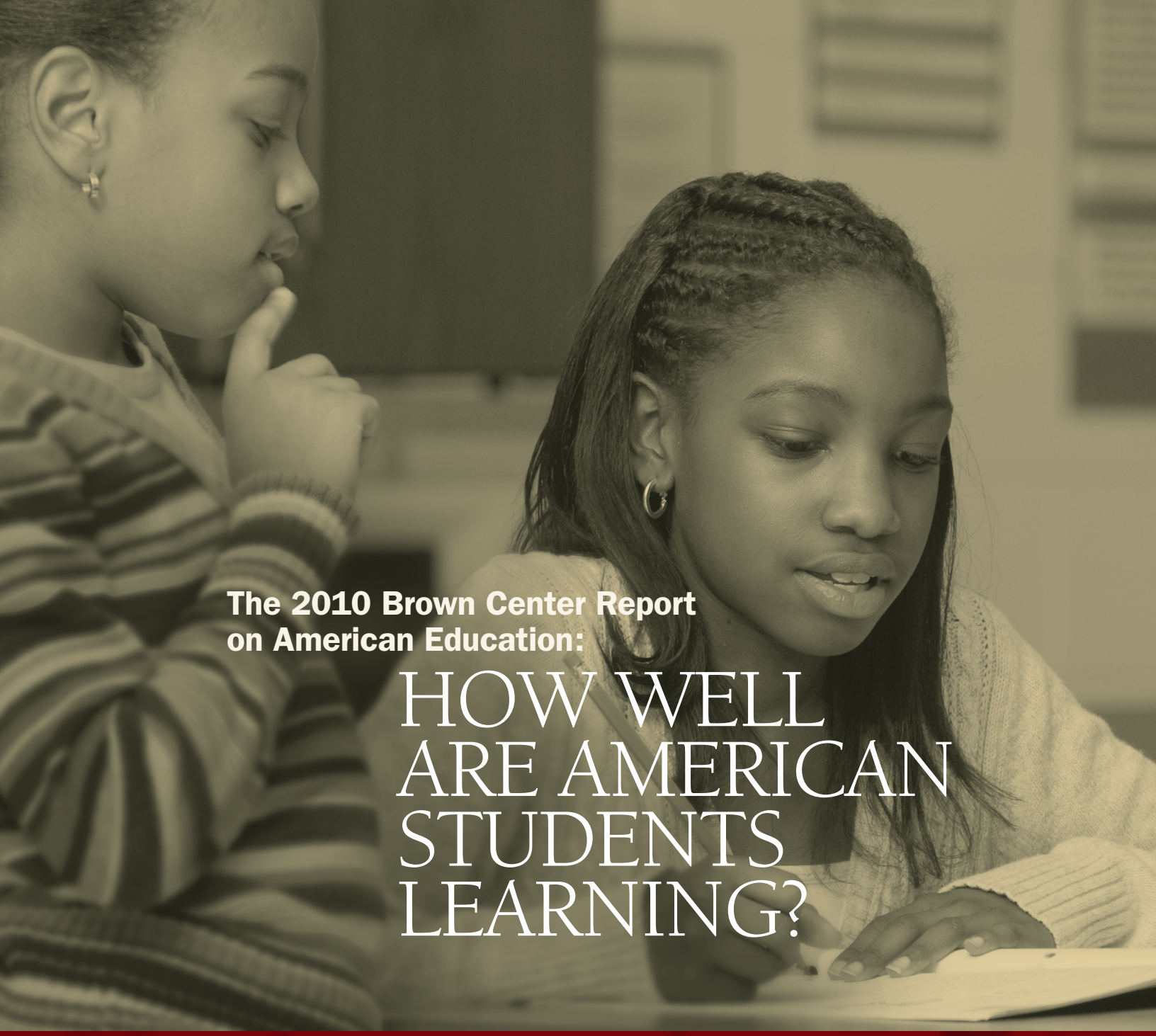

The 2010 Brown Center Report on American Education:

HOW WELL ARE AMERICAN STUDENTS LEARNING?

An Early Release of Part III

BROWN CENTER on Education Policy at BROOKINGS

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Part III NAEP AND THE COMMON CORE STATE STANDARDS

UNLIKE MOST COUNTRIES, THE UNITED STATES DOES NOT have national education standards, no single set of expectations for what all American teachers should teach and all American students should learn. It never has. A question that the rest of the world considers foundational to its national school systems—deciding the content of the curriculum—sits in the hands of local authorities. That is because the United States has 50 state school systems. Heterogeneity extends to the deepest levels of schooling. Even students transferring from one teacher to another within the same school may, as a consequence, learn a different curriculum than their former classmates.

So it was an historical event when the Common Core State Standards in mathematics and reading were released in June 2010. Launched by the National Governors Association and the Council of Chief State School Officers, the Common Core Standards project brought together experts in both reading and math to develop a set of standards that would be, in what became a mantra, both "higher and fewer in number" than existing state standards.[1] The standards are voluntary—states choose whether to participate—but for the first time most American students will study a uniform curriculum through at least the eighth grade. A draft of the experts' work circulated for several months, and, based on input from other experts and the general public, the standards were finalized.[2] In September 2010, two consortia were awarded federal grants totaling $330 million to develop annual assessments aligned with the Common Core standards, and as of December 2010, 43 states and the District of Columbia have signed on to those efforts.[3] The tests are due to be given for the first time in the 2014–2015 school year.[4]

The nation currently monitors the math achievement of fourth, eighth, and twelfth graders on the National Assessment of Educational Progress (NAEP).[5] Since 1990, the main NAEP has assessed mathematics proficiency in five content strands—number properties and operations, algebra, geometry, measurement, and data analysis/

statistics/probability.[6] How well does NAEP match up with the Common Core standards in mathematics?

We tackled this question by analyzing NAEP items from the eighth-grade assessment. NAEP items are periodically released to the public to give an idea of the content of the test. For the current study, we coded all public release items from the algebra and number strands[7] based on the grade at which the Common Core recommends teaching the mathematics assessed by the item. The 2009 NAEP Framework in Mathematics calls for number and algebra items to comprise half of the eighth-grade assessment.[8] A total of 171 items were available, 98 from the number strand and 73 from algebra.[9] We were unable to code four items (two from each strand) because they assess skills not found in the Common Core.

A precursor to this study can be found in the 2004 Brown Center Report.[10] In that study, we coded the grade level of public release items labeled as "problem solving," one of NAEP's process strands (different from the content strands). Only problems involving the application of arithmetic were analyzed. At what grade level are students taught the arithmetic required to answer NAEP problem-solving items? We discovered that the mean fourth-grade NAEP item registered at 3.2 and the mean eighth-grade item at 3.7, suggesting that the typical item could be answered using arithmetic taught by the end of third grade. Primarily, this finding stems from NAEP's reliance on whole number arithmetic in word problems. We found that approximately 70 percent of the eighth-grade items focused on whole numbers. Problems with fractions, decimals, or percents—forms of rational numbers taught after third grade—are not common on NAEP.[11]

The 2004 study used the Singapore Math program as a rubric to code the grade level of items, assigning a value according to the grade and semester in which the arithmetic of the item was taught. By using the Common Core and evaluating the entire context of items, the current study's rubric produces higher grade-level estimates for items. Problems involving only simple arithmetic are classified at a higher grade level if they are posed in the context of more sophisticated topics that are taught at a later grade (e.g., coordinate plane, equations with two variables). Selected NAEP items are shown below.

Grade Level of NAEP Items in the Common Core (Number, 8th-Grade Test)

Table 3-1

	Number		
Grade	**Total (N)**	**Calculator (N)**	**Average Percent Correct**
2	1	0	64.0%
3	9	0	79.3%
4	27	4	72.1%
5	17	7	61.2%
6	23	12	53.4%
7	15	8	37.5%
8	6	4	31.5%
TOTAL	**98**	**35**	**58.6%**

Note: Mean grade level: 5.2, median grade level: 5

Findings

Table 3-1 displays data on items from the number strand. In terms of grade level on the Common Core, the items assess mathematics found at second through eighth grades. The number strand of the eighth-grade NAEP is best described as pitched at the fifth-grade level if calibrated by the Common Core. The average grade level for the items is 5.2. The median item also registers at the fifth-grade level, meaning that about half of the items cover material from the fifth grade or earlier and half from the fifth grade or later. More than 90 percent of the items (92 out of 98) cover material

More than 90 percent of the items cover material below the eighth grade.

Grade Level of NAEP Items in the Common Core (Algebra, 8th-Grade Test)

Table 3-2

Algebra			
Grade	**Total (N)**	**Calculator (N)**	**Average Percent Correct**
2	1	0	86.0%
3	0	0	–
4	6	0	74.2%
5	8	1	60.5%
6	27	8	54.4%
7	16	9	48.7%
8	15	3	45.4%
Total	**73**	**21**	**54.0%**

Note: Mean grade level: 6.3, median grade level: 6

below the eighth grade. Note that this does not make the test easy for eighth graders. The average item is answered correctly by 58.6 percent of eighth graders nationally, and for items pitched at the sixth-grade level and later, the percentage answering correctly is only 45.0 percent.

Calculators are an interesting factor. According to the NAEP framework, calculators are provided to students on approximately one-third of the eighth-grade test.[12] As indicated in Table 3-1, the number items in public release reflect a similar proportion, with 35.7 percent involving a calculator. Calculators are more likely to be provided on items with content from higher grades (sixth grade and above) than from lower grades. About half of the items coded as sixth to eighth grades allow calculators, compared with one-fifth of the items from earlier grades. The more advanced the grade level of the NAEP item, the more likely that a calculator is allowed.

Table 3-2 presents data on algebra items. They appear about one grade more challenging than number items, with a mean grade level of 6.3 and median of sixth grade. Performance on the algebra items is similar to that in the number strand. The average item is answered correctly by 54.0 percent of students. Performance on items encompassing material from the sixth to eighth grades averages 50.5 percent. And, again, calculators tend to be provided on items from higher rather than lower grades.

Frankly, most of the skills measured in the algebra strand, especially those appearing before eighth grade in the Common Core, assess algebraic reasoning, not content from a formal algebra course.

Let's examine a few problems considered "algebra" on NAEP.

Sample NAEP Items

One of the items from the algebra strand is coded at the second-grade level. What does second-grade algebra look like? Here is the item:

Block M5, Question 6 (2009)

□ – 8 = 21

What number should be put in the box to make the number sentence above true?

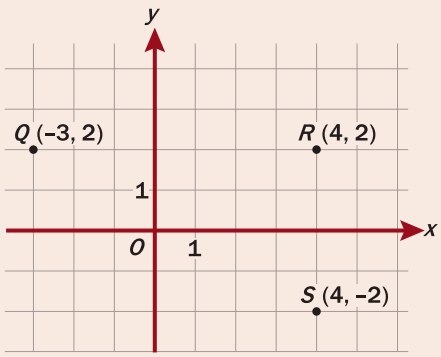
Answer: (29)

The item was answered correctly by 85.6 percent of eighth graders. It is almost a first-grade item. In first grade, the Common Core recommends problem solving with addition and subtraction using numbers within 20. The skill is extended to numbers within 100 in second grade,[13] as noted here:

> Use addition and subtraction within 100 to solve one- and two-step word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem. (Page 19, Operations and Algebraic Thinking 2.0A)

A more difficult item is:

Block M3, Question 13 (2005)



If the points *Q*, *R*, and *S* shown above are three of the vertices of rectangle *QRST*, which of the following are the coordinates of *T* (not shown) ?

A. (4, –3)
B. (3, –2)
C. (–3, 4)
D. (–3, –2)
E. (–2, –3)

This is a sixth-grade problem. It was answered correctly by 60.0 percent of eighth graders.

One must know something about a rectangle (that opposite sides are parallel and equal in length) and some basic knowledge of coordinates—in this case, that *T* will have the x value of *Q* and the y value of *S*. The coordinate plane is introduced in fifth grade, but initially students work with only the first quadrant and learn how to locate individual points. In sixth grade, the Common Core extends study to all four quadrants, incorporates the construction of polygons, and recommends teaching the following skills:

> Draw polygons in the coordinate plane given coordinates for the vertices; use coordinates to find the length of a side joining points with the same first coordinate or the same second coordinate. Apply these techniques in the context of solving real-world and mathematical problems. (Page 45, Geometry 6.G)

A still more difficult problem follows:

Block M6, Question 27 (2003)

X	Y
0	–3
1	–1
2	1

Which of the following equations is true for the three pairs of *x* and *y* values in the table above?

A. $3x + 2 = y$
B. $3x - 2 = y$
C. $2x + 3 = y$
D. $2x - 3 = y$
E. $x - 3 = y$

The item was answered correctly by 45 percent, incorrectly by 52 percent, and was omitted by 3 percent. The item was difficult to code using the Common Core. We wound up labeling it as recommended for eighth grade. An eighth-grade standard exists that is close to capturing the above task, but the standard demands a more complex understanding of functions.

> Determine the rate of change and initial value of the function from a description of a relationship or from two (*x*, *y*) values, including reading these from a table or from a graph. (Page 55, Functions 8.F)

The item does not require students to calculate rate of change, although this is an elementary linear function with a slope first-year algebra students would be expected to calculate. The task is to identify a

The coordinate plane is introduced in fifth grade, but initially students work with only the first quadrant…

…the Common Core embraces the notion that students can learn to see algebra as generalized arithmetic if they are taught concepts sequentially…

simple two-variable equation that matches a table of values. Students who use a "plug and chug" strategy with the first pair (0, –3) will eliminate A, B, and C, thereby narrowing potentially the correct answer to D or E. The second pair (1, –1) eliminates E and leaves D as the only possible correct answer. Supporting the theory that plug and chug is a popular approach, E is the incorrect item most often selected (17 percent), but not by much—C (15 percent), B (14 percent), and A (7 percent). Students who plug and chug using the third pair (2, 1) will arrive at the correct answer in one step.

The next item was easier to classify, but not for students to answer:

Block M12, Question 3 (2005)

Which of the following is equal to 6 (x + 6) ?

A. x + 12
B. 6x + 6
C. 6x + 12
D. 6x + 36
E. 6x + 66

This is a sixth-grade item. It was answered correctly by 44 percent of eighth graders. It assesses the understanding of an important concept, the distributive property of multiplication over addition.

> Apply the properties of operations to generate equivalent expressions. For example, apply the distributive property to the expression 3 (2 + x) to produce the equivalent expression 6 + 3x; apply the distributive property to the expression 24x + 18y to produce the equivalent expression 6 (4x + 3y); apply properties of operations to y + y + y to produce the equivalent expression 3y. (Page 44, Expressions and Equations, 6.EE [italics omitted])

Students first encounter the distributive property in third and fourth grades as they learn multiplication with whole numbers, but, as this standard illustrates, the concept is generalized to include unknowns in sixth grade. When it comes to properties, the Common Core embraces the notion that students can learn to see algebra as generalized arithmetic if they are taught some of the structure behind arithmetic operations which will later be used in algebra and if care is given to developing fluency with numbers and engaging students in a variety of applications.

Summary and Discussion

This study coded the grade level of 171 items from the number and algebra strands of the eighth-grade NAEP test. The Common Core standards in math were used as the coding rubric. Items from the number strand range from the first to eighth grade, with a median level of fifth grade and mean of 5.2. Items from the algebra strand range from the second to eighth grades, with a median level of sixth grade and mean of 6.3. In both strands, calculators are provided about 33 percent of the time overall and 2½ times more often on items from upper grades (sixth through eighth) compared with items from lower grades.

Sample NAEP algebra items were presented. The items would all come from a pre-algebra course or earlier in a student's mathematics education and would not be part of a formal algebra course. The items support two criticisms. Critics of the Common Core have complained that the eighth-grade standards reflect mathematics learned prior to algebra, undermining the contemporary movement to provide "algebra for all" in eighth grade.[14] Critics of NAEP have similarly pointed out that the eighth-grade assessment contains problems

called "algebra" that are in fact pre-algebra in origin.[15]

The Common Core and NAEP share common ground—and some would say a common weakness—in how they test algebra. And yet they seem to diverge on the crucial question of content. The public release items of the eighth-grade NAEP are, on average, two to three years below the eighth-grade mathematics recommended by the Common Core.

The discrepancy arises because of varying definitions of an "eighth-grade" math test. Two very different models are in play. One kind, which NAEP typifies, assesses all of the mathematics learned through eighth grade. Eighth-grade skills and knowledge are the most difficult content on such a test, but they comprise a portion of the items, perhaps corresponding to only a single grade's share of the K–8 grade span. Consequently, the average item on NAEP registers significantly below eighth grade, and approximately 90 percent of eighth-grade NAEP items are taught before that grade. Several items on the eighth-grade NAEP test are also on the fourth-grade NAEP test.

The second model is an eighth-grade test that assesses what is learned in eighth grade. The tests keyed to the Common Core appear to be heading in that direction. Tests will be administered at each grade level in grades 3–8 and reflect the skills and knowledge that the Common Core recommends for that particular grade. Items out of grade level, either below or above, may be included but are rare on such a test. The average item falls near the middle of the grade being tested. End-of-course exams and Advanced Placement (AP) tests are examples of this kind of test, although anchored to a particular course rather than grade level. AP tests are not interested in what a student learned in fifth grade. Nor will eighth-grade Common Core tests be interested in such content. That will be the job of the fifth-grade test.

Both models can legitimately be called an "eighth-grade test," and yet they assess different mathematics. Consider floors and ceilings. The first (NAEP) has a low floor (a primary grade) and tight ceiling (end of eighth grade) and assesses several years of mathematics curriculum. The second (Common Core) has a high floor (beginning of eighth grade) and tight ceiling (end of eighth grade) and assesses a single year's curriculum.

So what does the future hold for NAEP and the Common Core? As currently planned, the two programs will assess different mathematics and might report different results. Even if they report similar results, each score will reveal something different about American students' math skills. Bear in mind that the two programs serve different purposes. NAEP is a survey. It is "top-down" and draws a random sample of students from which inferences are drawn. It monitors national and state progress and, except for several large urban districts, reports no score below the state level. The Common Core, meanwhile, will be "bottom-up," testing all students. It promises to produce student-level scores that can be aggregated to yield performance measures for classes, schools, districts, and states—even a national score if all states eventually participate. It also can generate data during the school year, providing useful feedback to teachers on the effectiveness of instruction and curricular materials.

In the beginning, the two programs will overlap in issuing state scores. And that could cause confusion, especially in states receiving contradictory signals from the two tests about their students' performance. Factor in the confusion from reporting the percentage of students performing at differ-

The discrepancy arises because of varying definitions of an "eighth-grade" math test. Two very different models are in play.

Much work remains to bring the Common Core standards to life in a real assessment.

ent levels (i.e., basic, proficient, advanced, and the like) on tests of vastly different content, and conflicts are bound to arise. One option is to ratchet up the difficulty of NAEP items, bringing the test in harmony with the Common Core. That could merely achieve test redundancy, however, and lead some to question the necessity of continuing one or the other program.

Another possibility is that adaptive testing will bridge the chasm between the two tests. Adaptive testing delivers computer-based assessments. It enhances the capability of delivering items that are sensitive to students' individual achievement profiles and would expand the scales of both assessments by including more lower level and advanced items. While taking the same test, struggling math students can get items that are below grade level and precocious math students can get items more suited to their advanced standing. If it becomes a feature of both assessments, adaptive testing may bring NAEP and the Common Core assessments in closer alignment.

Of course, all of this admittedly is crystal ball gazing. Much work remains to bring the Common Core standards to life in a real assessment. Once that happens, an education process will be needed that informs the public and political leaders on what the NAEP and Common Core measure, what they have in common, and what differentiates their results. A similar challenge exists with the main and long-term trend NAEP assessments, but unfortunately, even after 20 years of shared history between these two tests, very few observers who comment on their results in the press seem aware of the tests' key differences. The same is true of the main NAEP and state assessments.

A new era is dawning for NAEP. The program has supplied the nation with progress reports on student learning since 1969. Now, Common Core assessments are on the way. Whether the new assessments push NAEP aside, succeed in augmenting the information provided by NAEP, or force a redefinition of NAEP's role in monitoring student learning will be at the top of the NAEP policy agenda in the years ahead.

NOTES

1 "Common Core State Standards Development Work and Feedback Group Announced," News Release (Washington: National Governors Association Center for Best Practices and the Council of Chief State School Officers, July 1, 2009).

2 See the Common Core State Standards Initiative website on About the Standards, http://www.corestandards.org/about-the-standards.

3 Catherine Gewertz, "Common-Standards Watch: South Dakota Makes 44," *Curriculum Matters*, Education Week, November 29, 2010.

4 "Beyond the Bubble Tests: The Next Generation of Assessments," Prepared Remarks of U.S. Secretary of Education Arne Duncan to State Leaders at Achieve's American Diploma Project (ADP) Leadership Team Meeting, Alexandria, VA, September 2, 2010.

5 The long-term trend NAEP test assesses students at ages 9, 13, and 17.

6 See the NCES website on the NAEP Mathematics Framework, http://nces.ed.gov/nationsreportcard/mathematics/whatmeasure.asp.

7 The number strand refers to the number sense, properties, and operations strand for the 1990–2003 NAEP mathematics framework and the number properties and operations strand in the current mathematics framework.

8 National Assessment Governing Board, U.S. Department of Education, *Mathematics Frameworks for the 2009 National Assessment of Educational Progress* (Washington: 2008).

9 See the NAEP Questions Tool, http://nces.ed.gov/nationsreportcard/itmrlsx/landing.aspx.

10 Tom Loveless, *The 2004 Brown Center Report on American Education: How Well Are American Students Learning?* (Washington: The Brookings Institution, 2004), pp. 5–17.

11 Theresa Smith Neidorf and others, *Comparing Mathematics Content in the National Assessment of Educational Progress (NAEP), Trends in International Mathematics and Science Study (TIMSS), and Program for International Student Assessment (PISA) 2003 Assessments* (NCES 2006–029). (U.S. Department of Education, 2006).

12 The NAEP is organized by blocks of items, with calculators allowed on one-third of blocks.

13 The Common Core also allows for mentally adding or subtracting 10 with numbers within 100.

14 Catherine Gewertz, "Draft Common Standards Elicit Kudos and Criticism," *Education Week*, March 17, 2010, pp. 1, 14–15.

15 See David Klein, "What Do the NAEP Math Tests Really Measure?" *Notices of the AMS*, January 2011, pp. 53–55. Also see *2004 Brown Center Report*.

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