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Long-Term Trends in Student Mathematics Performance

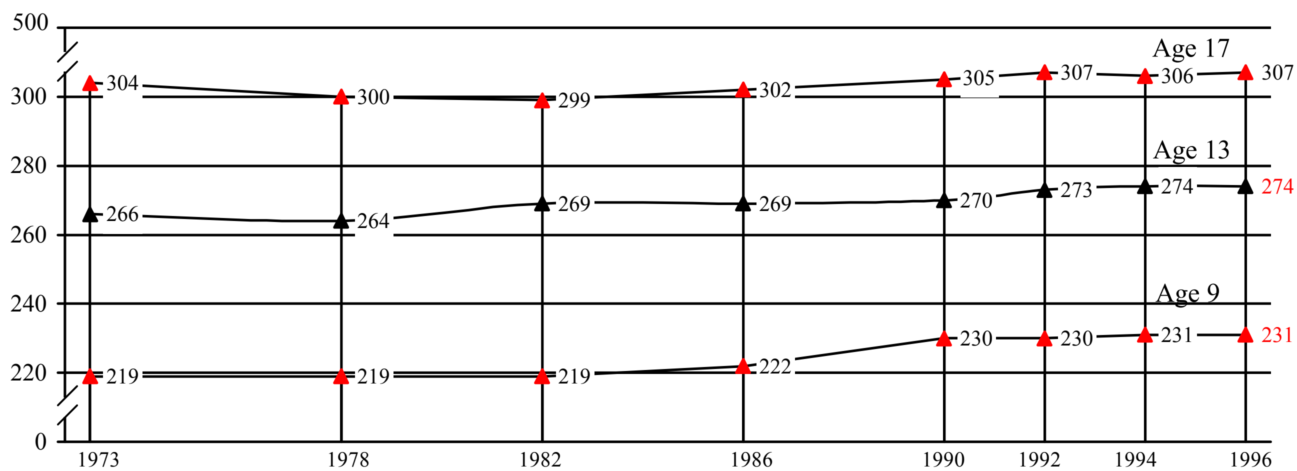
Summary: Data from the NAEP 1996 Long-Term Mathematics Assessment show a positive linear trend for all three age groups since the first assessment in 1973, indicating improving scores over time. All subgroups, including blacks and Hispanics, showed positive linear trends as well, at all three age levels.

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 NAEP facts 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 series¾ in science, mathematics, and reading ¾ 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.

Figure1.— NAEP Mathematics Average Scales 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.

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.

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.

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 (data are not shown). However, the differences for both 9- and 13-year-olds showed changes over time (1973 1996) in favor of male students.

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**.

[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 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, 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.

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