Organizing Coherent and Equitable State Systems of Science Education

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Education is a complex system made up of many interconnected elements and processes. Many competing priorities shape the system, and the elements and processes of the system are always in need of intentional coordination on fast timelines and with limited resources. This is the challenge states face in K-12 science education as we seek to implement a new vision for K-12 science education—as represented in the NRC Framework for K-12 Science Education. Implementation presents an opportunity to address these challenges within state teams and to get ideas and support from a network of states, build new capacities, and develop knowledge about how to move a complex system toward a new vision.

Science Education from a Student and Teacher Perspective
Consider three children who all live in the same state. Imagine a sixth grade boy, a recent immigrant from Japan, entering a science classroom, asked to jump into a discussion about why earthquakes and volcanoes seem to fall along a big arc around the edges of the Pacific Ocean. Now imagine a fourth grader living in a rural area of the state, suddenly curious about how and where she can learn more about how mobile phones allow her to talk to friends. Picture a high school student living in a big city who works on the floor of a science museum, explaining exhibits, wondering whether she will be the first to go to college in her family and how she can get there.

Now imagine these children's classroom science teachers, faced with the challenge of figuring out just how to respond to the messages about what and how they should teach, while keeping their students engaged and excited about science learning. The messages come from lots of places and people: from standards documents, from the district curriculum office, from assessments, from their life experiences, from principals, from colleagues, and from parents. The resources are just as varied: there's the district textbook, things that the teachers have learned about through professional development workshops and at conferences, and also a whole host of curated and open resources of different kinds to draw from on the internet.

Consider these questions as you imagine these children and teachers:

1. What would it mean to build a state system of science education that equitably serves each of these children—and all of the children in this state?
2. How can such a system be deeply informed by the vision of *A Framework for K-12 Science Education* in order to promote a coherent learning experience for youth and for their teachers?
3. What strategies and resources do we need to employ, to create such a system?

Equity
The vision of the *Framework* is ambitious, made more so by the inequities of opportunities that exist for a deep learning of science. Equity demands not only adequate time for science instruction but also instruction that connects to learners' everyday lives, experiences, and interests. It demands that we create inclusive learning

environments and extended learning pathways for all youth, dismantling adverse stereotypes about youth while building capacity for culturally relevant instruction. It demands we provide resources to multilingual students who are learning English to support them to participate equitably in science and engineering practices, which demand a broad and flexible linguistic repertoire. And it demands we find ways to expand learning opportunities outside of school for students to pursue their interests and build a network of support that can ready them for college, careers, and citizenry. Just as it takes a village to raise a child, it takes a well-connected community with abundant and diverse learning opportunities in and out of school to enable all children to find ways that science and engineering can be relevant to their lives and futures.

Horizontal Coherence: Consistency of Messages and Experiences

For students and teachers to grow in their understanding and love of science, the messages they hear and the learning opportunities they experiences need to be consistent, cumulative, and relevant. Students need to hear and experience the idea that "people like me do science and engineering"—in order to identify with science as something they can relate to and perhaps contribute to. They need multiple experiences of using science to make sense of their everyday worlds and engaging in engineering practices help solve their community's problems. These experiences should accumulate over time and across settings of schools, community settings, and family life in a way that builds their understanding of science ideas and crosscutting concepts. Teachers, for their part, need to hear consistent messages about science teaching and learning from standards documents, assessments, curriculum and instructional resources, and professional development that align with the vision of the Framework. They need those who are guiding to provide support over time that allows them to deepen their understanding of how to tap into the resources and experiences of a wider and wider range of learners of different cultural, racial, and linguistic backgrounds given that science learning is viewed as a multidimensional, cultural accomplishment in the *Framework*.

Vertical Coherence: Shared Vision Across Levels of Systems

People at all levels of a system, from state science supervisor to teacher, need to have a common understanding of the aims and vision of the Framework, if messages are to be consistent and resources are to be designed that build the needed capacity. Vertical coherence—the alignment or agreement of actors across the levels of a system around a common image of what good teaching and learning looks like—is needed. At the core of a vision are the principles that underlie it, since each person is likely to have a different way to express or a different context in which to enact the vision. The principles are important for linking people who have different roles to play in the system, whether from inside it or as supporters of it (e.g., community and business partners). For the Framework, those principles include the idea that: (a) children are born investigators, (b) that science requires both a focus on content and practice, (c) that understanding develops over time, that (d) that science teaching should build on and connect to student interests and experience, and (e) that promoting equity should be at the center of efforts to improve science education. People who are responsible for designing instructional materials, leading professional development, designing and implementing assessments, and creating out of school learning opportunities need to value these elements of the vision and have a common understanding of the implications of the principles to role they play in K-12 science education.