

Meeting the Standards—Investigating Evidence

The *Investigating Evidence* curriculum serves as a scaffold for teachers as they lead students through the process of answering the questions they pose about the natural world. The strength of this curriculum is not in the science content it contains, because that is dependent on the questions your students ask. The strength of this curriculum is in its ability to be applied to any science content to engage students in science practices while building English and math skills. *Investigating Evidence* is a framework for you to follow as you support students in answering the questions they have posed. You can employ it in any area of science you teach. It is a process to follow, rather than the content you teach.

Next Generation Science Standards

A Framework for K–12 Science Education (NRC, 2012) lays out the vision that students will learn about science by integrating content knowledge with experience in the practices of scientific investigation. Students should be engaged with fundamental questions about the natural world and how scientists investigate these questions. The *Framework* identifies eight science practices for the K–12 science classroom. Each is supported by *Investigating Evidence*.

NGSS Scientific Practices

1. Asking questions and defining problems
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 and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

1. Asking questions and defining problems—In this unit, students ask and refine questions about how the natural world works. These activities will help students meet the following performance expectations for grades 6–8:

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.
- Ask questions to determine relationships between independent and dependent variables and relationships in models.
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.
- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

2. Developing and using models—In this unit, students visualize the science process as a model. These activities will help students meet the following performance expectations for grades 6–8:

- Evaluate limitations of a model for a proposed object or tool.
- Develop and/or use a model to predict and/or describe phenomena.
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

3. Planning and carrying out investigations—In this unit, students work collaboratively to carry out investigations to answer their own question. These activities will help students meet the following performance expectations for grades 6–8:

- Plan an investigation individually and collaboratively. In the design identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data is needed to support a claim.
- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meets the goals of the investigation.
- Evaluate the accuracy of various methods for collecting data.
- Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

4. Analyzing and interpreting data—Students collect data as participants in citizen science. They also collect and analyze data to answer questions within their own investigations. These activities will help students meet the following performance expectations for grades 6–8:

- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
- Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
- Distinguish between causal and correlational

relationships in data.

- Analyze and interpret data to provide evidence for phenomena.
- Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
- Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).
- Analyze and interpret data to determine similarities and differences in findings.

5. Using mathematics and computational thinking—In this unit, students use computational thinking to plan their investigations, and use mathematics to measure and record their experimental results. These activities will help students meet the following performance expectations for grades 6–8:

- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- Use mathematical representations to describe and/or support scientific conclusions and design solutions.
- Create algorithms (a series of ordered steps) to solve a problem.
- Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.
- Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.

6. Constructing explanations and designing solutions—Students develop and test hypotheses. These activities will help students meet the following performance expectations for grades 6–8:

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
- Construct an explanation using models or representations.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events.
- Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.

7. Engaging in argument from evidence—In the beginning of this unit, students look at various sources, setting the stage for their own investigations. They then defend and/or evaluate their initial hypothesis. These activities will help students meet the following performance expectations for grades 6–8:

- Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.
- Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
- Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system, based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.

8. Obtaining, evaluating, and communicating information—Students communicate clearly and persuasively the ideas and methods they generate. These activities will help students meet the following performance expectations for grades 6–8:

- Critically read scientific texts adapted for classroom use to determine the central ideas

and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.
- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.
- Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts.
- Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.

*National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

The Nature of Science and NGSS

The nature of science is included in the Next Generation Science Standards. The basic understandings about the nature of science are:

- Scientific investigations use a variety of methods
- Scientific knowledge is based on empirical evidence
- Scientific knowledge is open to revision in light of new evidence
- Scientific models, laws, mechanisms, and theories explain natural phenomena
- Science is a way of knowing
- Scientific knowledge assumes an order and consistency in natural systems
- Science is a human endeavor
- Science addresses questions about the natural and material world

Common Core State Standards

The following is an example of some Common Core Math and ELA Standards potentially addressed in this curriculum for grades 6–8. These are dependent on the nature of the investigation students design and are organized by domain within or across grade levels.

Mathematical Practices for Grades 6–8

- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Construct viable arguments and critique the reasoning of others.
- Model with mathematics.
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

Common Core Math Standards

Grade 6

The Number System

- Apply and extend previous understandings of multiplication and division to divide fractions by fractions.
- Multiply and divide multi-digit numbers and find common factors and multiples.
- Apply and extend previous understandings of numbers to the system of rational numbers.

Expressions and Equations

- Represent and analyze quantitative relationships between dependent and independent variables.

Geometry

- Solve real-world and mathematical problems involving area, surface area, and volume.

Statistics and Probability

- Develop understanding of statistical variability.
- Summarize and describe distributions.

Grade 7

Ratios and Proportional Relationships

- Analyze proportional relationships and use them to solve real-world and mathematical problems.

The Number System

- Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.

Expressions and Equations

- Solve real-life and mathematical problems using numerical and algebraic expressions and equations.

Geometry

- Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.

Statistics and Probability

- Use random sampling to draw inferences about a population.
- Draw informal comparative inferences about two populations.

Grade 8

Functions

- Use functions to model relationships between quantities.

Statistics and Probability

- Investigate patterns of association in bivariate data.

Common Core English Language Arts Standards for grades 6 through 8

Science & Technical Subjects

Key Ideas and Details

- Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure

- Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

Integration of Knowledge and Ideas

- Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
- Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Writing

Text Types and Purposes

- Write arguments to support claims with clear reasons and relevant evidence.
- Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Production and Distribution of Writing

- Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

- With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.
- Use technology, including the Internet, to produce and publish writing and link to and cite sources as well as to interact and collaborate with others, including linking to and citing sources.

Speaking & Listening

Presentation of Knowledge and Ideas

- Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation.
- Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

Language

Conventions of Standard English

- Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
- Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

Vocabulary Acquisition and Use

- Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade level reading and content, choosing flexibly from a range of strategies.
- Acquire and accurately use grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.