Science and the Engineering Practices Grades K-2 Quick Reference

Asking Questions and Defining Problems

Summary: Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. For engineering, they should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution (NRC Framework 2012, p. 56). Video summarizing Asking Questions and Defining Problems.

Elements of Asking Questions and Defining Problems:

- ✓ Ask questions based on observations to find more information about the natural and/or designed world(s).
- ✓ Ask and/or identify questions that can be answered by an investigation.
- ✓ Define a simple problem that can be solved through the development of a new or improved object or tool.

Developing and Using Models

Summary: Modeling can begin in the earliest grades, with students' models progressing from concrete "pictures" and/or physical scale models (e.g., a toy car) to more abstract representations of relevant relationships in later grades, such as a diagram representing forces on a particular object in a system. (NRC Framework, 2012, p. 58) Video summarizing Developing and Using Models.

Elements of Developing and Using Models:

- ✓ Distinguish between a model and the actual object, process, and/or events the model represents.
- ✓ Compare models to identify common features and differences.
- ✓ Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).
- ✓ Develop a simple model based on evidence to represent a proposed object or tool.

Planning and Carrying Out Investigations

Summary: Students should have opportunities to plan and carry out several different kinds of investigations during their K-12 years. At all levels, they should engage in investigations that range from those structured by the teacher—in order to expose an issue or question that they would be unlikely to explore on their own (e.g., measuring specific properties of materials)— to those that emerge from students' own questions (NRC Framework, 2012, p. 61). Video summarizing Planning and Carrying Out Investigations.

Elements of Planning and Carrying Out Investigations:

- ✓ With guidance, plan and conduct an investigation in collaboration with peers (for K).
- ✓ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.
- ✓ Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question.
- ✓ Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons.
- ✓ Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.
- ✓ Make predictions based on prior experiences.

Analyzing and Interpreting Data

Summary: Once collected, data must be presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others. Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence.

Engineers, too, make decisions based on evidence that a given design will work; they rarely rely on trial and error. Engineers often analyze a design by creating a model or prototype and collecting extensive data on how it performs, including under extreme conditions. Analysis of this kind of data not only informs design decisions and enables the prediction or assessment of performance but also helps define or clarify problems, determine economic feasibility, evaluate alternatives, and investigate failures (NRC Framework, 2012, p. 61-62).Video summarizing Analyzing and Interpreting Data.

Elements of Analyzing and Interpreting Data:

- ✓ Record information (observations, thoughts, and ideas).
- ✓ Use and share pictures, drawings, and/or writings of observations.
- ✓ Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.
- ✓ Compare predictions (based on prior experiences) to what occurred (observable events).
- ✓ Analyze data from tests of an object or tool to determine if it works as intended.

Using Mathematics and Computational Thinking

Summary: Although there are differences in how mathematics and computational thinking are applied in science and in engineering, mathematics often brings these two fields together by enabling engineers to apply the mathematical form of scientific theories and by enabling scientists to use powerful information technologies designed by engineers. Both kinds of professionals can thereby accomplish investigations and analyses and build complex models, which might otherwise be out of the question (NRC Framework, 2012, p. 65). Video summarizing Using Mathematics and Computational Thinking.

Elements of Using Mathematics and Computational Thinking:

- ✓ Decide when to use qualitative vs. quantitative data.
- ✓ Use counting and numbers to identify and describe patterns in the natural and designed world(s).
- ✓ Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.
- ✓ Use quantitative data to compare two alternative solutions to a problem.

Note, the mathematics that students should be using in grades K-2 is the New Jersey Student Learning Standards for Mathematics.

Constructing Explanations (for science) and Designing Solutions (for engineering)

Summary: "The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories"(NRC Framework, 2012, p. 52). Video summary of Constructing Explanations and Designing Solutions.

Elements of Constructing explanations (for science) and designing solutions (for engineering)

- ✓ Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.
- ✓ Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.
- ✓ Generate and/or compare multiple solutions to a problem.

Engaging in Argument from Evidence

Summary: The study of science and engineering should produce a sense of the process of argument necessary for advancing and defending a new idea or an explanation of a phenomenon and the norms for conducting such arguments. In that spirit, students should argue for the explanations they construct, defend their interpretations of the associated data, and advocate for the designs they propose (NRC Framework, 2012, p. 73). Video summary of Engaging in Argument from Evidence.

Elements of Engaging in Argument from Evidence:

- ✓ Identify arguments that are supported by evidence.
- ✓ Distinguish between explanations that account for all gathered evidence and those that do not.
- ✓ Analyze why some evidence is relevant to a scientific question and some is not.
- ✓ Distinguish between opinions and evidence in one's own explanations.
- ✓ Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.
- ✓ Construct an argument with evidence to support a claim.
- ✓ Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.

Obtaining, Evaluating, and Communicating Information

Summary: Any education in science and engineering needs to develop students' ability to read and produce domain-specific text. As such, every science or engineering lesson is in part a language lesson, particularly reading and producing the genres of texts that are intrinsic to science and engineering (NRC Framework, 2012, p. 76). Video summary of Obtaining, Evaluating, and Communicating Information.

Elements of Obtaining, Evaluating, and Communicating Information:

- ✓ Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).
- ✓ Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea.
- ✓ Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim.
- ✓ Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.