Math Modeling Vital in Upcoming K–12 Science Curriculum Standards

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Just as Common Core State Standards in Mathematics (CCSSM) are rearranging the landscape of K–12 mathematics education in the United States, science is next—and with these new “Next Generation Science Standards” (NGSS), mathematics proficiency will play a major theme. Math educators of K–16 will do well to pay attention to this movement, as its waves will surely affect our students and our colleagues in science. We may be called upon to lend a hand in helping give science teachers insight into math pedagogy, and we may also hope to see additional interest in mathematics among students thanks to this effort to highlight its relevance to science, engineering, and technology.

The NGSS underwent a second period of public review in January, and it would seem that they will be released in a finalized form some time in 2013. After that, states will choose whether to adopt these standards, and just as with CCSSM there will likely be federal incentives to do so. The National Governor’s Association and the Council of Chief State School Officers turned their attention to science after the completion of the CCSSM and discovered that recommendations for national science standards had not been revised for 15 years. The National Research Council was enlisted to help draft a new set of recommendations. The result, which came out in 2012, is A Framework for Science Education: Practices, Cross-Cutting Concepts, and Core Ideas, a free-to-download report on the National Academies website and highly recommended as a field guide to the standards to come and the intentions behind them.

The authors of Framework for Science Education made it clear that mathematics is key to scientific literacy. The authors of the NGSS have been careful not to require mathematics proficiencies before the content has been introduced in the mathematics standards. Furthermore, just as the CCSSM feature an emphasis on “Mathematical Practices” interwoven throughout the framework, so too will the NGSS feature “Scientific and Engineering Practices.” It’s notable that two of the eight science and engineering practices mention quantitative skills explicitly (“Using mathematics and computational thinking” and “Analyzing and interpreting data”), and one more implicitly (“Developing and using models”—mathematical and computational models being just two possible types of model, as scientists also consider conceptual models, diagrams, physical replicas and analogies to be important tools in this category). Mayes and Koballa (2012), in a recent article in Science Scope, connect mathematical practices with practices from NGSS showing alignment of all eight of CCSSM’s Mathematical Practice areas with all of the NGSS’s Scientific and Engineering Practices.

The new emphasis on modeling in K–12 education is beginning to generate interest in the mathematics community. The National Science Foundation together with SIAM sponsored a workshop on “Modeling Across the Curriculum” on August 30–31, 2012. The theme was to increase mathematical modeling activity across the undergraduate curriculum, develop STEM high school courses based on modeling, and to assess college STEM readiness. Participants included university professors, high school teachers, NSF program officers and some representatives from education foundations. This workshop resulted in a session and a panel discussion on this topic at the 2013 Joint Math Meetings. We also note that many of the Mathematics of Planet Earth (MPE) sessions at the meetings included education components with modeling. Looking ahead to 2014–2015, there will be six NSF sponsored workshops continuing the MPE theme with research and education components; the initiative and leadership of these workshops are coming through Fred Roberts at DIMACS, Rutgers University.

Teaching modeling to high school students and engaging younger students in the modeling practice highlights the issue of developing modeling competence in their teachers. There needs to be an effort to engage teachers in modeling problems for which they have appropriate science and mathematical background. Modeling activities should be flexible enough to incorporate a variety of math standards, involve open-ended activities, and use descriptive, analytic and computing tools. The modeling activities should be seen as relevant to the manner in which modeling will be assessed in schools. Such professional activities are being piloted at several universities, including San Diego State University by Susan Nickerson and her colleagues.

The science and engineering standards explicitly discuss computational thinking. The analytic and computing tools required in modeling with mathematics also bring computational thinking to the foreground. A key skill of computational thinking is the ability to create a precise set of
instructions for solving a problem that can be easily followed by a computer. (Barr and Stephenson, 2011) At our university, many freshmen students struggle with introductory computer science courses. And in our freshman mathematics courses, we see students having trouble understanding iterative processes, so building "loops" in simple computer programs may be challenging. While the math community embraces and explores more math modeling in curricula, we should remember the relevance of computational thinking as well!

The standards are learning outcomes but they are also instructional strategies to achieve these learning outcomes; they are both ends and means (Bybee, 2011). We have an opportunity in this changing landscape for our students to have coherent and focused preparation for engaging with science and mathematics content through aligned science and mathematics practices.

**IM&E and the CCMMS**

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In June of 2010 the National Governors Association (NGA) and Council of Chief State School Officers (CCSSO) released the Common Core State Standards for Mathematics (CCSSM). These have been adopted by 45 different states as well as a number of territories and the District of Columbia. Now, for the first time, K–12 students in different states will be held to the same rigorous achievement expectations, aimed to prepare them for college and careers. This consistency in desired achievement leads to the possibility of increased collaboration between different states as we all work towards the same standards. Because the Institute for Mathematics and Education (IM&E) at the University of Arizona was founded by lead writer of the Common Core, Bill McCallum, it is well positioned to assist in understanding and implementing the new standards. At IM&E, we have developed several projects (described on our website: http://ime.math.arizona.edu/commoncore/) to work together towards this implementation.

Illustrative Mathematics, http://illustrativemathematics.org/, is a project of the Institute that seeks to help teachers and other educators understand the Common Core State Standards for Mathematics and to build a community of teachers, mathematicians, and mathematics educators who work to improve their own teaching and learning through the sharing of resources and peer feedback. Blossoming from the idea of building an online resource sharing center into the development of a searchable website and vibrant online community, Illustrative Mathematics is now a virtual destination for people interested in K–12 mathematics education. Armed with a new interface in the 2011–2012 school year, the website now hosts more than 600 tasks and 9,000 registered users. It includes not only tasks illustrating the Standards for Mathematical Content but also illustrations of the Standards for Mathematical Practice, as well as an illustration of how fractions develop across grade levels in the Common Core.

The IM&E runs periodic large-scale weekend conferences for an audience of teachers and district level mathematics specialists to learn about the mathematics of the Common Core. The facilitators for these workshops are mathematics teachers, mathematicians, mathematics educators, math coaches, and district math specialists who work together to bring a variety of expertise to the workshop. The next large-scale workshop occurs on the weekend of March 1–3, 2013 in Syracuse, New York.

The Mathematics Common Core Toolkit, run by the institute, is a one-day add-on to existing professional development that includes materials useful for understanding and teaching the Common Core designed by teachers. Initiated by the Committee on Teachers as Professionals (c-TaP), an ad-hoc committee of the Conference Board of the Mathematical Sciences (CBMS), this online Toolkit aims to address four main themes through multi-media content including videos, example tasks, student work, progressions documents, excellent lesson examples, and interactive
discussion continued on page 24

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**Resources**


Next Generation Science Standards website: www.nextgenscience.org