NATIONAL CENTER FOR EDUCATION STATISTICS

Statistics in Brief January 1994

Changes in Math Proficiency Between 8th and 10th Grades

Contact:
Jeffrey Owings
(202) 219-1777

Authors:
Don Rock
Educational Testing Service

Jeffrey Owings
Ralph Lee
NCES

Between eighth and tenth grades,[1] many students are asked to make curriculum-related decisions that may ultimately influence their achievement in core academic subjects such as mathematics. For these decisions to have meaning to the student, they cannot be made in isolation of either past mathematics achievement or the student's aspirations for further education. While past achievement often limits the level of courses available to a student, aspirations for postsecondary education ultimately determine the level of mathematics needed to meet selected occupational or postsecondary education goals. The interrelationships between coursework,[2] prior achievement, and aspirations can be seen when recent findings from an analysis of an NCES-sponsored longitudinal study are examined. These findings include:

- As expected, students who take higher level mathematics courses (i.e., Geometry, Algebra II, Trigonometry, Pre-calculus, Calculus) between 8th and 10th grades are more likely to be classified as being proficient at higher levels of mathematics[3] than are students who do not take higher levels of mathematics courses.
- Students who have fallen furthest behind by 8th grade are the ones who are most likely to continue to fall behind 2 years later.
- Students who expect to go to college are classified at higher mathematics proficiency levels at the 8th grade level.

This report presents findings regarding changes in mathematics proficiency levels[4] experienced by students as they move from 8th to 10th grade. Data were obtained from the base year and first follow-up surveys of the National Education Longitudinal Study of 1988 (NELS:88)[5]. The scope of the NELS:88 sample used in this report is limited to the 16,659 students who were attending school both at the time of the base year and first follow-up surveys[6].

Eighth Grade Mathematics Proficiency Levels

In 1988, more than half of the sampled 8th graders (54.6 percent) were classified as not being proficient at performing simple mathematics operations such as decimals, fractions, and roots[7] (see figure 1). About one in five (23.3 percent) were classified as being proficient at simple operations using decimals, fractions, and roots but not at "simple problem solving." The remaining students (22.1 percent) were classified as being proficient at simple problem solving requiring conceptual understanding and/or the development of a solution strategy.

U.S. Department of Education
Office of Educational Research and Improvement NCES 93-455

Proficiency 2 Years Later—As 10th Graders

Two years later, in 1990, these same students were assessed again. This time, almost two-fifths (38.1 percent) still were not classified as being proficient at performing simple operations such as decimals, fractions, and roots (see figure 1). Another 14.7 percent were classified as being proficient at this level but not at the higher levels. Nearly one-quarter (24.7 percent) were now classified as being proficient at the level of simple problem solving but not at the level of complex problem solving. The remaining students (22.5 percent) were classified as being proficient at all levels including complex problem solving, a new level added to the 10th grade assessment. In addition to being proficient with simple operations on decimals, fractions, and roots and simple problem solving, these students were also proficient at conceptual understanding and complex problem solving.

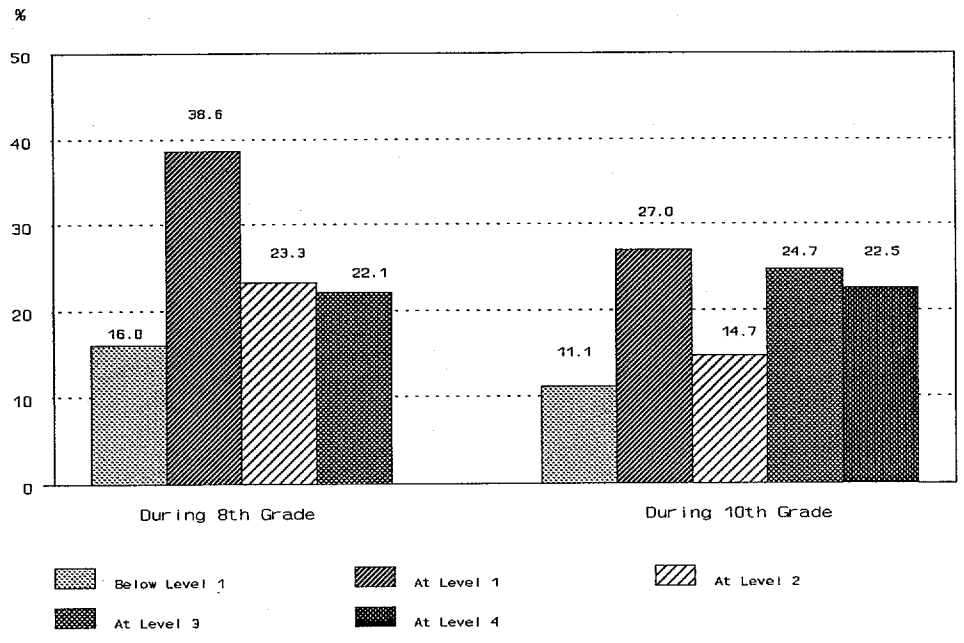
Overall Changes in Proficiency Levels

During the 2 years between NELS:88 assessments, 57.6 percent of the sample was classified at higher proficiency levels at the 10th grade than at the 8th grade (see table 2). One-third (32.9 percent) remained at the same proficiency level while nearly 1 in 10 (9.6 percent) regressed to a lower proficiency level.

Controlling for Past Performance and Course Taking

A combination of factors such as parental involvement in school and/or parental education level have been used in the past to help explain why some students gain in math proficiency while others regress. The effect of other variables such as past achievement and course-taking patterns are less well understood because they have not been available on large national datasets. In the following sections, gains in math proficiency are again examined, but this time with information about 8th grade math achievement and self-reported course-taking patterns.

Figure 1.—Percentage of students classified into specific mathematics proficiency levels: 1988 and 1990



NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

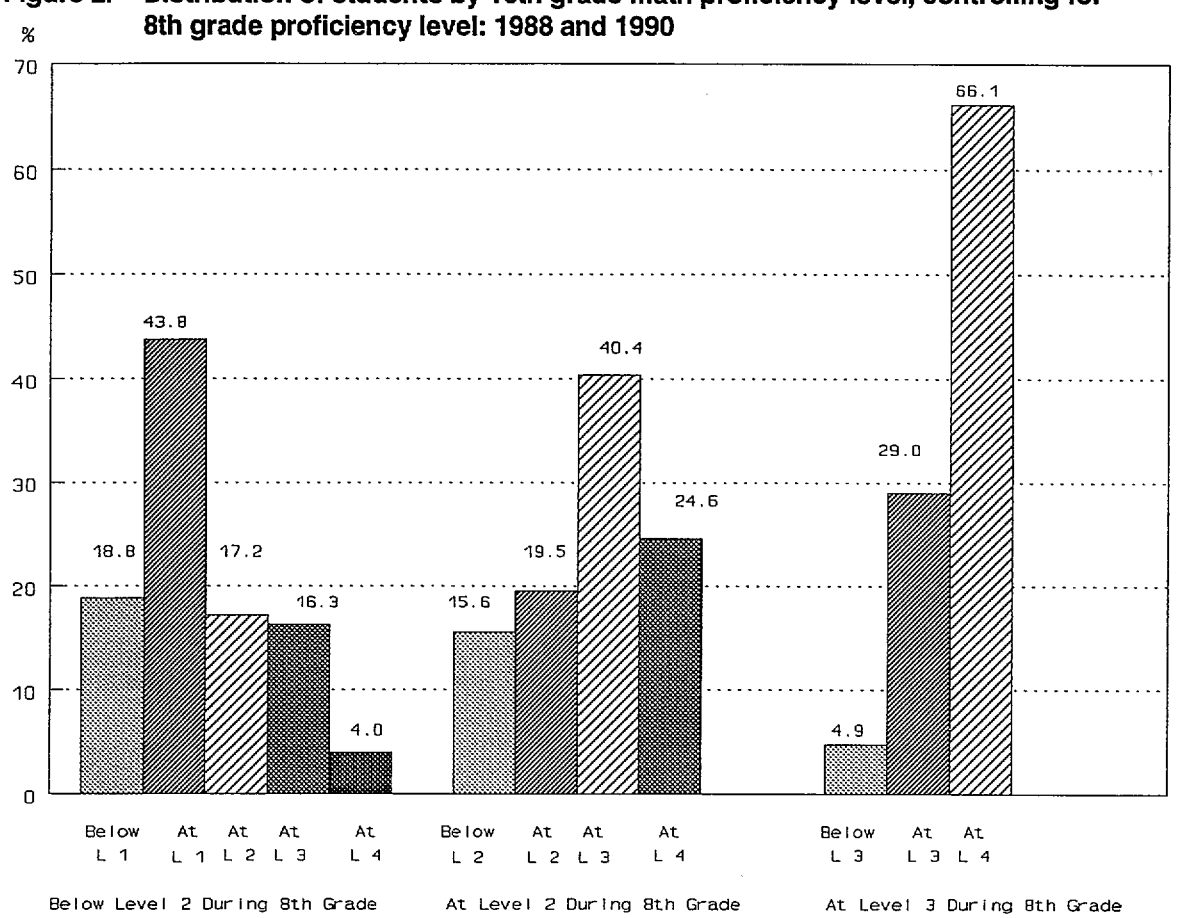
Controlling for Eighth Grade Math Proficiency

Not proficient at decimals. For those students who were not classified as being proficient at performing operations involving decimals, fractions, and roots (or higher levels) during the 8th grade, 62.6 percent were still classified at this level 2 years later (18.8 percent were classified as not being proficient at performing simple operations on whole numbers; 43.8 percent were classified as being proficient at whole numbers but not at higher levels) (see figure 2). Only 37.5 percent were now classified as being proficient at the level of performing operations on decimals, fractions, and roots or higher (17.2 percent were now classified as proficient in decimals, fractions, and roots; 16.3 percent were now classified as proficient at simple problem solving; and 4.0 percent were classified as proficient at complex problem solving).

Proficient at decimals but not at higher levels. For those students who were classified as being proficient at performing operations involving decimals, fractions, and roots (but not higher levels) during the 8th grade, 15.6 percent were classified 2 years later as being below this level, while 19.5 percent were still classified at this same level (see figure 2). Almost two-thirds (65.0 percent) were classified as making gains; 40.4 percent were classified as being proficient at simple problem solving, and 24.6 percent were classified as being proficient at complex problem solving).

Proficient at simple problem solving. For those students who were classified as being proficient at the level of simple problem solving during the 8th grade, 4.9 percent were classified at a lower level 2 years later, while 29.0 percent were still classified at this level. The remaining students (66.1 percent) were now classified as being proficient at the level of complex problem solving (see figure 2).

Figure 2.—Distribution of students by 10th grade math proficiency level, controlling for 8th grade proficiency level: 1988 and 1990



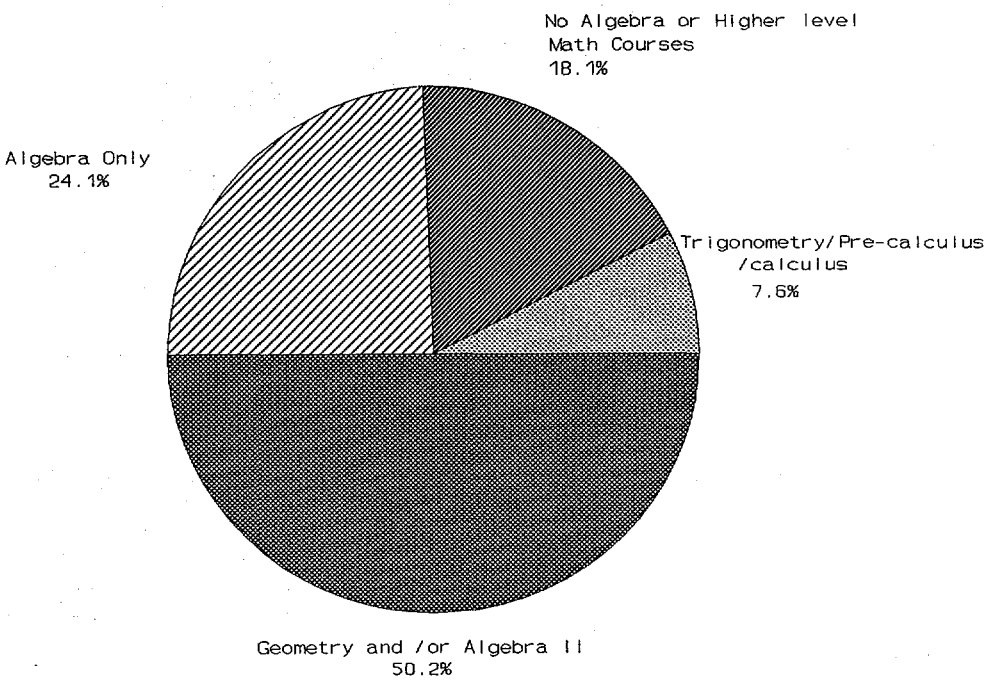
NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Controlling for Level of Math Courses Taken

During both the base year and the first follow-up surveys, students were asked about math courses they had taken during 8th (base year), 9th, and 10th (follow-up) grades. These self-reported math experiences from the two surveys were combined and categorized into the following four "math course-taking" patterns: (1) no coursework in Algebra or higher level math during 8th, 9th, and 10th grades—18.1 percent of students; (2) highest math course taken was Algebra I—24.1 percent of students; (3) highest course taken was Geometry and/or Algebra II—50.2 percent of students; and (4) highest course taken was Trigonometry, Pre-calculus, and/or Calculus—7.6 percent of students (see figure 3). Testing the premise that an individual's course-taking pattern may be affected by his or her prior math achievement, these four course-taking patterns were compared to 8th grade proficiency levels. This analysis shows that students are more likely to have taken a higher level of course if their math proficiency at 8th grade was classified at a higher level (see table 4).

Figure 3.—Percentage of students reporting specific patterns of mathematics course-taking behavior between 8th and 10th grades: 1988 and 1990

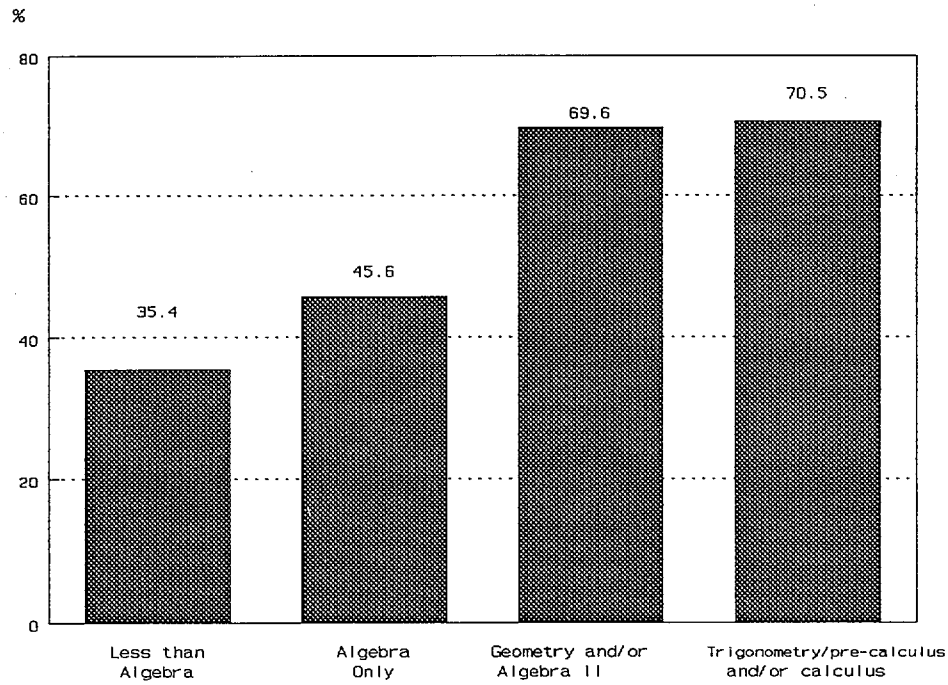


NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Gains by course-taking patterns. For those students whose highest mathematics course taken between 8th and 10th grades was below Algebra I, 35.4 percent were classified one or more proficiency levels higher at the first follow-up than at the base-year compared to: 45.6 percent for those students who completed Algebra I (but not any higher level math); 69.6 percent for those students who took Geometry and/or Algebra II; and 70.5 percent for those students who took Trigonometry, Pre-calculus and/or Calculus (see figure 4).

Figure 4.—Percentage of students who made progress in math proficiency between base year and first follow-up, by specific math course-taking pattern: 1988 and 1990



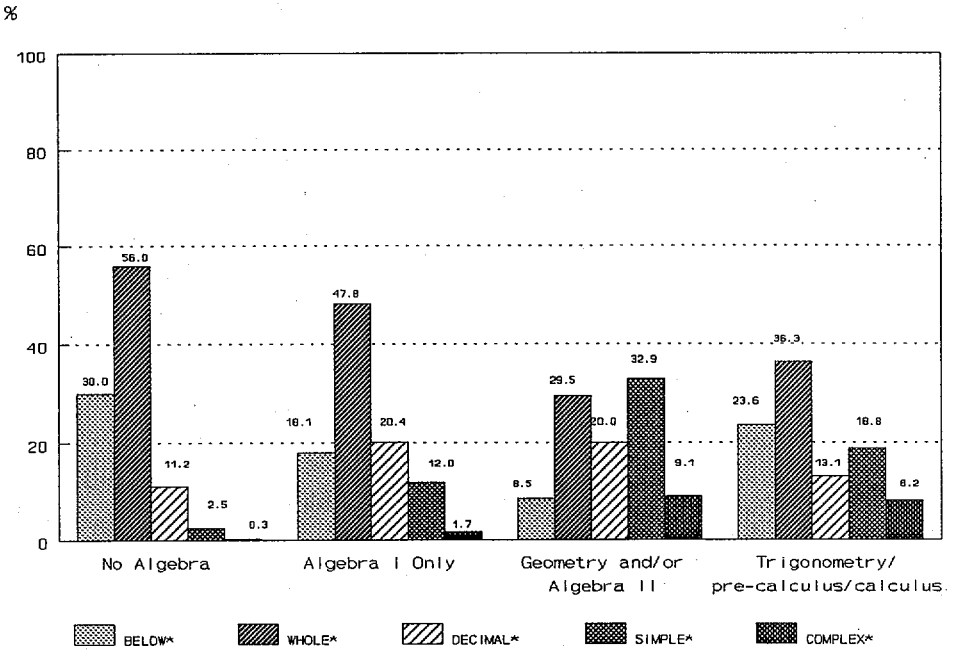
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Gains by Course-Taking Patterns and Prior Achievement

Proficiency level less than decimals. For those students who were not classified as being proficient at the level of decimals, fractions, and roots during the 8th grade, 14.0 percent of those students not taking Algebra I were now classified as being proficient at least at the level of decimals (11.2 percent at simple operations on decimals, 2.5 percent at simple problem solving, and .3 percent at complex problem solving) compared to: 34.1 percent of those students who took Algebra I but no higher (20.4 percent at simple operations on decimals, 12.0 percent at simple problem solving, and 1.7 percent at complex problem solving); 62.0 percent of those students who took Geometry and/or Algebra II (20.0 percent at simple operations on decimals, 32.9 percent at simple problem solving, and 9.1 percent at complex problem solving); and 40.1 percent of those students who took Trigonometry/Pre-calculus/Calculus (13.1 percent at simple operations on decimals, 18.8 percent at simple problem solving, and 8.2 percent at complex problem solving) (see figure 5).

Proficient at decimals but not higher. For those students who were classified as being proficient at performing simple operations on decimals, fractions, and roots during 8th grade, 23.6 percent of those students not taking Algebra I were now classified as being proficient at least at the level of simple problem solving (20.1 percent at simple problem solving and 3.5 percent at complex problem solving) compared to: 40.5 percent of those students who stopped at Algebra I (30.8 percent at simple problem solving and 9.7 percent at complex problem solving); 76.2 percent of those students taking Geometry and/or Algebra II (45.1 percent at simple problem solving and 31.1 percent at complex problem solving); and 72.6 percent of those students who took Trigonometry, Pre-calculus, and/or Calculus (45.0 percent at simple problem solving and 27.6 percent at complex problem solving) (see figure 6).

Figure 5.—Distribution of proficiency levels in mathematics during 10th grade for those students classified as not being proficient at decimals, fractions, and roots at 8th grade, by math course-taking pattern: 1988 and 1990



*BELOW—Less than whole numbers; WHOLE—Proficient at whole numbers; DECIMAL—Proficient at decimals, fractions, and roots; SIMPLE—Proficient at simple problem solving; COMPLEX—Proficient at complex problem solving

NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Proficient at simple problem solving. For those students who were classified as being master at the level of simple problem solving during 8th grade, 39.8 percent of those students who stopped at Algebra I were now classified as being proficient at the level of complex problem solving compared to 64.5 percent of those who took Geometry/Algebra II and 82.4 percent of those students who took Trigonometry, Pre-calculus, and/or Calculus (see figure 7).

Males versus Females

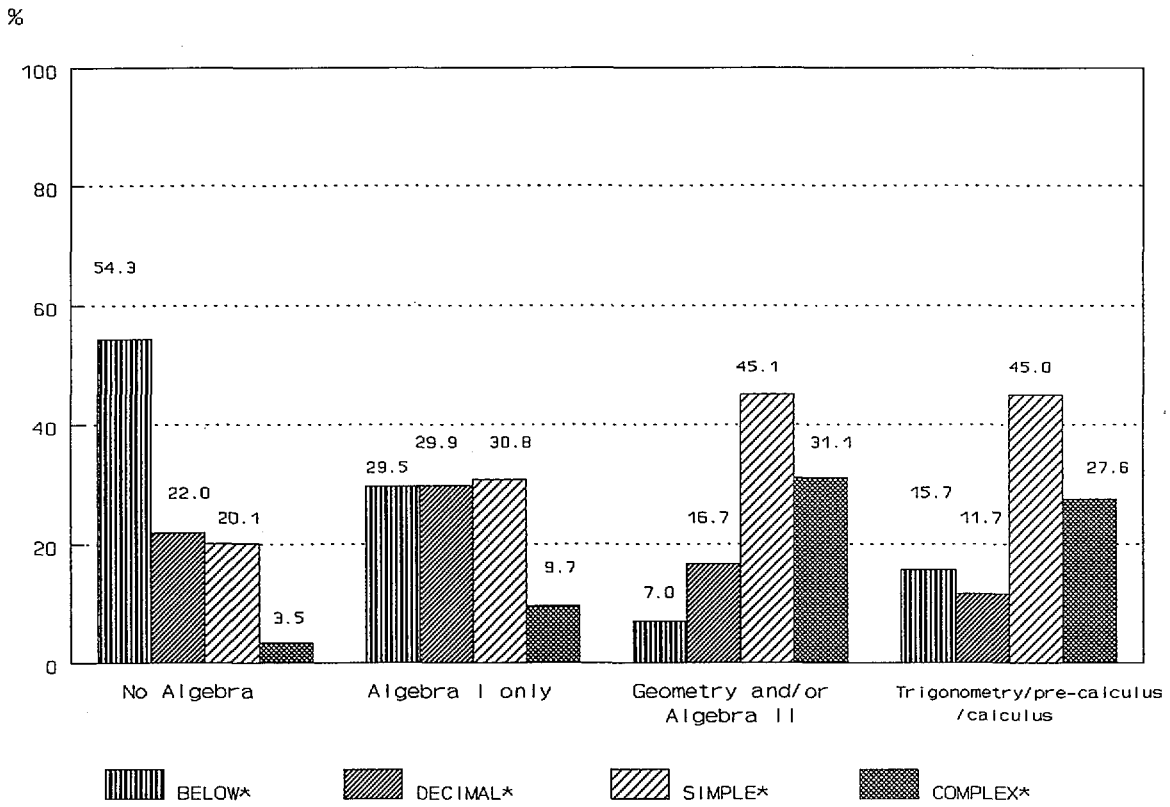
In general, males made more gains between 8th and 10th grades than did females (60.7 percent versus 54.5 percent) (see figure 8). When course-taking patterns were examined though, this trend did not exist across all groups. For example, no difference was observed between male and female students who were enrolled in either (1) Algebra only (48.7 percent versus 42.6 percent) or (2) Trigonometry/Pre-calculus/Calculus (71.1 percent versus 69.9 percent). For two other groups (no Algebra: 41.3 percent versus 28.3 percent; Geometry/Algebra II: 73.1 percent versus 66.5 percent) a difference was found.

These conflicting findings were further confounded, if 8th grade proficiency levels were also examined. For students who reported being in the normal mathematics progression pattern; that is, Geometry/Algebra II, significant gender gains in proficiency can only be found for those individuals who were classified as being proficient at simple problem solving at the 8th grade (70.6 percent versus 58.3 percent) (see table 5).

Respondent Aspirations for Higher Education

Comparing their 8th and 10th grade math proficiency levels, students with higher aspirations at the 8th grade (for at least a college degree) were more likely to have gains in math proficiency levels (63.9 percent) than students who had less than "college degree" aspirations (43.8 percent). This same statement can also be made after controlling for 8th grade math proficiency. For example, of those students who were classified as being

Figure 6.—Distribution of proficiency levels in mathematics during 10th grade for those students classified as being proficient at decimals, fractions, and roots at 8th grade, by math course-taking pattern: 1988 and 1990



*BELOW—Less than decimals; DECIMAL—Proficient at decimals, fractions, and roots; SIMPLE—Proficient at simple problem solving; COMPLEX—Proficient at complex problem solving

NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

proficient at simple operations using decimals during 8th grade, 72.3 percent (43.8 percent at simple problem solving and 28.5 percent at complex problem solving) of those who planned to graduate from college were classified at higher proficiency levels (during 10th grade) compared to 42.9 percent (30.2 percent at simple problem solving and 12.8 percent at complex problem solving) of those who did not plan to receive a college degree (see figure 9).

Summary

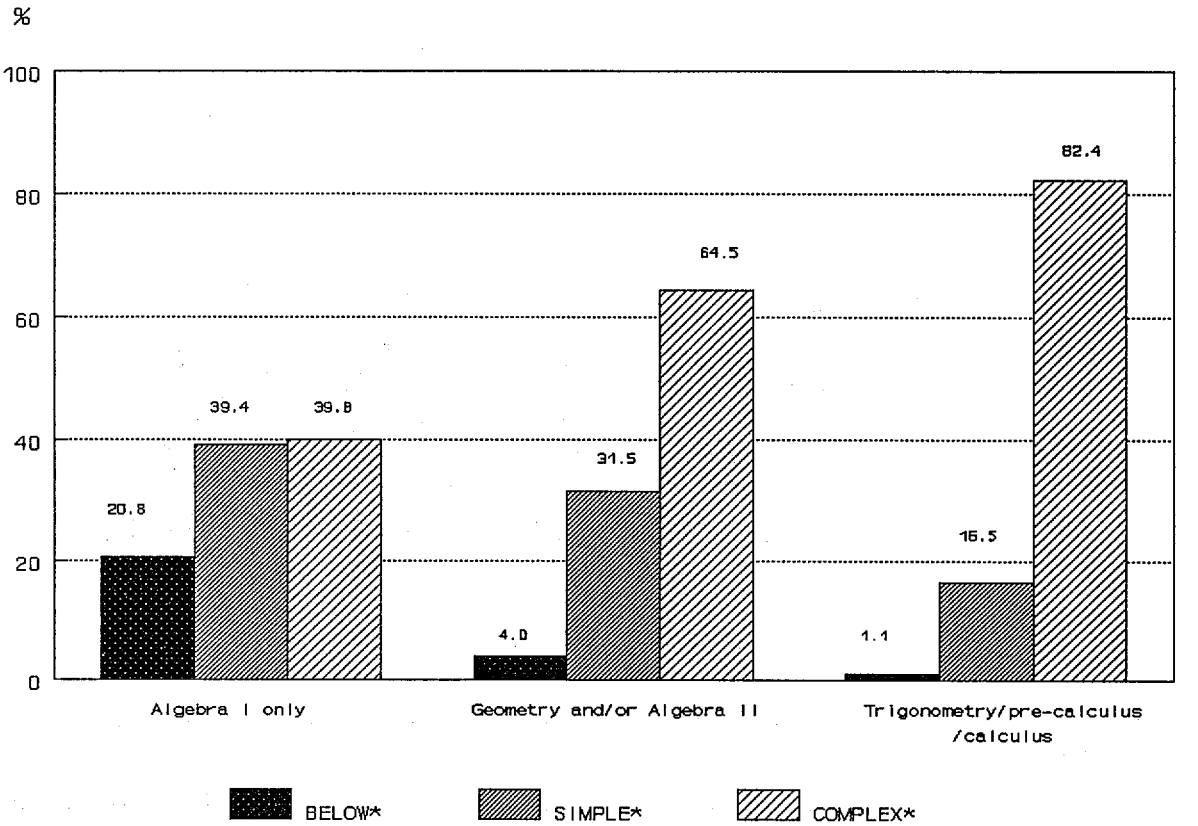
The findings presented in this report suggest that course-taking patterns in mathematics between 8th and 10th grades is an important factor in explaining increased math proficiency at the 10th grade level. For example, even after controlling for 8th grade math proficiency, higher math gains were associated with course-taking patterns that reflected advanced level math courses. This report also suggests that 8th grade students who have higher aspirations for postsecondary education are also more likely to show positive math gains.

In several forthcoming NELS:88 first and second follow-up reports, student gains in both mathematics and science are examined in more detail. Major topics will include changes in math proficiency between 8th, 10th, and 12th grades; and changes in science proficiency between 8th, 10th, and 12th grades.

For Further Information

NELS:88 has comprehensive information about student backgrounds as well as students' educational and other personal development. For further information about the databases contact Jeffrey Owings at (202) 219-1777.

Figure 7.—Distribution of proficiency levels in mathematics during 10th grade for those students classified as being proficient at simple problem solving at 8th grade, by math course-taking pattern: 1988 and 1990

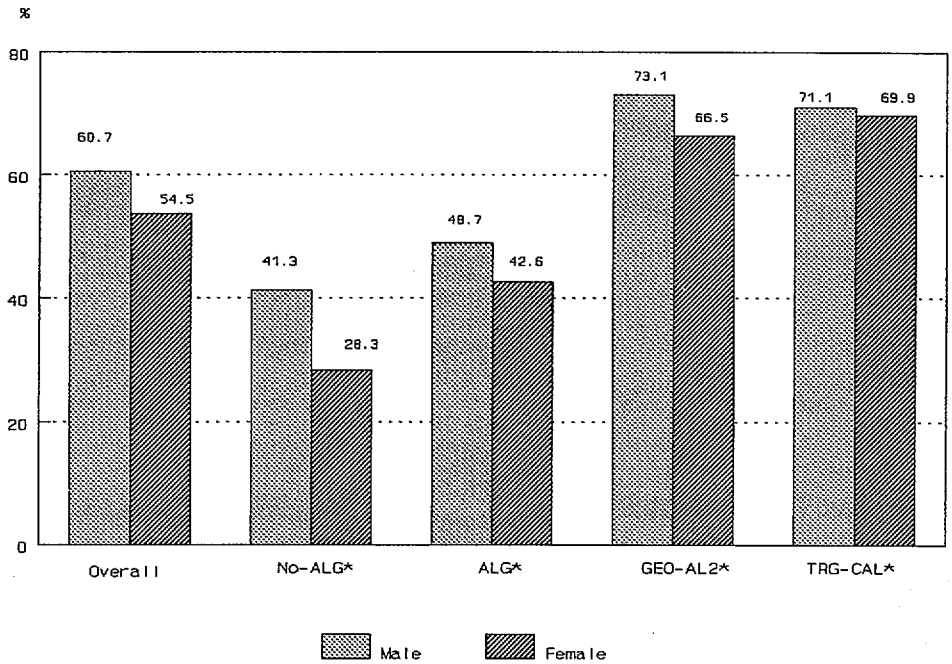


*BELOW—Less than simple problem solving; SIMPLE—Proficient at simple problem solving; COMPLEX—Proficient at complex problem solving

NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

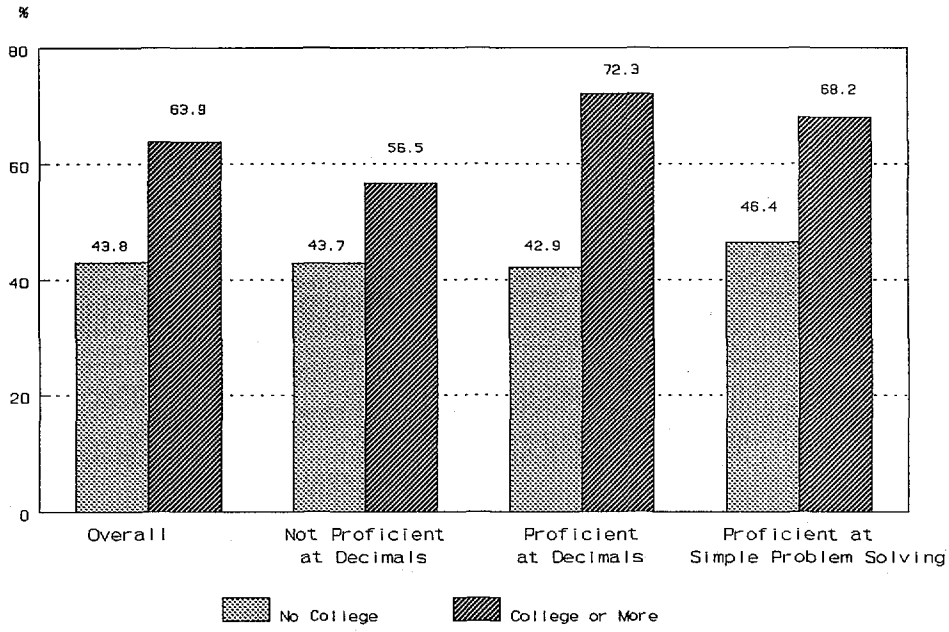
Figure 8.—Gains in proficiency levels in mathematics between 8th and 10th grades, by gender and math course-taking pattern: 1988 and 1990



*NO-ALGE—No algebra or higher; ALG–Algebra only; GEO–AL2—Geometry and/or Algebra II; TRG-CAL—Trigonometry/pre-calculus/calculus

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Figure 9.—Gains in proficiency levels in mathematics between 8th and 10th grade, by educational aspirations and by 8th grade proficiency classification: 1988 and 1990



SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

References

Ingels, S.J., L.A. Scott, J.T. Lindmark, M.R. Frankel, and S.L. Myers (1992). *NELS:88 First Follow-Up Student Component Data File User's Manual.* Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

Rock, Donald A. and Judith M. Pollack (1991). *Psychometric Report for the NELS:88 Base Year Test Battery.* Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

Endnotes

[1]During the base year of NELS:88, 8th grade schools and students were sampled across the nation. Two years later (1990), these same students were resurveyed as part of the first follow-up. A majority (96.5 percent) of these students who were still in school were then 10th graders. For purposes of this report, this transition period will be referred to as 8th to 10th grade.

[2]During both the base year and first follow-up of NELS:88, students were asked to report on the courses taken in mathematics. The reliability of these self-reports have been shown to be as high as .85 for geometry and in the .60s for second-year algebra (.68), calculus (.67), and trigonometry (.63) in past longitudinal studies (e.g., High School and Beyond) when self-reported courses are compared to high school transcripts. NELS:88 collected high school transcripts as part of the second follow-up.

[3]For this analysis, mathematics test performance at the 8th and 10th grades was categorized into the following proficiency levels: (1) not proficient at performing operations involving decimals, fractions, and roots; (2) proficient at performing operations involving decimals, fractions, and roots but not higher levels; and (3) proficient at solving simple problemsolving tasks that require conceptual understanding. At the 10th grade level, an additional category was added: proficient at performing tasks at lower levels and also able to successfully solve more complex problems.

[4]See the appendix for a description of progression in mathematics (changes in proficiency levels) and reliability of proficiency levels.

[5]Descriptions of the sampling design unit, item nonresponse, and the variables included in this report are included in the appendix.

[6]Responses for the in-scope sample whose math proficiency levels were not available for either the base year or the first follow-up were treated as missing. A descriptive comparison between "valid" and "missing" students reveals that the group with valid responses was slightly more likely than the group with missing responses to: (1) be classified at a higher proficiency level in 8th grade; (2) be classified at a higher proficiency level in 10th grade; (3) have taken higher levels of math courses; and (4) have aspired to higher levels of postsecondary education (see table 1). Because the missing students are less likely to be proficient at higher levels than the valid students in 8th grade, this indicates that the distribution of the 8th grade math proficiency levels reported in this analysis is biased upward. Similarly, the distribution of 10th grade mathematics proficiency reported here is also biased upward. Since 8th grade math proficiency, levels of mathematics courses taken, and postsecondary education aspirations have been observed in this analysis to be correlated positively to the individual's gain in math, the above findings between valid and missing groups suggest that the missing group would have made smaller gains than the valid group. Thus, the estimates stated in this report may be biased upward. Additional information about this study is presented in the appendix. A detailed discussion of the NELS:88 math proficiency levels can be found in the report entitled "Psychometric Report for the NELS:88 Base Year Battery.

[7]This group includes those students who were classified as either (1) not being proficient at performing simple operations on whole numbers (16.0 percent) or (2) being proficient at performing simple operations on whole numbers (38.6 percent).

[8]About 11.1 percent of students were classified as not being proficient at performing simple operations on whole numbers; 27.0 percent were classified as being proficient at performing simple operations on whole numbers.

Appendix: Technical Notes for NELS:88

The NELS:88 baseline comprised a national probability sample of all regular public and private 8th grade schools in the 50 states and the District of Columbia in the 1987-88 school year. During the base year data collection, students, parents, teachers, and school administrators were selected to participate in the survey. The total 8th grade enrollment from 1,052 NELS:88 sample schools was 202,996. During the listing procedures (before 24-26 students were selected per school), 5.35 percent of students were excluded because they were identified by school staff as being incapable of completing the NELS:88 instruments because of limitations in their language proficiency or because of mental or physical disabilities. Ultimately, 93 percent,

or 24,599, of the sample students participated in the base year survey in the spring of 1988.

The NELS:88 first follow-up survey was conducted during the spring of 1990. Students, dropouts, teachers, and school administrators participated in the follow-up, with a successful data collection effort for 17,424 individuals in the student survey. (Approximately 93 percent of the subsampled base year student respondents completed the survey instrument.) In addition, because the characteristics and education outcomes of the students excluded from the base year survey may differ from those students who participated in the base-year data collection, a special study was initiated to identify the enrollment of a representative sample of the base year ineligible (BYI) students. For the current report, data from base year ineligibles were not used because measures that reflect math proficiency for two points in time (base year and first follow-up), a necessary requirement for determining the progression of math skills of students, are not available for these students.

The scope of the cohort data presented in this report is limited to students who were sampled and attending schools both during the base year and first follow-up surveys. Excluded from this study are sampled 8th graders who dropped out of school at the 9th or 10th grades (765 cases). Also excluded from this analysis are BYI students and freshened (10th grade students in 1990 who did not have the opportunity to participate in 1988 for various reasons including not being in country) students who were not selected in the base year sample. Altogether, the in-scope sample consists of 16,659 cases. Among them, 4,111 students did not complete sufficient numbers of test items so that their math proficiency could be determined in the base year and/or the first follow-up. Due to the absence of math proficiencies at two points in time, their responses (i.e., change in math proficiency) are treated as missing. In addition, the responses of 16 students are also treated as missing because their self-reported math coursework is regarded as questionable. Thus, 12,532 cases are used for this analysis, and 4,127 were treated as missing. Among the cases classified as missing, 2,382 were missing first follow-up math proficiency scores, 1,402 were missing base year math proficiency scores, and 343 were missing both base year and first follow-up math proficiency scores.

No weighting adjustment for valid or missing responses was attempted for this analysis. Instead, descriptive summaries were produced for key variables (see table 1). This table indicates that there are differences between the two groups. For example, 22.1 percent (weighted) of students who were labeled as "valid" were classified as being at the level of simple problem solving during 8th grade compared to 11.3 percent of students who were labeled as "missing." Similarly, the valid group is slightly more likely to have (1) taken higher level math courses and (2) aspired to higher postsecondary education levels than the missing group. Because of these differences, the estimates obtained for the 8th/10th grade panel may be biased slightly upward (see table 1). The weighted percent of the 8th/10th grade panel who were classified as being at the simple problem solving level during 8th grade is 20.2 percent if calculated from the entire sample (valid plus missing) compared to 22.1 percent if calculated from the valid responses only. Since 8th grade proficiency, levels of math courses taken, and postsecondary education aspiration have been observed to be correlated positively to gains in math, the upward bias of these distributions (e.g., 8th grade proficiency) will likely cause upward bias for estimates of gains.

Sampling Errors

The data were weighted using the first follow-up panel weight (F1PNLWT) to reflect the sampling rates (probability of selection) and adjustments for unit nonresponse. The complex sample design was taken into account when a Taylor series approximation procedure was used to compute the standard errors in this report. The standard error is a measure of the variability of a sample estimate due to sampling. It indicates, for a given sample size, how much variance there is in the population of possible estimates of a parameter. If all possible samples were selected under similar conditions, intervals of 1.96 standard errors below to 1.96 standard errors above a particular statistic would include the true population parameter being estimated for about 95 percent of these samples (i.e., 95 percent confidence interval). Comparisons noted in this report are significant at the 0.05 level and were determined using Bonferroni adjusted t-tests.

Standard errors for all of the estimates are presented in tables 3 and 6. These standard errors can be used to produce confidence intervals. For example, an estimated 57.6 percent of 8th grade students were classified at higher mathematics proficiency levels in the 10th grade than at the 8th grade (see table 2). This figure has an estimated standard error of 0.78 percent. Therefore, the estimated 95 percent confidence interval

for this statistic is approximately 56.0 percent to 59.2 percent.

Variables Used in Analysis

Math proficiency (BYTXMPRO in base year and F1TXMPRO in first follow-up). Four proficiency levels in math achievement form a hierarchial scale with each succeeding level characterized by increased complexity. A proficiency at higher levels implies proficiency at the lower level. The four levels are defined as follows:

Level 1—Students are able to successfully carry out simple arithmetic operations on whole numbers.

Level 2—Students are proficient at performing all level 1 tasks as well as simple operations with decimals, fractions, and roots.

Level 3—Students are proficient at performing the two lower proficiency levels and are able to successfully solve simple problem solving tasks that require conceptual understanding and/or the development of a solution strategy.

Level 4—Students are proficient at performing all tasks of the lower three levels and are able to successfully solve more complex problems.

Each proficiency level is marked by a block of four items that are relatively internally consistent with respect to the cognitive processes required. For example, level 1 "marker" items all deal with simple arithmetic operations on whole numbers.

Item # 1—Compare two quantities of money expressed differently.

Item # 2—Compare two simple arithmetic expressions involving division of integers.

Item # 3—Compare two simple arithmetic expressions involving multiplication of integers.

Item # 4—Set up a simple equation involving addition or subtraction of integers that is the solution to a word problem.

In addition to requiring the same cognitive operations, the items within a particular marker block exhibit similar item difficulty parameters. Since the underlying cognitive demand model is assumed to be hierarchical, students who are proficient on the level 3 block of marker items should also demonstrate proficiency on the level 2 and level 1 items. While four items may seem like a relatively small number of items, it should be remembered that all four are essentially parallel measures of the same content or processing skill. The four items are not a subscale that attempts to discriminate individuals along a continuous dimension but are simply used to make a "go/no go" decision at a certain point referencing a specific skill. A full description of the psychometric properties of the NELS:88 base year test battery is presented by Rock & Pollack (1991).

During the base year, four categories were used to classify students' math proficiency: below Level 1, at Level 1, at Level 2, and at Level 3. During the first follow-up, five categories were used to classify students: below Level 1, at Level 1, at Level 2, at Level 3, and at Level 4.

Reliability of proficiency levels: The classical reliability (coefficient alpha) estimates for each of the four levels and more appropriately the classical reliability estimate for 16 items involved in the criterion referencing are:

Level 1 = .44
Level 2 = .64
Level 3 = .60
Level 4 = .40

Sixteen items defining the hierarchical model = .80.

The coefficients for the separate levels are based on the "middle" ability sample, which would be relatively appropriate for levels 2 and 3. The estimates for levels 1 and 4 are somewhat underestimated since they are most appropriate for students in the lower 25 percent (level 1) and the upper 25 percent (level 4), respectively. Information on the reliability of the lowest and highest levels is more appropriately estimated from the Item Response Theory scaled information function since this takes into consideration what ability level the discrimination is designed for. For this report, decisions about proficiency levels are based on all 16 items since the pass-fail criterion referenced levels (0, 1 scores) are only given for those who fit the full hierarchical model. A lower bound estimate of the traditional reliability coefficient would be the .80 given above. This is a lower bound estimate since it reflects the ability to consistently rank order individuals, rather than simply make a decision about whether a person is above or below some cutoff based on all 16 items. In addition, this report includes only analyses of group data which do not require the same accuracy as that required by procedures that rank order individuals. More precisely, the Guttman coefficient of reproducibility of the hierarchical scale based on the four 4-item parcel is 1.0. Another way of looking at it is that to be at the highest level a student not only had to get at least 3 out of 4 correct on the

highest level parcel but also had to maintain at least that level of performance on all the subordinate levels also.

Math coursework. During the base year, students were asked whether they had taken Algebra at 8th grade (BYS67C). During the first follow-up these same students were asked if they had taken or were taking the following math courses (F1S22A to F1S22J) since 8th grade:

- General Math
- Pre-algebra
- Algebra I
- Geometry
- Algebra II
- Trigonometry
- Pre-calculus
- Calculus
- Consumer/Business Math
- Other math

Based on students' responses to their math coursework, they were grouped into four categories according to the highest math course they had taken:

- Students who never took Algebra or math courses higher than Algebra.
- Students for whom the highest math course they had taken was Algebra I (between 8th and 10th grades).
- Students for whom the highest math course taken was Geometry and/or Algebra II.
- Students for whom the highest math course taken was Trigonometry, Pre-calculus, and/or Calculus.

Sex of the student (F1SEX): 1 = male; 2 = female

Respondent aspirations (BYPSEPLN). Responses for this variable (ranged from "won't finish high school" to "will attend a higher level of school after graduating from college") were recategorized into a two-level aspiration variable: (1) less-than-4-year college degree aspirations (codes 1 to 4) and (2) at least 4-year degree aspirations (codes 5 and 6).

Table 1.—Comparison of responses between "valid"[1] and "missing"[2] respondents on selected variables: 1988 and 1990

	Gender		Highest math course taken				Eighth grade math proficiency			Tenth grade math proficiency				Eighth grade education aspirations	
	Male	Female	No algebra	Algebra only	Algebra/ geometry	Trg/pre-cal calculus	Below decimals	At decimals	At simple problem solving	Below decimals	At decimals	At simple problem solving	At complex problem solving	No coll degree	Coll. degree or more
Unweighted %															
Valid	49.4	50.6	6.8	22.1	51.6	9.5	50.7	23.2	26.1	34.9	14.5	24.9	25.7	28.9	71.1
(n)	(6,187)	(6,345)	(2,099)	(2,759)	(6,437)	(1,191)	(6,359)	(2,902)	(3,271)	(4,374)	(1,814)	(3,120)	(3,224)	(3,601)	(8,880)
Missing	50.0	50.0	16.9	27.6	46.9	8.7	62.5	24.4	13.1	37.0	13.3	28.5	21.3	32.9	67.1
(n)	(2,064)	(2,063)	(653)	(1,069)	(1,817)	(336)	(1,489)	(581)	(312)	(518)	(187)	(399)	(298)	(1,334)	(2,721)
Valid + Missing	49.5	50.5	16.8	23.4	50.4	9.3	52.6	24.4	24.0	35.1	14.4	25.3	25.3	29.8	70.2
(n)	(8,251)	(8,408)	(2,752)	(3,838)	(8,254)	(1,527)	(7,848)	(3,483)	(3,583)	(4,892)	(2,001)	(3,519)	(3,522)	(4,935)	(11,601)
Weighted %															
Valid	49.9	50.1	18.1	24.1	50.2	7.6	54.6	23.3	22.1	38.1	14.7	24.7	22.5	31.0	69.0
(s.e.)	(0.72)	(0.72)	(0.69)	(0.71)	(0.88)	(0.40)	(0.88)	(0.63)	(0.69)	(0.90)	(0.46)	(0.58)	(0.70)	(0.76)	(0.76)
Missing	50.3	49.7	19.2	30.5	43.4	6.9	65.4	23.3	11.3	40.6	15.9	25.2	18.3	35.4	64.6
(s.e.)	(1.25)	(1.25)	(1.07)	(1.21)	(1.32)	(0.61)	(1.53)	(1.31)	(0.96)	(2.25)	(1.73)	(1.61)	(1.45)	(1.30)	(1.30)
Valid + Missing	50.0	50.0	18.4	25.7	48.5	7.4	56.5	23.3	20.2	38.4	14.8	24.8	22.1	32.1	67.9
(s.e.)	(0.63)	(0.63)	(0.61)	(0.64)	(0.80)	(0.36)	(0.81)	(0.58)	(0.63)	(0.86)	(0.45)	(0.55)	(0.07)	(0.69)	(0.69)

[1]"Valid" consists of students whose math proficiency levels were available for both the base year and first follow-up surveys.

[2]"Missing" consists of students whose math proficiency levels were not available for the base year and/or first follow-up surveys.

NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Table 2.-- Gains in proficiency levels in mathematics between 8th and 10th grades for 1990 10th graders, by 8th grade proficiency classification, gender, math course-taking patterns, and education aspirations

	Overall changes between 8th & 10th grade			Not proficient at decimals, fractions, and roots during 8th grade			Proficient at decimals, fractions, and roots during 8th grade			Proficient at simple problem solving during 8th grade		
	Loss	Remain the same	Gain	Loss	Remain the same	Gain	Loss	Remain the same	Gain	Loss	Remain the same	Gain
	%	%	%	%	%	%	%	%	%	%	%	%
Total	9.6	32.9	57.6	8.8	40.1	50.0	15.6	19.5	65.0	4.9	29.0	66.1
Composite gender												
Male	9.1	30.2	60.7	8.8	37.2	54.0	14.3	19.8	65.8	4.6	24.4	71.0
Female	10.0	35.5	54.5	8.9	43.0	48.1	16.8	19.1	64.1	5.3	34.1	60.7
Self-reported math course patterns												
No algebra	16.9	47.7	35.4	12.4	51.0	36.6	54.3	22.0	23.7	--	--	--
Algebra	13.8	40.6	45.6	9.3	43.4	47.3	29.5	29.9	40.6	20.8	39.4	39.8
Geo-alge II	5.4	25.0	69.6	5.2	26.3	68.6	7.0	16.7	76.2	4.0	31.5	64.5
Trg/pre-cal	6.0	23.5	70.5	9.4	42.3	48.3	15.7	11.7	72.6	1.1	16.5	82.4
Education aspirations at 8th grade												
No college	13.3	42.9	43.8	9.1	47.1	43.7	28.9	28.2	42.9	16.3	37.3	46.4
College or more	7.8	28.3	63.9	8.4	35.1	56.5	11.2	16.5	72.3	3.7	28.1	68.2
Gender by math course pattern												
No alge male	15.7	43.0	41.3	11.2	46.2	42.6	49.1	20.1	30.8	--	--	--
No alge female	18.5	53.3	28.3	13.9	56.6	29.5	61.0	24.5	14.5	--	--	--
Alge male	13.3	38.0	48.7	9.1	39.7	51.2	26.6	31.5	41.9	19.0	39.5	41.5
Alge female	14.3	43.1	42.6	9.5	46.9	43.7	32.7	28.2	39.1	23.3	39.3	37.4
Geo-alge II male	5.0	21.9	73.1	5.8	22.6	71.6	5.9	16.7	77.5	3.5	25.9	70.6
Geo-alge II female	5.7	27.9	66.5	4.7	29.2	66.1	8.1	16.8	75.1	4.6	37.2	58.3
Trg-cal male	5.3	23.6	71.1	10.8	44.8	44.4	12.3	12.9	74.8	0.7	15.2	84.2
Trg-cal female	6.8	23.3	69.9	7.8	39.4	52.8	18.7	10.6	70.7	1.7	18.4	80.0
Education aspiration by math course pattern												
No alge low	17.3	49.8	32.9	12.3	53.3	34.4	59.3	20.5	20.2	--	--	--
No alge college	15.6	44.6	39.8	11.8	47.5	40.7	47.1	23.9	29.0	--	--	--
Alge low	12.4	42.4	45.3	6.3	46.0	47.8	34.8	30.0	35.2	28.5	28.5	43.0
Alge college	14.9	39.4	45.7	11.6	41.7	46.7	26.4	29.6	44.0	17.4	44.2	38.4
Geo-alge II low	8.5	33.2	58.3	6.3	31.9	61.8	11.7	31.0	57.3	9.2	41.4	49.4
Geo-alge II college	4.7	23.3	72.0	4.7	24.5	70.8	6.0	13.7	80.3	3.5	30.5	66.0
Trg-cal low	19.7	48.8	31.5	13.3	59.0	27.7	--	--	--	--	--	--
Trg-cal college	3.5	19.1	77.4	6.7	34.2	59.0	7.4	11.4	81.2	1.1	15.3	83.6

--Sample size available for estimation is less than 30. The estimates are thus suppressed.

NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Table 3.— Standard errors for gains in proficiency levels in mathematics between 8th and 10th grades for 1990 10th graders, by 8th grade proficiency classification, gender, math course-taking patterns, and education aspirations

	Overall changes between 8th and 10th grade			Not proficient at decimals, fractions, and roots during 8th grade			Proficient at decimals, fractions, and roots during 8th grade			Proficient at simple problem solving during 8th grade		
	Loss	Remain the same	Gain	Loss	Remain the same	Gain	Loss	Remain the same	Gain	Loss	Remain the same	Gain
	%	%	%	%	%	%	%	%	%	%	%	%
Total	0.44	0.71	0.78	0.61	1.05	1.07	1.02	1.15	1.36	0.48	1.17	1.27
Composite gender												
Male	0.64	1.04	1.09	0.98	1.62	1.60	1.24	1.44	1.67	0.72	1.43	1.58
Female	0.53	0.95	1.01	0.67	1.32	1.29	1.56	1.87	2.15	0.62	1.74	1.79
Self-reported math course pattern												
No alge	1.09	1.73	1.64	0.98	1.87	1.77	4.37	3.29	3.89	--	--	--
Alge	1.25	1.66	1.56	1.49	2.06	1.92	2.64	2.69	2.52	3.47	5.20	5.42
Geo-alge II	0.37	0.79	0.87	0.72	1.50	1.59	0.69	1.47	1.55	0.49	1.41	1.51
Trg/pre-cal	1.40	1.89	2.30	2.29	4.20	3.98	6.57	2.74	6.27	0.42	1.99	2.03
Education aspirations at eighth grade												
No college	0.79	1.21	1.18	0.74	1.36	1.31	2.80	3.23	3.07	2.50	3.60	3.89
College or more	0.51	0.83	0.95	0.94	1.48	1.56	0.87	1.00	1.29	0.44	1.24	1.32
Gender by math course pattern												
No alge male	1.46	2.65	2.57	1.29	2.91	2.84	5.78	3.97	5.48	--	--	--
No alge female	1.61	1.91	1.77	1.55	2.04	1.85	6.14	5.24	4.04	--	--	--
Alge male	1.98	2.50	2.33	2.47	3.14	2.99	3.46	3.84	3.53	4.07	5.92	6.11
Alge female	1.32	2.15	2.00	1.33	2.61	2.38	4.06	3.75	3.76	6.02	9.04	9.28
Geo-alge II male	0.56	1.03	1.12	1.29	1.99	2.23	0.86	1.64	1.82	0.73	1.76	1.86
Geo-alge II female	0.48	1.26	1.34	0.77	2.08	2.09	1.10	2.47	2.57	0.66	2.01	2.09
Trg-cal male	1.42	2.78	2.90	3.72	5.96	5.56	5.58	4.12	6.31	0.36	2.74	2.76
Trg-cal female	2.54	2.52	3.11	2.39	5.78	5.54	11.04	3.65	10.25	0.86	2.57	2.68
Education aspiration by math course pattern												
No alge low	1.34	1.87	1.71	1.17	1.99	1.84	5.45	4.08	4.24	--	--	--
No alge college	1.81	3.44	3.25	1.77	3.83	3.65	5.92	5.12	5.68	--	--	--
Alge low	1.42	2.26	2.16	0.95	2.54	2.46	4.99	4.80	4.34	7.74	7.85	11.26
Alge college	1.90	2.28	2.23	2.46	3.00	2.84	3.09	3.07	3.25	3.75	6.19	5.84
Geo-alge II low	1.22	2.44	2.47	1.99	2.84	3.08	2.16	5.76	5.36	1.63	4.34	4.20
Geo-alge II college	0.36	0.83	0.90	0.67	1.71	1.81	0.69	1.07	1.28	0.51	1.50	1.60
Trg-cal low	6.85	5.83	5.85	5.30	7.18	5.94	--	--	--	--	--	--
Trg-cal college	0.75	1.86	1.96	1.85	5.03	4.84	3.28	2.80	4.07	0.44	1.98	12.02

--Sample size available for estimation is less than 30. The estimates are thus suppressed.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Table 4.– Percentage of students reporting specific patterns of mathematics course-taking behavior between 8th and 10th grades, by 8th grade proficiency level: 1988 and 1990

	Highest math courses taken			
Eighth grade proficiency level	No algebra	Algebra only	Algebra/geometry	Trg/pre-cal
Below level 1	44.4	31.2	20.5	4.0
At level 1	23.5	34.2	38.1	4.3
At level 2	7.4	20.1	67.2	5.3
At level 3	1.2	5.6	74.8	18.3

NOTE: Percentages may not add to 100 due to rounding.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

Table 5.— Changes in proficiency levels in mathematics between 8th and 10th grade for 1990 10th graders, by 8th grade proficiency classification, gender, math course-taking patterns, and education aspirations

Tenth grade proficiency	Overall changes between 8th & 10th grades			Not proficient at decimals, fractions, and roots during 8th grade					Proficient at decimals, fractions, and roots during 8th grade				Proficient at simple problem solving during 8th grade		
	Loss	Remain the same	Gain	LT whole numbers	At whole numbers	At decimals	At simple problem solving	At complex problem solving	LT decimals	At decimals	At simple problem solving	At complex problem solving	LT simple problem solving	At simple problem solving	At complex problem solving
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Total	9.6	32.9	57.6	18.8	43.8	17.2	16.3	4.0	15.6	19.5	40.4	24.6	4.9	29.0	66.1
Composite gender															
Male	9.1	30.2	60.7	20.2	41.1	17.6	16.8	4.3	14.3	19.8	38.4	27.5	4.6	24.4	71.0
Female	10.0	35.5	54.5	17.5	46.3	16.8	15.8	3.6	16.8	19.1	42.3	21.8	5.3	34.1	60.7
Self-reported math course pattern															
No algebra	16.9	47.7	35.4	30.0	56.0	11.2	2.5	0.3	54.3	22.0	20.1	3.5	–	–	–
Algebra	13.8	40.6	45.6	18.1	47.8	20.4	12.0	1.7	29.5	29.9	30.8	9.7	20.8	39.4	39.8
Geometry II and/or algebra	5.4	25.0	69.6	8.5	29.5	20.0	32.9	9.1	7.0	16.7	45.1	31.1	4.0	31.5	64.5
Trg/pre-cal/ Calculus	6.0	23.5	70.5	23.6	36.3	13.1	18.8	8.2	15.7	11.7	45.0	27.6	1.1	16.5	82.4
Education aspirations at eighth grade															
No college degree	13.3	42.9	43.8	23.2	50.4	15.3	9.6	1.4	28.9	28.2	30.2	12.8	16.3	37.3	46.4
College graduate or more	7.8	28.3	63.9	15.3	38.9	18.6	21.2	5.9	11.2	16.5	43.8	28.5	3.7	28.1	68.2
Gender by math course pattern															
No alge male	15.7	43.0	41.3	30.0	53.5	12.7	3.7	0.1	49.1	20.1	27.0	3.8	--	--	–
No alge female	18.5	53.3	28.3	30.1	58.9	9.5	1.1	0.4	61.0	24.5	11.3	3.3	--	--	–
Alge male	13.3	38.0	48.7	17.6	45.4	21.3	13.4	2.3	26.6	31.5	29.8	12.1	19.0	39.5	41.5
Alge female	14.3	43.1	42.6	18.5	49.9	19.6	10.8	1.2	32.7	28.2	31.9	7.2	23.3	39.3	37.4
Geo-alge II male	5.0	21.9	73.1	10.4	24.0	20.0	35.6	9.9	5.9	16.7	42.8	34.6	3.5	25.9	70.6
Geo-alge II female	5.7	27.9	66.5	7.0	34.0	19.9	30.7	8.4	8.1	16.8	47.2	27.9	4.6	37.2	58.3
Trg-cal male	5.3	23.6	71.1	28.9	34.7	11.9	12.6	12.0	12.3	12.9	36.5	38.3	0.7	15.2	84.2
Trg-cal female	6.8	23.3	69.9	17.5	38.2	14.6	25.9	3.8	18.7	10.6	52.4	18.2	1.7	18.4	80.0
Education aspiration, by math course pattern															
No alge low	17.3	49.8	32.9	30.7	57.7	10.0	1.5	0.1	59.3	20.5	18.7	1.5	--	--	--
No alge coll	15.6	44.6	39.8	28.1	53.4	13.7	4.3	0.5	47.1	23.9	22.5	6.5	--	--	–
Alge low	12.4	42.4	45.3	17.1	51.7	21.5	8.8	1.0	34.8	30.0	26.7	8.4	28.5	28.5	43.0
Alge coll	14.9	39.4	45.7	18.8	45.0	19.4	14.5	2.3	26.4	29.6	33.5	10.5	17.4	44.2	38.4
Geo-alge II low	8.5	33.2	58.3	12.5	33.7	18.2	30.0	5.5	11.7	31.0	37.6	19.7	9.2	41.4	49.4
Geo-alge II coll	4.7	23.3	72.0	7.2	28.2	20.6	33.7	10.3	6.0	13.7	46.7	33.6	3.5	30.5	66.0
Trg-cal low	19.7	48.8	31.5	41.7	38.9	8.4	11.0	0.0	--	--	--	--	--	--	–
Trg-cal coll	3.5	19.1	77.4	14.2	35.1	15.6	22.8	12.3	7.4	11.4	50.6	30.6	1.1	15.3	83.6

--Sample size available for estimation is less than 30. The estimates are thus suppressed.
NOTE: Percentages may not add to 100 due to rounding.
SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1994 – 364-352 – 814/90718

Table 6.– Standard errors for changes in proficiency levels in mathematics between 8th and 10th grades for 1990 10th graders, by eighth grade proficiency classification, gender, math course taking patterns, and education aspirations

Tenth grade proficiency		Overall changes between 8th & 10th grade			Not proficient at decimals, fractions, and roots during 8th grade					Proficient at decimals, fractions, and roots during 8th grade				Proficient at simple problem solving during 8th grade		
		Loss	Remain the same	Gain	Less than whole number	At whole numbers	At decimals	At simple problem solving	At complex problem solving	Less than decimals	At decimals	At simple problem solving	At complex problem solving	Less than simple problem solving	At simple problem solving	At complex problem solving
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Total	s.e.	0.44	0.71	0.78	0.90	1.06	0.68	0.78	0.38	1.02	1.15	1.31	1.24	0.48	1.17	1.27
Composite gender																
Male	s.e.	0.64	1.04	1.09	1.39	1.62	0.98	1.26	0.56	1.24	1.44	1.85	1.50	0.72	1.43	1.58
Female	s.e.	0.53	0.95	1.01	0.97	1.35	0.89	0.90	0.50	1.56	1.87	1.94	1.94	0.62	1.74	1.79
Self-reported math course pattern																
No algebra	s.e.	1.09	1.73	1.64	1.77	1.78	0.98	0.49	0.12	4.37	3.29	3.63	1.28	--	--	--
Algebra I	s.e.	1.25	1.66	1.56	1.65	2.00	1.39	1.04	0.41	2.64	2.69	2.40	1.35	3.47	5.20	5.42
Geometry and/or Algebra II	s.e.	0.37	0.79	0.87	0.87	1.49	1.13	1.74	0.96	0.69	1.47	1.72	1.72	0.49	1.41	1.51
Trg/pre-cal/ calculus	s.e.	1.40	1.89	2.30	3.39	4.29	2.02	2.99	2.40	6.57	2.74	5.18	4.34	0.42	1.99	2.03
Education aspirations at 8th grade																
No college degree	s.e.	0.79	1.21	1.18	1.14	1.39	1.02	0.89	0.24	2.80	3.23	2.66	1.50	2.50	3.60	3.89
College graduate or more	s.e.	0.51	0.83	0.95	1.35	1.51	0.96	1.19	0.63	0.87	1.00	1.51	1.49	0.44	1.24	1.32
Gender by math course pattern																
No alge male	s.e.	1.46	2.65	2.57	2.81	2.79	1.51	0.86	0.10	5.78	3.97	5.41	1.92	--	--	--
No alge female	s.e.	1.61	1.91	1.77	2.01	2.09	1.20	0.32	0.24	6.14	5.24	3.36	1.67	--	--	--
Alge males	s.e.	1.98	2.50	2.33	2.52	3.10	2.02	1.70	0.78	3.46	3.84	3.25	2.15	4.07	5.92	6.11
Alge females	s.e.	1.32	2.15	2.00	1.84	2.56	1.91	1.26	0.31	4.06	3.75	3.64	1.62	6.02	9.04	9.28
Geo-alge II males	s.e.	0.56	1.03	1.12	1.56	1.78	1.78	2.87	1.48	0.86	1.64	2.45	2.19	0.73	1.76	1.86
Geo-alge II female	s.e.	0.48	1.26	1.34	0.90	2.13	1.37	1.84	1.29	1.10	2.47	2.51	2.64	0.66	2.01	2.09
Trg-cal male	s.e.	1.42	2.78	2.90	5.32	6.09	2.79	2.88	4.26	5.58	4.12	6.37	6.45	0.36	2.74	2.76
Trg-cal female	s.e.	2.54	2.52	3.11	4.01	5.68	3.01	4.98	1.47	11.04	3.65	8.50	5.15	0.86	2.57	2.68
Education aspiration by math course pattern																
No alge low	s.e.	1.34	1.87	1.71	1.75	1.90	1.12	0.39	0.09	5.45	4.08	4.14	1.12	--	--	--
No alge coll	s.e.	1.81	3.44	3.25	4.03	3.75	1.90	1.19	0.29	5.92	5.12	4.97	2.61	--	--	--
Alge low	s.e.	1.42	2.26	2.16	1.85	2.51	2.25	1.06	0.31	4.99	4.80	4.08	1.83	7.74	7.85	11.26
Alge coll	s.e.	1.90	2.28	2.23	2.55	2.95	1.81	1.63	0.67	3.09	3.07	3.16	1.92	3.75	6.19	5.84
Geo-alge II low	s.e.	1.22	2.44	2.47	2.45	2.88	2.10	3.47	1.14	2.16	5.76	4.67	2.99	1.63	4.34	4.20
Geo-alg II coll	s.e.	0.36	0.83	0.90	0.78	1.74	1.35	1.98	1.23	0.69	1.07	1.84	1.87	0.51	1.50	1.60
Trg-cal low	s.e.	6.85	5.83	5.85	7.48	8.10	3.46	4.18	0.00	--	--	--	--	--	--	--
Trg-cal coll	s.e.	0.75	1.86	1.96	3.13	4.98	2.65	3.79	3.47	3.28	2.80	4.72	4.40	0.44	1.98	2.02

--Sample size available for estimation is less than 30. The estimates are thus suppressed.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Education Longitudinal Study of 1988: Base Year and First Follow-Up Student Surveys.