NCES 98–465

The assessments used by NAEP to evaluate long-term trends in student performance began in the early 1970s. Three long-term assessment series—in science, mathematics, and reading—began at this time. Students were assessed at ages 9, 13, and 17. In 1984 a fourth subject, writing, was added.

Over the past 28 years, NAEP has administered nine long-term trend assessments to monitor progress in the science performance of 9-, 13-, and 17-year-old students. NAEP has used the same administration procedures and assessment content in each of these assessments, in order to measure trends in science achievement over time.

Table 1.—Average Scale Scores in Science by Race/Ethnicity and Gender

	Age 9			Age 13			Age 17		
	1970†	1996	Trend	1970†	1996	Trend	1969†	1996	Trend
Nation	**225***	**230**	**LQ**	**255**	**256**	**LQ**	**305***	**296**	**lQ**
White	236	239	LQ	263	266	LQ	312*	307	Q
Black	179*	202	L	215*	226	L	258	260	LQ
Hispanic	192*	207	L	213*	232	L	262	269	L
Male	228	231	LQ	257	260	LQ	314*	300	lQ
Female	223*	228	LQ	253	252	LQ	297*	292	Q

†For Hispanic students, the data cover assessments from 1977 to 1996.

*Statistically significant difference from 1996, at a 5 percent combined significance level per set of comparisons.

L=Positive Linear Trend l=Negative Linear Trend

Q=Positive Quadratic Trend q=Negative Quadratic Trend

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment. Consult this publication for graphs and complete scale score data for all subgroups on each assessment.

Analyzing Long-Term Trend Data

Long-term trend data can be analyzed in a number of ways. Student scores for given years can be compared for statistically significant differences. In this report, scores for student groups or subgroups from the first assessment are compared with the results from the most recent assessment. Scores are described as "higher" or "lower" only if the difference is statistically significant— that is, unlikely to be the result of the chance factors associated with the inevitable sampling and measurement errors inherent in any large-scale sample survey effort like NAEP.

It is also possible to analyze a series of scores for overall trends, rather than year-to-year variations. Specifically, a series of scores can be analyzed for "linear" and "quadratic" trends. Linear trends can be represented as straight lines. A positive linear trend indicates that overall the average scores for a given student group form a rising line, while a negative linear trend indicates a declining one. A series of scores can show a linear trend despite wide variation among individual scores, as long as the overall pattern is either up or down.[1]

Quadratic trends can be represented as simple curves, and can be represented mathematically by quadratic equations.[2] A positive quadratic trend indicates that scores form a simple curve with one or both ends higher than its center—scores sagged and then either leveled off or rose, or were flat and then rose. A negative quadratic trend indicates a simple curve whose center is higher than one or both ends—scores rose and then either leveled off or declined, or were flat and then declined.

It is possible for scores to display both a linear and a quadratic trend. For example, if scores rose sharply and then flattened out, this would constitute a negative quadratic trend. However, if the pattern of the scores still showed an increase for the entire time period, the scores would also display a positive linear trend.

Overall Performance

Scores for all three age groups showed a positive quadratic trend over the years 1970–1996 (see figure 1). That is, scores fell and then rose. (For 17-year-olds only, the first assessment was given in 1969). For both 9- and 13-year-olds, scores rose enough to achieve a positive linear trend. Scores for 17-year-old students did not, showing a negative linear trend. The average score for 9-year-olds in 1996 was higher than scores in 1970. The 1996 average score for 17-year-olds was lower than the 1969 average. The average score for 13-year-olds in 1996 was neither higher nor lower than in 1969.

Race/Ethnicity and Gender

With one exception, scores for white students mirrored overall performance (see table 1). All three age groups showed a positive quadratic trend, as scores first fell and then rose. Both 9- and 13-year-old white students showed a positive linear trend, as did 9- and 13-year-olds overall. Unlike 17-year-olds overall, 17-year-old white students did not show a negative linear trend. But like them their 1996 average was lower than their 1969 average.

Scores for black and Hispanic students generally showed improved performance. Scores for both black and Hispanic students showed positive linear trends at all three age levels, as scores trended upwards over

time. (Separate data for Hispanic students only go back as far as 1977.) Scores for black 17-year-olds showed a positive quadratic trend, as scores first fell and then rose. Black students at age 9 and 13 had higher scores in 1996 than in 1970. Hispanic students in the same age groups had higher scores in 1996 than in 1977.

Results for male students mirrored overall results, with one exception: 9-year-old males did not have significantly higher scores in 1996 than in 1970. Results for female students were also very similar to overall results. All three age groups showed a positive quadratic trend; age 9- and 13-year-olds showed a positive linear trend; 17-year-olds did not show a negative linear trend, but their 1996 average score was below their 1969 score. Nine-year-old females, like 9-year-olds overall, had a higher average score in 1996 than in 1970.

Performance Differences

As in the past, the 1996 Long-Term Trend Science Assessment found some differences in the performance of different racial/ethnic subgroups and between male and female students. In general, scores for white students have tended to be higher than scores for black and Hispanic students, and scores for male students have tended to be higher than scores for females. Table 2 displays the differences in average scale scores for the1969–70 and 1996 assessments, as well as the trends in performance differences over all the assessments between 1969–70 and 1996. (For Hispanics only, comparisons cover the years 1977–1996.)

The difference between average scale scores for blacks and whites showed a negative linear trend for all three age groups; that is, the size of the difference declined over time. The difference in scores for both 9- and 13-year-olds also showed a positive quadratic trend—the difference remained unchanged for the first few assessments, and then began to decline. In addition, the difference in scores for these two age groups was lower in 1996 than in 1970.

The difference in scores for black and white 17-year-olds showed a decline because scores for black students were trending upwards while scores for 17-year-old white students were lower in 1996 than they had been in 1969. Scores for both black and white 9- and 13-year-olds were trending upwards over time, but black students' scores showed more of an increase.

Differences in scores for white and Hispanic students showed a change over the period 1977–1996 for only one age group. The difference in scores for 13-year-olds showed a positive quadratic trend as the difference first fell and then rose. Generally, increases in Hispanics' scores were offset by increases in scores of white students.

Table 2.—Trends in Differences in Average Science Scale Scores by Race/Ethnicity and Gender

	1969–70	1996	Trends
White vs. Black Students (white minus black)			
Age 17	54	47	l
Age 13	49*	40	lQ
Age 9	57*	38	lQ
White vs. Hispanic Students† (white minus Hispanic)			
Age 17	35	38	
Age 13	43	34	Q
Age 9	38	33	
Male vs. Female Students (male minus female)			
Age 17	17*	8	l
Age 13	4	9	q
Age 9	5	4	

†For Hispanic students, the data cover assessments from 1977 to 1996.

*Differences in scores were significantly higher than in 1996, at a 5 percent combined significance level per set of comparisons.

L=Positive Linear Trend l=Negative Linear Trend

Q=Positive Quadratic Trend q=Negative Quadratic Trend

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment. Consult this publication for graphs and complete scale score data for all subgroups on each assessment.

Differences in scores between male and female students showed a few changes. The difference in scores between 17-year-old male and female students declined, comparing results for the years 1969 and 1996. The difference in scores showed a negative linear trend as well over the period 1969–1996. Scores for 17-year-old females fell, but male scores fell even more.

The difference in scores for 13-year-old males and females showed a negative quadratic trend: the difference increased and then leveled off. Scores for both male and female 13-year-olds first declined and then rose.

Conclusion

Average scale scores for science showed a mixed pattern by 1996. Scores for all three age groups fell after the initial assessment. By 1996, scores were trending upwards for 9- and 13-year-olds, but not for 17-year-olds. Scores for blacks and Hispanics showed positive

trends for all three grade levels, but scores for these students remained below the scores of white students.

Differences in scores between whites and blacks showed a downward trend for all three age groups, reflecting increases in scores among black students. There was little change in differences in scores for whites and Hispanics. Differences in scores for males and females declined for 17-year-olds only.

Notes

[1]A series of scores may show a linear trend, either positive or negative, even though a comparison of the first and last scores does not show a statistically significant difference. The reverse is true as well.

[2]Quadratic equations, familiar from elementary algebra, involve variables with a power no greater than 2. For example, the equation $y^2=R^2- x^2$ (or $y = \sqrt{R^2 - x^2}$) is a quadratic equation, in particular, the equation used for graphing a circle. For purposes of trend analysis, this equation could be used to represent either a positive quadratic trend in which scores first fell and then rose to their original starting point, or a negative quadratic trend in which scores first rose and then fell to their original starting point.

For Further Information

NAEP 1996 Trends in Academic Progress is the complete report. Single copies are available free from the National Center for Education Statistics, U.S. Department of Education, Washington, DC 20208–5653. Copies may also be obtained over the World Wide Web at **http://nces.ed.gov/NAEP/96report/97986.shtml**.

NAEPfacts briefly summarize findings from the National Assessment of Educational Progress (NAEP). The series is a product of the National Center for Education Statistics (NCES), Pascal D. Forgione, Jr., Commissioner, and Gary W. Phillips, Associate Commissioner for Education Assessment. This issue of *NAEPfacts* was written by Alan Vanneman, of the Education Statistics Services Institute, in support of the National Center for Education Statistics. To order other NAEP publications, call Bob Clemons at 202–219–1690, or e–mail bob_clemons@ed.gov.

The NCES World Wide Web Home Page is **http://nces.ed.gov/**. The NAEP World Wide Web Home Page is **http://nces.ed.gov/naep/**.

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NAEPFACTS

Vol. 3, No. 4 September 1998

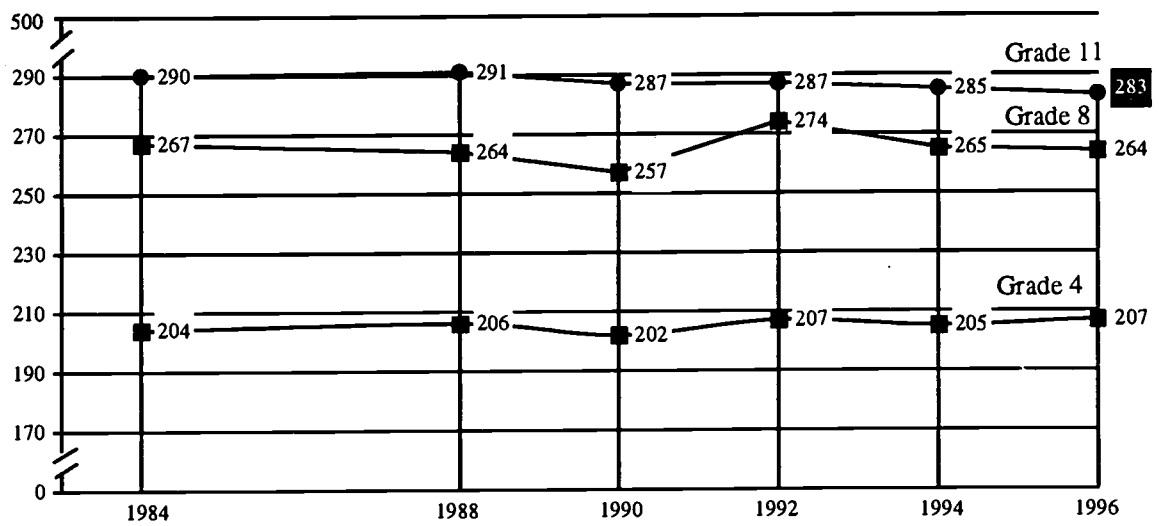
Long-Term Trends in Student Writing Performance

Summary: Data from the NAEP 1996 Long-Term Trend Writing Assessment show a decline in scores for grade 11 students over the period 1984–1996. Scores for students in grades 4 and 8 remained unchanged. White students continued to have higher scores than both black and Hispanic students in all three grades. Female students continued to have higher scores than male students in all three grades. Scores for 8th-grade male students declined.

The National Assessment of Educational Progress (NAEP) continuously monitors the knowledge, skills, and performance of the nation's children and youth in a variety of academic subjects. The data collected are available in a series of major reports. The *NAEPfacts* series takes selected data from these reports and uses them to highlight specific issues of particular interest to teachers, researchers, policymakers, and other individuals with an interest in education.

The assessments used by NAEP to evaluate long-term trends in student performance began in the early 1970s. Long-term trend assessments in science, mathematics, and reading go back to this period. Stu-

Figure 1.—NAEP Writing Average Scale Scores for the Nation



Round data markers indicate a negative linear trend (scores show an overall decrease).

Square data markers indicated no linear trend.

White numbers on a red background indicate 1996 scores were significantly lower than 1984 scores, at a 5 percent combined significance level per set of comparisons

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment.

dents were assessed at ages 9, 13, and 17. In 1984 a long-term trend assessment in a fourth subject, writing, was added. NAEP's writing assessments assess students by grade, unlike the other three long-term assessments.

Over the past 14 years, NAEP has administered six long-term trend assessments to monitor progress in the writing performance of 4th-, 8th-, and 11th-grade students. NAEP has used the same administration procedures and the same 12 writing tasks in each of these assessments, in order to measure trends in writing achievement over time.

Table 1.—Average Scale Scores in Writing by Race/Ethnicity and Gender

	Grade 4			Grade 8			Grade 11		
	1984	1996	Trend	1984	1996	Trend	1984	1996	Trend
Nation	**204**	**207**		**267**	**264**		**290***	**283**	l
White	211	216		272	271		297*	289	l
Black	182	182		247	242		270	267	
Hispanic	189	191		247	246		259	269	q
Male	201	200		258*	251		281*	275	l
Female	208	214		276	276		299	292	l

*Statistically significant difference from 1996, at a 5 percent combined significance level per set of comparisons.

L=Positive Linear Trend l=Negative Linear Trend

Q=Positive Quadratic Trend q=Negative Quadratic Trend

SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 Long-Term Trend Assessment. Consult this publication for graphs and complete scale score data for all subgroups on each assessment.

The assessments examine students' abilities in three types of writing: informative, persuasive, and narrative. Informative tasks asked students to write descriptions, reports, and analyses; persuasive tasks asked students to write convincing letters and arguments; and narrative tasks asked students to write fictional stories. Students' performance on these tasks were evaluated on the basis of their success in achieving the purpose of the task.

Analyzing Long-Term Trend Data

Changes in long-term trend data can be analyzed in a number of ways. Student scores for given years can be compared for statistically significant differences. In this report, scores for student groups or subgroups from the first assessment are compared with the results from the most recent assessment. Scores are described as "higher" or "lower" only if the difference is statistically significant—that is, unlikely to be the result of the chance factors associated with the sampling and measurement errors inherent in any large-scale sample survey effort like NAEP.

It is also possible to analyze a series of scores for overall trends, rather than year-to-year variations. Specifically, a series of scores can be analyzed for "linear" and "quadratic" trends. Linear trends can be represented as straight lines. A positive linear trend indicates that overall the average scores for a given student group form a rising line, while a negative linear trend indicates a declining one. A series of scores can show a linear trend despite wide variation among individual scores, as long as the overall pattern is either up or down.[1]

Quadratic trends can be represented as simple curves, and can be represented mathematically by quadratic equations.[2] A positive quadratic trend indicates that scores form a simple curve with one or both ends higher than its center—scores sagged, and then either leveled off or rose, or were flat and then rose. A negative quadratic trend indicates a simple curve whose center is higher than one or both ends—scores rose, and then either leveled off or declined, or were flat and then declined. It is possible for scores to display both a linear and a quadratic trend. For example, if scores rose sharply and then flattened out, this would constitute a negative quadratic trend. However, if the pattern of the scores still showed an increase for the entire

time period, the scores would also display a positive linear trend.

Overall Performance

Scores for 11th graders were lower in 1996 than in 1984, the first writing assessment (see figure 1). Eleventh graders' scores showed a negative linear trend over time. Scores for both 4th and 8th graders showed no trends of any kind, and comparisons of 1984 and 1996 scores show no change.[3]

Race/Ethnicity and Gender

In 1996, white students outperformed black and Hispanic students in writing, in all three grades, as they have done in the past (see table 1). Female students outperformed male students for all three grades, as they have done in the past.

Few subgroups recorded any changes in writing scores over the years 1984–1996. No changes at all were recorded for 4th graders. Among 8th graders, male students had a lower average score in 1996 than in 1984.

Among 11th graders, whites and males had lower scores in 1996 than in 1984, and had negative linear trends as well. Scores for female 11th graders also showed a negative linear trend. Scores for Hispanic 11th graders showed a negative quadratic trend: scores first rose and then fell.

Traditionally, NAEP long-term trend reports discuss changes in the differences in performance among subgroups as determined by race/ethnicity and gender. However, no changes of any kind have occurred in the differences in performance of these subgroups on the long-term trend writing assessments.

Conclusion

Student writing performance remained largely unchanged from 1984 to 1996, except for the decline in scores noted for 11th grade students. One issue to consider when looking at student writing performance is the use of computers in education. Recent research by Russell and Haney indicates that the use of computers in schools for instructional purposes may reduce student writing performance on paper-and-pencil writing assessments like the NAEP Long-Term Trend Writing Assessment.[4] Russell and Haney found that students tested using paper and pencil scored less well than those using computers, when given the same writing assignments.

Statistics assembled by the National Center for Education Statistics show a steady increase in computer use by students in grades one through eight: 31.5 percent in 1984, to 52.3 percent in 1989, and 68.9 percent in 1993.[5] Readers interested in the issues raised by the increase in computerized writing instruction should consult the paper by Russell and Haney cited in footnote 4 below.

Notes

[1] A series of scores may show a linear trend, either positive or negative, even though a comparison of the first and last scores does not show a statistically significant difference. The reverse is true as well.

[2] Quadratic equations, familiar from elementary algebra, involve variables with a power no greater than 2. For example, the equation $y^2=R^2- x^2$ (or $y = \sqrt{R^2 - x^2}$) is a quadratic equation, in particular, the equation used for graphing a circle. For purposes of trend analysis, this equation could be used to represent either a positive quadratic trend in which scores first fell and then rose to their original starting point, or a negative quadratic trend in which scores first rose and then fell to their original starting point.

[3] Eighth-grade scores dropped in 1990 and then rebounded sharply in 1992. The Educational Testing Service, which administers NAEP on behalf of NCES, reviewed and evaluated all of its administrative, scoring, and analysis procedures to ensure that the changes reflected actual student performance. The review and evaluation found no inconsistencies. For more detailed information see Carlson, J. & Johnson, E. (1994). Grade 8 writing trend: Investigation of the changes in mean proficiency between 1988 and 1990 and between 1990 and 1992. In E.G. Johnson, and J.E. Carlson, *The NAEP 1992 Technical Report.* National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.

[4] Russell, M. & Haney, W. (1997) Testing Writing on Computers. *Education Policy Analysis Archives.* Tempe, AZ. **http://olam.ed.asu.edu/epaa/v5n3.html**.

[5] Snyder, T.D. & Hoffman, C.M. (1990) Digest of Education Statistics. Washington, DC: U.S. Department of Education.
Snyder, T.D. & Hoffman, C.M. (1994) Digest of Education Statistics. Washington, DC: U.S. Department of Education. **http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=94115 XXXXX**.

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