SCIENCE AND ENGINEERING PRACTICES
PERFORMANCE EXPECTATIONS
PERFORMANCE INDICATOR
S.1A.6: CONSTRUCT EXPLANATIONS

GRADE LEVEL PROGRESSIONS

<table>
<thead>
<tr>
<th>K.S.1A.6</th>
<th>Construct explanations of phenomena using (1) student-generated observations and measurements, (2) results of investigations, or (3) data communicated in graphs, tables, or diagrams.</th>
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</thead>
<tbody>
<tr>
<td>1.S.1A.6</td>
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<tr>
<td>2.S.1A.6</td>
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<tr>
<td>3.S.1A.6</td>
<td>Construct explanations of phenomena using (1) scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.</td>
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<td>4.S.1A.6</td>
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<td>5.S.1A.6</td>
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<tr>
<td>6.S.1A.6</td>
<td>Construct explanations of phenomena using (1) primary or secondary scientific evidence and models, (2) conclusions from scientific investigations, (3) predictions based on observations and measurements, or (4) data communicated in graphs, tables, or diagrams.</td>
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<td>7.S.1A.6</td>
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<td>8.S.1A.6</td>
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<td>H.B.1A.6</td>
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<td>H.E.1A.6</td>
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SPECIFIC CHANGES PER GRADE

- Starting in grade 1, performance expectations expand to include using the results of scientific investigations, as defined in S.1A.3, Plan and Carry Out Investigations.
- Starting in grade 3, performance expectations expand to include using the following as evidence to construct explanations: scientific evidence and models, conclusions from scientific investigations, predictions based on observations and measurements.
- Starting in grade 6, performance expectations expand to include using both primary and secondary scientific evidence.
  - In this context, primary scientific evidence refers to evidence directly gathered through student investigations and observation whereas secondary scientific evidence refers to evidence that has been acquired by other sources (e.g. national weather data from NOAA).
Scientists construct explanations in order to describe phenomena, predict future events, or make inferences about past events. Far from guesses, scientific theories and explanations are constructed from bodies of knowledge and evidence, are refined when new evidence becomes available, and must withstand scientific scrutiny. By contrast, a scientific hypothesis is neither a scientific theory, nor a guess. It is a plausible explanation for something that serves as the basis for a testable prediction. Scientific explanations link scientific theory with specific observations or phenomena that serve as evidence to support these explanations. Similarly, engineers design solutions to problems and needs through the process of identifying a need, developing a plan, testing a solution, evaluating the solution, and refining/redesigning based on performance and data.

**Constructing Explanations**

In science, explanations are constructed through the following process:

- A question is posed.
- Different ideas are proposed as hypotheses (plausible explanations) to answer the question.
- These ideas are tested experimentally.
- Evidence from the experiments is evaluated to determine whether or not it supports the idea.
- If the evidence does not support the idea, the scientist must start again with a different idea.
- If the evidence does support the idea, it can then lead to a theory that can be used to explain some natural phenomena.

It is important to note the difference between a theory (constructed explanation supported by evidence) and a hypothesis.

* A *hypothesis*
  - is NOT a theory.
  - is NOT just an educated guess.
  - IS a plausible explanation for some phenomena.

**Design Process**

Similarly, the design process follows a sequence to meet a need or construct a solution.

- Identify a problem to be solved or a need to be fulfilled.
- Design a solution that addresses this need or problem.
- Create and test the solution.
- Evaluate the solution.
- Based on the evaluation of data acquired when the solution is being tested, the initial design may be further refined and improved.

In both processes (constructing explanations and designing solutions), data and observations are used as evidence to evaluate the validity of a plausible explanation or proposed design and can lead to the refinement of either.

The goals for this practice are for students to construct their own explanations based on their knowledge and linked to models and evidence, to use scientific evidence to support, refine, or refute explanations, to identify gaps in proposed explanations, to solve design problems through
undertaking the design process, to construct or test a design solution, and to evaluate and critique competing solutions.

### INSTRUCTIONAL GUIDANCE AND CONSIDERATIONS

**Student challenges in using evidence**
- Use evidence to support their ideas.
  - Students want to rely on their own opinions and have difficulty using sufficient evidence.
- Explain why their evidence supports their ideas.
  - Students have difficulty articulating the link between their ideas and supporting evidence.
- Consider multiple explanations.
  - Students tend to focus on only one idea.
- Revising explanations and solutions based on new evidence or scientific knowledge.
  - Students have a hard time abandoning their original ideas.

**Developing compelling questions/problems**
For students to construct explanations or design solutions, they must start with a compelling question or problem. To develop a compelling question/problem you must:
- Identify the data students can use as evidence
- Identify scientific principles (core ideas) students can apply to make sense of the data
- Ensure that there are multiple plausible answers
- Consider the clarity of the question

**What to look for in explanations and solutions**
- The claim (the proposed explanation or solution)
- Supporting evidence, including evidence of reproducibility and of repeated trials
- Reasoning behind how the evidence supports the claim

### EVIDENCE OF MASTERY

Students who show evidence of mastery in this practice will be able to:
- Use evidence from appropriate sources to describe the cause and effect relationship or a process or phenomenon. Appropriate sources of evidence are defined by each grade-level performance indicator.
- Support their reasoning using appropriate evidence.
- Connect their supporting evidence to a claim or proposed explanation.

### CONNECTIONS WITH OTHER SCIENCE AND ENGINEERING PRACTICES

- Ask Questions (S.1A.1) and Plan and Carry Out Investigations (S.1A.3)
  - The data that comes out of investigations (which are driven by questions and problems) is used as evidence to construct explanations which serve as answers to questions. When tests of proposed solutions are conducted, the data from those tests is used to refine and design viable solutions to problems.
- Analyze and Interpret Data (S.1A.4) and Use Mathematics and Computational Thinking (S.1A.5)
  - When analyzed through the application of mathematics, data becomes evidence that is ultimately used to construct and support explanations as well as refine the design of viable solutions to problems.
- Engage in Argument from Evidence (S.1A.7)
  - The argumentation process uses evidence to support claims made about the causation of phenomena or the best design solution. Those claims that are successfully supported by the evidence and stand up to scientific scrutiny can become explanations and solutions.
- Obtain, Evaluate and Communicate Information (S.1A.8) and Developing and Using Models (S.1A.2)
  - Part of the process of constructing explanations can involve accessing and applying prior knowledge and information. Models can also serve as a source of prior knowledge in the construction of valid explanations.
  - Explanations can also lead to the development of models that can be used to communicate processes and phenomena defined by these explanations.
- Construct Devices or Design Solutions (S.1B.1)
  - Just as scientists construction explanations supported by evidence, engineers design solutions that have been tested and supported by data that has been analyzed and evaluated.

### PERFORMANCE TASK EXAMPLES

The following are selected examples of performance tasks aligned with sample grade band content standards and performance indicators. The purpose of these examples are to illustrate what a performance task would look like that meets the performance expectations of both a given content performance indicator and the science and engineering performance indicator. Examples of performance tasks that do not meet the criteria of the science and engineering performance indicator are also provided for comparison. This list does not provide examples for every grade level.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Subject</th>
<th>Example</th>
<th>Non-example</th>
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<tbody>
<tr>
<td>K</td>
<td>Life Science</td>
<td>After observing worms, snails, and chicks, students use data collected from their observations to support claims about what animals need to survive including air, water, nutrients, and shelter.</td>
<td>Students watch a video about different animals and what they need to survive. Students write or draw what animals need based on the video.</td>
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<tr>
<td>1-2</td>
<td>Life Science</td>
<td>After observing plant growth over a structured period of time and under a variety of student-generated conditions, students will collect data on plant growth. Their data will be organized in a graph, table, or diagram to depict the data they collected. Students will use the data to construct explanations of what occurs during each stage of plant growth.</td>
<td>Students will watch plants that the teacher has planted grow and chart their growth on a teacher made sheet.</td>
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<tr>
<td></td>
<td>Subject</td>
<td>Activity Description</td>
<td>Notes</td>
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<td>4</td>
<td>Earth Science</td>
<td>Students use online data or other informational text to study and compare the long term weather conditions of several regions. Students reason with their data to construct an explanation for the climate differences between regions.</td>
<td>Students are provided data and teacher explains the meaning of the data and provides chart outlining climate differences between regions.</td>
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<td>5</td>
<td>Earth Science</td>
<td>After explorations with a virtual and physical watershed model (stream tables), students use data collected through observations to make inferences about how various landform features have formed. Students work in groups to reach consensus.</td>
<td>Students watch a video and take notes on how landforms are shaped by the movement of water on Earth.</td>
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<tr>
<td>7</td>
<td>Life Science</td>
<td>Students conduct research on different diseases, focusing on the effect the disease has on specific organ systems. Students use information from their research to support an explanation for how the loss of function of an affected organ system harms the entire human body as a result of the interdependent nature of the major human body systems.</td>
<td>Students do research on different organ systems and present their findings to the class.</td>
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<td>High School</td>
<td>Earth Science</td>
<td>Students analyze seismic evidence from around the world and plot seismic activity data on a world map. Reasoning with the map and seismic data, students support an explanation of the relationship between the forces responsible for crustal movement and the occurrence of landforms and seismic/tectonic activity.</td>
<td>Students take notes on the relationship between tectonic forces, activity, and landforms. They then plot the occurrence of the activity on a map to validate the expected outcomes from their notes.</td>
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