ATLANTA SCIENCE FESTIVAL

Lesson Title	How do you keep an ice cube from melting?: The Penguin Problem
Grade Band	3rd Heat Energy
Submitted by	Donna Barrett & Denise Huddlestun, Metro RESA

Georgia Performance Standards:

S3P1. Students will investigate how heat is produced and the effects of heating and cooling, and will understand a change in temperature indicates a change in heat.

a. Categorize ways to produce heat energy such as burning, rubbing (friction), and mixing one thing with another.
b. Investigate how insulation affects heating and cooling.
c. Investigate the transfer of heat energy from the sun to various materials.
d. Use thermometers to measure the changes in temperatures of water samples (hot, warm, cold) over time.

S3L1. Students will investigate the habitats of different organisms and the dependence of organisms on their habitat.

S3CS2. Students will have the computation and estimation skills necessary for analyzing data and following scientific explanations.
a. Add, subtract, multiply, and divide whole numbers mentally, on paper, and with a calculator.

S3CS4 b. Use geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and stories to represent corresponding features of objects, events, and processes in the real world.

Safety Considerations:

Students should wear safety goggles when constructing structures. Students should use caution with heat lamps (low wattage bulbs are recommended) and thermometers. Digital thermometers are preferred. Traditional thermometers should be alcohol based or environmentally friendly thermometers. Use an empty box or plastic aquarium as the chamber to test the structures. Be careful that the lamps do not come in contact with the cardboard.

This material is created and submitted by individual authors as recommended lesson plans to incorporate engineering design challenges and to review key science concepts. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the Atlanta Science Festival. For more info about the Atlanta Science Festival, visit http://AtlantaScienceFestival.org

Materials & Time Required:

2-4 class periods:
Day 1: Introduction to the problem & testing of materials (Read Penguin Adaptations)
Day 2: Building and testing of structure
Day 3: Presenting results & discussing redesign
Day 4: Redesigning and test structure

Materials:
For measurement: balance, graduated cylinder (optional), rulers, clock for elapsed time

For testing: thermometers, heat lamps, empty paper box to place the structures in for testing; heat lamps to shine into the box, ice cubes (penguin ice cubes, optional)

For construction (may be modified): plastic bag or small plastic cups, foam board (thin) in assorted colors, aluminum foil, mylar, construction paper in assorted colors, foam packing peanuts, cotton balls, bubble wrap, newspaper, plastic feathers, etc.

For presenting results: chart paper or dry erase boards, markers, graph paper (class data)

Lesson Logistics (for teacher):

Ask students to bring in materials from the list.

Use an empty box or plastic aquarium as the chamber to test the structures. Be careful that the lamps do not come in contact with the cardboard when the lamps are on.

The Siemen's Ice Wars activity is similar. It is a free download at:

http://siemensscienceday.discoveryeducation.com/activities/ice_wars.cfm

Look for opportunities to integrate ELA and mathematics:

There are many possible mathematics applications that involve measuring, elapsed time and the representation of data.

Links to the Common Core ELA standards include constructing an explanation, reading informational text, and speaking and listening.

Opening: ENGAGE (Day 1)

The Problem: African penguins are coming to Atlanta! African penguins live in South Africa and are very endangered. Your challenge is to make a model of a shelter that will keep the temperatures of the environment low during the summer. You will use a penguin shaped ice cube to represent the penguin. Your goal will be to develop a structure to keep your ice cube from melting. You will have different materials to choose from to develop your structure.

Engineering Constraints:

- *Materials:* The structure may contain only one type of material on the inside and one type of material on the outside.
- *Time:* you will have 10 minutes to research and test materials, 15 minutes build, and 20 minutes to test your structure
- *Size:* the structure cannot be bigger than 5 cm x 5 cm
- The ice will remain in the plastic bag or plastic cup when measuring

Brainstorm: What do we need to know to solve this problem? Here are a few ideas:

First, we need to learn more about penguins. Read the penguin adaptations article and identify ways penguins keep their body warm when it is cool AND cool when it is warm.

Second, let's read information about insulators and conductors. Let's look at the materials we have available to build our structures. We can design tests of these materials. Suggested test: *A recommended test would be to put the materials under a heat lamp for 2-3 minutes, then measure the temperature before and after. (Place the material on the table. Place the thermometer under the material when testing.)*

Third, following the tests, students should make a claim about which materials will be the best to use as the insulator and covering on the outside.

Work Session: EXPLORE/EXPLAIN (Day 2)

Students should sketch then design their structure.

Engineering Constraints:

- *Materials:* The structure may contain only one type of material on the inside and one type of material on the outside.
- *Time:* you will have 15 minutes build, and 20 minutes to test your structure
- *Size:* the structure cannot be bigger than 5 cm x 5 cm
- The ice will remain in the plastic bag or plastic cup when measuring

Students should build their structures. They should measure the mass of the ice cube just before placing it into the structure. Put all structures in the box. Shine several lamps into the box. Be careful that the lamps do not come in contact with the cardboard. Wait 40 minutes and have students quickly measure the mass of the ice cubes. Optional: use a graduated cylinder to measure the liquid.
Each group will calculate the mass lost by subtracting the ending mass from the beginning mass. Make a bar graph of the data. Discuss which insulators worked the best in their designs.

Closing: EXTEND/EVALUATE

Sharing our Results: Complete the Claims, Evidence, Reasoning framework in the activity. Use chart paper or dry erase boards to report findings.

If time permits, allow students to redesign their structures using combinations of two or more materials. Challenge them to reduce the amount of ice lost.

Documentation of Resources:

Adapted from:

England Aquarium Penguin Fact Sheets:
http://www.neaq.org/education_and_activities/teacher_resources/classroom_resources/teacher_guides/penguin_teacher_guide/penguin_species_sheets.php
Peacock, J. (2014). Evidence Based Writing.
"Polar Brrs." Georgia AIMS for 3rd Grade
SeaWorld: http://seaworld.org/en/animal-info/animal-infobooks/penguin/adaptations/ & New
Sheerer, K., Schnittka, C. (March 2012). Save the Boulder Beach Penguins. Science Scope.

A similar activity can be found at:
http://siemensscienceday.discoveryeducation.com/activities/ice_wars.cfm

Protect the Penguin

The Problem: African penguins are coming to Atlanta! African penguins live in South Africa and are very endangered. Your challenge is to make a model of a shelter that will keep the temperatures of the environment low during the summer. You will use a penguin shaped ice cube to represent the penguin. Your goal will be to develop a structure to keep your ice cube from melting.

Important Background
Water freezes at 0° Celsius, which is equal to or the same as 32° Fahrenheit. When ice begins to melt, it absorbs heat energy from its surroundings. Heat energy travels from the warmer air to the cooler ice. Heat energy always moves from a warmer temperature to a colder temperature. Conductors speed up this movement, but insulators slow it down. Some materials are insulators, but they vary in how well they slow down this movement. See the *Penguin Adaptations Reading* for more information about how penguins regulate their body temperature.

Engineering Challenge: Your goal will be to develop a model of a structure to keep your ice cube from melting. You structure will be placed under a heat lamp for 20 minutes. You will measure the mass of the ice before and after it is under the heat lamp. You will measure the volume of water that melted.

Constraints:

- *Materials:* The structure may contain only one type of material on the inside and one type of material on the outside.
- *Time:* you will have 10 minutes to research and test materials, 15 minutes build, and 20 minutes to test your structure
- *Size:* the structure cannot be bigger than 5 cm x 5 cm
- The ice will remain in the plastic bag when measuring

Materials Available: balance, graduated cylinder, rulers, thermometers, heat lamps, foam board (thin), assorted colors, aluminum foil, mylar, construction paper, foam packing peanuts, cotton balls, bubble wrap, newspaper, plastic feathers, etc.

Sequence of Learning

1. **Research:** Make a claim about which materials you predict will be the best insulators for your cooler. You may conduct tests on the materials before making the claim and using them in your structure. You may use the materials, heat lamp, and thermometers to conduct your test. *A recommended test would be to put the materials under a heat lamp for 2-3 minutes, then measure the temperature before and after. (Place the thermometer under the material)*
2. **Plan & Build:** Make a sketch of the structure. Build your structure.

3. **Test:**
    a. Measure the mass of your ice cube right before you place it in your structure.
    b. Measure the beginning time. You will have 20 minutes to test your structure. Determine the elapsed time.
    c. At the end of the time, pour the water into the graduated cylinder and measure the volume of the water. Measure the mass of the ice using the balance.
4. **Data:**

	Beginning	**Ending**
Elapsed Time		
Mass		
Volume		
	Write an equation to show how the mass changed.	

Report Your Findings:

<table>
<tr><td colspan="2">Question: How long can you keep an ice cube from melting?</td></tr>
<tr><td>Claim: (Often you can use part of the question to formulate your claim. You will identify the insulator you predict will be the most effective. You should include information about the material you selected for the covering.)</td><td>Evidence:
1. The first source of evidence is data gathered from your research and from the data you used when you test the materials. This data will help you answer the question. Use evidence that supports your claim.
2. The source of evidence is from the test you conducted on your structure.
3. The third source of evidence is the class data.</td></tr>
<tr><td colspan="2">Reasoning: (This is the most important part of your answer. It provides an explanation for your claim, and it explains how your evidence supports or does not support your claim.)

The evidence shows:

I know (relevant disciplinary ideas – i.e., scientific facts and concepts that help answer the question):

The best insulator was _____ because:

The material selected for the covering help/didn't help by:

Therefore, I can conclude that:</td></tr>
</table>

Representing Your Class Data

1. Group numbers (representing the data) – frequency table (#'s); group #'s and indicate the
2. Make a line plot of the data
3. Graph the difference in mass of the class data. Which insulators were chosen? Which one's had the smallest differences in mass?

Redesign (using combinations of materials)

Based on your research and the class data, how would you redesign your habitat?

Adapted from:

Peacock, J. (2014). Evidence Based Writing.

Sheerer, K., Schnittka, C. (March 2012). Save the Boulder Beach Penguins. Science Scope.

A similar activity can be found at:

http://siemensscienceday.discoveryeducation.com/activities/ice_wars.cfm

Penguin Adaptations Related to Temperature

The body temperature of penguins is between 37.8°C to 38.9°C (100°F-102°F). Some of the ways that penguins are able to maintain this body temperature are:

1. The feathers of penguins have adaptations that help to keep the penguin warm. First, their feathers are waterproof and overlap. This makes it hard for water or wind to get through the feathers. A special type of feathers, called down feathers are soft and fluffy. This layer of feathers provides 80 – 84% of the thermal insulation for penguins.

2. Another way penguins conserve heat is to tuck their flippers close to their bodies. They also shiver which helps to generate heat.

3. Penguins have a layer of fat under their skin that improves insulation. They must move actively while under water to generate body heat. Penguins living in colder climates have longer feathers and less body fat than penguins living in cold environments.

4. The dark feathers on the backs of penguins absorb heat from the Sun. This helps to increase the penguin's body temperature.

5. During storms, emperor penguins huddle together to conserve heat. They move into the inside of the circle and the outside to share the warmth.

6. On land, overheating can be a problem. To prevent overheating, penguins may:
    a. They may move into shaded areas.
    b. They may ruffle their feathers to break up the insulating layer of feathers next to their skin. This allows them to release heat.
    c. They may hold their flippers away from their body.
    d. Some species live in warmer climates, such as the Humboldt and African penguins. These penguins do not have feathers on their legs. They also have bare patches on their faces. Heat can be released from these areas without feathers.

Adapted from: http://seaworld.org/en/animal-info/animal-infobooks/penguin/adaptations/