Eight Practices of Science and Engineering

Standards and performance expectations that are aligned to the framework must take into account that students cannot fully understand scientific and engineering ideas without engaging in the practices of inquiry and the discourses by which such ideas are developed and refined. At the same time, they cannot learn or show competence in practices except in the context of specific content. (NRC *Framework*, 2012, p. 218)

The *Framework* specifies that each performance expectation must combine a relevant practice of science or engineering, and a core disciplinary idea, appropriate for students of the designated grade level. That guideline is perhaps the most significant way in which the NGSS differs from prior standards documents.

Science assessments will not assess students' understanding of core ideas separately from their abilities to use the practices of science and engineering.

We use the term "practices" instead of a term such as "skills" to emphasize that engaging in scientific investigation requires not only skill but also knowledge that is specific to each practice. (NRC *Framework*, 2012, p. 30)

Eight practices of science and engineering

- Eight practices based on an analysis of what professional scientists and engineers do.
- Understand what it means to combine practices of science and engineering with the core disciplines of science.
- **The eight practices are not separate; they intentionally overlap and interconnect.**
- Important for students to be able to carry out each of the individual practices, it is important for them to see the connections among the eight practices.
- We point out which aspects of the practice are reflected in the performance expectation.

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

Rationale

Chapter 3 of the *Framework* describes each of the eight practices of science and engineering and presents the following rationale for why they are essential.

Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science. Participation in these practices also helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview.

The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study; the insights thus gained help them recognize that the work of scientists and engineers is a creative endeavor—one that has deeply affected the world they live in. Students may then recognize that science and engineering can contribute to meeting many of the major challenges that confront society today, such as generating sufficient energy, preventing and treating disease, maintaining supplies of fresh water and food, and addressing climate change.
Any education that focuses predominantly on the detailed products of scientific labor—the facts of science—without developing an understanding of how those facts were established or that ignores the many important applications of science in the world misrepresents science and marginalizes the importance of engineering. (NRC *Framework* 2012, pp. 42-43)

Begin at the kindergarten level with well-structured situations in which students have assistance in identifying phenomena to be investigated, and how to observe, measure, and record outcomes

By upper elementary school students should be able to plan their own investigations

Each practice may reflect science or engineering. Each of the eight practices can be used in the service of science inquiry or engineering design. The best way to tell if a practice is being used for science or engineering is to ask about the goal of the activity. Is it to answer a question? In which case, they are doing science. Is the purpose to define and solve a problem? In which case, they are doing engineering.

Box 3-2 on pages 50-53 of the *Framework* provides a side-by-side comparison of how scientists and engineers use these practices. This chapter briefly summarizes what it "looks like" for a student to use each practice for science or for engineering

Practices represent what students are expected to do, and are not teaching methods or curriculum. The *Framework* occasionally offers suggestions for instruction, such as how a science unit might begin with a scientific investigation, which then leads to the solution of an engineering problem.

In the NGSS we have attempted to avoid such suggestions since our goal is to describe, as clearly as possible, what students are able to do, rather than how they should be taught.

College and Career Ready Students can demonstrate evidence of:

1. Applying a blend of Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas (DCIs) to make sense of the world and approach problems not previously encountered by the student, new situations, new phenomena, and new information;

2. Self-directed planning, monitoring, and evaluation;

3. Applying knowledge more flexibly across various disciplines through the continual exploration of Science and Engineering Practices, Crosscutting Concepts, and DCIs;

4. Employing valid and reliable research strategies; and

5. Exhibiting evidence of the effective transfer of mathematics and disciplinary literacy skills to science.