Should the Current NAEP Mathematics Framework Be Changed - And, If So, Why and How?

Zalman Usiskin

To answer the question in the title of this essay, I consider five current major trends of mathematics in society in general, and in education in particular (numbered **[1]** through **[5]** below), and the implications of these for the current NAEP framework at grades 4, 8, and 12.

(1) The increasing importance of statistics and financial mathematics to the citizen and in careers. From understanding the variability of results of polls to the probabilities inherent in medical diagnoses, lotteries, and investments, today's citizen needs to be able to make decisions based on statistical information. Today's citizen needs to be familiar with the mathematics of loans and mortgages and long-term financial planning and, if the citizen is an investor, to understand the relationship between risks and rewards. The current NAEP framework creators had the foresight to allot 10 percent of the items at grade 4, 15 percent at grade 8, and 25 percent at grade 12 to Data Analysis, Statistics, and Probability.

> **Implication 1:** The *current* percentages allocated to Data Analysis, Statistics, and Probability seem appropriate at all three grade levels. For what might be taught 10 or 15 years *in the future*, an argument might be made for increasing the grade 12 (and perhaps even the grade 8) allocations to 30 percent and 20 percent, respectively, but no greater.

It is reasonable to consider deleting probability and statistics from the grade 4 assessment because the American Institutes for Research (AIR) analysis of state standards indicates that in almost all states, there is little or no probability or statistics content in grades K-4.However, I believe the current small allocation of 10 percent of the items to this strand should be maintained despite the AIR analysis, (a) because of the long history of having such a strand at grade 4, (b) because we do not know to what extent state standards are translated into what is taught, and (3) because we would lose data that might inform us about any changes in performance at the 8th-grade level in this strand.

More generally, the AIR analysis is limited to state objectives and does not necessarily match opportunity-to-learn (OTL)—what is actually encountered by students in their classrooms, a well-known significant variable in performance. Even when there is a match between OTL and state objectives, content that is in state objectives at grade 4 or 8 may not have been encountered yet by students in that grade by the time they participate in NAEP, because NAEP is given around February of the school year.

(2) The increasing breadth of college-level applications of mathematics. A report of the National Research Council (NRC) describes this growth as follows: "Mathematical sciences work is becoming an increasingly integral and essential component of a growing array of areas of investigation in biology, medicine, social sciences, business, advanced design, climate, finance, advanced materials, and much more" (NRC, 2013).

> **Implication 2:** K-12 mathematics, and thus future NAEP assessments need to cover groundwork not only for traditional calculus but also for important mathematics apart from calculus.

(3) The increasing availability of technology (computer, calculator, smartphone) that can *do* mathematics. Smartphones everywhere are equipped to do arithmetic computations. As a result, outside of school, paper-and-pencil computation has become virtually obsolete. In its place, on the job and in the marketplace, there is general recognition that mental arithmetic and estimation of reasonableness of answers are critical skills. Free or inexpensive dynamic geometry software can manipulate geometric figures; computer algebra systems can do all the symbolic algebraic manipulations that students have historically been expected to do by hand. Based on the current NAEP framework, in the 2017 NAEP assessment there exist items at all grade levels for which a student was expected to use a calculator: 4-function at grade 4, scientific at grade 8, and graphing calculators at grade 12. Also, estimation is one of the six components of the Number Properties and Operations content area at all three tested grade levels.

> **Implication 3:** The current calculator policies should be maintained. More sophisticated technologies have not gained enough traction in classrooms to definitively warrant inclusion in NAEP, but a future-looking assessment – particularly because students are already taking NAEP on computers – might include items at grades 8 and 12 to test student ability to use and interpret results found by more sophisticated technology that does algebraic manipulations.

(4) The existence of the international studies. Trends in International Mathematics and Science Study (TIMSS, since 1995) and Program for International Student Assessment (PISA, since 2003).[1] TIMSS involves 4th, 8th, and 12th-graders in the U.S. and is generally viewed as testing academic content much like NAEP. In contrast, PISA measures 15-year-olds on applying mathematics to real-world problems in real-world contexts. In 2015, 72 countries participated in PISA, 49 at 4th-grade TIMSS, 38 at 8th-grade TIMSS, and 9 at advanced TIMSS. The international studies have provided interesting benchmarks for U.S. student performance,

[1] A history of U.S. participation in international studies can be found in Dossey, McCrone, & Halvorsen (2016), pp. 67-86.

but the reasons for the scores of the highest-performing countries involve far more than curriculum (Usiskin, 2012).

> **Implication 4:** The growing breadth and importance of mathematical applications, as mentioned in (1) and (2) above, bolstered by the international popularity of PISA, suggests that adding a PISA-like domain of mathematical literacy to domains in the current 12th-grade NAEP should be considered.

(5) The widespread use of the Common Core State Standards for Mathematics (CCSS-M) (CCSSI, 2010) and state-level variants, state tests, and guidelines for publishers (www.corestandards.org, 2012, 2013). Although U.S. Secretary of Education Betsy DeVos declared that the Common Core is dead (U.S. Department of Education, 2018) and will receive no funding at the national level, the CCSS-M remain powerful determiners of what is taught in almost all states. With only a few exceptions, all states have curricula that follow or closely emulate the Common Core, and the state-specific editions of popular textbook series in grades K-8 are typically the "Common Core edition" modified to handle discrepancies in individual states and without identification of standards in non-Common Core states. However, Secretary DeVos's declaration reflects significant dissatisfaction with the Common Core on many fronts, and not just from political conservatives. As Behuniak (2015) noted in a NAEP validity study, "The reduction of state participation in SBAC [Smarter Balanced Assessment Consortium] and PARCC [the Partnership for Assessment of Readiness for College and Careers], combined with the increasing discontent with the CCSS, significantly increases the likelihood that NAEP will continue to serve as the nation's report card for the foreseeable future."

Implication 5a: The Common Core has a questionable future, and for this reason any move of NAEP towards the CCSS-M should be minor.

Some of the moves in the CCSS-M at grades K-8 from what were standard approaches are controversial, including the treatment of decimals, the increase in paper-and-pencil computation expectations with no attention given to calculators, the absence of statistics in the early grades, and the spotty development of geometry. At grades 9-12 the CCSS-M give little or no attention to mathematical systems, to logic, to limits, and to discrete mathematics. These moves, coupled with states exerting their constitutionally given rights, state testing not showing much benefit, and the historical ebb and flow of movements to improve education in the U.S. suggest that the Common Core's influence is very likely to wane and there may be a move back to practices more common between 1990 and the existence of the Common Core.

Should student learning trajectories be considered? The CCSS-M standards are by individual grade for each of the grades K-8, because the CCSS-M were designed with the goal of testing at each grade from grades 3-8. So, the CCSS-M provides a year-by-year sequence of instruction in each area of its standards. Because the NAEP is given only at grades 4 and 8, the NAEP framework should not focus on the sequence of instruction but continue to focus on the final product.

With the exception of the acquisition of the whole number sequence and the simplest addition and subtraction problems, there is little research leading to a common view of trajectories for the development of even the most important mathematics concepts. Some of us think that the best learning progressions are those that begin with real-world situations and develop the mathematics from them, while others believe that it is better to handle the mathematical skills and properties first and apply them later. The CCSS-M use fraction ideas to get at decimals, reversing decades-long trends in the other direction or doing them simultaneously. The CCSS-M ignore the power of data collection in the acquisition of concepts of order and size of numbers. Regardless of the trajectory differences, the ultimate goals in K-8 mathematics are today much the same as they have been for decades. To discuss trajectories, the state tests, given at each grade and in each year, are more likely to match what is taught in the classrooms of a given state and consequently, the state tests provide a better vehicle than NAEP assessments.

> **Implication 5b:** The greater detail of the CCSS-M is necessary in part due to testing at each grade and does not constitute a significant consideration for changing anything in the NAEP framework at either grade 4 or grade 8.

The intent of the CCSS-M authors was to deliver a "more focused and coherent curriculum" (CCSSI, 2010). Consequently, the guidelines for publishers to strip their programs of content not directly associated with a Common Core standard at that grade. Teachers and teaching materials are judged by their adherence to the CCSS-M with reluctance to include anything that is not a recognizable standard (for criteria, see www.corestandards.org, 2012, 2013, https://www.edreports.org/about/index.html). Furthermore, the CCSS-M discourage putting students in Algebra in grade 8 and Calculus in grade 12. The result is that students receive a curriculum that is purposely deeper but narrower in breadth. This is particularly true in grades K-4, where the CCSS-M have no statistics, less algebra, and less geometry; and in grades 9-12, where the CCSS-M identify a curriculum that is aimed at calculus and does not cover those students (likely a majority, even in the future) who will not need calculus for their careers, whereas the NAEP framework is designed for the mathematics needed by all students.

Implication 5c: The NAEP framework should remain broader than CCSS-M at all levels.

Although Daro, Hughes, and Stancavage (2015) suggested that the Governing Board add content to the grade 8 NAEP framework to bring it in agreement with the CCSS-M, there are reasons that would be unwise. Fundamental among these is that there exists little data to indicate that the CCSS-M have improved mathematics performance – even on tests designed specifically to cover the Common Core (Loveless, 2018; SBAC, 2018). Moving the NAEP framework towards the Common Core would constitute an endorsement of a curriculum that has not proved itself even with ample opportunities throughout the nation for such proof. In each of the states, data exist to indicate whether the Common Core or other standards are being reached in that state, and to determine whether student performance has improved or not; in each state an independent broader-based assessment is exactly what is needed to counter the narrowness of the CCSS-M. *NAEP presents the only ongoing national evaluation that can compare current performance with performance before 2010 (see, e.g., Loveless, 2018).*

Two consultants suggested that systems of equations be added to the grade 8 framework because that topic is on the Grade 8 CCSS-M. However, it is unlikely that most students would encounter the topic before the administration of NAEP in February of the grade 8 year.

Implication 5d: Bending the NAEP framework to the CCSS-M standards would cause unnecessary redundancy in testing, lessen opportunities for historical comparisons, and serve to stifle attempts to update the mathematics curriculum in the U.S. to reflect the changes in mathematics noted at the top of this essay.

"Historically the NAEP frameworks have aspired to represent the union of all the various state curricula while reaching beyond these curricula to lead as well as reflect. As a result, NAEP often has pushed on the leading edge of what the nation's children know and should be able to do." (Hughes, Daro, Holtzman, & Middleton, 2013). I hope that the Governing Board enables NAEP to continue this fine and valuable tradition.

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