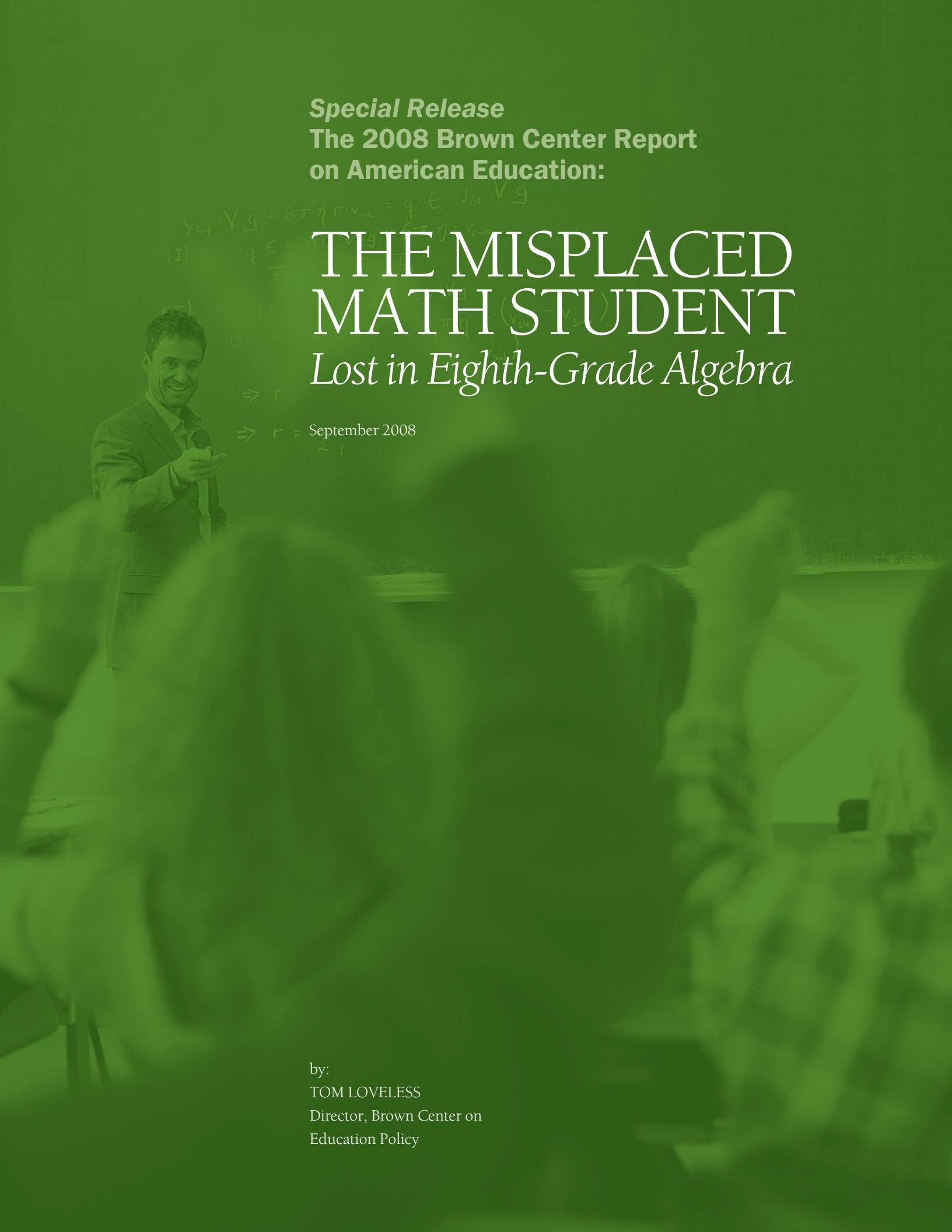


Special Release
The 2008 Brown Center Report on American Education:

THE MISPLACED MATH STUDENT

Lost in Eighth-Grade Algebra

September 2008

by:
TOM LOVELESS
Director, Brown Center on Education Policy

ALGEBRA IN EIGHTH GRADE WAS ONCE RESERVED FOR THE mathematically gifted student. In 1990, very few eighth graders, about one out of six, were enrolled in an algebra course. As the decade unfolded, leaders began urging schools to increase that number. President Clinton lamented, "Around the world, middle students are learning algebra and geometry. Here at home, just a quarter of all students take algebra before high school."[1] The administration made enrolling all children in an algebra course by eighth grade a national goal. In a handbook offering advice to middle school students on how to plan for college, U.S. Secretary of Education Richard Riley urged, "Take algebra beginning in the eighth grade and build from there."[2] Robert Moses ratcheted up the significance of the issue by labeling algebra "The New Civil Right," thereby highlighting the social consequences of so many poor and minority students taking remedial and general math courses instead of algebra.[3]

Are we enrolling eighth graders who know very little mathematics in higher-level math classes?

The campaign was incredibly successful. Several urban school districts declared a goal of algebra for all eighth graders. In 1996, the District of Columbia led the nation with 53 percent of eighth graders enrolled in algebra. From 1990 to 2000, national enrollment in algebra courses soared from 16 percent to 24 percent of all eighth graders. The surge continued into the next decade. Eighth-grade enrollment in algebra hit 31 percent nationally in 2007, a near doubling of the 1990 proportion. Today more U.S. eighth graders take algebra than any other math course.[4] In July 2008, the State of California decided to adopt an algebra test as its eighth-grade assessment of student proficiency. The policy in effect mandates that all eighth graders will be enrolled in algebra by 2011.

At first glance, this appears to be good news. Transcript studies indicate that 83 percent of students who take geometry in ninth grade, most of whom completed algebra in eighth grade, complete calculus or another advanced math course during high school.[5] Research also suggests that students who take algebra earlier rather than later subsequently have higher math skills.[6] These findings, however, are clouded by selection effects—by the presence of unmeasured factors influencing who takes algebra early and

Statewide Enrollment in Advanced Math Classes, 2007 (with 8th-grade NAEP math score) **Table 2-1**

Jurisdiction	8th-Grade NAEP Score	Total Advanced Enrollment
National	281	38%
Massachusetts	298	45%
Minnesota	292	35%
North Dakota	292	21%
Vermont	291	26%
Kansas	290	39%
New Jersey	289	40%
South Dakota	288	30%
Virginia	288	42%
New Hampshire	288	30%
Montana	287	24%
Wyoming	287	32%
Maine	286	29%
Colorado	286	44%
Pennsylvania	286	42%
Texas	286	28%
Maryland	286	52%
Wisconsin	286	30%
Iowa	285	27%
DoDEA	285	40%
Indiana	285	33%
Washington	285	31%
Ohio	285	35%
North Carolina	284	33%
Oregon	284	39%
Nebraska	284	35%
Idaho	284	37%
Delaware	283	36%
Connecticut	282	39%
South Carolina	282	41%
Utah	281	58%
Missouri	281	33%
Illinois	280	33%
New York	280	21%
Kentucky	279	34%
Florida	277	42%
Michigan	277	38%
Arizona	276	32%
Rhode Island	275	41%
Georgia	275	49%
Oklahoma	275	27%
Tennessee	274	31%
Arkansas	274	33%
Louisiana	272	24%
Nevada	271	34%
California	270	59%
West Virginia	270	33%
Hawaii	269	28%
New Mexico	268	34%
Alabama	266	30%
Mississippi	265	21%
District of Columbia	248	51%

Source: Author's calculations from 8th grade math state main NAEP, NAEP data explorer http://nces.ed.gov/nationsreportcard/nde/

who takes it late. Schools routinely assign incoming eighth graders to math courses based on how much math students already know. Moreover, it is no surprise that excellent math students want to take the most challenging math courses available to them and that low-achieving students avoid these courses as long as possible. Whether algebra for eighth graders is a good idea, especially for those who have not learned basic arithmetic, cannot be concluded from existing evidence. Studies that test for causality, such as experiments with random assignment of students to treatment and control groups, have not been conducted.

The push for universal eighth-grade algebra is based on an argument for equity, not on empirical evidence. General or remedial math courses tend to be curricular dead-ends, leading to more courses with the same title (for example, General Math 9, General Math 10) and no real progression in mathematical content. By completing algebra in eighth grade—and then completing a sequence of geometry as freshmen, advanced algebra as sophomores, and trigonometry, math analysis, or pre-calculus as juniors—students are able to take calculus in the senior year of high school. Waiting until ninth grade to take algebra makes taking calculus in high school more difficult. From this point of view, expanding eighth-grade algebra to include all students opens up opportunities for advancement to students who previously had not been afforded them, in particular, students of color and from poor families. Democratizing eighth-grade algebra promotes social justice.

Two Curious Patterns in NAEP Data

One catch. Course-taking is a means to an end, not an end in itself. Students take math courses to learn mathematics. Will policies mandating algebra for all eighth graders mean that the nation's students learn more math? Not necessarily. Although cross-sectional state test data cannot answer such a question, they can answer a different question: do states that enroll more students in advanced math courses score higher than states enrolling fewer students in advanced courses?

Table 2-1 shows the 2007 eighth-grade National Assessment of Educational Progress (NAEP) scores for states and jurisdictions and the percentage of eighth graders enrolled in advanced math classes (Algebra I, Geometry, and Algebra II). Massachusetts scores at the top (298) and has 45 percent of eighth graders enrolled in advanced math, more than the national average of 38 percent. But several high-scoring states enroll fewer students in advanced classes. North Dakota and Vermont, for example, are ranked third and fourth in math achievement but enroll a relatively low percentage of eighth graders in advanced math (21 percent and 26 percent, respectively). On the other end of the spectrum, the District of Columbia scores last on NAEP but continues to be one of the leaders in the percentage of students taking advanced math.[7] The Pearson correlation coefficient, a measure of the statistical relationship between two variables, for NAEP score and advanced math enrollment is -0.09, indicating no correlation.

Another intriguing pattern in eighth-grade NAEP scores emerges from examining the scores of eighth graders taking advanced math courses. The national average in eighth-grade math has been rising steadily, increasing by 8 points from 2000 to 2007, from 273 to 281 (see Figure 2-1). But one group stands out for not participating in the score increase—eighth graders in advanced classes. Their NAEP scores have declined from 299 in 2000 to 295 in 2007, a loss of

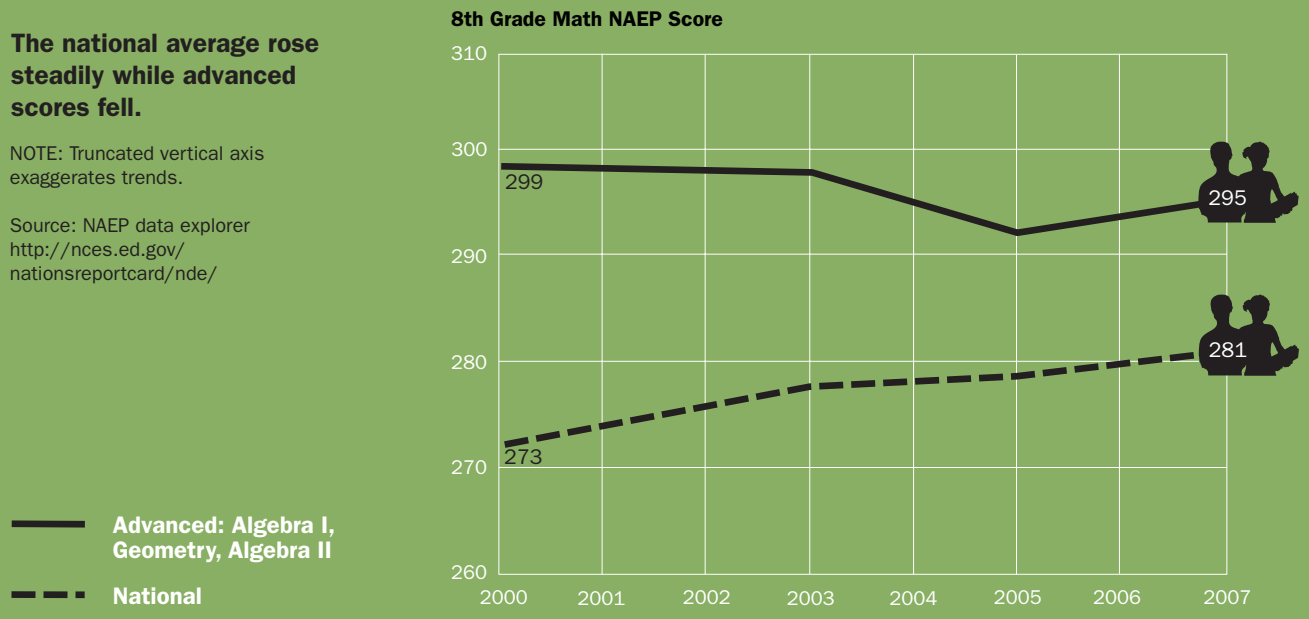
Eighth-grade NAEP scores: National average for students in advanced math (2000–2007)

Fig 2-1

The national average rose steadily while advanced scores fell.

NOTE: Truncated vertical axis exaggerates trends.

Source: NAEP data explorer http://nces.ed.gov/nationsreportcard/nde/



4 scale score points. The typical eighth grader knows more math today than in 2000. But the typical eighth grader in an advanced math course knows less. How can that happen?

As a cross-sectional measure of student achievement, NAEP provides snapshots of math achievement at one point in time. The data cannot prove or disprove causality. But NAEP data do provide rich descriptive information on what is going on in schools. Access to eighth-grade algebra has expanded dramatically. Almost nothing is known about the students who are taking these courses. Are we enrolling eighth graders who know very little mathematics in higher-level math classes?

Methods

We tackled this question by examining data on students in advanced math courses, their schools, and their teachers. The data analyzed below are from the 2005 NAEP restricted-use files, providing student-level information on a nationally representative sample of 160,000 eighth graders. Unlike the data used in most NAEP studies, these files require licensing for use and allow investigators to drill down to individual student characteristics. The 2005 data are the most recent available for this type of analysis. Advanced math courses are typically the courses that good math students take in the transition from middle to high school mathematics—in previous eras, during the first few years of high school. "Basic" refers to courses taken before students enroll in formal algebra, including pre-algebra, naturally, but also general math.

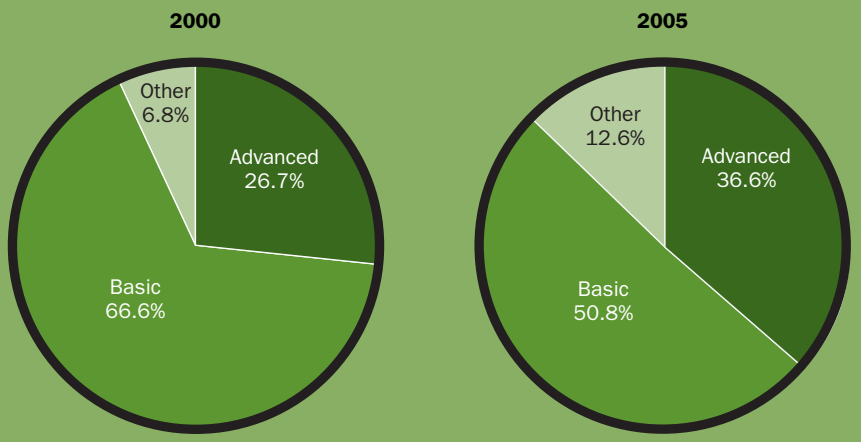
One important limitation to the data. Course-taking on the eighth-grade NAEP is reported by students. They are asked to check off the math course in which they are currently enrolled. Many students may not know the actual title of their math course, may exaggerate the level of the course, or

Course-taking in eighth-grade math, 2000 and 2005

Fig 2-2

Eighth-grade enrollment in Algebra I and other advanced math classes rose sharply from 2000 to 2005. Enrollment in basic math saw a decline.

Source: Author's calculations from NAEP restricted-use data sets: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2000 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2003-506rev) and NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).



Advanced Math: Algebra I, Geometry, Algebra II

Basic Math: General Math & Pre-Algebra

Other[8]

may for some other reason not report the course accurately. Transcripts would provide more accurate information. Although they have been collected on high school students for other national surveys, transcripts generally are not available for eighth graders. Because of this, the NAEP data are the most authoritative in existence for tracking national trends in course-taking in eighth grade. Whatever flaws arise from student self-reports, there is no reason to believe that the reliability of the reports has changed significantly over time, allowing for reasonably accurate estimates of changes in course enrollments.

What Math Courses Are Eighth Graders Taking?

As shown in Figure 2-2, between 2000 and 2005 eighth graders shifted towards tougher courses. The percentage of students taking advanced courses shot up while basic math courses experienced enrollment declines. Enrollment in advanced courses increased by about 10 percentage points, from 26.7 percent to 36.6 percent, and in basic courses fell by about 16 percentage points, from 66.6 percent to 50.8 percent. It appears that many students who would have taken lower level math courses were taking algebra, geometry, or advanced algebra in 2005. The campaign for algebra by eighth grade clearly succeeded in boosting the number of American youngsters enrolled in tougher mathematics courses.

Are all of these new students in advanced courses actually good at math? Unfortunately, the answer is no. In fact, many are very poor math students, at least as measured by their performance on the NAEP math test. Let's consider students at the 10th percentile and below—the bottom 10 percent of students nationally on the NAEP test—as low-achieving or struggling math students. How did their course-

Math courses taken by low achievers (10th percentile and below students), 2000 and 2005
Percentage of low achievers enrolled in various math classes.

Table 2-2

		2000		2005	
Advanced	**Algebra I**	4.8		17.4	
	Geometry	2.1	**8.0**	5.0	**28.6**
	Algebra II	1.1		6.2	
Basic	**General math**	50.7		27.1	
	Pre-algebra	23.0	**73.7**	19.2	**46.3**
Other		18.3	**18.3**	25.0	**25.0**

Source: Author's calculations from NAEP restricted-use data sets: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2000 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2003-506rev) and NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).

taking change from 2000 to 2005? In 2000, only 8.0 percent of low-achieving students enrolled in advanced math courses (see Table 2-2). Almost nine times as many, 73.7 percent, took general math or pre-algebra. In 2005, the percentage of low achievers enrolled in advanced math classes had ballooned to 28.6 percent. The percentage enrolled in basic courses fell to 46.3 percent. The ratio had fallen to less than two to one.

How Has the Composition of Advanced Classes Changed?

High achievers—students scoring at the 90th percentile or above—made up 27.0 percent of the advanced classes in 2000. In 2005, the percentage dropped to 20.0 percent. Low achievers more than doubled as a proportion of advanced classes, increasing from 3.0 percent in 2000 to 7.8 percent in 2005. Although appearing to be trivial, this small percentage adds up to approximately 120,000 students nationwide, a number that is growing and a phenomenon that, until now, has been viewed as an accomplishment, not a cause for worry.[9]

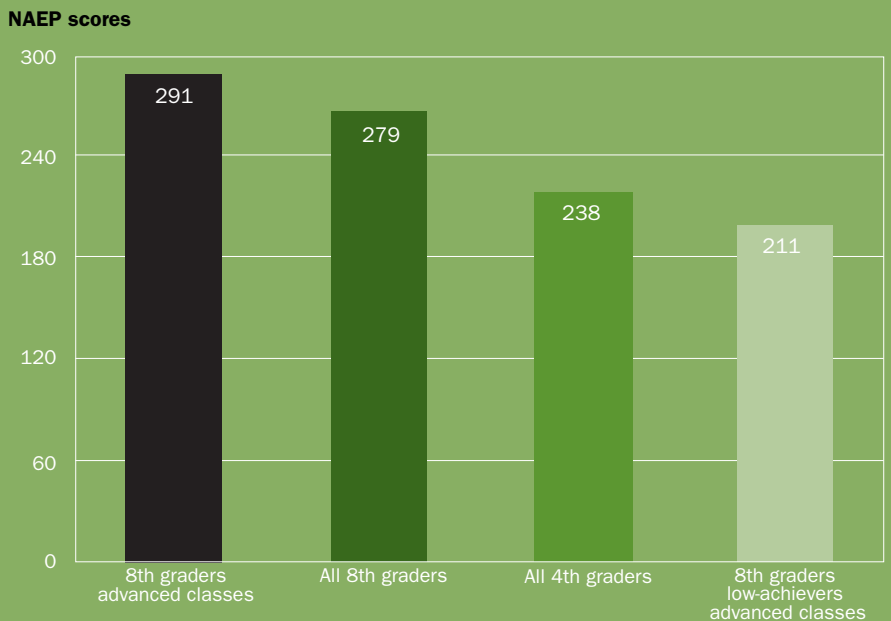
The scope of this development is also significant when viewed from the perspective of a classroom teacher. About one out of every thirteen eighth graders in an advanced math class knows very little mathematics. An algebra teacher with a class of twenty-six kids can expect to have two students performing

NAEP scores of different student groups, 2005

Fig 2-3

Low-performing eighth graders in advanced classes score even below the average fourth-grade student.

Source: Author's calculations from NAEP restricted-use data set: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486) and NAEP data explorer http://nces.ed.gov/nationsreportcard/nde/



Sample NAEP item (working with percentages)
Grade 8 Item Block 2005-8M3 No. 17:

There were 90 employees in a company last year. This year the number of employees increased by 10 percent. How many employees are in the company this year?

A) 9
B) 81
C) 91
D) 99 ✔
E) 100

Table 2-3

	Overall	Advanced Classes	Misplaced 10th
Percent answering correctly	36.5	48.7	9.8

Source: NAEP question tool http://nces.ed.gov/nationsreportcard/itmrls/startsearch.asp and author's calculations from NAEP restricted-use data set: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).

Sample NAEP item (rounding decimals)
Grade 8 Item Block 2005-8M4 No. 9:

Alba needed to know about how much the sum of 19.6, 23.8, and 38.4 is. She correctly rounded each of these numbers to the nearest whole number. What three numbers did she use?

A) 19, 23, 38
B) 19, 24, 38
C) 20, 24, 38 ✔
D) 20, 24, 39

Table 2-4

	Overall	Advanced Classes	Misplaced 10th
Percent answering correctly	85.2	87.9	37.1

Source: NAEP question tool http://nces.ed.gov/nationsreportcard/itmrls/startsearch.asp and author's calculations from NAEP restricted-use data set: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).

several years below grade level. The vast majority of students taking the class are functioning above grade level, but the number of struggling math students in advanced classes is increasing at the same time the proportion of high-achieving students in those classes is declining.

How Far Behind Are the Misplaced Students?

The average NAEP score for eighth graders in advanced math classes is 291 (see Figure 2-3). The national average for all eighth graders is 279. On the same NAEP scale, the national average for fourth graders is 238. The misplaced eighth graders score an average of 211, which is 27 scale score points below the national average for fourth grade. Analysts consider 11 NAEP scale score points as approximately equivalent to one year of learning, which means that these misplaced students know about as much math as a typical second grader. Advanced students score about one year above grade level. The misplaced students function about seven grade levels below peers enrolled in the same courses.

Examining a few sample NAEP items illustrates the misplaced students' gaps in knowledge. The first item is quite challenging for eighth graders (see Table 2-3). It asks students to calculate the result of a particular percentage increase, an arithmetic skill that, as shown in previous Brown Center Reports, eludes most eighth graders. Indeed, in 2005 only 36.5 percent of eighth graders answered the question correctly. Students in advanced courses did somewhat better, with 48.7 percent arriving at the correct solution. The misplaced students in advanced courses performed abysmally, with only 9.8 percent getting this item right.

The second item is much easier (see Table 2-4). Students are asked to round decimals to the nearest whole number. Rounding requires number sense, especially in terms of understanding the relative value of numbers on a number line. Most eighth graders have no trouble with this item—85.2 percent of all eighth graders got it right in 2005, 87.9 percent of the students enrolled in advanced classes. But only 37.1 percent of misplaced students could answer the item correctly. Failing to round simple decimals accurately to the nearest whole number signals a serious lack of understanding of the number system. Taking the same math courses as peers who easily grasp such concepts makes such deficiencies even more glaring.

Performance on sample NAEP items involving fractions (percentage answering correctly)

Table 2-5

	Overall	Advanced Classes	Misplaced 10th
Item A	72.6	78.4	42.3
Item B	45.1	57.2	3.9
Item C	47.2	58.4	6.6

Source: Author's calculations from NAEP restricted-use data set: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).

Those two NAEP items are in public release, meaning that they are no longer used on NAEP tests and can be made public. We gathered data on three additional items involving fractions. Math educators consider knowledge of fractions essential to preparation for algebra.[10] Although the three items are not in public release and cannot be disclosed, performance on them can be reported.

Table 2-5 compares the performance of the misplaced 10th percentile students who are enrolled in advanced courses with students in advanced courses and all eighth graders in the nation. On the easiest of the three items, item A, the misplaced students scored far below their peers in advanced classes. Less than half get an item right that their classmates find relatively easy. On the more difficult items, items B and C, fewer than one in ten misplaced students answer these items correctly. They score even lower than the 20 percent rate attained by simply guessing on a multiple choice item with five possible answers.

Fractions are taught in elementary school, not in an algebra course. Sadly, facility with fractions is a skill that the misplaced students do not know, need to know, and are unlikely to be taught in the math course in which they are enrolled.

The argument that advanced math courses are a civil right apparently has had an impact on schools.

Characteristics of the Misplaced Students

Who are these 120,000 misplaced students? We examined information contained in the NAEP surveys on the students' families, schools, and teachers. What we found is troubling. These students tend to be some of the nation's most vulnerable children. We already know that they struggle at mathematics, scoring among the bottom 10 percent of all eighth graders in the country. They also possess characteristics that make recovery from a lost year of math instruction unlikely.

The tables below describe the misplaced students and compare them to students in advanced math classes and the typical American eighth grader. All of the differences highlighted in the following discussion, unless otherwise noted, are statistically significant ($p < .05$).

What Are the Background Characteristics of the Misplaced Students?

Table 2-6 displays demographic data. Misplaced students are more likely to come from poor families—69.8 percent qualify for the federal free or reduced-price lunch program, a proxy for family income. This is more than double the percentage for students in advanced classes (30.4 percent) and nearly twice that of the national average (36.1 percent). Misplaced students are overwhelmingly black and Hispanic, about 77.0 percent versus 32.3 percent of all eighth graders in the nation. Only 20.3 percent report that their mothers graduated from college. The argument that advanced math courses are a civil right apparently has had an impact on schools, boosting the enrollment of black, Hispanic, and poor children in advanced courses. Unfortunately, the children in the current study are unprepared for algebra. And they come

Demographic characteristics: misplaced students and comparison groups, 2005
Percentage of students by characteristic

Table 2-6

	Misplaced 10th	Advanced Classes	National Average
Eligible Free Lunch	69.8	30.4	36.1
White	18.5	60.9	61.1
Black	38.4	14.2	16.1
Hispanic	38.6	17.1	16.2
Mother College Grad	20.3	44.8	36.9

Source: Author's calculations from NAEP restricted-use data set: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).

School characteristics: misplaced students and comparison groups, 2005

Table 2-7

	Misplaced 10th	Advanced Classes	National Average
Urban	50.9%	33.4%	31.3%
Suburban	35.4%	46.4%	43.1%
Rural	13.7%	20.2%	25.6%
School enrollment	1012	844	794
Private school	2.3%	10.5%	8.8%
>50% eligible lunch	67.6%	30.4%	31.6%
8th-grade math untracked	34.8%	22.8%	26.9%

Source: Author's calculations from NAEP restricted-use data set: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).

from homes in which, probably lacking the resources to afford tutors and other remedial materials, support may be tenuous when academic troubles occur.

What Kind of Schools Do the Misplaced Students Attend?

Table 2-7 shows the characteristics of these students' schools. About half of the misplaced students attend urban schools (50.9 percent), and they are less likely to attend suburban or rural schools than the average eighth grader. Their schools tend to be large, enrolling about 27 percent more students than the typical school housing an eighth grade (1,012 students versus 794). Almost all of the misplaced students are attending public schools, with only 2.3 percent going to private schools. The schools serve vast numbers of students in poverty. Two-thirds of the schools (67.6 percent) are high-poverty schools, defined as schools in which more than half of the students qualify for free or reduced-price lunch. Only about one-third of schools in the country fit this definition.

Schools attended by misplaced students also are more likely to shun the assignment of students to eighth-grade math classes based on mathematics ability (also known as tracking). The advanced math classes attended by misplaced students attempt to serve a wider range of mathematics abilities than the typical eighth-grade advanced math class, with 34.8 percent of schools reporting that math is untracked compared to 22.8 percent.

In sum, the profile sketched here—academically diverse classes in large, urban public schools attended predominantly by students from poverty—resembles the kind of setting that, being under great stress, many federal and state programs attempt to assist with extra financial aid. Unfortunately, it is also the kind of setting where students who are enrolled in the wrong course may fall through the cracks and flounder academically.

What Are the Teachers of Misplaced Students Like?

What do we know about the teachers of misplaced students? Teacher characteristics are displayed in Table 2-8. Compared to teachers of the typical eighth grader, the teachers of misplaced students are more likely to have taught for less than five years (30.3 percent versus 22.5 percent), less likely to hold a regular or advanced teaching certificate (74.7 percent versus 82.5 percent) and less likely

Teacher characteristics: misplaced students and comparison groups, 2005
Percentage of students by characteristic

Table **2-8**

	Misplaced 10th	Advanced Classes	National Average
Less than 5 years experience	**30.3**	**21.3**	**22.5**
Regular or advanced teaching certificate	**74.7**	**83.7**	**82.5**
Undergraduate major: mathematics	**20.1**	**28.6**	**26.2**

Source: Author's calculations from NAEP restricted-use data set: U.S. Department of Education. Institute of Education Sciences, National Center for Education Statistics. NAEP 2005 Mathematics Restricted-Use Data Files, Grade 8 (NCES 2007-486).

to have majored in mathematics as an undergraduate (20.1 percent versus 26.2 percent). Granted, these factors are only crude indicators of teacher quality, but they are recognized by many experts as important. Less experience, fewer formal credentials, and weaker mathematics training are characteristics associated with lower-, not higher-quality teaching staffs. These unprepared students are arriving in algebra classes that are staffed by underprepared teachers.

In less than two decades, policies designed to push eighth graders into algebra classes have succeeded in doubling the percentage of students enrolled in advanced mathematics. The data assembled here document a stark consequence of such policies: large numbers of students taking courses for which they are unprepared in settings that are not particularly conducive to learning.

Discussion and Policy Recommendations

One hundred twenty thousand eighth graders are sitting in advanced math classes even though they score in the bottom 10 percent of students nationwide on the NAEP math test. They know about as much math as the typical second grader. They do not know basic arithmetic and cannot correctly answer NAEP items using fractions, decimals, or percents. These students are disproportionately black and Hispanic. They hail from poor households with parents whose own education is below the national average. The schools that these children attend are large, urban public schools with predominantly low socioeconomic status populations. Their algebra classes are populated by students with mathematical abilities spanning several years. Their math teachers are less experienced, less credentialed, and less well prepared in mathematics training than the typical teacher of advanced math students in eighth grade.

No social benefit is produced by placing students in classes for which they are unprepared.

No element of this story is educationally sound. It arose from good intentions: to democratize advanced math courses by assigning students to Algebra I, Geometry, and Algebra II who were once locked out of such courses. But this is false democratization. No social benefit is produced by placing students in classes for which they are unprepared. Indeed, it is difficult to imagine any educational benefit accruing to these students. They do not possess the family or school resources to overcome problems arising from taking inappropriate courses.

Let us not forget the hundreds of thousands of well-prepared students—who are also predominantly black, Hispanic, or poor—sitting in the same classrooms as the misplaced students and equally deserving of a good education. Well-prepared students need a real algebra class, not a fake one teaching elementary school mathematics. Any teacher who stops to teach misplaced students fractions shortchanges the well-prepared students who sit in that algebra class. William Sanders, whose studies on effective teachers in Tennessee are widely cited in the literature, declared high-achieving minority students the children "whom the system serves worst." In particular,

The burden of realizing such an idealistic view of mathematics learning falls on the classroom teacher.

Sanders attributed the decline in test scores of high-achieving black students to "their higher likelihood of being in a succession of classrooms where the instruction is geared to lower achievers."[11]

The chances of algebra classrooms existing with instruction geared to low achievers is probably much greater than the current study documents. In some schools, courses purported to be covering algebra have been revealed to be fraudulent—covering a watered down form of basic math. The entire class of students may be misplaced and receiving counterfeit algebra to make up for it.[12] Moreover, using the 10th percentile as the upper boundary of defining the misplaced student yields a conservative estimate of the real dimensions of the phenomenon. Are students at the 20th, 30th, or 40th percentiles on NAEP adequately prepared for algebra? They, too, function significantly below grade level in mathematics, and by including them in the pool of misplaced math students, the numbers skyrocket.

There will be advocates, despite the data presented here, who will continue to argue for placing low-performing eighth graders in algebra classes. They believe that a more rigorous course is always preferable to a less rigorous one. Many do not believe that students must learn basic mathematics in order to successfully tackle higher-level mathematics.[13] They will argue that keeping remedial math students out of algebra in eighth grade denies these students the opportunities that good math students take for granted. What they will not say is this: the burden of realizing such an idealistic view of mathematics learning falls on the classroom teacher. Teachers are expected to make up for students' skill deficiencies. If students enter algebra classes without the preparation to succeed, then algebra teachers must find a way to fix the problem.

Algebra teachers already feel the strain of such unrealistic expectations. The National Opinion Research Center (NORC) surveyed a nationally representative sample of Algebra I teachers in 2007. The teachers described their students' preparation for algebra as weak, especially in working with rational numbers and word problems.The teachers named poor work habits as a prominent barrier to learning. When asked how they would change the emphasis on mathematical topics in the elementary grades to improve preparation, the teachers' most common answer was to focus more on the mastery of basic mathematical concepts and skills. More than half felt that mixed-ability classes were a moderate (28 percent) or serious (23 percent) problem. When given ten response options to describe the "single most challenging aspect of teaching Algebra I students successfully," the most frequent response—by a landslide, chosen by 58 percent—was "working with unmotivated students." The second most frequent response, selected by 14 percent of middle school teachers and 9 percent of high school teachers, was "making mathematics accessible and comprehensible to all my students."[14]

A simple calculation illustrates the predicament. Recall that the misplaced students described above are eighth graders who function at approximately the second-grade level in math. In other words, after eight years of schooling they have learned about one-third of what the average student has learned. In eighth grade they are now expected to learn, in a single year, the six years of math that they have not yet learned along with a full year of algebra. No one—no teacher, no researcher, no governor, no school board member, no philanthropist—knows how to teach in one year what has not been learned in six and then how to teach algebra on top of that. Algebra teachers are being asked to

do the impossible. The greatest teachers in the world do not know how to teach algebra to students who do not know basic arithmetic.

Elements of a Realistic Algebra Policy.

1. Get the goal right. Focus on learning, not completing a course. California is a good example. At least it puts the emphasis in the right place, by mandating a test of algebra. But why eighth grade? The mathematics on the current California High School Exit Exam is pitched below the level of the test proposed for eighth grade. Needless to say, requiring more out of eighth graders than twelfth graders is bizarre. Require that students pass a comprehensive test of algebra before graduating from high school, a requirement that about half of current American high school graduates (and more in California) would not fulfill. As economists Richard Murnane and Frank Levy have documented, research exists showing that knowledge of algebra is now essential for entry into occupations earning middle class wages. No evidence exists that it matters whether algebra is learned in eighth grade or later, and some students may need more than a year to learn the subject.[15]

2. Teach and assess prerequisite skills. The recent report of the National Mathematics Advisory Panel identified facility with whole numbers and fractions as key to preparation for algebra. Proficiency on these fundamental mathematical topics needs to be acquired before entry to algebra. Indeed, in a 2008 study of students in San Diego, Zau and Betts found that fourth-grade math scores were as good at predicting success on the California high school exit exam as ninth-grade scores.[16] This finding suggests that elementary mathematics is essential and failure to learn it has long term consequences.

True, in 1960 the man on the moon goal was ambitious, but a body of science indicated that going to the moon was possible.

3. Early intervention. Preparing students for algebra is the culmination of many, many years of teaching and learning and the product of hard work by students, teachers, and families. Mandating algebra in eighth grade is the equivalent of mandating, by policy, that all buildings immediately erect a fiftieth floor—regardless of their current height. Use diagnostic assessments of whole number and fraction arithmetic in the elementary grades to identify students who are struggling at math. Build student accountability into the system by requiring summer school for students who need more time to learn the building blocks of mathematics.

4. Collect data, conduct research. Many advocates of algebra for all eighth graders express the belief that lofty public policy goals can be attained through sheer will power, a "mandate it and it will be accomplished" ideal. Governor Schwarzenegger, for example, in a letter to the California State Board of Education, compared mandatory algebra in eighth grade to President Kennedy's pledge that Americans would reach the moon. The analogy is specious. True, in 1960 the man on the moon goal was ambitious, but a body of science indicated that going to the moon was possible. President Kennedy did not say we would put a man on Pluto. Not even Venus. He said the moon because the principles of physics, decades of experiments with rocketry, and the early successes of Russia and the United States in space proved that it could be done. No such science supports algebra for all eighth graders.[17]

Algebra for eighth graders is an ideal policy for randomized experiments. The mandate could be introduced in some schools and districts but not others and student outcomes compared. Just as charter schools use lotteries to decide who can attend when the number

We must establish the right goals and pursue sound strategies for achieving them.

of applicants exceed available seats, lotteries could be employed to assign students to eighth-grade algebra classes. By controlling for unobservable characteristics that influence math learning, studies with random assignment can offer a reasonable estimate of the true effects of a particular class on student outcomes. Summer boot camps that attempt different strategies for remediation could be started and carefully evaluated, again with randomized studies, and the effective programs then should be funded for dissemination.

Conclusion

One hundred twenty thousand students are misplaced in their eighth-grade math classes. They have not been prepared to learn the mathematics that they are expected to learn. This unfortunate situation arose from good intentions and the worthy objective of raising expectations for all American students. Two groups of students pay a price. The misplaced eighth graders waste a year of mathematics, lost in a curriculum of advanced math when they have not yet learned elementary arithmetic. They should be taught whole number and fraction arithmetic so that they can then move on to successfully learn advanced mathematics.

Their classmates also lose—students who are good at math and ready for algebra. These well-prepared but ill-served students also tend to be black and Hispanic and to come from low socioeconomic backgrounds. Teachers report that classes of students with widely diverse mathematics preparation impede effective teaching, that too many students arrive in algebra classes unmotivated to learn, and that they wish that elementary schools gave greater emphasis to basic skills and concepts in math. When algebra teachers have to depart from the curriculum to teach arithmetic, the students who already know arithmetic and are ready for algebra are the losers.

This study is not a call to lower expectations. Nor is it a call for cynicism. But we must establish the right goals and pursue sound strategies for achieving them. The goal must not be for students to take an algebra course by eighth grade; it must be for more students to learn algebra. The strategy must not be to designate an arbitrary grade—unsupported by research or policy experience—in which all students are swept into an algebra course. Universal eighth-grade algebra is creating more problems than it solves, with 120,000 students not learning the mathematics that they need to know and hundreds of thousands of their classmates paying an educational price along with them.

NOTES

1 Remarks by President Clinton, Education Roundtable, Springbrook High School, Silver Spring, Md., March 16, 1998. Available at http://www.ed.gov/inits/Math/timsroun.html.

2 Quoted in Matthew Bowers, "Virginia and the U.S. are Improving Slightly at Math, but We Lag Behind Our Economic Competitors in the Developed World," *The Virginian Pilot,* March 28, 1997, p. B3.

3 Robert Moses, "Algebra, the New Civil Right," in *The Algebra Initiative Colloquium, Volume II,* edited by Carol Lacampagne and others (U.S. Department of Education, 1995), pp. 53-67.

4 Data available on the main NAEP data explorer: http://nces.ed.gov/nationsreportcard/nde/. See also Jay Matthews, "Adding Eighth Graders to the Equation," *The Washington Post,* March 12, 2007, p. B1.

5 Carolyn Shettle and others, *America's High School Graduates: Results from the 2005 NAEP High School Transcript Study* (Department of Education, 2007), p. 11. Other than calculus, advanced math is defined as pre-calculus or AP statistics.

6 Julia B. Smith, "Does an Extra Year Make Any Difference? The Impact of Early Algebra on Long-term Gains in Mathematics Attainment," *Educational Evaluation and Policy Analysis,* 18 no. 2 (1996): 141-153.

7 Both California and D.C. schools serve a large number of students of low socioeconomic status. Nevertheless, the math scores for California and D.C. look dismal even if comparisons are made among similar groups of students in terms of race, ethnicity, and parental education.

8 Other includes all other courses, along with no responses and multiple responses, on the NAEP survey item.

9 In 2005, approximately 4.2 million students were enrolled in eighth grade. The estimate of 120,000 comes from [0.078 * 0.366 * 4,200,000 = 119,901.6]. All other figures in this paragraph are author's calculations from restricted use NAEP data.

10 U.S. Department of Education, ***Foundations for Success: The Final Report of the National Mathematics Advisory Panel*** (Washington: 2008).

11 William Sanders, "Teachers, Teachers, Teachers," *Blueprint Magazine,* September 1, 1999.

12 William Schmidt and others, "Relationship of Tracking to Content Coverage and Achievement: A Study of Eighth Grade Mathematics," Michigan State University, 2008.

13 Several years ago, a prominent education scholar gave a talk at Brookings in which she commented that her own son had never learned the multiplication tables but went on to graduate from an Ivy League college.

14 U.S. Department of Education, *Foundations for Success: The Final Report of the National Mathematics Advisory Panel* (Washington: 2008).

15 Richard J. Murnane and Frank Levy, *Teaching the New Basic Skills,* (New York: The Free Press, 1996).

16 Andrew Zau and Julian Betts, "Predicting Success, Preventing Failure: An Investigation of the California High School Exit Exam," Public Policy Institute of California, 2008.

17 Indeed, Kennedy mentioned the first astronaut in space, Alan Shepherd, whose suborbital flight had occurred about three weeks before the speech. President John F. Kennedy, "Special Message to the Congress on Urgent National Needs," May 25, 1961. Text available at: www.presentationhelper.co.uk/kennedy_man_on_the_moon_speech.htm.

Designed by Lipman Hearne, Chicago/Washington

BROWN CENTER on
Education Policy
at BROOKINGS

Brookings
1775 Massachusetts Avenue, NW • Washington, DC 20036
Tel: 202-797-6000 • Fax: 202-797-6004
www.brookings.edu

The Brown Center on Education Policy
Tel: 202-797-6469 • Fax: 202-797-2480
www.brookings.edu/brown.aspx