SCIENCE AND ENGINEERING PRACTICES
PERFORMANCE EXPECTATIONS
PERFORMANCE INDICATOR
S.1A.7: ENGAGE IN SCIENTIFIC ARGUMENTS FROM EVIDENCE

GRADE LEVEL PROGRESSIONS

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Performance Expectation</th>
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<tbody>
<tr>
<td>K.S.1A.7</td>
<td>Construct scientific arguments to support explanations using evidence from observations or data collected.</td>
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<tr>
<td>1.S.1A.7</td>
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SPECIFIC CHANGES PER GRADE

- In Kindergarten, performance expectations include supporting explanations using evidence from observation or collected data.
- Starting in grade 1, performance expectations expand to include supporting claims as well as explanations.
- Starting in grade 3, performance expectations expand to include supporting designs.
- Starting in grade 3, performance expectations expand to include the use of information texts as evidence.
- Starting in grade 6, performance expectations expand to include the analysis of scientific arguments.
- Starting in grade 9, performance expectations expand to include using evidence and valid reasoning.
Scientists and engineers engage in reasoning and argumentation from evidence to propose new explanations and theories, to interpret data, and to propose and evaluate technological design solutions. Arguing from evidence is an essential part of the scientific process in order to identify weaknesses and limitations in explanations and design. It is essential that scientists, engineers, and citizens possess the capacity to evaluate claims and judgments about the validity of science-related topics and events, as well as to detect “bad science”. Engineers use argument as part of the process of evaluating the initial stages of a design in order to compare competing proposed solutions to a problem or need.

In science, engaging in argument leads towards identifying the best explanation for a phenomenon. In engineering, argument leads towards the development of the best possible solution to a problem.

Scientists and engineers understand that engaging in argument is not about personal ego. Arguing in science and engineering is not about fighting over who is right and who is wrong. It is about coming to the best explanation or solution supported by evidence. Scientists and engineers do not feel threatened if their claim or solution is challenged, shown to be inaccurate, or is demonstrated to not be the best solution to the problem.

Two types of arguments
- Informal: Putting forth ideas and sharing them with others in a dialogue where these ideas are discussed and debated in an informal manner.
- Formal: Conducting investigations to gather evidence in support of an explanation, the results of which are then put forth for formal peer review where other scientists attempt to replicate the results of the investigation to either support or refute the proposed explanation.

The goals of argument in science and engineering are to:
- construct arguments as proposed explanations to questions or proposed solutions to problems.
- defend claims and models using evidence and reasoning
- critique other claims and arguments using evidence.
- engage in peer review to see if proposed/published results can be replicated.

Additionally, scientists and engineers use argument to defend:
- interpretation of data
- experimental designs
- method of data analysis
- appropriateness of a question

Difference between argument and explanation
- Explanations are the products of science, how and why phenomena occur, supported by evidence.
- Argumentations is the process of defending explanations by carefully ruling out alternative explanations and building a case using evidence for the current claim.
Argumentation is the process of building explanations. Explanations are the final products of the process.

**Benefits of argumentation in science**

- Supports students’ understandings of scientific concepts
- Argumentation from evidence is an important 21st century life skill
- Promotes literacy development (strong English Language Arts connection)
- Helps students building an understanding of the nature of science and the development of scientific concepts and ideas
- Allows students to critically examine claims made by others and the media

The goals for this practice are for students to construct scientific arguments supported by data; to identify weaknesses in scientific arguments (of others and their own) using reasoning and evidence; to recognize that scientific arguments include claims, data, and reasoning; to explain the nature of scientific controversies and indicate why one particular theory succeeded; and to read media reports of science or technology in a critical, evaluative manner.

**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
  - Student have difficulty articulating the link between their ideas and supporting evidence
- Consider multiple explanations and the viewpoints of others
  - 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

**Instructional strategies for employing argumentation**

- Provide a framework and communicate expectations
- Model and describe performance expectations
- Provide examples
- Communicate the importance of the process
- Critique each other’s written arguments
- Allow students to debate ideas
- Provide various scaffolds to facilitate (e.g. guiding questions)

**A framework for argumentation**

1. Make a claim (a conclusion about a problem).
2. Provide appropriate scientific data to sufficiently support the claim.
3. Provide reasoning for why the data counts as evidence in the context of appropriate scientific principles to support the claim.
4. Describe other plausible claims.
5. Provide counter evidence and reasoning to rebut alternate claims.
A framework for debate

- Give students permission to disagree.
- Establish norms of acceptable behavior.
  - Students should use evidence and reasoning to support their claims.
  - Students should NOT put down other students' ideas.
  - Students should NOT talk when someone else is talking to the class.
- Help students learn to listen.

It is important that students understand that engaging in argument in science and engineering is not about personal ego. Arguing in science is not about fighting over who is right and who is wrong. It is about coming to the best explanation or solution supported by evidence. Students should not feel threatened if their argument/explanation is challenged or proven inaccurate. Teachers should model this practice.

EVIDENCE OF MASTERY

Students who show evidence of mastery in this practice will be able to:
- Use evidence to support claims made about natural phenomena. Evidence can come from student generated observations, measurements, models, scientific text and media, secondary sources of data.
- Analyze and evaluate other claims based on scientific evidence.
- Determine if the evidence supports a scientific claim.
- Use evidence to support claims made about designs and solutions.

CONNECTIONS WITH OTHER SCIENCE AND ENGINEERING PRACTICES

- Ask Questions (S.1A.1) and Plan and Carry Out Investigations (S.1A.3)
  - Questions and problems lead to Investigations and tests which generate evidence that is used to support claims through argumentation.
- Analyze and Interpret Data (S.1A.4) and Use Mathematics and Computational Thinking (S.1A.5)
  - In order for data to serve as evidence in supporting claims, it must be analyzed and interpreted in order to identify patterns and trends, determine relationships and causation, and identify anomalies.
- Construct Explanations (S.1A.6)
  - Claims that are successfully supported and survive the argumentation process can lead to viable scientific explanations or successful designs.
- Obtain, Evaluate, and Communicate Information (S.1A.8) and Develop and Use Models (S.1A.2)
  - Information and models can provide context and prior knowledge used in framing claims using evidence.
  - Claims successfully defended through argumentation and supported by evidence lead to scientific explanations that, in turn, can lead to the development of models to communicate phenomena and processes.
- Construct Devices or Design Solutions (S.1B.1)
Whereas scientists support claims using reasoning and evidence, engineers use reasoning and evidence to support proposed designs and solutions that have been tested.

### 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.

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<thead>
<tr>
<th>Grade</th>
<th>Subject</th>
<th>Example</th>
<th>Non-Example</th>
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<tbody>
<tr>
<td>2</td>
<td>Physical Science</td>
<td>Students conduct a series of investigations in which they conduct observations of matter as heat is added and removed, resulting in changes from solid to liquid and liquid to solid (freezing and melting). Students use data from their observations to support claims that some changes in matter are reversible when heat is added or removed and some are not.</td>
<td>Students make observations of melting and freezing and list their observations in a chart.</td>
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<tr>
<td>3</td>
<td>Earth Science</td>
<td>Students gather observational data from a variety of fossils. Students make inferences, supported by their data, for what type of environments the organisms must have lived in when they were alive in the past. Students find the locations of their fossils on a map and construct scientific arguments supported by their data for what the environment at each location was once like.</td>
<td>Students watch videos or read books about fossils and take notes on what kinds of plants and animals used to live in the past.</td>
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<tr>
<td>5</td>
<td>Earth Science</td>
<td>Students use data from the US Forest service to analyze the impact of human activity on woodlands. Students reason through their analysis to support claims for how human activities, both beneficial and detrimental, have impacted the affected area.</td>
<td>Students watch a video about the effect of human activities on the land and write a summary.</td>
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<tr>
<td>7</td>
<td>Life Science</td>
<td>Students obtain information through library and online research and explorations about the various roles bacteria play in organisms and the environment. Students reason with this information to support the claim that bacteria can be both harmful and helpful.</td>
<td>Students fill in a T chart or other graphic organizer to list the pros and cons of bacteria.</td>
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### High School Biology

Students read different scientific journal articles about pros and cons of the biotechnological applications of stem cells and evaluate the claims made in the articles. They then use information from the articles and additional research to support or challenge the claims made in the articles based on the validity of the data and procedures.

Students generate a chart comparing the pros and cons of stem cell research and medical applications.