NSTA Position Statement

Transitioning from Scientific Inquiry to Three-Dimensional Teaching and Learning

Introduction

For decades, scientific inquiry has played a central role in high-quality science teaching and learning. Scientific inquiry reflects how scientists come to understand the natural world and is at the heart of how students learn science. From a very early age, children interact with their environment, ask questions, and seek ways to answer those questions. Understanding science content is significantly enhanced when ideas are anchored to inquiry experiences.

Scientific inquiry was first introduced as a method of thinking that was equally important to science content, but often interpreted as a set of steps and procedures, such as the "scientific method." Later, scientific inquiry became understood as a hands-on and minds-on approach requiring more than a set of steps, and was referred to as a "habit of the mind" (Minstrell 2000). The *National Science Education Standards* (NSES; NRC 1996) further developed our understanding of scientific inquiry, defining it as encompassing both knowledge and skill (NRC 2000, p. 23), and giving it prominent position as its own content area (AIR & WDPI 2016). Even so, scientific inquiry continued to have numerous meanings and be applied to a broad range of classroom activities (AIR & WDPI 2016). As a result, an uneven implementation of scientific inquiry has occurred in science classrooms.

A New Vision for Science Teaching and Learning

The release of *A Framework for K–12 Science Education* (Framework; NRC 2012) refined the goals for science teaching and learning and better specified what is meant by scientific inquiry. The *Framework* reflects a significant growing body of knowledge about how students learn science and recommends important conceptual shifts for science teaching and learning. NSTA supports the recommendations of the *Framework* and their application in the *Next Generation Science Standards* (NSTA 2016), including the ideas that strengthen previous conceptions of inquiry and the nature of science. These ideas include the use of science and engineering practices to actively engage students in science learning, the integration of these practices with disciplinary core ideas and crosscutting concepts, and student learning to be driven by the need to explain phenomena and/or design solutions to problems.

Science and Engineering Practices Should Be Used to Actively Engage Students in Science Learning

Engaging in science and engineering practices as articulated in the *Framework* should be the central focus of science teaching and learning (NRC 2012). The *Framework* offers eight science and engineering practices that focus on knowledge building and articulate the range of ways scientists engage in their work. The science and engineering practices more fully reflect the work of scientists as they make sense of phenomena and engineers as they develop solutions to problems.

Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts Should Be Integrated

The integration of science and engineering practices, disciplinary core ideas, and crosscutting concepts in science teaching and learning is currently considered an effective method of gaining a deeper understanding of science and engineering concepts and applying them to daily life. As the *Framework* states, "knowledge and practice must be intertwined in designing learning experiences in K–12 science education." Engaging solely in the practices without including disciplinary core ideas and crosscutting concepts is insufficient because each of these concepts is required to make sense of phenomena.

Phenomena Should Be Used to Engage Students in Three-Dimensional Instruction

> The goal of building knowledge in science is to develop ideas, based on evidence, that can explain and predict events in the natural or designed world. These events—called phenomena—are observable and repeatable and can be explained or predicted using science knowledge (Achieve, Next Generation Science Storylines & STEM Teaching Tools 2016). Effective three-dimensional instruction requires student learning be driven by the need to explain phenomena and/or design solutions to problems. An understanding of the disciplinary core ideas and the crosscutting concepts is used in concert with science and engineering practices to explain phenomena. Crosscutting concepts provide a different lens from which scientists and engineers ask questions and reflect on the world around them. Engineering requires an individual to understand a phenomenon well enough to define problems related to it, and use that understanding to design a solution. Therefore, phenomena are central to the work of both the scientist and the engineer.

NSTA recommends a transition to three-dimensional teaching and learning and supports reflective teaching that helps students understand the connections of science and engineering practices and crosscutting concepts with the nature of science (*NGSS* Lead States, Appendix H). It's important to note that this transition is not a rejection of scientific inquiry, but represents further evolution of our understanding about what is essential to promote student learning.

Declarations

NSTA calls on all stakeholders at the local, district, and state level to assume a shared and collaborative role to adopt and implement three-dimensional science education standards as articulated by the *Framework*. To make the transition from conflicting notions of scientific inquiry to three-dimensional teaching, NSTA recommends stakeholders:

- make explaining phenomena and/or designing solutions to problems the central focus of science instruction;
- choose phenomena carefully based on learning goals or curriculum, and encourage the observation of phenomena both inside and outside the classroom;
- integrate science and engineering practices, crosscutting concepts, and disciplinary core ideas into all science instruction beginning at the early grades and continuing through high school and beyond;
- promote three-dimensional teaching and learning for all children regardless of language, gender, race, ethnicity, age, skill, cognitive and physical abilities, or economic status;
- ensure that students' learning of practices, core ideas, and crosscutting concepts builds over time as described by the learning progressions in the *Framework*;
- ensure students use evidence when providing explanations of phenomena and/or solutions to problems;
- help students engage in meaningful discourse with their peers—similar to the work of scientists and engineers—as they make sense of phenomena or design solutions to problems;
- create opportunities for students to make sense of phenomena using the three dimensions, construct their own explanations and arguments, and evaluate these explanations and arguments based on evidence;
- encourage students to apply their knowledge of science and their understanding of the nature of science to make informed decisions on personal, societal, and global issues;
- understand the variety of instructional models that can be used in three-dimensional science instruction and reject ideas that promote one single prescribed model or way of teaching; and
- ensure assessment of students' learning reflects their three-dimensional learning experiences.

Adopted by the NSTA Board of Directors
February 2018

References

Achieve, Next Generation Science Storylines & STEM Teaching Tools. 2016. Using Phenomena in NGSS-Designed Lessons and Units. STEM Teaching Tools, Institute for Science and Math Education, University of Washington. Seattle, WA. Retrieved from http://stemteachingtools.org/brief/42.

Midwest Comprehensive Center at the American Institutes for Research (AIR) & the Wisconsin Department of Public Instruction (WDPI). 2016. *What ever happened to scientific inquiry? A look at evolving notions of inquiry within the science education community and national standards.*

Minstrell, J. 2000. Implications for teaching and learning inquiry: A summary. As quoted in Barrow, L. H. 2006. A brief history of inquiry: From Dewey to standards. *Journal of Science Teacher Education,* 17: 265–278.

National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

National Research Council (NRC). 2000. *Inquiry and the national science education standards: A guide for teaching and learning.* Washington, DC: National Academies Press.

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.

National Science Teachers Association (NSTA). 2016. *NSTA Position Statement: The Next Generation Science Standards.*

NGSS Lead States. 2013. *Next generation science standards: For states, by states.* Washington, DC; National Academies Press.

Additional Resources

Belland, B. R. 2017. Instructional scaffolding: Foundations and evolving definition. In *Instructional scaffolding in STEM education,*17–53. Basel, Switzerland: Springer International Publishing AG.

Campbell, T., C. Schwarz, & M. Windschitl. 2016. What we call misconceptions may be necessary stepping-stones toward making sense of the world. *Science and Children* 53(7): 28.

Lee, O., H. Quinn, & G. Valdés. 2013. Science and language for English language learners in relation to next generation science standards and with implications for common core state standards for English language arts and mathematics. *Educational Researcher* 42(4): 223–233.

National Research Council (NRC). 2000. *How people learn: Brain, mind, experience, and school.* Expanded ed. Washington, DC: National Academies Press.

National Research Council (NRC). 2005. *America's lab report: Investigations in high school science.* Washington, DC: National Academies Press.

National Research Council (NRC). 2005. *How students learn: Science in the classroom.* Washington, DC: National Academies Press.

National Research Council (NRC). 2007. *Taking science to school: Learning and teaching science in grades K–8.* Washington, DC: National Academies Press.

National Research Council (NRC). 2009. *Learning science in informal environments: People, places, and pursuits.* Washington, DC: National Academies Press.

Niaz, M. 2016. Nature of science in science education: An integrated view. In *Chemistry education and contributions from history and philosophy of science.* 37–89. Springer International Publishing AG.

Penuel, W. R., K. Van Horne, S. Severance, D. Quigley, & T. Sumner. 2016. Students' responses to curricular activities as indicator of coherence in project-based science. Paper presented at *Transforming Learning, Empowering Learners,* International Conference of the Learning Sciences, Singapore.

Reiser, B. J., S. Michaels, E. Dyer, K. D. Edwards, & T. A. McGill. 2017. Scaling up three-dimensional science learning through teacher-led study groups across a state. *Journal of Teacher Education* 68(3): 280–298.

Shepard, L. A., W. R. Penuel, & K. Davidson. 2016. *Using formative assessment to create coherent and equitable assessment systems.* Boulder, CO: University of Colorado Boulder.