

My Journey to Understand and Implement the NGSS



by Karen Mesmer

I walked into the classroom at the University of Wisconsin–Oshkosh, ready to participate in an NSTA-sponsored review of the preliminary version of the *Next Generation Science Standards (NGSS)* before they were sent out for the initial public review. I had read most of *A Framework for K–12 Science Education* and was curious to see how it would be translated into standards to guide classroom instruction. Glancing at the first page of life science standards, I was taken aback by how busy the page seemed. As the layout was explained to us, it started to dawn on me how intricate and cohesive these standards were. The writers of the *Framework* and the *NGSS* connected the big ideas of science and showed how they worked together in the real world.

As I dug deeper into the *NGSS* and began to understand their vision of students learning by blending science and engineering practices, disciplinary core ideas, and crosscutting concepts, the word *exquisite* kept coming to mind. They reminded me of a limnology course I had taken in graduate school, where we had learned how the biology of food chains in a lake created by Earth science processes were affected by the physical properties of light waves and the chemistry of the water. Upon making this series of connections, it occurred to me that this is what science is in the real world! What I didn't realize at the time was where the course fell short. It didn't help me understand how the underlying science practices helped form the knowledge I was learning or that energy remained energy whether it was in biological organisms, physical waves, or chemicals. The *NGSS*, however, promised to create these missing connections for my students.

Familiarizing myself with the NGSS

I was so excited about the *Next Generation Science Standards* after my initial review that I wanted to learn as much as I could about them. To dig deeper into the disciplinary core ideas, science and engineering

practices, and crosscutting concepts, I participated in NSTA webinars focused on an in-depth look at these three key dimensions and how they might look in the classroom (see Resources for a link to the webinar archive). NSTA Press books such as *The NSTA Reader's Guide to the Next Generation Science Standards* and *Translating the NGSS for Classroom Instruction* were also valuable in helping me visualize the changes that needed to take place with my teaching, understand the role of the student in the classroom, and gather some ideas for curricula. Many articles from NSTA journals added to my knowledge, and their ideas have been incorporated into our district science curriculum. Attending NSTA and Wisconsin Society of Science Teacher conferences and participating in Wisconsin Science Educator Leadership Association meetings provided me with additional information about the *NGSS* and opportunities to ask questions of the experts. I then had the opportunity to serve as an *NGSS@NSTA* curator, which provided me with training to evaluate resources using the EQUIP (Educators Evaluating the Quality of Instructional Products) rubric developed by Achieve and NSTA (see Resources). These experiences gave me the skill set needed to examine a resource, see whether it aligned with the *NGSS*, and offer suggestions on how to make it more three dimensional. Achieve, the organization that coordinated the writing of the *NGSS*, published sample classroom tasks for both middle and high school teachers. These tasks provide a vision of how the *NGSS* can be integrated with the *Common Core State Standards* to assess students. Links to the EQUIP Rubric, resources vetted using the rubric that can be found at NSTA's *NGSS* Hub, and Achieve's sample classroom tasks can be found in the Resources section.

Spreading the word

Wisconsin is not an *NGSS* adoption state, but our school districts enjoy local control that allows them

to adopt their own standards. I educated the school board members and presented to the public at Optimist and Rotary meetings. Articles appeared in the city newspaper. I enlisted the help of local, science-oriented professionals, such as engineers, wildlife scientists, doctors, university science professors, and conservationists, to help champion the cause of the *NGSS*. When the school board met to discuss adopting the Standards, the vote was unanimous. We were official adopters.

About a year before the *NGSS* were adopted, I had met with my superintendent and curriculum director to pitch the idea of having me teach part-time while serving as a science coach. Although we are not a large district, we have a history of investing in coaching, especially in literacy and math. They approved of my idea, so when the *NGSS* were adopted, I found myself responsible for

- coordinating the alignment of our curriculum;
- searching out and writing *NGSS*-aligned lessons;
- doing professional development with teachers to help them understand three-dimensional learning; and
- visiting classes to offer suggestions, model teaching strategies, and coteach.

Where to start?

Our district decided to begin our *NGSS* implementation efforts at the middle and high school levels using ideas outlined in Appendix K. In middle school, we decided to introduce the *NGSS* in seventh-grade life science and in a blended course of physical and Earth science for sixth and eighth grades. We completed an audit of how we currently addressed disciplinary core ideas in the classroom and compared this to the *NGSS*. Consequently, some restructuring was required. For example, we used to teach separate units on the major taxonomic categories of bacteria, protists, fungi, plants, and animals. Now, we have students develop and use a model to describe the structure of living things and how multicellular organisms are systems. Our lab on cells moved beyond a simple microscopic viewing to an activity that requires students to plan and carry out an investigation and use the data gathered to construct a scientific explanation that supports the claim that living things are made of cells. Students now design a plant experiment and a bacteria lab, which give them the opportunity to engage in argument from evidence about how living things respond and grow. These labs also help them

obtain, evaluate, and communicate information. Our unit on heredity now requires students to develop a model of meiosis and fertilization by using paper chromosomes; they then analyze and interpret data from Mendel's peas to extend their model to dominant and recessive genes. After learning about DNA, students also incorporate this concept into their existing model. The evolution unit used many of the ideas in "Making Sense of Natural Selection" (Passmore 2013), as students developed a model of natural selection after grappling with the concepts of variation in a population, selective advantage, survival, reproduction, and heredity. They were then able to use the model to solve novel problems, such as antibacterial resistance and finch-beak evolution in the Galapagos Islands. All of these activities were the result of embracing the three-dimensional learning set forth in the *NGSS*.

Why is three-dimensional learning so important?

Incorporating three-dimensional learning into the curriculum involves students in doing science using science and engineering practices and learning how certain concepts such as energy and patterns are interwoven in all science disciplines. This gives students a much more realistic picture of our world and how it works, and it allows them to see the world as a single, interconnected entity.

Evolution is a topic that is a personal favorite of mine, because it ties together multiple lines of evidence from paleontology, genetics, chemistry, population ecology, and many other science disciplines. Tying all three dimensions together for this concept allows students to find patterns in the data to develop a model that explains the diversity of life on Earth. None of these three dimensions by itself is sufficient for students to understand science and evolutionary biology. However, all three together give a much broader picture and help students make sense of the past and understand how it relates to the present.

I like working with disciplinary core ideas when teaching instead of "subjects." Disciplinary core ideas allow me to focus on a major idea that can be tied to many disciplines and used as an organizing tool. Students can use what they learn about a disciplinary core idea to solve problems that are interesting to them and related to their life experiences. They can start with an idea in the early grades and build on their understanding throughout their school career. There is power in teaching and learning that allows students to appreciate the world as a coherent

whole and not just a series of unrelated facts. Using the example above, evolution can be used to explain why armadillos look similar, but not identical, to giant glyptodonts. Or why the limbs of horses, whales, bats, and humans are all composed of similar bones, and why embryos are almost identical at the early stages, regardless of species. The problem of antibiotic and pesticide resistance can also easily be explained by evolution. Students begin to see how many different phenomena make sense with evolution as a lens.

Research strongly suggests that students learn and can use scientific concepts more effectively if they are asked to develop a model to explain phenomena in the natural world and then argue their ideas with their peers. In the example above, students developed a model to explain the diversity of life on Earth and the process involved. Other practices, such as asking questions, analyzing and interpreting data, and constructing explanations, can be incorporated into the practices of modeling and argumentation. Students are doing science, not just learning the end result of scientific research.

The most difficult change was incorporating the crosscutting concepts. We had to make explicit efforts to help students see that they were finding patterns in data, that structure relates to function, and that systems are found in many areas that they investigated. With evolution, students were asked to find patterns in the data to explain paleontology, genetics, biochemistry, population ecology, and the multitude of evidence supporting evolution. I'm sure that more connections will be made in the future.

Learning progressions

As we expanded NGSS implementation across the grade levels, I became more aware of the learning progressions in each of the disciplinary core ideas, science and engineering practices, and crosscutting concepts. It made so much sense that students in K–2 would understand that heating and cooling cause changes in substances, students in grades 3–5 that chemical reactions occur and a new substance is formed with different properties, students in grades 6–8 would develop a model of atoms and molecules that explains how this happens, and students in grades 9–12 would understand how collisions of molecules, rearrangements of atoms, and changes in energy are involved. Each practice and crosscutting concept also has learning progressions that take into account the latest research on what students can understand and do at different ages. If students start learning science in kindergarten with the NGSS, the next generation

could understand our natural world in such a way that they could participate in public discussions on science issues, be able to evaluate scientific claims related to their lives, and have a sense of wonder and a desire to learn about science beyond school.

Conclusion

I look forward to the next decade of seeing how the NGSS are implemented in classrooms across the country. It has been so exciting to see the changes in science education that have happened so far, even though I know that we have a long way to go to truly have the next generation understand the natural world. ■

Resources

Print

Banko, W., M.L. Grant, M.E. Jabot, A.J. McCormack, and T. O'Brien. 2013. *Science for the next generation: Preparing for the new standards*. Arlington, VA: NSTA Press.

Bybee, R.W. 2013. *Translating the NGSS for classroom instruction*. Arlington, VA: NSTA Press.

NGSS Lead States. 2013. *Next generation science standards: For states, by states*. Washington, DC: National Academies Press. www.nextgenscience.org/next-generation-science-standards.

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

Passmore, C., 2013. Making sense of natural selection. *The Science Teacher* 48 (6):44–49.

Pratt, H. 2013. *The NSTA reader's guide to the next generation science standards*. Arlington, VA: NSTA Press.

Online

EQuIP Rubric—http://nstahosted.org/pdfs/ngss/resources/EQUIPRubricForScienceOctober2014_0.pdf

NGSS Hub: Classroom resources—<http://NGSS.nsta.org/Classroom-Resources.aspx>

NGSS classroom sample tasks—www.nextgenscience.org/classroom-sample-assessment-tasks

NSTA Learning Center web seminar archives—<http://ngss.nsta.org/web-seminar-archives.aspx>

Karen Mesmer (klmesmer@gmail.com) is a recently retired middle school science teacher and science coach for the School District of Baraboo in Baraboo, Wisconsin. She currently runs Mesmer Science Education Consulting.