NSTA Feedback to Achieve on Next Generation Science Standards First Public Draft

June 2012

INTRODUCTION

NSTA fully supports the development of Next Generation Science Standards (NGSS). These new standards have the ability to help science educators better connect the science that children will be learning across the K–12 grade spans and give all students the opportunity to learn and understand core ideas in science and engineering and key science practices.

NSTA is a committed partner in the process of developing new standards, and we want to ensure that the NGSS are the best they can be. We have provided feedback on early drafts of both *A Framework for K–12 Science Education* (*Framework*) and two private drafts of NGSS. The following feedback on the May 11 NGSS public draft is an outgrowth and continuation of our work. NSTA's ongoing review of standards documents is led by an expert review team comprised of Susan Koba, Mike Padilla, Harold Pratt, Jim Rutherford, JoAnne Vasquez, and select NSTA staff. In addition, our feedback has been informed by hundreds of individuals, including groups of science educators brought together in dispersed geographical areas across the country for a one-day facilitated review of an early private draft of NGSS.

NSTA has raised numerous issues throughout the process of reviewing early drafts of NGSS, as well as the *Framework*. NSTA is pleased to see improvements in the current NGSS draft that have been made since our last review; however, we continue to have serious and extensive concerns about the current content and architecture of the NGSS. These issues are similar to the ones we voiced in our review in November 2011 and January 2012 and are outlined below. The level of our concern has intensified considerably as a result of an increased number of individuals who have seen and commented on the draft. As we inch closer to a final draft of the standards, the NSTA leadership is concerned that some of the issues we have raised have yet to be addressed and strongly recommends that these issues be addressed now so that they are reflected in the next draft. We offer the following seven recommendations to Achieve and strongly encourage its writers to edit the current NGSS draft to reflect these recommendations. NSTA welcomes the opportunity to work together with Achieve and its writers to address these concerns in the current draft.

SUMMARY OF NSTA RECOMMENDATIONS

NSTA Recommendation 1: The NGSS should include a section on *Connections to the Nature and History of Science* in a manner similar to the *Connections to Engineering, Technology, and Applications of Science.*

NSTA Recommendation 2: The front matter of the NGSS should contain an overarching essay that explains the architecture of the standards, including the relationship between the individual performance expectations in a set and how each performance expectation relates to the practices, core ideas, and crosscutting concepts within the foundation box. The essay should also make clear how the performance expectations, practices, core ideas, and crosscutting concepts should be used in planning instruction and provide some examples for various topics and grade levels.

NSTA Recommendation 3: Each set of performance expectations in the NGSS should include an opening statement that explains why this set of performance expectations has been grouped together.

NSTA Recommendation 4: Every core idea should have at least two performance expectations that probe it. The first performance expectation should combine the core idea with the practice of modeling, explanation, or argumentation, and the second performance expectation should combine the core idea with one of the other five practices. The connection between these performance expectations and the core idea should be explicit.

NSTA Recommendation 5: The appropriate grade level for students to learn a particular science concept in the NGSS should not differ from the recommendations in the *National Science Education Standards* and *Benchmarks for Science Literacy* unless there is published research that provides evidence in favor of the move.

NSTA Recommendation 6: Any assumptions about the resources, time, and teacher expertise needed for students to achieve particular standards should be made explicit (Note: This is identical to Recommendation 11 on p. 305 of *A Framework for K–12 Science Education*.)

NSTA Recommendation 7: The survey mechanism used for the next public draft of the NGSS should be more user friendly than the mechanism that was used for this first public draft, and the timing of the release should be sensitive to the schedules of all educators, but particularly the schedules of classroom teachers.

DETAILED FEEDBACK AND RECOMMENDATIONS

Nature of Science Must Be Included in NGSS

NSTA's most serious and profound concern with the NGSS first public draft is the explicit omission of nature of science. NSTA feels strongly that nature of science must be included in the NGSS, and we have made this appeal in two earlier reports to Achieve following private reviews. This recommendation was also made to Achieve following the release of the final NRC *Framework* (see *http://www.nsta.org/about/standardsupdate/recommendations.aspx*).

NSTA recognizes that the NRC failed to include the nature of science in the *Framework*, which serves as the foundation for NGSS and charge to Achieve. We consider this omission to be a major weakness of the *Framework.* Regardless of the omission, we appeal to Achieve to include *Connections to the Nature and History of Science* in a manner similar to the *Connections to Engineering, Technology, and Applications of Science*. NSTA is also appealing to the National Research Council to encourage them to support this inclusion in the standards.

Furthermore, there is a fundamental lack of understanding in the *Framework* on the nature and purpose of the practices. The practices in NGSS describe abilities, but there is also a critical need for an **understanding** of science as a human activity and how scientists work. In our recommendation following the release of the *Framework*, NSTA noted the need to clearly delineate between *what* students are to know and be able to do and *how* they should be taught those things. This distinction is still not clear in the draft NGSS. The *Framework* states on pages 42–43 that "Engaging in the practices of science helps students understand how scientific knowledge develops." (Understanding how scientific knowledge develops is one aspect of the nature of science, i.e. *what* should be learned.) In the same paragraph the following text appears: "Participating in these practices also helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering." (This is a teaching strategy of *how* core ideas should be learned.) This blurred distinction also exists in NGSS because there are no standards on the understanding of the nature of science. Incorporating practices within the performance expectations as learning outcomes (that are essentially abilities of the practices) does not clearly distinguish between the outcomes and the strategies used to achieve those outcomes.

We appreciate Achieve's attempt to explain how the nature of science is addressed in the NGSS with the document, *The Nature of Science in NGSS*, which was posted online along with the NGSS draft. Unfortunately, this document does nothing to fix the omission of nature of science in the NGSS draft and simply offers weak excuses for not including it.

For example the claim that simply *doing inquiry* (engaging with scientific practices) will result in *knowing about inquiry* (a claim that knowledge about inquiry and nature of science would develop implicitly) is refuted by 50 years of empirical research. Much of the earlier work is summarized in Abd-El-Khalick and Lederman (2000)[1] but even more recent work by Khishfe and Abd-El-Khalick (2002)[2], Howe and Rudge (2005)[3], Peters and Kitsantas (2010)[4], and Yacoubian and BouJaoude (2010)[5] provide ample evidence to dispute that claim. Even strong proponents of practice-based approaches to science education such as Sandoval and Morrison (2003)[6] found that while there are many benefits of such approaches, they do not lead to helping students develop ideas about the nature of science.

While the NGSS draft document notes that certain activities provide an opportunity for teaching about the nature of science, the failure to include them in the standards implies that it is not essential to address the nature of science. This does not match the importance that the science education community places on the nature of science.

The original draft of the *Framework* (released July 2010) included concepts about the nature of science in *Topics in Science, Engineering, Technology, and Society* as a crosscutting concept, so there is already some precedent for thinking of the nature of science as a crosscutting concept. The overall set included:

- History and Cultural Roles of Science, Engineering, and Technology
- Impacts of Science, Engineering, and Technology on Society
- Impact of Societal Norms and Values on the Practices of Science and Engineering
- Professional Responsibilities of Scientists and Engineers
- Roles of Scientific and Technical Knowledge in Personal Decisions
- Careers and Professions Related to Science and Engineering

In addition, since the NGSS draft includes *Connections to Engineering, Technology, and the Applications of Science* in the box where crosscutting concepts are listed, there is also a precedent for including that type of connection in this area.

NSTA Recommendation 1: The NGSS should include a section on *Connections to the Nature and History of Science* in a manner similar to the *Connections to Engineering, Technology, and Applications of Science*.

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[1] Abd-El-Khalick, F., and N. G. Lederman. 2000. Improving science teachers' conceptions of the nature of science: A critical review of the literature. International Journal of Science Education, 22(7), 665–701.

[2] Khishfe, R., and F. Abd-El-Khalick. 2002. Influence of explicit reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. Journal of Research in Science Teaching, 39(7), 551-578.

[3] Howe, E. M., and D.W. Rudge. 2005. Recapitulating the history of sickle-cellanemia research: Improving students' NOS views explicitly and reflectively. *Science & Education, 14*(3-5), 423–41.

[4] Peters, E., and A. Kitsantas. 2010. The effect of nature of science metacognitive prompts on science students' content and nature of science knowledge, metacognition, and self-regulatory efficacy. *School Science and Mathematics, 110*(8), 382–396.

[5] Yacoubian, H. A., and S. BouJaoude. 2010. The effect of reflective discussions following inquiry-based laboratory activities on students' views of nature of science. *Journal of Research in Science Teaching, 47*(10), 1229–1252.

[6] Sandoval, W. A., and K. Morrison. 2003. High school students' ideas about theories and theory change after a biological inquiry unit. *Journal of Research in Science Teaching, 40*(4), 369–392.

Lack of Clarity and Coherence of Performance Expectations

The architecture of the NGSS is made up of performance expectations supported by foundation boxes and a connection box. A detailed explanation of these elements that make up the architecture is provided, but the relationship of the performance expectations to each other or to the foundation boxes is not explained. It appears as though the foundation boxes are designed to clarify or supplement the performance expectations, but they are not part of the expectation. A fundamental grounding is needed to give readers a big picture about the scope and interconnectedness of these elements and how they should be read, understood, and used. One person described it as the box of a jigsaw puzzle missing a clear picture on its cover.

Although the standards are not designed or obligated to specify the exact nature of instructional strategies and instructional materials that need to be created to help meet the expectations in the standards, it is important for the NGSS document to provide suggestions on how to use the document to accomplish these ends. These suggestions are essential because the vast majority of educators have little experience with or understanding of the nature and purpose of standards, and because the architecture of the NGSS is significantly more complex than existing standards. It will take a significant amount of effort for science educators to translate these new standards into practice and clear guidance is essential if we expect consistent implementation across the country. A front matter section that suggests how the standards can be used to design instruction and instructional material would enhance the reader's understanding of the document itself.

NSTA Recommendation 2: The front matter of the NGSS should contain an overarching essay that explains the architecture of the standards, including the relationship between the individual performance expectations in a set and how each performance expectation relates to the practices, core ideas, and crosscutting concepts within the foundation box. The essay should also make clear how the performance expectations, practices, core ideas, and crosscutting concepts should be used in planning instruction and provide some examples for various topics and grade levels.

A related recommendation addresses the relationship among the grouping of performance expectations. Each set of performance expectations currently read as independent lists of expectations that lack cohesiveness or connection to one another. The reader is unable to get a sense of the overarching theme and scope of the "standard" without first having to read all of the performance expectations, make the necessary jumps to the foundation boxes, and then attempt to interpret what they have in common. In addition, the way that Achieve has promoted the possibility of regrouping performance expectations undercuts the idea that coherence has been a driving consideration in the writing of the performance expectations. While we understand that states may demand the freedom to reorganize the material in the standards, Achieve should make a case for the advantages of working with the sets of performance expectations it has put together.

NSTA Recommendation 3: Each set of performance expectations in the NGSS should include an opening statement that explains why this set of performance expectations has been grouped together.

Performance Expectations Fail to Determine Mastery of Core Idea

As NSTA highlighted in its winter review, there are serious problems and inconsistencies with the current performance expectations. The performance expectations give the impression that the practice included in the performance expectation and expanded in the foundation box is the only practice that needs to be addressed during instruction. Commercial sources will undoubtedly make claims in their products that "the standard has been met" by simply addressing the practice mentioned in the performance expectation. This interpretation distorts and limits the role of the practices in learning the disciplinary core ideas.

Furthermore, while each practice and crosscutting concept is addressed in multiple performance expectations, most core ideas are addressed in just one performance expectation. This creates a problem because it means that there is often only one check as to whether a particular core idea is understood. The result of specifying just one performance expectation with just one practice may be worse than not assigning any specific practices at all. Multiple performance expectations employing a variety of practices should be used to provide multiple opportunities for students to show their understanding. This is a serious flaw that should be addressed.

In addition, many of the performance expectations involve practices that allow them to be addressed successfully without understanding the knowledge described in the core idea. For example, a student can ask questions or carry out an investigation in some topic without understanding the core ideas in that topic.

It is important that there be performance expectations involving these practices to ensure that students have mastered all of the practices, but only three of the practices (*Developing and Using Models, Constructing Explanations and Designing Solutions,* and *Engaging in Argument from Evidence*) require full comprehension of the core ideas. At least one performance expectation that carries the burden determining whether the core idea is understood (i.e., construct an explanation, create a model, or engage in an argument based on evidence) should be included for each core idea.

NSTA Recommendation 4: Every core idea should have at least two performance expectations that probe it. The first performance expectation should combine the core idea with the practice of modeling, explanation, or argumentation, and the second performance expectation should combine the core idea with one of the other five practices. The connection between these performance expectations and the core idea should be explicit.

Level of Difficulty and Achievability

The NGSS should be designed so that all students can be expected to attain them. As NSTA has noted before, simply moving a disciplinary core idea to a lower grade level from where it is taught in many schools is not the way to produce "higher" standards. Higher-level standards are produced by developing deeper understanding and more connections to other standards with the core ideas that are included. Expecting students to be able to engage with all of the practices on a particular core idea already "raises" the level of expectation, as it requires not just that students "know" that idea, but they need to be able to explain a model or make an argument for why it is the scientifically accepted idea.

There continue to be a number of performance expectations we think are higher than the grade level to which they were typically assigned. This is particularly true in the elementary grades. Even when the performance expectations were written at an acceptable level for elementary teachers, the disciplinary core ideas in the foundation box could intimidate them.

NSTA Recommendation 5: The appropriate grade level for students to learn a particular science concept in the NGSS should not differ from the recommendations in the *National Science Education Standards* and *Benchmarks for Science Literacy* unless there is published research that provides evidence in favor of the move.

Amount of Time and Resources Needed

The Carnegie report called for "fewer" standards in the next iteration of standards (*The Opportunity Equation*, p. 3). Determining the **number** of standards needed to produce a scientifically literate citizen is virtually meaningless, but determining the amount of time and other resources needed to produce educated citizen as defined by the NGSS is critical and called for in the *Framework* (Recommendation 11, p. 305). The cost in time and other resources to achieve the standards is difficult to determine because of the variable conditions that exist across the nation, but it cannot be ignored and avoided.

The results of following this recommendation may call for more resources than are typically provided in many states and schools. The recommendation to account for the needed resources does not preclude the need to increase the amount, but it does expect that the cost in time and other resources will be known.

Identifying the time and resources needed to accomplish standards will help Achieve determine the amount of overall content that can be included in the document. It should be noted that this is a case where following this recommendation in the *Framework* should prompt Achieve to provide feedback to NRC that could require a modification of the *Framework* specifications regarding what and how much should be included in the NGSS.

Documentation should include the results of this recommendation so the states, districts, and schools are aware of the resources needed to achieve the standards. Furthermore, the results of this recommendation should be used by the NGSS writers in determining the amount of content to include in the next draft of NGSS. This recommendation does not suggest that the resources required should conform to those currently available in some states and districts, but it does recommend that if there is a need to increase them, that fact should be clear. In an era of greater accountability for students, teachers, and schools, it would be tremendously unfair to create a set of expectations that have no hope of being effectively achieved. The NGSS should not set up students, teachers, and schools for failure, but set them on a path toward greater and greater successes.

NSTA Recommendation 6: Any assumptions about the resources, time, and teacher expertise needed for students to achieve particular standards should be made explicit (Note: This is identical to Recommendation 11 on p. 305 of *A Framework for K–12 Science Education*.)

Survey Mechanism

Educators were asked to comment on the draft during a three-week window in May 2012, which was far from ideal in terms of giving science teachers the opportunity to comment on the draft. In addition, there were numerous complaints about the complexity of the survey mechanism, which left many teachers frustrated and led them to give up on sharing feedback. Achieve has reported that more than 8,000 people registered to complete the survey; however, far fewer actually completed it. When the NRC conducted a public review of the draft *Framework*, it received more than 2,000 public comments. It appears as though fewer individuals completed the NGSS Achieve survey than those who commented on the *Framework*, even though interest around standards has been growing.

NSTA Recommendation 7: The survey mechanism used for the next public draft of the NGSS should be more user friendly than the mechanism that was used for this first public draft, and the timing of the release should be sensitive to the schedules of all educators, but particularly the schedules of classroom teachers.