Supporting the Implementation of *NGSS* through Research: **Professional Development**

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The Next Generation Science Standards (*NGSS*) have great potential to act as a catalyst for improving K–12 science education, but successful implementation of the *NGSS* presents a number of challenges and will require major changes throughout the education system. The *NGSS* sets forth an ambitious set of goals for what students should know and be able to do as a result of their science education. Meeting these goals will require many teachers to change what and how they teach as the *NGSS* calls for the teaching of core disciplinary ideas, cross-cutting concepts, and science and engineering practices in an integrated manner. It will also depend on the support of other stakeholders in the system, including parents and administrators at the state, district, and school levels.

Much has been learned in the last several years about effective science instruction, including the importance of paying attention to student thinking throughout instruction, providing opportunities to delve deeply into substantive scientific ideas, and metacognition (NRC, 2000; NRC, 2005). Similarly, the field has gained much knowledge about effective professional learning experiences for teachers, which provide opportunities for them to deepen their understanding of science, how students learn science, and reflect on their practice. In order to realize the potential of the *NGSS*, it will be critical to invest in professional development for teachers of science, as well as those who play an important role in shaping what happens in classrooms.

Professional Knowledge to Support the *NGSS*

As in any field that benefits from ongoing research and new developments, professional educators must have opportunities to update their knowledge and skills. Professional learning opportunities should include a number of foci, described below, to support teachers in implementing the *NGSS*. Although these foci are presented as separate points, they are interrelated and will require that teachers have opportunities to not only experience learning that incorporates these foci, but also opportunities for explicit discussion and reflection on how they translate into classroom instruction. It is important to note that these foci are not exhaustive, but rather represent a foundation of knowledge and skills that teachers need to help all students achieve the goals set forth in the NGSS.

- Professional development programs should focus on helping teachers develop an understanding of the core disciplinary ideas in the *NGSS*. Not only should teachers have a deep understanding of the content they are expected to teach, they should have an understanding of how that scientific knowledge was generated, including the evidence to support the ideas. Teachers should also have opportunities to understand why the core

disciplinary ideas included in the standards have been selected, how those ideas build across the grade levels, and the boundaries of what should be taught at each grade level.

- Professional development programs also need to help teachers understand the scientific and engineering practices in the *NGSS* in the context of the disciplinary core ideas and crosscutting concepts they are expected to teach. Although the practices relate to the nature of scientific knowledge and how it is developed, incorporating the practices into instruction in meaningful ways will likely be difficult for many teachers, particularly the engineering practices.[1] Professional development programs also should provide teachers with opportunities to understand when and in what ways key aspects of these practices should be highlighted in instruction.

- Professional development programs should provide opportunities for teachers to deepen their understanding of the crosscutting concepts, including when and in what ways these concepts should be highlighted.

- Professional development programs, especially those involving elementary grades teachers, should identify the connections between the *NGSS* and the *Common Core State Standards*. Given the limited instructional time devoted to science in the elementary grades (Banilower et al., 2013), making these connections explicit may help build support for allocating the instructional time needed to implement the *NGSS* as intended.

- In addition to helping teachers understand what they are being asked to teach, professional development programs to support the *NGSS* should provide opportunities for teachers to develop a common vision of instruction that begins with the needs of the learners, has high expectations for all, and integrates what is known about effective instruction with the core disciplinary ideas, crosscutting concepts, and practices in the *NGSS*. To do so, professional development must be based on the conviction that all students can learn, and that instruction should include strategies that are research based, relevant, culturally responsive, and inclusive in their support of all backgrounds and abilities.

- Professional development programs should also include a focus on Topic Specific Professional Knowledge (Gess-Newsome, 2013) (sometimes referred to as canonical pedagogical content knowledge) grounded in recent advances in research. Much has been learned about how students learn science in general and there has been a great deal of research on the teaching and learning of specific ideas in science. Although more research is needed in this area, professional development programs should take advantage of what is already known about how students learn various science ideas.

- Teachers will also need opportunities to consider how assessment, both formative and summative, should be used in the implementation of the *NGSS*. Instruction that

[1] A recent study found that very few teachers feel well prepared to teach engineering ideas (Banilower, Smith, Weiss, Campbell, & Weis, 2013). This study also found that requiring students to use evidence to support conclusions in science instruction is less common than the *NGSS* will require.

effectively integrates the disciplinary core ideas, crosscutting concepts, and practices will require teachers to use a system of assessment that provides both teachers and students with information about student learning, and which sends consistent messages about what is valued in the classroom.

Professional Development Practice

The substantial professional knowledge that science teachers will need to implement the *NGSS* points to the critical importance of moving away from one-shot professional development experiences to creating a culture of coherent, on-going professional learning. As time for professional development is typically limited, it is important that professional learning experiences for teachers be efficient and relevant, taking into account what is known from research.

- Professional development programs must recognize that all teachers have different backgrounds and learning needs. Just like classroom instruction, professional development must effectively use and augment the incoming knowledge and skills of teachers within the context of their practice. For example, the background and needs of elementary, middle, and high school teachers are very different in both content and form.

- Professional learning experiences should also be appropriate for where teachers are in the trajectories of their careers. Research indicates that it takes about 10,000 hours of practice to develop expertise (approximately 8 years of teaching). Consequently, the learning needs of teachers in their first four years, for whom extended induction programs may be more appropriate, are very different than those of mid-career or veteran teachers (Hargraves & Fullan, 2012).

- Professional learning experiences should be sustained over time, ongoing, and of sufficient depth to be meaningful. They should also be embedded in the work of teaching: built on actual instructional and curriculum materials that can be used with students and that support the *NGSS* with fidelity. Professional learning should be collaborative and designed to engage a critical mass of teachers who are members of learning communities (Elmore, 2002; Garet, Porter, Desimone, Birman, & Suk Yoon, 2001; Wilson, 2013).

- Professional development programs must support teacher habits of mind that are based on inquiry, reflection, and continuous change and refinement of practice in an effort to improve the learning of all students. In this sense, change is viewed as occurring through mediating processes of reflecting and acting in the personal domain (teacher beliefs, knowledge, and attitudes), practice domain (professional experimentation), and consequence domain (salient outcomes) (Clarke & Hollingsworth, 2002). Professional learning experiences should provide opportunities for frequent classroom feedback and support structures to shape and refine instructional practice. Both reflection on action and reflection in action are critical to professional practice (Ball & Cohen, 1996; Garet et al., 2001).

- Professional development should model and engage teachers in designing instructional practices that support learning, and incorporate explicit discussion of what they experienced and its implications for their own classrooms. In the context of the NGSS, professional development should model instruction that utilizes the scientific practices in the service of developing science knowledge. In addition, the professional development should provide opportunities for participants to examine critically what they experienced, discussing: (a) the important aspects of instruction that are likely to lead to student learning of science concepts, and (b) the key components of scientific practices that were used. Modeling high quality instruction is important but not sufficient; explicit discussion will make it more likely that teachers will make sense of what is being learned in the context of their own instruction (Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003; Wilson, 2013).

- Professional development should also provide opportunities for teachers to try new approaches in the classroom and then collaborate with others in critically reflecting on those experiences.

Systems That Impact Professional Development

Although professional development will be essential, it will only have the intended impacts if all aspects of the education system are aligned to support the successful implementation of the *NGSS*. Specifically, to be effective, professional development programs will need to:

- Be supported by instructional materials and assessment systems that are coherent and capture the vision of the *NGSS* (Ball & Cohen, 1996).

- Be rigorously evaluated to provide data for mid-course corrections and evidence of impact on teachers' knowledge, beliefs, skills, and practices. They should also be evaluated for longer-term impacts on students, including, but not limited to, achievement, attitudes toward science, and advanced course taking.

- Be supported with sufficient resources, including time, funds, and assessment systems, to have and document impacts on teachers and students.

- Recruit, develop, and sustain skilled professional development providers, including experienced teachers, who have deep understanding of the content and practices inherent in the standards, as well as the knowledge bases about effective teaching and professional development.

- Build on pre-service programs that have been re-designed to prepare new teachers with a foundation of knowledge that will allow them to become lifelong learners of science and science teaching.

- Include other key stakeholders who influence science instruction, including administrators at all levels of the education system (school, district, state), parents, business leaders, community members, and Institutions of Higher Education faculty.

- Be supported by a robust research and development agenda aimed at creating and validating professional development programs that can be implemented at scale, including how technological advancement can support this undertaking.

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