Thoughts about Standards and Assessments as Applied to the Draft Common Core State Standards in Mathematics

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We now have two decades of experience with the crafting of content standards and their use as a guide for designing and implementing curriculum, instruction and assessment. As noted in a National Academy of Education white paper (NAED, 2009), the history of standards in the educational system is less than what was envisioned. Some would even argue that standards, as they have been typically crafted, have produced any number of problems that were largely unforeseen and unintended. This includes national standards for mathematics such as those first authored by NCTM (1989) and then elaborated in various forms over time by NCTM (e.g., 1995, 2000), as well as by individual states.

With the wisdom of hindsight we can better understand one of the typical weaknesses in the description of standards, a weakness that extends to the current draft CCSSM. As written, such standards are often ambiguous and vague with respect to the actual forms of knowledge and understanding that students are expected to attain at a given age or grade level and how that is supposed to change in sophistication over time. This is often because they are stated in terms of two verbs of cognition – know and/or understand -- that fail to specify the intended *competence* that students are expected to achieve and the *performances* that would be expected of students as evidence of that competence. The current draft CCSSM often uses these terms, as well as other more circumscribed cognitive verbs, to describe the standards for specific knowledge topics.

Standards that employ such vague descriptors have very unclear implications for the design of curriculum, instruction, and assessment. In the case of assessment, if we follow the logic of Evidence-Centered Design (Pellegrino, et al., 2001; Mislevy & Riconscente, 2006), then very clear specifications are needed for the *claims* we wish to make about student competence which in turn are coupled with clear statements of the forms of *evidence* that would provide warrants for those claims. Standards derive their meaning and true interpretation in terms of two things that are conceptually linked: (1) the performances that are expected and (2) the mapping of those performances to the types of specific knowledge in long-term memory that would support them, including the scope of generalization and transfer. The nature of those linkages is often uncertain for the draft CCSSM.

To see an example of how the draft CCSSM statements are problematic for assessment, we can examine Grade 4, Number—Fractions; Operations on fractions, a portion of which is reproduced below. The language “understand addition of fractions” in #1 does not indicate what specific claims are intended about student competency, and does not indicate forms of evidence that would warrant such claims. Bullet point (a) is written as a statement of mathematical fact. It describes one algorithmic approach to adding fractions with like denominator without in any way indicating the expected nature of a student’s understanding and reasoning about fractions addition, about why this algorithm is true, about other possible alternative methods for adding fractions with like denominator, and whether and how the particular algorithm supports reasoning and understanding of fraction addition. Bullet point (b) similarly asserts one algorithm for adding "related fractions." The examples offered in each bullet point do not indicate what range of mathematics tasks should be included in gathering evidence for this standard, do not indicate for example what other types of questions the student should be able to answer as evidence of attainment of this standard.

Grade 4: Number—Fractions (taken from page 23 of the CCSS for Mathematics):

Operations on fractions

1. Understand addition of fractions:

   a. Adding or subtracting fractions with the same denominator means adding or subtracting copies of unit fractions. *For example, 2/3 + 4/3 is 2 copies of 1/3 plus 4 copies of 1/3, or 6 copies of 1/3 in all, that is 6/3.*

   b. Sums of related fractions can be computed by replacing one with an equivalent fraction that has the same denominator as the other. *For example, the sum of the related fractions 2/3 and 1/6 can be computed by rewriting 2/3 as 4/6 and computing 4/6 + 1/6 = 5/6.*

This example is representative of standards statements across content areas and across grades, and falls short in at least three significant ways. First the standards statement focuses on selected algorithms without including any specific information about what performances should be used to demonstrate higher order reasoning and deeper conceptual understandings. Second, the standards statement in this example, and many other similar examples, fails to specify the range of performances that should be included within this standard. Third, there is no indication where this standard sits relative to a trajectory of learning, how this standard relates to prior fractions and arithmetic understandings, and how it should lead to more sophisticated and complex understandings resulting from instruction. These three shortcomings are not exclusive to this example or a few examples but are pervasive throughout the standards statements, and together have a pernicious effect on curriculum development, instruction and assessment.

In general, the draft CCSSM are highly variable in their specificity and utility for the design of assessment. As noted above, this applies to two aspects of the knowledge and skills that students would be expected to attain across the K-12 grade span – what the competence should be at any given point in time and how that competence should change over time as a result of instruction. Given the current national policy focus on assessing growth in knowledge and skill, it is unclear what the underlying theory and model of growth would be other than perhaps a simplistic notion of accumulating bits and pieces of declarative and procedural knowledge. This is hardly in line with contemporary theory and research on the development of students' knowledge for major conceptual and procedural strands in mathematics (e.g., Confrey, 2008; Kilpatrick et al., 2001; Pellegrino, 2010). In addition to the areas of expertise already represented, we would expect that the committee charged with drafting the CCSSM would include expertise in the learning sciences and assessment who could help to clarify critical issues about knowledge acquisition and its assessment as they apply to the conceptualization and language of the standards.

Beyond broadening the scope of expertise on the committee, we make two recommendations about subsequent drafts of the CCSSM:

1. The standards should be written in a form that describes as precisely as possible what students are expected to know and be able to do and the scope or extent of that competence.

2. The set of standards should describe clearly how knowledge and skill would be expected to develop with instruction, including the nature of the expected changes in performance and the forms of competence that are implied in that progression.

References

Confrey, J. (2008, July). *A synthesis of the research on rational number reasoning: A learning progressions trajectories approach to synthesis*. Paper presented at the 11th meeting of the International Congress of Mathematics Instruction, Monterrey, Mexico.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics.* Washington, DC: National Academies Press.

Mislevy, R. J., & Riconscente, M. M. (2006). Evidence-centered assessment design: Layers, concepts, and terminology. In S. Downing & T. Haladyna (Eds.), *Handbook of test development* (pp. 61-90). Mahwah, NJ: Erlbaum.

National Academy of Education (2009). *Standards, assessments, and accountability*. National Academy of Education White Paper, L. Shepard, J, Hannaway, & E. Baker (Eds.). Washington, DC: National Academy of Education.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1995). *Assessment standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Pellegrino, J. W. (2010). The design of an assessment system for the race to the top: A learning sciences perspective on issues of growth and measurement. In P. Forgione & N. Doorey (Eds.), *Exploratory Seminar: Measurement Challenges Within the Race to the Top Agenda.* Princeton, NJ: Center for K–12 Assessment & Performance Management, Educational Testing Service.

Pellegrino, J. W., Chudowsky, N., & Glaser, R. (Eds.). (2001). *Knowing what students know: The science and design of educational assessment.* Washington, DC: National Academies Press.