PEEC-Alignment: NGSS Publisher's Criteria excerpt p.4-10

- Aiding decisions about the review, selection, and purchasing of school science textbooks, textbook series, and instructional materials that represent comprehensive programs; or
- Evaluation of current materials to identify adaptations and modifications to increase alignment with the NGSS.

Beginning on page 22, the accompanying Appendix describes and guides the PEEC-Alignment review process. The primary innovations from the *Framework* and the NGSS along with their implications for instructional materials and school programs are described below. However, this document does not substitute for the breadth and depth of information contained in the NGSS and the *Framework*, and a thorough knowledge of these documents is necessary before attempting to apply the PEEC-Alignment process to instructional materials.

NGSS INNOVATIONS

The architecture of the NGSS differs significantly from prior standards for science education. In the NGSS, the three dimensions of Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Crosscutting Concepts (CCCs) are crafted into performance expectations that describe what is to be assessable following instruction. The NGSS performance expectations are therefore a measure of competency. The foundation boxes for each of the three dimensions provide additional information and clarity for the design or redesign of school programs.

source document can be found at:

http://www.nextgenscience.org/sites/ngss/files/Draft_PEEC-Alignment%20May%202015.pdf

Figure 1. Example of NGSS Architecture for Standards

2-PS1-1 Matter and Its Interactions

Students who demonstrate understanding can:

2-PS1-1. **Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.** [Clarification Statement: Observations could include color, texture, hardness, and flexibility. Patterns could include the similar properties that different materials share.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Planning and Carrying Out Investigations	PS1.A: Structure and Properties of Matter	Patterns
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	• Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties.	• Patterns in the natural and human designed world can be observed.

Connections to other DCIs in second grade: N/A

Articulation of DCIs across grade-levels:
5.PS1.A

Common Core State Standards Connections:

ELA/Literacy —

- **W.2.7** Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations). (2-PS1-1)
- **W.2.8** Recall information from experiences or gather information from provided sources to answer a question. (2-PS1-1)

Mathematics —

- **MP.4** Model with mathematics. *(2-PS1-1)*
- **2.MD.D.10** Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph. *(2-PS1-1)*

A comprehensive program should provide opportunities for students to develop their understanding of DCIs through their engagement in SEPs and their application of CCCs. This three-dimensional learning leads to eventual mastery of performance expectations. In this perspective, a quality program should clearly describe or show how the cumulative learning experience works coherently with previous and following experiences to build scientific literacy.

The following innovations in the NGSS are hallmarks of current thinking about how students learn science, and they set a vision for future science education. These innovations will not only cause a shift in instructional programs in American classrooms but should also affect and refocus the efforts of curriculum developers and the design of comprehensive school science programs.

Innovation 1: K–12 science education reflects three-dimensional learning.

In the NGSS, science is described as having three distinct dimensions, each of which represents equally important learning outcomes: (1) SEPs, (2) DCIs, and (3) CCCs (The Next Generation Science Standards 2013). The NGSS expectations for students include making connections among all three dimensions. Students develop and apply the skills and abilities described in the SEP, as well as learn to make connections between

*students do this

different DCIs through the CCC to help gain a better understanding of the natural and designed world. Current research suggests that both knowledge (DCIs and CCCs) and practice (SEPs) are necessary for a full understanding of science.

Each NGSS standard integrates one specific SEP, CCC, and DCI into a performance expectation that details what students should be proficient in by the end of instruction. In past standards the separation of skills and knowledge often led to an emphasis (in both instruction and assessment) on science concepts and an omission of inquiry and practices. It is important to note that the NGSS performance expectations do not specify or limit the intersection of the three dimensions in classroom instruction. Multiple SEPs, CCCs, and DCIs that blend and work together in several contexts will be needed to help students build toward competency in the targeted performance expectations. For example, if the end goal (the performance expectation) for students is to plan an investigation to determine the causes and effects of plant growth (2-LS2-1), they can build toward this goal through asking good questions about patterns that they have seen in plant growth and engaging in argument about what kinds of data would be important to collect in an investigation to answer these questions.

It should also be noted that one performance expectation should not be equated to one lesson. Performance expectations define the three-dimensional learning expectations for students, and it is unlikely that a single lesson would provide adequate opportunities for a student to demonstrate proficiency in every dimension of a performance expectation. A series of high-quality lessons or a unit in a program are more likely to provide these opportunities.

For more information about these three dimensions, see the NRC *Framework*, pages 29-33. Evaluating materials for three-dimensional learning is described in the EQuIP professional development module 6. Three-dimensional assessment of student learning is described in the document *Developing Assessments for the Next Generation Science Standards* (NRC 2014).

School programs must change:

From: providing discrete facts and concepts in science disciplines, with limited application of practice or the interconnected nature of the disciplines. Where crosscutting themes were included, they were implicit and not noticed or used by the student. Assessments within the programs exclusively addressed disciplinary concepts of science; neither the processes, inquiry, or SEPs nor the CCCs, unifying themes, or big ideas were included in the assessments.

To: providing learning experiences for students that blend multiple SEPs, CCCs, and DCIs — even those SEPs, CCCs, and DCIs not specified within the targeted performance expectations — with the goal that students are actively engaged in scientific processes to develop an understanding of each of the three dimensions. CCCs are included explicitly, and students learn to use them as tools to make sense of phenomena and make connections across disciplines. Assessments within the programs reflect each of the three distinct dimensions of science and their interconnectedness.

Innovation 2: Students engage in explaining phenomena and designing solutions.

In educational programs aligned to the NGSS, the goal of instruction is not solely for students to memorize content. Content becomes meaningful to students when they see its usefulness — when they need it to answer a question. Therefore, in programs aligned to the NGSS, an important component of instruction is to pique students' curiosity to help them see a need for the content.

The ultimate goal of an NGSS-aligned science education is for students to be able to explain real-world phenomena and to design solutions to problems using their understanding of the DCIs, CCCs, and SEPs. Students also develop their understanding of the DCIs by engaging in the SEPs and applying the CCCs. These three dimensions are tools that students can acquire and use to answer questions about the world around them and to solve design problems.

School programs must change:

From: focusing on disconnected topics, with content treated as an end in itself.

To: focusing on engaging students with meaningful phenomena or problems that can be explained or solved through the application of SEPs, CCCs, and DCIs. Instructional units that focus on students explaining relevant phenomena can provide the motivation students need to become invested in their own learning.

Innovation 3: The NGSS incorporate engineering design and the nature of science as SEPs and CCCs.

The NGSS include engineering design (see Appendices I and J) and the nature of science (see Appendix H) as significant elements. Some of the unique aspects of engineering design (e.g., identifying and designing solutions for problems), as well as common aspects of both science and engineering (e.g., designing investigations and communicating information), are incorporated throughout the NGSS as expectations for students from kindergarten through high school. In addition, unique aspects of the nature of science (e.g., scientific investigations use a variety of methods; scientific knowledge is based on empirical evidence; science is a way of knowing; science is a human endeavor) are included as SEPs and CCCs throughout the grade bands.

School programs must change:

From: presenting engineering design and the nature of science as supplemental or as disconnected from science learning (e.g., design projects that do not require science knowledge to complete successfully), with neither included in assessments.

To: incorporating learning experiences that include the DCIs of engineering design as well as the SEPs and CCCs of both engineering and the nature of science, with both included in assessments. Both engineering design and the nature of science are taught in an integrated manner with science disciplines (e.g., design projects require science knowledge in order to develop a good solution; the engineering process contributes to building science knowledge).

Innovation 4. SEPs, DCIs, and CCCs build coherent learning progressions from kindergarten to grade 12.

The NGSS provide for sustained opportunities from elementary through high school for students to engage in and develop a progressively deeper understanding of each of the three dimensions. Students require coherent learning progressions both within a grade level and across grade levels so they can continually build on and revise their knowledge to expand their understanding of each of the three dimensions by grade 12.

See NGSS appendices E, F, and G for more information about the learning progressions for each dimension and how they build over time.

School programs must change:

From: a curriculum that lacks coherence in knowledge and experiences; provides repetitive, discrete knowledge that students memorize at each grade level; and often misses essential knowledge that has to be filled at later grade levels.

To: providing learning experiences for students that develop a coherent progression of knowledge and skills from elementary through high school. The learning experiences focus on a smaller set of disciplinary concepts that build on what has been learned in previous grades and provide the foundation for learning at the next grade span as detailed in the NGSS learning progressions.

Innovation 5. The NGSS connect to English language arts (ELA) and mathematics.

The NGSS not only provide for coherence in science teaching and learning but also unite science with other relevant classroom subjects: mathematics and ELA. This connection is deliberate because science literacy requires proficiency in mathematical computations and in communication skills. In fact, there are many inherent overlaps in the mathematics, ELA, and science practices (e.g., see the Stanford Understanding Language Initiative's Venn diagram). Therefore as the NGSS were being drafted, the writers ensured alignment to and identified some possible connections with the Common Core State Standards for ELA/literacy and mathematics as an example of ways to connect the three subjects. In instruction within the science classroom, mathematical and linguistic skills can be applied and enhanced to ensure a symbiotic pace of learning in all content areas. This meaningful and substantive overlapping of skills and knowledge helps provide all students equitable with access to the learning standards for science, math, and literacy (e.g., see NGSS Appendix D Case Study 4). The fact that science can be connected to the "basics" should not go unnoticed. Indeed, it presents science as a basic!

School programs must change:

From: providing siloed science knowledge that students learn in isolation from reading, writing, and arithmetic — the historical "basic" knowledge.

To: providing science learning experiences for students that explicitly connect to mathematics and ELA learning in meaningful and substantive ways and that provide broad and deep conceptual understanding in all three subject areas.

Figure 2 summarizes the NGSS innovations and components for the reform of comprehensive school science programs.

Figure 2. NGSS Innovations and Design of Instructional Materials

FROM	TO	CHANGE IN SCHOOL PROGRAMS
Sole focus on discrete content	Integration of three dimensions (SEP, DCI, CCC)	Curriculum, instruction, and assessment
Learning content as the goal of lessons	Explaining phenomena through application of content as the goal of lessons	Curriculum and instruction
Engineering design and/or nature of science as supplemental	Engineering design and nature of science incorporated throughout science programs	Curriculum, instruction, and assessment
Concepts disconnected from prior learning	K–12 learning progressions	Curriculum, instruction, and assessment
Few connections to other subjects	Explicit connections to and alignment with ELA and mathematics	Curriculum and instruction

The implementation of NGSS-based reform has implications for all components of the school program and education system. The next sections discuss implications and recommendations for student materials, teacher materials and support, assessments within instructional materials, and how instructional materials can foster equitable opportunities to learn.