Solar Cooking Race

Grade 3

Standards

GPS S3P1a, b, c, d;
NGSS 2PS1b, MSPS3.A, B

Time

3 (45 min) periods + cooking time

Supplies

2 sided Lab Report (1 per student)

(per group of 4 – 6 students)

Ice Cube Race
- ice (in ice chest or thermos)

Urban Heat Island Effect
- wide-range, instant thermometer
- meter stick or measuring tape

Heat Transfer Investigations
- ultraviolet-detecting "solar beads"
- chenille stems
- cups (clear, of plant-based material)
- red and blue food coloring
- hot and cold water
- paper funnel (free at gas stations)
- glove

Solar Oven Design Challenge
- construction paper, various colors
- roll of aluminum foil
- roll of plastic cling wrap
- glue stick
- pizza box or similar container
- newspaper or recycled paper
- squash slices, sliced uniformly
- paper bowl or other cooking surface

Garden Connection

Students will harvest and cook veggies in the garden with a solar oven, compare temperatures in the garden and the schoolyard, and design structures to protect tender plants from cold weather.

Overview

Third grade students will explore heat energy and transfer in the garden by melting an ice cube as quickly as possible, investigating radiation with ultraviolet-detecting solar beads, observing convection currents using hot and cold colored water, measuring the temperature above different surfaces outside, designing a solar oven, cooking veggies from the garden and designing a way to protect tender plants from cold weather.

Engaging Students

Ice Cube Melting Race

Students will melt ice cubes as quickly as possible, to launch a discussion about different ways heat can be transferred: friction, applying mechanical or electrical energy, mixing substances to create chemical reactions, or burning.

Exploration

Urban Heat Island Effect

Students will test their theories about the coolest places in the schoolyard by measuring the temperature at 0.5 m above ground level at locations with different types of surfaces (asphalt, cement, rock, dirt, grass, and garden).

Investigation of Heat Transfer Methods

Students will investigate the way heat is transferred in these activities:
Radiation: observe ultraviolet-detecting beads in sun and shade
Convection: use colored water to create and observe convection currents
Conduction and Insulation: use a glove as protection from a hot surface

Engineering Design Challenge

Students will design and build solar ovens that take into account heat transfer methods, reflectivity or absorption, and insulation. They will harvest squash or another veggie from the garden and race to cook it in their solar ovens, using thermometers to measure oven temperatures.

Explanation

Students will be able to articulate their discoveries about heat, define temperature as a measure of heat, and discuss energy transfer methods.

Environmental Stewardship

Students will apply what they learned to design and install a garden device or structure to protect tender plants from cold weather.

Evaluation

A rubric and Lab Report are provided to assist in assessing student proficiency.

Standards

Georgia Performance Standards in Science

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 things.
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 over time.

Next Generation Science Standards

Core Idea in Physical Science: Energy
2.PS1.B: Chemical Reactions
Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not. (2-PS1-4)

MS.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 energy transferred due to the temperature difference between two objects. (secondary to MS-PS1-4)The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (secondary to MS-PS1-4)

MS.PS3.B: Conservation of Energy and Energy Transfer
When the motion 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)

Teacher Background Information

Teacher Guide on Heat from JPL/NASA: http://genesismission.jpl.nasa.gov/educate/scimodule/heat/explorat_2TG.pdf
Atoms, Molecules and States of Matter: Key Ideas and Misconceptions: http://assessment.aaas.org/topics/AM#
Energy Forms, Transformation, Transfer, and Conservation: http://assessment.aaas.org/topics/EG#/

Examples of solar cookers

Darfur Refugee Camp: http://solarcooking.wikia.com/wiki/Iridimi_Refugee_Camp
Solar Cooking Project Best Practices Manual: http://www.jewishworldwatch.org/downloads/scp_best_practices.pdf
Purple Fig Solar Cooker: http://www.instructables.com/id/Purple-Fig-Solar-Cooker/

Teacher Preparation

- Assemble supplies needed for lesson (keeping solar beads in the dark).
- Copy a lab report form for each student. (Included in this lesson)
- Divide the class into groups of four (or six) for investigations of heat transfer and engineering design challenges.
- Conduct this activity on a sunny, windless day.
- Do introductory activities about states of matter and heat, if students do not have prior knowledge.
- (See Teacher Guide on Heat, in Background section, for information and sample activities)

PROCEDURES FOR LESSON ACTIVITIES

Day 1: In the Garden

Engagement

Distribute Lab Report forms to every student. Clipboards will be handy outside.

Ice Cube Melting Race (in the garden)

Students will melt ice cubes as quickly as possible, to launch a discussion about different ways heat can be transferred: friction, applying mechanical or electrical energy, mixing substances to create chemical reactions, or burning.

- Describe ice cube melting race challenge to students, distribute an ice cube to each student, set a timer, and call start and end times.
- See how much ice each student has left and ask students to describe their melting techniques.
- Ask what students would do differently if their goal was to preserve the ice as long as possible. What materials would students predict have the greatest insulating properties? If time allows, conduct a Pet Ice Cube challenge, where students attempt to keep their ice cubes from melting.
- Students should record results on Lab Report.

Exploration

Urban Heat Island Effect

Students will test their theories about the coolest places in the schoolyard by measuring the temperature at 0.5 m above ground level in locations with different types of surfaces (asphalt, cement, rock, dirt, grass, and garden).

- Ask students to predict the coolest place in the schoolyard
- Distribute instant-read thermometers to small groups of students and have them measure temperatures at 0.5 meters above the surface in six different types of locations: ask them to predict the coolest place in the schoolyard.
- Students should record results on Lab Report.
- Ask students what color surface would be coolest or hottest if exposed to the same amount of sunlight.
- Discuss what would happen if all the surfaces in the schoolyard were paved and black. The temperature of large cities is increased by the same "urban heat island effect" that results from many roads, parking lots, rooftops.

Investigation of Heat Transfer Methods

Students will investigate the way heat is transferred, through these activities:

Radiation: observe ultraviolet-detecting beads in sun and shade

- Each student will make a bracelet using a chenille strip or pipe cleaner and an ultraviolet-detecting solar bead
- Students will observe the effects of solar radiation in full sunlight and in shade
- Students should record results on Lab Report.

Convection: use colored water to create and observe convection currents

- Students will observe what happens when red-dyed hot water is slowly introduced to the bottom of a cup of cold blue-dyed water with a funnel
- Note- hot water rises by convection; red layer of hot water stratifies and moves to top of cup with blue cold water layer below; water then changes to purple as heat energy is transferred from warmer area to colder area.

Conduction and Insulation: use a glove as protection from a hot surface

- Students will use gloves, folded paper, or cloth to touch an object sitting in the sun and compare to touching the same object with an unprotected hand. Heat is conducted from one object to another when they touch.
- Ask students to think of ways insulation is used to keep heat from being transferred by conduction.

Day 2: In the Garden

Engineering Design Challenge: Solar Ovens

Students will design and build solar ovens that take into account heat transfer methods, reflectivity or absorption, and insulation. They will harvest squash or another veggie from the garden and race to cook it in their solar ovens.

- Allow students to conduct their own research on solar cookers using Internet connected computers.
- OR show the class various solar oven designs using an LCD projector or smartboard. See Background Info.
- Each team will draw a sketch of the solar oven they plan to build, labeling its features.
- Provide a variety of materials for solar oven-making and allow teams of students to test a design they saw or make their own designs. Materials may include pizza boxes or cardboard, aluminum foil, glue, colored construction paper, clear plastic wrap, and recycled paper, shoe laces, hole punchers, brads, poster board.
- Have a race to cook slices of squash in the solar ovens. At the end of the set "race" time (ideally all day), determine internal doneness for each team's squash with an infrared thermometer or clean instant -read, wide-range thermometer. Share results with students, who will record data in Lab Report.
- Let students eat squash while considering how they would re-design the solar oven for better effect next time.

Day 3: In the Garden

Engineering Design Challenge: Solar Oven Re-Design **VERY IMPORTANT- DO NOT SKIP THIS PART**

Allow students the opportunity to re-design and re-build their solar ovens and repeat the solar cooking race to compare results. Note that it is more important for students to gain experience with the iterative design process that to actually increase the temperature the second time around. In the real world, the re-design process often requires multiple iterations before the best model is developed. Students will sketch the revised design and record results on Lab Report.

Explanation

Encourage students to articulate their discoveries about heat, define temperature (a measure of heat), and discuss examples of insulation and energy transfer in the garden or schoolyard (conduction, convection and radiation). Refer to the Teacher Background Information for key ideas and common misconceptions.

Environmental Stewardship

Engineering Design Challenge: Garden Season Extenders

Encourage students to apply what they learned in this lesson to design a device or structure that will extend the growing season of tender garden plants during cold weather.

Evaluation

A Lab Report form and rubric are provided to assist in assessing student proficiency.

Heat Investigations and Solar Cooking Race Lab Report

Name: ____________________________________Date: ________________

1. Ice Cube Melt

Time to melt ice cube (min:sec): ________ Method(s) of transferring heat: ________________

2. Pet Ice Cube Contest

Test any method for slowing the transfer of energy from a warmer object to a cooler one, such as use of insulation. How long did it take for your ice cube to melt (min: sec)?________ Describe your technique.

____

____

3. Urban Heat Island Effect

Temperatures of the air 0.5 meters above various surfaces (e.g., asphalt, grass, garden, etc):

Surface type: ________ Temp: __	Surface type: ________ Temp: __	Surface type: ________ Temp: __	Surface type: ________ Temp: __	Surface type: ________ Temp: __	Surface type: ________ Temp: __	Surface type: _____ Temp: __ OPTIONAL

4. Heat Transfer Investigations: Identify the heat transfer method demonstrated by each of the following:

Solar bead bracelet: ____

Hot /cold water model: ____

Pot holder or glove: ____

5. Solar Cooker Design and Results

Color of cooking surface or pot: _______________ Insulation used, if any: ______________________

Number and total area of foil reflectors? _________________ Plastic to trap heat? _________________

Number of times solar cooker was re-oriented to face the sun, during cooking: ______________________

Sketch your solar oven design:

Results of Solar Oven

Start time: ______ End time: ______ Temp of squash when cook time started: _______ ended: ______

Weather: ambient air temp_________ % sunny ____________ wind? ____________

Highest temperature recorded inside cooker: _________ after how long? _________

Heat Investigations and Solar Cooking Lab Report, Back side

6. Solar Cooking Re-Design: Back to the Drawing Board!

What could you do differently to improve the effectiveness of your solar oven?

Draw and label your revised design below. Then build it and compare to the results of your first solar oven.

Results of Solar Oven #2

Start time: ______ End time: ______ Temp of squash when cook time started: ________ ended: ______

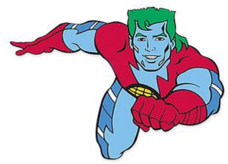
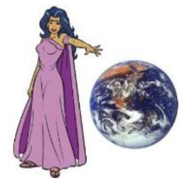
Weather: ambient air temp________ % sunny _________ wind? _________

Highest temperature recorded inside cooker: _________ after how long? __________

7. Based on what you have learned about heat transfer and insulation, invent and build a device or structure that could protect a tender plant in the school garden from cold weather. Draw and label your design below:

Assessment for Heat Investigations and Solar Cooking Race

Student Name(s): ____ **Date:** _________________

Level of Mastery Benchmark or Performance Measure	 **EMERGING** **Not yet proficient** **1 point**	 **COMPETENT** **Partially proficient** **4 points**	 **PROFICIENT** **Mastered task** **5 points**	**TOTAL POINTS**
Ice Cubes	Student participated but did not record data.	Student participated and recorded data for one activity.	Student recorded data for ice cube melting and preserving.	
Urban Heat Island Effect	Three or fewer different surfaces identified and temperatures recorded	Four or five different surfaces identified and temperatures recorded	Six different surfaces identified and temperatures recorded	
Heat Transfer Investigations	Student does not accurately identify heat transfer methods and data is missing from lab report.	Student accurately identifies conduction, convection, radiation and insulation but data is missing on Lab Report	Student accurately identifies conduction, convection, radiation and insulation in the activities. All data recorded.	
Engineering Design Challenge: Solar Oven	Student built a solar oven.	Student researched, sketched, built and tested a solar oven.	Student researched, sketched, built and tested a solar oven; then re-designed and improved the oven and re-tested it.	
Explanation **Engineering Design Challenge: Garden Season Extender**	Student designed a way to extend the season for growing tender plants but cannot explain how it incorporates key ideas of heat transfer and insulation.	Student designed a way to extend the season for growing tender plants and explains how it incorporates key ideas of heat transfer and insulation, AND sketched it AND built a model.	Student designed a way to extend the season for growing tender plants and explains how it incorporates key ideas of heat transfer and insulation, sketched it, built a model AND tested it.	