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REL Mid-Atlantic Teacher Effectiveness Webinar Series
Science Education and Teacher Effectiveness: Implications of the Next Generation Science Standards (NGSS)
Q&A with Chris Wilson, Ph.D., and Jody Bintz, M.S.
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This webinar explored how the Next Generation Science Standards (NGSS) provide an instructional framework to support professional growth and inform teacher evaluation systems for science instruction. This Q&A addressed the questions participants had for Dr. Wilson and Jody Bintz following the webinar. The webinar recording and PowerPoint presentation are also available.

Questions

1. What are the major shifts in instruction related to the Next Generation Science Standards (NGSS)?

Conceptual shifts in the NGSS include the following (see NGSS, Volume 2, Appendix A, for more information):

1. K–12 science education should reflect the interconnected nature of science as it is practiced and experienced in the real world.
2. The NGSS are student performance expectations, NOT curriculum.
3. The science concepts in the NGSS build coherently from K–12.
4. The NGSS focus on deeper understanding and application of content.
5. Science and engineering are integrated in the NGSS, from K–12.
6. The NGSS are designed to prepare students for college, career, and citizenship.
7. The NGSS and Common Core State Standards (CCSS) (English language arts [ELA]/literacy and mathematics) are aligned.

Previous standards presented each of the dimensions—core concepts, practices, and unifying concepts and processes or themes of science—as separate entities. In the NGSS, the expectation is that students will learn at the intersection of these dimensions and have opportunities to apply the disciplinary core ideas, cross-cutting concepts, and science and engineering practices. By teaching at the nexus of disciplinary core ideas, science and engineering practices, and cross-cutting concepts, teachers will support students in building deeper scientific understanding.

In the classroom, students will demonstrate their understandings and abilities in ways consistent with the performance expectations. Curriculum will guide these efforts. Teachers will implement units of instruction designed to support teaching and learning in ways that integrate practices and concepts. The NGSS explicitly make connections among the dimensions and the nature of science; engineering, technology, and applications of science; and with the Common Core as a way to guide planning for instruction and to promote the foundational principal of “all standards, all students.” These coherent experiences will promote the vision for science teaching and learning inherent in the NGSS to prepare students for future endeavors.

2. How do the NGSS incorporate all aspects of STEM education?

One of the major shifts of the NGSS is the idea that science and engineering are integrated. By teaching at the nexus of disciplinary core ideas, cross-cutting concepts, and science practices, the NGSS help prepare students for college and careers. The NGSS specifically address engineering practices, design, and links with technology and applications of science. The *Framework for K-12 Science Education* (National Research Council, 2012a) addresses specific limitations related to engineering and technology in Chapter 1 (pp. 11–15). In addition, the NGSS include explicit links to math in the connection to the mathematics Common Core and in Science and Engineering Practice 5, Using Mathematics and Computational Thinking. How you interpret “incorporate all aspects” probably depends on how you think about the NGSS and how you think about STEM education. My personal perspective is this: The NGSS provide at least a partial vision for STEM education and clear expectations for the integration of science and engineering.

3. How will the NGSS influence mathematics instruction? How do educators connect the NGSS to mathematics instruction? How can we integrate ELA standards and the NGSS?

During the development of the NGSS, the standards were explicitly and carefully matched to the CCSS in ELA/literacy and mathematics. This was done in recognition that science is a quantitative discipline and to ensure that mathematical concepts are introduced at the same grade level in each set of standards.

Language (e.g., reading, writing, speaking, and listening) plays a critical role in science, particularly as students engage in the practices of science and engineering and in the engineering design process. Language is also critical to the construction of knowledge and the development of abilities. The NGSS attend to these roles.

The sets of standards complement each other and are designed to prepare students for college and careers in the 21st century. Through the NGSS, students are encouraged to apply their learning. These experiences offer opportunities for students to make applications to real-world situations, which could certainly include cross-discipline connections. The NGSS include a cross-walk with CCSS in Volume 2, Appendix D. The text is informative, and the graphic on p. 28 is helpful in showing the relationships among math, science and engineering, and ELA practices.

4. How do the NGSS correlate with CCSS? What is the purpose of the correlation?

Science needs to be part of every K–12 learner’s education. The NGSS were created to promote equity among the content areas. The CCSS and NGSS complement each other and are both intended to prepare students with the skills and knowledge necessary for college and careers in the 21st century global economy. NGSS Volume 2, Appendix D, discusses the correlation in the context of making the NGSS accessible to all students. For more information on the alignment between the NGSS and CCSS, please refer to Appendices L and M in Volume 2 of the NGSS.

5. **Are there textbook or resource companies that are creating NGSS materials and assessments?**

   There are many resources to support teachers in implementing the NGSS. Both the NGSS and the National Science Teachers Association (NSTA) websites include various resources for teachers.

   Materials still need to be developed and field tests need to be conducted to ensure that materials are effective before widespread dissemination.

6. **What will be the biggest changes in instructional practices for teachers adopting the NGSS?**

   The seven conceptual shifts in the NGSS (see question 1) are all potential changes that teachers adopting the NGSS may face. The most challenging shifts identified in the poll during this webinar included: Shift 2, "the NGSS are student performance expectations"; Shift 4, "the NGSS focus on deeper understanding"; and Shift 5, "science and engineering are integrated." In our work with teachers and leaders, we find that they also identify Shift 1, "education should reflect the interconnected nature of science as it is practiced and experienced in the real world."

   The two most challenging shifts that directly pertain to instructional practices are Shift 1 and Shift 5. The NGSS expect students to learn at the intersection of the dimensions as well as to learn important engineering concepts, processes, and practices. Supporting students in the development of these understandings and abilities has always been and will continue to be a challenge. Some teachers *may* feel ill-prepared for this student-centered approach and/or for the focus on engineering. Other teachers welcome the changes inherent in the NGSS.

   Review NGSS Volume 2, Appendix A, for more information.

7. **How and in what ways do the NGSS support inquiry-based instructional practices?**

   The *Framework* (National Research Council, 2012) explicitly addresses this question in the Summary (p. 2), the description of the New Conceptual Framework (p. 11), Guiding Assumptions (p. 26), the overview of the Dimensions (p. 30), and in Chapter 3 (beginning on p. 41). The *Framework* indicates that engaging in scientific inquiry requires the simultaneous coordination of knowledge and skills. By applying this definition, teaching and learning at the nexus is consistent with inquiry-based teaching and learning. Students' use of the science and engineering practices to develop understanding of disciplinary core ideas (including engineering) and cross-cutting concepts does not quite reach the bar set by the NGSS. Students also need to know they are using the practices and be metacognitive about how their use is influencing their thinking.

8. **How can teachers develop formative assessments based on the NGSS?**

Teachers can use evidence-centered design to develop formative assessments. By clearly defining exactly what they are measuring and knowing what claims they want to make about student learning, they will create clear descriptions of what students will be able to do. From these clear descriptions, teachers can think about the tasks that would allow students to demonstrate this understanding. Teachers will think creatively about various ways in which students can demonstrate their understanding. Teachers will build off of performance expectations to determine what students should be able to demonstrate based on the NGSS. The National Research Council report *Developing Assessments for the Next Generation Science Standards* (National Research Council, 2014; http://www.nap.edu/catalog.php?record_id=18409) is an excellent summary of how assessments can be developed that align with the NGSS.

9. What are the expectations around NGSS-aligned assessments?

Just as the NGSS are going to lead to dramatic changes in the way science is taught, they will require major changes in the way we measure achievement and learning. Three-dimensional science learning will therefore be a major focus of NGSS-aligned science assessments—something that will be new for those developing assessments from the classroom level to the state level. The report *Developing Assessments for the Next Generation Science Standards* (National Research Council, 2014; http://www.nap.edu/catalog.php?record_id=18409) provides a review of the research and a number of conclusions on assessment and the NGSS. These conclusions include (a) students will need multiple and varied opportunities to demonstrate their understanding, (b) assessments that measure three-dimensional learning will need to have multiple parts and questions that measure the dimensions both in isolation and in combination, and (c) assessments must be able to place students along a continuum of progressively more complex understandings.

10. How can the implementation of the NGSS be used as an opportunity to create a better system for science education?

Implementation of the NGSS requires students to learn important subject matter and cross-cutting concepts through the use of the science and engineering practices. Based on our brief (about 3 minutes) shared experience with the video clip, we might say that students were doing just that as they were using a model of the Earth-Sun system to identify patterns of more direct (or less direct) light at different places on Earth's curved surface at different times of the year. These patterns were based on Earth's location in its orbit around the sun. The teacher was asking questions to help students identify patterns, discern differences in their ideas, and use evidence to negotiate their ideas about these patterns.

During the webinar, we asked participants how well this video clip represented learning at the intersection of the NGSS dimensions. The results of the poll revealed a wide range of responses. The variation in results is one indication that we don't share an understanding of what this kind of teaching and learning looks like in the classroom. This difference offers an opportunity to open a dialogue that includes reaching consensus about what teaching and learning with the NGSS looks like and then creating a system for science education that supports achieving this vision.

The implementation of the NGSS requires high-quality instructional materials aligned with the NGSS. These materials must be conceptually coherent and offer multiple opportunities to learn important science and engineering disciplinary core ideas, develop the science and engineering practices and be aware of how the use of the practices influences thinking, and connect these important ideas and practices through the cross-cutting concepts. These learning opportunities must include experiences that carefully weave together the NGSS dimensions and promote the application of concepts, design, and practices.

The implementation of the NGSS requires assessments (both formative and summative) that uncover students' understanding—not just of one dimension, but at the intersection of the dimensions. These assessments must exist at the classroom level, the district level, and the state level.

For a teacher, school, district, or state to implement the NGSS effectively, stakeholders need a shared vision of curriculum, instruction, and assessment at the classroom level as well as carefully aligned system components. These components include a thoughtfully sequenced and resourced K–12 science program, coherent assessment systems, and effective professional development for teachers, teacher leaders, and other leaders. We also need to continue to focus research on questions of the effectiveness of initiatives designed to improve science education.

11. On what should districts adopting the NGSS focus their attention? How can we implement the NGSS smoothly?

As described in the response to question 10, districts adopting the NGSS may want to pay attention to—well, everything. The key is in effective and strategic planning to determine what, when, and how to focus energy and resources. What is your vision of teaching and learning in light of the NGSS? To what extent is this vision shared by others? What do you have in place that will support implementation? How can you leverage this strength to move forward? How can you make a case for change? How do other components of the system (including formal leaders) need to change? How can you help teachers and other key stakeholders *want* to change?

Implementation of a complex innovation such as the NGSS will likely *not* be smooth. However, through thoughtful planning, we can increase the likelihood that implementation will indeed occur! The *Framework* (National Research Council, 2012) describes implementation at a systems level in Chapter 10 (beginning on p. 241). While the authors don't make recommendations, they point us to other resources and describe key components of the system.

12. How can administrators and instructional coaches alleviate anxiety for teachers implementing the NGSS?

You may not be able to alleviate anxiety—theirs or yours! However, district leaders can support and monitor the implementation of the NGSS in ways consistent with the research and literature on the change process. What you can do is develop a system of support for teachers that includes opportunities to understand the NGSS and develop a shared vision of implementation; professional development (meaning more than just workshops) to support teacher collaboration as they enact the NGSS; and opportunities, tools, and resources to assess and revise instructional materials to be more aligned with the NGSS. The support system should also promote a culture conducive to change. One way to develop this kind of culture is to engage teachers in cycles of reflective practice to promote a growth mind-set.

13. What are best practices for professional development and teacher training that ensure fidelity of the implementation and application of the NGSS?

The *Framework* (National Research Council, 2012) describes key aspects of teacher development (beginning on p. 255 in Chapter 10). To ensure fidelity, we have to agree on what implementation and application of the NGSS look like, sound like, and feel like in the classroom, school, district, and state. We must have professional development models, designs, tools, and resources that support implementation of the NGSS.

As presented in the webinar, we are finding very positive results (i.e., student learning, teacher learning, and teacher practice) from a scale-up study of the Science Teachers Learning from Lesson Analysis (STeLLA) professional development model. The focus on engaging teachers in analyzing practice through student thinking and on science content storyline lenses is leading to significant learning gains by both teachers and students. From our study of the *Framework*, we think that programs like STeLLA could serve as effective models of professional development to support teachers as they implement the NGSS.

The STeLLA program is a one-year program that includes a summer institute and monthly group meetings for teachers participating. In the STeLLA lesson analysis program, teachers deepen their content knowledge and learn strategies to reveal, support, and challenge student thinking. They focus on asking questions to elicit student ideas and predictions, challenge student thinking, and engage students in applying new ideas. Students have the opportunity to apply their scientific learning and communicate in scientific ways. Teachers learn strategies to increase the focus and coherence of individual lessons and sequences of lessons. These strategies help them develop clear goals, use the goals to select (or refine) activities, and make explicit links and highlight key ideas.

Through the program, teachers have multiple opportunities to analyze practice cycles during which they learn (or deepen understanding), apply what they learn, and reflect on their efforts based on analysis of one or more artifacts. Teachers are supported in improving their practice.

14. What types of classroom observation protocols have been effective in observing the implementation of the NGSS?

Research groups are currently working both to adapt current observation protocols to align with the NGSS and to develop new tools built around the structure of the NGSS. This work is grounded in developing clear descriptions of classrooms and agreement on the characteristics and qualities of effective implementation of the NGSS.

One important question you might consider is the purpose of using an observation protocol. When you consider using a new protocol, it will be important to consider who will do the observing, who will be observed, and who will use the information gathered and for what purpose. Another important consideration is how teachers are engaged in learning about the content, focus, use, and purpose of the protocol.

15. What research have you found regarding the appropriate scope and sequence for middle school science?

The NGSS are based on *A Framework for K–12 Science Education* developed by the National Research Council (2012), which draws on current research focused on the ways that students learn science effectively. The NGSS include model course maps that might inform your thinking. The maps can be found in NGSS Volume 2, Appendix K.

16. How do the NGSS align with current high school courses (biology, chemistry, physics), and how do they align with specialty science courses (marine biology, animal science, etc.)? Will teachers have to restructure these courses?

If you are wondering if course sequences and content will change, then your thinking is probably best informed by what your state is doing regarding the NGSS and the stance of your district in terms of your overall science program including assessments. If your question is more focused on structures within an individual classroom, then the extent of needed change will depend on the teacher's current practice in light of the NGSS.

17. Can ideas from the NGSS be applied to higher education?

Absolutely. The NGSS were developed with college readiness in mind and in consultation with stakeholders at the college level. You can find information on this connection in Appendix C of Volume 2 of the NGSS. Further, just as K–12 research on teaching and learning has contributed to how science is taught at the college level, so will research and development on learning at the nexus of the three NGSS dimensions. We also don't just train scientists in science classes in colleges; we also educate teachers. For a long time, there has been a disconnect between the types of understandings students develop during their science courses in college and the types of understandings pre-service teachers need to become effective science teachers. So the more consistent science instruction at the college level can be with science learning that integrates science ideas and practices, and that allows students to apply scientific principles across topics, the greater chance we have of developing effective K–12 teachers.

18. How can I learn more about if and when my state will adopt the NGSS?

To learn more about the NGSS in your state, you can contact your state science supervisor or the person with science responsibilities in your state department of education.

19. Are the NGSS being implemented in NSTA Science Teacher Preparation Standards? How are we preparing new science teachers to teach the NGSS?

The current NSTA Science Teacher Preparation Standards were released before the NGSS in 2012. Information on the standards can be found here:

http://www.nsta.org/preservice/.

BSCS has a program with resources to support pre-service teacher education. Information about this program can be found at http://www.bscs.org/vista. In addition, we are currently conducting research and development on the next version of the Videocases for Science Teaching Analysis (ViSTA) program. Stay tuned for the release of findings and products related to this program.

20. How can parents support the implementation of NGSS?

Parents can read and become familiar with the NGSS and the *Framework for K-12 Science Education* (National Research Council, 2012). Parents can watch the videos and use the resources on the NGSS and NSTA websites. Parents can support their children's science learning by challenging them to think deeply about the science they are learning in and out of school: asking them to provide evidence for claims that they make, probing how they know what they know, questioning sources of information, and helping them delve deeper by moving away from seeing science as a body of facts to memorize and towards regarding science as a way of thinking about and questioning the world. In our work, we encounter stakeholders who are hungry to improve the system—teachers who are committed to improving their classroom practice and student learning, school and district leaders who are dedicated to supporting teachers and to building a system of support, and other stakeholders who are committed to working at various levels of the system to support these efforts.

Action Steps

Participants responded to the question "As a result of today's webinar, what action steps do you plan to take?" and some of their responses are listed below.

- *Keep learning and participating in additional webinars and other PD to help support the evolution of the process.*
- *Incorporate information into our research and evaluation plans.*
- *Provide teachers with actionable steps to incorporate NGSS.*
- *Work on changing some activities with my students a little at a time so that they can adjust to the changes as well.*
- *Go to BSCS website to look for science teaching videos that I might be able to use with teacher candidates.*
- *Find resources that I can share with teachers so that they can effectively implement NGSS.*
- *Look for resources, thinking outside the box for new ways to facilitate lessons instead of directing the lessons.*
- *Prepare teachers to implement NGSS and communicate a basic understanding of NGSS to parents/community.*
- *Ensure teachers are aware of the need for their own growth in the instruction they do and the increased rigor that needs to be obtained.*
- *Continue collaborating with others. We need to work together to think out our PD, not just react.*
- *Focus on increasing inquiry and discourse in classrooms.*

- *Conduct analysis of our university science course content and pedagogy in relation to NGSS.*

Additional Resources

- Achieve, http://www.achieve.org/
- American Association for the Advancement of Science (AAAS): Advancing Science, Serving Society, http://www.aaas.org/
- BSCS, A Science Education Curriculum Study, www.BSCS.org
- An elementary journey to the Next Generation Science Standards, http://elemngss.blogspot.com/
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