Science and the Engineering Practices Grades 3-5 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 about what would happen if a variable is changed.
- ✓ Identify scientific (testable) and non-scientific (non-testable) questions.
- ✓ Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
- ✓ Use prior knowledge to describe problems that can be solved.
- ✓ Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

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:

- ✓ Identify limitations of models.
- ✓ Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.
- ✓ Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.
- ✓ Develop and/or use models to describe and/or predict phenomena.
- ✓ Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.
- ✓ Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.

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:

- ✓ Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- ✓ Evaluate appropriate methods and/or tools for collecting data.
- ✓ Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
- ✓ Make predictions about what would happen if a variable changes.
- ✓ Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.

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:

- ✓ Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
- ✓ Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
- ✓ Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
- ✓ Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
- ✓ Use data to evaluate and refine design solutions.

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 if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
- ✓ Organize simple data sets to reveal patterns that suggest relationships.
- ✓ Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.
- ✓ Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.

Note, the mathematics that students should be using in grades 3-5 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). Summary of Constructing Explanations and Designing Solutions.

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

- ✓ Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard).
- ✓ Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- ✓ Identify the evidence that supports particular points in an explanation.
- ✓ Apply scientific ideas to solve design problems.
- ✓ Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

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).

Elements of Engaging in Argument from Evidence:

- ✓ Compare and refine arguments based on an evaluation of the evidence presented.
- ✓ Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.
- ✓ Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.
- ✓ Construct and/or support an argument with evidence, data, and/or a model.
- ✓ Use data to evaluate claims about cause and effect.
- ✓ Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

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 and comprehend grade appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence.
- ✓ Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.
- ✓ Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.
- ✓ Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.
- ✓ Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.