Next Generation Science: Bridge to the Future

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ABSTRACT

The *Next Generation Science Standards (NGSS) for Today's Students and Tomorrow's Workforce,* developed over the past year through a collaborative, state-led process, were recently released. This paper will give a brief overview of the history and structure of the new standards. Attention is given to how the NGSS differ from previous standards and the implications of these differences for classroom instruction.

Keywords: STEM, Conference Proceedings, Science, Learning Outcomes

INTRODUCTION

The *Next Generation Science Standards (NGSS) for Today's Students and Tomorrow's Workforce* were developed "through a collaborative, state-led process. These new K–12 science standards will be rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education. Based on the *Framework for K-12 Science Education,* the NGSS are intended to provide a new vision for science education" (NGSS, Appendix A, 2013) that reflects the" interconnected nature of science as it is practiced and experienced in the real world", "focuses on a deeper understanding of content as well as application of content" and "integrates technology and engineering from kindergarten to 12th grade." (NSTA Web Seminar, 2013)

This new generation of science standards is built on work done over the past twenty years following the release of the National Science Education Standards in 1993. Since that time, the National Research Council has supported research on how students learn science effectively publishing *How People Learn, How Students Learn,* and most recently, *Taking Science to School.* In the summer of 2011, the NRC released the *Framework for K-12 Science Education* providing a sound, evidence-based foundation for the new standards drawing on this research. The *Framework* also identifies the science that all K-12 students should know, providing a roadmap for science education for the next quarter century. Findings in cognitive science permeate the *Framework* and have been central to developing the *Next Generation Science Standards.*

Under the guidance of the National Research Council (NRC), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), and Achieve (an education reform organization led by a Board of Directors of governors and business leaders), the NGSS are being developed collaboratively with 26 lead states and other stakeholders in science, science education, higher education and industry. To date, the standards have been through multiple internal and state reviews in addition to two public reviews in the May 2012 and January 2013. The goal of this process is to produce a set of high quality, college- and career-ready K–12 science standards ready for state adoption. The

standards were released in mid-April at the National Science Teachers Association Conference in San Antonio, Texas.

STRUCTURE OF THE STANDARDS

"Science, engineering and technology permeate modern life and are essential for all individuals. In addition, an understanding of science and engineering is critical to participation in public policy and life. Science, engineering and technology are cultural achievements and a shared good of humankind." (Krajcik, 2013) Recognizing this context, the NGSS are designed to meet the needs of what all students need to know in order to be career and college ready in our current global society.

The structure of the NGSS is based on three dimensions**:**

Dimension 1: *Science and Engineering Practices*

"This dimension focuses on important practices used by scientists and engineers: modeling, developing explanations, and engaging in argumentation." (BSE, 2011)

1. Asking questions (for science) and defining problems (for engineering) 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data	5. Using mathematics and computational thinking 6. Constructing explanations (for science) and designing solutions (for engineering) 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information

Dimension #2: *Cross-cutting concepts*

"These seven cross-cutting concepts are key across science and engineering." (BSE, 2011)

1. Patterns 2. Cause and effect: mechanism and explanation 3. Scale, proportion, and quantity 4. Systems and system models	5. Energy and matter: flows, cycles, and conservation 6. Structure and function 7. Stability and change

Dimension #3: *Disciplinary Core Ideas*

"The framework includes core ideas for the physical sciences, life sciences, and earth and space sciences because these are the disciplines typically included in science education in K-12 schools. Engineering and technology are featured alongside these disciplines for two critical reasons: to reflect the importance of understanding the human-built world and to recognize the value of better integrating the teaching and learning of science, engineering, and technology."(BSE, 2011)

Physical Sciences • PS 1: Matter and its interactions • PS 2: Motion and stability: Forces and interactions • PS 3: Energy • PS 4: Waves and their applications in technologies for information transfer	*Life Sciences* • LS 1: From molecules to organisms: Structures and processes • LS 2: Ecosystems: Interactions, energy, and dynamics • LS 3: Heredity: Inheritance and variation of traits • LS 4: Biological Evolution: Unity and diversity
Earth and Space Sciences • ESS 1: Earth's place in the universe • ESS 2: Earth's systems • ESS 3: Earth and human activity	*Engineering, Technology, & Applications of Science* • ETS 1: Engineering design • ETS 2: Links among engineering, technology, science, and society

As prescribed by the *Framework*, the NGSS is written as performance outcomes that combine a relevant practice of science or engineering, a core disciplinary idea, and at least one of seven crosscutting concepts. The integration of these three dimensions is intended to help students:

- Develop the ability to investigate the natural world through the practices of science inquiry or solve meaningful problems through the practices of engineering design,
- Focus on core ideas essential to the understanding of physical science, life science, earth systems science, and engineering
- Make sense of and connect core ideas across disciplines.

IMPLICATIONS FOR IMPLEMENTATION

So what is new and different about the Next Generation Science Standards? There are many areas in which the vision for science education put forth in this document is different than past standards.

1. Performance Expectations: The standards are written in such a way as to incorporate at least one practice of science or engineering, a core disciplinary idea, and crosscutting concepts into a singles statement of what is to be assessed. They are not objectives for a lesson. In past documents, inquiry (process of science) was addressed separately from content. In this document, they are integral part of the content and assessment.
2. Focus: The NGSS are organized around core explanatory ideas (the big of ideas of science that all kids have to know to live productive lives). This focus is on a limited number of core ideas in science and engineering in order to allow sufficient time for teachers and students to explore each idea in depth and thus with understanding. With each revision of the standards, the level of focus has narrowed and deepened.
3. Coherence: This generation of standards provides a template for building and applying ideas across time. Now, more than ever, it will be important for students in the elementary grades to be introduced to science concepts that will form the foundation for their science instruction in the upper grades. Also, the introduction cross cutting concepts provides students with

ways to connect knowledge from the various disciplines into a coherent and scientific view of the world.

4. Central Role of Scientific and Engineering Practices: The eight practices of science and engineering are essential in enabling students to understand the way that scientists investigate the natural world. These practices need to be addressed so that students can use their understanding to investigate the natural world through the practices of science inquiry, or solve meaningful problems through the practices of engineering design. It should be noted that there is considerable similarity between the practices in the NGSS and the eight mathematical practices in the new Common Core State Standards: Mathematics.
5. Inclusion of Engineering as a Disciplinary Core Idea: The inclusion of engineering in NGSS reflects a commitment on the part of the design team to fully integrate engineering design, technology, and mathematics into the structure of science education. "The intent is to raise engineering design to the same level as scientific inquiry when teaching science disciplines at all levels", (NGSS, Appendix A, 2013) from kindergarten to grade 12, thereby inspiring and equipping students with the knowledge and skills essential for addressing society's needs. The inclusion of engineering will generate the need for teacher professional development and classroom resources for effective instruction in this area.

TIMELINE

At the time of the writing of this paper, the final version of the NGSS has been released and is posted to the NGSS website, www.nextgenscience.org . Michigan is one of twenty-six lead states in the development process and is expected to adopt these standards by May 2013. The standards were presented to the Michigan State Board of Education in April 2013. Currently a survey is available for public comment. The vote to adopt the standards will take place at the May 2013 Board meeting. Once the standards are adopted by the Michigan State Board of Education, the Michigan Department of Education will begin to develop transition plans, curriculum alignment plans, teacher professional development, and implementation of assessment. It is expected that full K-12 implementation will be in place (including assessment) by the 2016-2017 academic year.

CONCLUSION

The *Next Generation Science Standards*, developed through an intensive process that allowed for considerable input from a variety of stakeholders, provides the blueprint for the next steps in science education. Implementation of this blueprint will change the way science is "taught and learned" in classrooms across the country by placing equal importance on both the content and process of science and acknowledging the importance of engineering in our society. Designed to provide all students the opportunity to be career and college ready upon high school graduation, these standards are a bridge to the future.

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Karen Meyers, Director of the Regional Math and Science Center, has been involved with mathematics and science education as a middle school teacher, professional developer, and administrator for over 30 years. She has been a principal investigator on several STEM-related grants. In addition, she coordinates several programs for the RMSC including the Region 12 Michigan Science Olympiad and Algebra for All. Ms. Meyers has a BS in Mathematics and an MA in Curriculum and Teaching from Michigan State University.