**REASONING IN ARGUMENTATION**
Helping Students Apply Science Concepts

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**Agenda**
- Introductions
- Overview of Scientific Argumentation and Reasoning
- Activity 1: Write an argument
- Activity 2: Analyze examples of student reasoning
- Discussion of student writing
- Strategies for supporting reasoning

**PowerPoint at:**
http://www.katherinelmcneill.com

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**Link to Next Generation Science Standards**

- "Argumentation is a process for reaching agreements about explanations and design solutions. In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon. In engineering, reasoning and argument are needed to identify the best solution to a design problem. Student engagement in scientific argumentation is critical if students are to understand the culture in which scientists live, and how to apply science and engineering for the benefit of society. As such, argument is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community." – NGSS Release 2013, Appendix F

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**CER Framework**
*Adapted from Toulmin (1958)*

- **Claim**
  a conclusion about a problem

- **Evidence**
  scientific data that is appropriate and sufficient to support the claim

- **Reasoning**
  a justification that shows why the data counts as evidence to support the claim and includes appropriate scientific principles
What is reasoning?

- **Reasoning**—uses appropriate and sufficient disciplinary core ideas (concepts, theories, laws) to describe how or why each piece of evidence supports the claim.

High-Quality Reasoning Provides:
- A link (Why the evidence supports the claim)
- Science ideas (Disciplinary core ideas)

These logical connections make the argument clear and understandable to the reader.

Performance Expectations from NGSS

- **Middle School**
  Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. (MS-LS1-4)

- **High School**
  Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (HS-PS4-3.)
**Physics Example**

Does a lever make work easier?

Lever sometimes make work easier. (Claim) When we picked up the load without the lever, it was 2.2 N. When the load was 5.0 cm from the fulcrum and the effort was 10 cm from the fulcrum, it was 0.8 N. When the load was 20 cm from the fulcrum and the effort was 10 cm from the fulcrum, it was 4.3 N. When the load was 10 cm from the fulcrum and the effort was 5.0 cm, it was 5.3 N. When the load was 10 cm from the fulcrum and the effort was 20 cm, it was 1.3 N. (Evidence) Doing work is the ability to move an object. If it takes less force, the work is easier. A lever can make work easier depending on the position of the fulcrum, effort and load. When the fulcrum is close to the load and far from the effort, the work is easier. (Reasoning)

**Biology Example**

What will happen to the shark population if the phytoplankton populations die out?

The shark population will die out. (Claim) The shark eats other fish such as the ocean fish and the lantern fish. The ocean fish and the lantern fish eat other organisms such as shrimp and copepods. The shrimp and copepods eat the phytoplankton. (Evidence) Phytoplankton are producers and they make their own food from the sun. All of the other organisms in the food web depend on the phytoplankton, even if they do not directly eat them. If the phytoplankton die, primary consumers (shrimp and copepods) will die because they will have no food which will cause the secondary consumers (ocean fish and lantern fish) to die, which will cause the shark to die. (Reasoning)

**Activity 1: Writing an Argument**

Write an argument as though you were a middle school student that answers the following question:

“What causes some earthquakes to have more destructive power than others? How do you know?”

- **Data:**
  - Earthquakes travel through the earth in waves. The waves begin at the focus, which is where the earthquake starts underground.
  - The epicenter is directly above the focus on the earth’s surface.
  - More powerful earthquakes happen when the focus of the earthquake occurs in soft ground material, because the earthquake waves can travel more easily through soft ground.

- **Main Science Ideas:**
  - Earthquakes travel through the earth in waves. The waves begin at the focus, which is where the earthquake starts underground.
  - The epicenter is directly above the focus on the earth’s surface.
  - More powerful earthquakes happen when the focus of the earthquake occurs in soft ground material, because the earthquake waves can travel more easily through soft ground.
**Activity 2: Analyzing Student Writing**

**Directions:**

- Identify and circle the reasoning in each student example.
- Work with someone near you to rank the four samples of student work from strongest (1) to weakest (4) in terms of their reasoning.
- Describe the criteria you used to rank the student writing.

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**Classroom Strategies**

- Introducing the CER framework
- Creating a question where there is “inappropriate data”
- Using an everyday example
- Modeling and critiquing examples
- Creating a multiple-choice format where students have to select the strongest reasoning
- Use scaffolds, discussion prompts and graphic organizers

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**Question with Inappropriate Data**

Examine the following data table:

<table>
<thead>
<tr>
<th></th>
<th>Density</th>
<th>Color</th>
<th>Mass</th>
<th>Melting Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid 1</td>
<td>0.93 g/cm³</td>
<td>no color</td>
<td>38 g</td>
<td>-98 °C</td>
</tr>
<tr>
<td>Liquid 2</td>
<td>0.79 g/cm³</td>
<td>no color</td>
<td>38 g</td>
<td>26 °C</td>
</tr>
<tr>
<td>Liquid 3</td>
<td>13.6 g/cm³</td>
<td>silver</td>
<td>21 g</td>
<td>-39 °C</td>
</tr>
<tr>
<td>Liquid 4</td>
<td>0.93 g/cm³</td>
<td>no color</td>
<td>16 g</td>
<td>-98 °C</td>
</tr>
</tbody>
</table>

Write a scientific argument that states whether any of the liquids are the same substance.
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Using an everyday example

- When introducing CER, Ms. Nelson said to her class:
  - “I could be an NFL quarterback. When I was younger, I played football every Saturday with my family. I have eight brothers and sisters. Every Saturday we went and we played football. And I had a 65% completion rate. I have also been watching Sunday NFL football I think my entire life, and Monday night football and the Thursday night addition to Monday night football and so – What do you think? Did I support my claim?”

Modeling and critiquing examples

Argument #1
Polar bears can live in the Arctic, because they have adaptations for the environment. Their webbed paws allow them to swim through the water to catch seals. Their claws also allow them to catch seals. Their fur keeps them warm in the cold environment. Adaptations are characteristics that allow an animal to survive in its environment. Getting food and staying warm are both necessary for an animal to live.

Argument #2
Polar bears are able to survive in their natural environment, because they like to live where it is cold. They always live somewhere that has lots of snow and ice and water. The Arctic has lots of snow and ice and water, which is why they are able to live there. They would not be able to live somewhere that was warm and did not have any snow. For example, they could not live in Hawaii because it is too warm there.
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Creating a multiple-choice format where students have to select the strongest reasoning

A. Our data table shows how to build the slowest parachute. We found that the largest parachute fell slower compared to the other three parachutes. The speed was the slowest for the largest parachute. We also found that the parachute made out of a plastic bag fell slower compared to the parachutes made of construction paper and cotton. The speed was the slowest for the plastic was slowest. [LINK]

B. The parachute should be 2,500 cm³ and made out of a plastic bag because those had the greatest air resistance. Air resistance is a force that slows down a moving object, because the object hits the air particles. The largest parachute hit more air as it fell, so it went slower. The plastic bag did not let much air go through the material, so it went slower. The more air resistance, the slower the parachute will fall. [LINK and SCIENCE CONCEPTS]

C. Speed is how fast something travels. In order to calculate speed, you divide distance by time. Air resistance is the force opposite the motion of a moving object. Air resistance can also be called drag and slows down objects when they fall because of the force exerted by the air particles. Even though we cannot see it, air has mass and that mass impacts the movement of an object [SCIENCE CONCEPTS].

Use scaffolds, discussion prompts and graphic organizers

Evidence

[Graphic organizer]

[Draw your parachute on the board]
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Conclusions

- Reasoning uses appropriate and sufficient scientific ideas (concepts, theories, laws) to describe how or why each piece of evidence supports the claim.
- Reasoning can be challenging for students
  - Just repeat their evidence or define science concepts without including a link
  - A variety of different strategies can be used to support students in providing stronger reasoning
  - Question design, examples, scaffolds, etc.

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