Unit 6.2-Thermal Energy

Content Area: **Science**
Course(s): **Science 6**
Time Period: **Marking Period 2**
Length: **MP2**
Status: **Published**

Essential Questions

How can containers keep stuff from warming up or cooling down?

Lesson 1 Why does the temperature of the liquid in some cup systems change more than in others?

Lesson 2 What cup features seem most important?

Lesson 3 How are the cup features that keep things cold the same or different for keeping things hot? for keeping a drink cold?

Lesson 4 How does a lid affect what happens to the liquid in the cup?

Lesson 5 Where does the water on the outside of the cold cup system come from?

Lesson 6 How can we explain the effect of a lid on what happens to the liquid in the cup over time?

Lesson 7 If matter cannot enter or exit a closed system, how does a liquid in the system change temperature?

Lesson 8 How does a cup's surface affect how light warms up a liquid inside the cup?

Lesson 9 How does the temperature of a liquid on one side of a cup wall affect the temperature of a liquid on the other side of the wall

Lesson 10 What is the difference between a hot and a cold liquid?

Lesson 11 Why do particles move in hot liquids?

Lesson 12 How does the motion of particles compare in a sample of matter at a given temperature?

Lesson 13 How could the motion of particles on one side of a solid wall affect the motion of the particles on the other side of that wall?

Lesson 14 Does our evidence support that cold is leaving the system or that heat is entering the system?

Lesson 15 How do certain design features slow down the transfer of energy into a cup?

Lesson 16 How can we design a cup system to slow energy transfer into the liquid inside it?

Lesson 17 How can we improve our first design to slow energy transfer into the cup system even more?

Lesson 18 How can containers keep stuff from warming up or cooling down?

Big Ideas

Unit Summary and Storyline

What keeps different cups or containers from warming up or cooling down? Students begin this 6th grade science unit by experimenting whether a new plastic cup sold by a store keeps a drink colder for longer than the regular plastic cup that comes free with the drink. Students find that the drink in the regular cup warms up more than the drink in the special cup. This prompts students to identify features of the cups that are different, such as the lid, walls, and hole for the straw, that might explain why one drink warms up more than the other.

In this 6th grade science unit, students investigate the different cup features they conjecture to explain the phenomenon, starting with the lid. They model how matter can enter or exit the cup via evaporation. However, they find that in a completely closed system, the liquid inside the cup still changes temperature. This motivates the need to trace the transfer of energy into the drink as it warms up. Through a series of lab investigations and simulations, students find two ways to transfer energy into the drink: (1) the absorption of light and (2) thermal energy from the warmer air around the drink. They are then challenged to design their own drink container that can perform as well as the store-bought container, following a set of design criteria and constraints.

Anchoring Phenomenon

The anchoring phenomenon for this unit is a double-walled, plastic cup that looks similar to a regular plastic cup, but can keep a drink cold for longer than the regular plastic cup. These double-walled cups are often sold with claims that they can keep beverages colder (or warmer) for longer periods of time compared to other cups. Double-walled cups are made using air or vacuum insulation. This air- or vacuum-insulated layer minimizes energy transfer via conduction. The result is a cup that slows energy transfer allowing a cold drink to remain cold or a hot drink to retain its energy to remain warm for a longer period of time. Students will initially think they can explain the phenomenon using terms like ‘insulated’ or ‘vacuum sealed’ but when pressed further in Lesson 1, gaps in their understanding of how and why this works are revealed, which are used to motivate student learning throughout the unit.

The choice for a unit focus on double-walled cup designs was made for the following reasons:

- The disciplinary core ideas for energy transfer focus on transfer by conduction (i.e., particles colliding with each other). Thus, other energy transfer devices, such as a solar cooker or emergency blanket, while related to this anchoring phenomenon, would require knowledge of transfer by radiation that students have not yet developed in the middle school OpenSciEd Sequence. Thus, the unit needed a phenomenon that would allow students to explore conduction deeply. Radiation and convection are added to students’ understanding of energy transfer in the Storms Unit that follows this unit.
- This unit includes a substantial engineering component with multiple iterations on design. Designing any device in the classroom can be costly and material intensive, but designing cups allowed for fewer materials and an easier design process compared to other options.
- The phenomenon is pervasive in our lives. Cups of different materials are used at home, restaurants, and fast food chains. Expensive vacuum sealed cups and coolers tout their quality is worth the added price. This unit makes this everyday phenomenon puzzling to students by engaging them in explaining why certain materials and designs work by minimizing energy transfer. This unit intentionally makes the everyday experience ‘phenomenal’.
- A pre-field test of the pilot for a cup design anchor produced Driving Question Boards with productive students’ questions and ideas for investigations and sources of data needed to answer those questions. We used these early pilots of the anchor lesson and the field test feedback to anticipate the kinds of

questions students would want to investigate throughout the unit. Teachers reported that students initially think they can explain the phenomenon but once they realize they do not understand vacuums and air insulations, there were high levels of engagement and curiosity about it.
- Focusing on keeping a drink cold, as opposed to keeping a drink warm, was preferred for safety reasons. Students participate in multiple labs using water or different temperatures. While they do work with warm water at times, we tried to limit use of warm or hot water. It was especially important in the design challenge to use cold water for safety, as opposed to hot water.

If students experience phenomenon fatigue with the cups given the length of the unit, it's possible to broaden to related objects and devices, such as coolers, lunch boxes, or other devices that minimize energy transfer by slowing conduction. It is recommended not to broaden too far into energy transfer via convection or radiation as those ideas will be developed later in the OpenSciEd sequence.

Cross-Curricular Integration

Integration Area: Language Arts

MS-ESS2-2 Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

W.6.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

Activity:

Students will use CERs (Claim, Evidence & Reason) on Fossils to convey their thinking and decision making in written form.

- Students will be answering the question, "Which rock layer(s) shows when the ground was no longer underwater?".
- Students provide evidence that supports their claim.
- Students will then write a reasoning that explains what their claim is, state knowledge they have on the topic, evidence to prove their topic, and close their reasoning with their claim again.

W.IW.6.2. Write informative/explanatory texts (including the narration of historical events, scientific procedures/ experiments, or technical processes) to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

RI.IT.6.3. Analyze how a particular text's (e.g., article, brochure, technical manual, procedural text) structure unfolds by using textual evidence to describe how a key individual, event, or idea is introduced, illustrated, and elaborated in a text.

RL.TS.6.4 Analyze how a particular piece (e.g., sentence, chapter, scene, stanza, or section) fits into the overall structure of a text and contributes to the development of the ideas, theme, setting, or plot.

Activity:

Drought-The Dust Bowl: The Dust Bowl was an environmental disaster with dire consequences for many Americans at the time. Write an essay that explains The Dust Bowl in the 1930s including characteristics, causes and means by which the event could have been prevented. Use details and evidence from your research to develop the topic. Include text features, such as bold, classification, captions, graphics and headings.

Integration Area: Math

MS-ESS2-2   Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

6.EE.B.7   Solve real-world and mathematical problems by writing and solving equations of the form x+p=q and px=q for cases in which p, q, and x are all nonnegative rational numbers.

Activity:

Students will learn about the Half-Life of C-14 and use their computational skills to complete equations to understand Absolute Dating.

- Students read what a half-life is and how we use half-lives to determine dating of fossils and layers of rock.
- Students then get a table where they are to complete the mathematical equations to find out how much C-14 is left after 5 half-lives of C-14 has happened.

CRLLKS- Career Education

9.2.8.B.4   Evaluate how traditional and nontraditional careers have evolved regionally, nationally, and globally.

9.2.8.B.5   Analyze labor market trends using state and federal labor market information and other resources available online.

Connection:

Focus on the question, "How do scientists study Earth's past?" explain the role of a science career focused on studying the Earth's history. Highlight scientists who have played an important role in studying and gathering information about Earth's past.

CSDT Technology Integration

8.1.8.DA.3 Identify the appropriate tool to access data based on its file format.

Activity:

Students will complete an interactive webquest using National Geographic to understand important events that happened during the main 3 prehistoric eras, and chart how the Earth has evolved into the way that it is today.

Diversity Integration

Objective: Students will complete a graphic organizer on a Scientist from a diverse background or protected class that had an impact on the study of Earth's surface, such as:

Jack Horner (June 15, 1946) - Dyslexia

Is an American paleontologist. He is one of the most well-known paleontologists in the United States

Activity:

1. Students are to make a copy of the graphic organizer that they are to complete on the scientists.
2. They will then need to complete the organizer by doing research on the person and their field of science that the scientists work in.
3. After finding information about the scientist, they will then need to write a paragraph on the person and explain to us “Why is this scientist famous? What have they done in their lifetime to help out the world?”

Climate Change

MS-ESS2-1: Develop a model to describe the cycling of Earth’s materials and the flow of energy that drives this process.

- Activity: Develop a model that describes the cycling of Earth's materials and explain how energy flow drives this process. Students can be assessed by creating or filling in a detailed diagram or 3D model that illustrates the cycleing of Earth's materials (e.g., rock cycle, water cycle, air) and demonstrate how energy from the sun and Earth's interior drives these processes. Provide a written explanation for each stage of the cycle and identify the energy sources involved. Include how humans effect this cycle (e.g., errosion, fracking.)

Science and Society

Charles Richter (April 26, 1900 – September 30, 1985),

Was an Ohioan seismologist and physicist. Richter is most famous as the creator of the Richter magnitude scale which, until the development of the moment magnitude scale in 1979, quantified the size of earthquakes.

Resources

Savvas Interactive Science - Earth's Surface 2016

Scientific Inquiry

MS-ESS2-1 (5.4.6.C.2) *How Does Pressure Affect Particles of Rock?,* p. 50
MS-ESS2-2 (5.4.6.C.3) *Moving the Continents*, p. 72

Enduring Understandings

NGSS Performance Expectations

MS-PS1-4*

MS-PS3-3

MS-PS3-4

MS-PS3-5

MS-PS4-2*

MS-ETS1-4

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.

(MS-PS1-4)
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4)
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

PS3.A: Definitions of Energy

- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (secondary to MS-PS1-4)
- Temperature is not a measure of energy; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (secondary to MS-PS1-4)
- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3), (MS-PS3-4)

PS3.B: Conservation of Energy and Energy Transfer

- When the kinetic energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)
- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. (MS-PS3-4)
- Energy is spontaneously transferred out of hotter regions or objects and into colder ones. (MS-PS3-3)

PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light. (MS-PS4-2)

ETS1.A: Defining and Delimiting an Engineering Problem

- The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-PS3-3)

*There is a strike through part of the DCI elements that are not developed in this unit. In the OpenSciEd Scope and Sequence, students will develop an understanding of changes in state, particularly as they relate to pressure, in OpenSciEd Unit 6.3, and frequency (color) of light in OpenSciEd Unit 8.4. The placement of this OpenSciEd Unit 6.2 and associated units are shown in the OpenSciEd Scope and Sequence.

Crosscutting Concepts

Systems & System Models

Energy & Matter

Structure & Function