Solar Oven

Subject: How do I decide which materials are best suited for building a solar oven? What advantages does solar energy provide over other types of energy? To whom could solar ovens be important and why?

Grade level(s): 3rd-5th grades

Prep Time: 15-30 min

Lesson length: 90 min

Teaching Location(s): outdoor

EFI to Group Size Required Ratio: 20:1

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In this activity students learn about using renewable energy from the sun for heating and cooking as they design and build a solar oven and compare its performance to others' designs. They explore the concepts of insulation, reflection, absorption, conduction and convection. They also utilize and apply information that they have gained from a previous activity that introduces them to properties of various materials to in order to construct a solar oven.

Objectives

- *The students will conduct an experiment to investigate how color influences the temperature of an object.*
- *The students will investigate how various materials influence the temperature of an object.*
- *The students will utilize and apply the engineering design process using the information they have gained about properties of various materials to construct a solar oven.*

Instructor Content Background Information

A detailed explanation of how to construct an example solar oven can be found at

http://www.backwoodshome.com/articles/radabaugh30.html

Materials

- Part 1:
  - Each group will need 5 cans of the same color
  - Plastic wrap
  - Construction paper
  - Felt
  - Aluminum foil
  - Temperature guns (1 per group)
  - Student Data Sheets 1 and 2
  - Large white boards or chart paper
  - Dry erase markers of regular markers
- Part 2:
  - Pizza boxes or other cardboard boxes
  - Paint stirrers
  - Plastic wrap
  - Felt (various colors)
  - Aluminum foil
  - Wax paper
  - Cellophane (various colors)
  - Plastic garbage bags (black and white)
  - Construction Paper (various colors)
  - Cotton batting
  - Various kinds of tape (masking, duct, electrical)
  - Scissors
  - Temperature guns
  - Large marshmallows

Word Bank

Reflection Refraction Absorption Insulator Emissivity
Conductor Transparent Translucent Opaque Heat Thermal
Temperature Constraint Variable Renewable resource

Instructions

Introdution (30 mins)

Use your introduction to spark ideas and connections, stimulate wonderment and excitement. Propose the following scenario to the students:

> *Pretend we are going on a fieldtrip on a hot sunny day and we are going to be outside for most of the day. What type of clothing should you wear? Why?*

Ask the students to record their thoughts in their science notebooks. Working in groups of three or four, ask students to share their response with their group members. Lead the class in a discussion about what type of clothing they would wear and why.

Cans experiment, part 1 (45 mins)

Give students time to explore and discover during this activity. The purpose of this activity is to guide students towards the understanding that darker colors absorb light while lighter colors reflect light. Students should begin to understand that as light is absorbed an energy transfer occurs and we have a shift from light energy to heat energy. The activity also provides students with experience in conducting controlled experiments and using data to draw and support conclusions.

1) Review the students' previous discussion and tell them that they are going to be doing an experiment to prove that some colors cause objects to get warmer than others.
2) Show the students a set of the colored cans (one of each – black, red, yellow, green blue, white) and explain that you will be putting these cans outside in the sun and taking their temperatures to see which can(s) gets the hottest.
3) Pass out the Student Data Sheet 1 and have the students make a hypothesis about which can they believe will get the hottest.
4) Pass out the colored can sets and temperature guns to the student groups.
5) Explain to the students the procedure for the experiment.
    a. Set the cans up in a straight row in direct sunlight.
    b. Take the temperature of the cans every minute for ten minutes and record the temperatures in the data table.
6) Conduct a practice round collecting data for three minutes so that the students can get the feel for taking the temperatures and recording the data.
7) Take the students outside to conduct the experiment.

If students are not familiar with the use of temperature guns, it may be beneficial to have them practice taking temperatures of various items in the classroom before using them in the experiment.

Cans experiment, part 2 (45 mins)

This Experiment could be run simultaneously with Part 1 in order to save time. One group could complete colored cans, while one does materials.

The purpose of this investigation is for students to begin identifying materials as insulators or conductors of thermal (heat) energy. The activity also provides students with experience conducting controlled experiments and using data to draw and support conclusions.

1) Explain to students that now that they know how color affects temperature, they are going to investigate how different materials influence temperature.
2) Give each student group five cans of the same color. Have the students wrap one can in aluminum foil, one can in plastic wrap, one can in construction paper, and one can in felt. The remaining can will be the control.
3) Explain to the students that they are going to be repeating the experiment to see which material makes the can the hottest.
4) Pass out Student Data Sheet 2 and ask the students to make a hypothesis regarding which can they think will be the hottest.
5) Explain the experiment procedure to the students.
6) Set the cans up in a straight row in direct sunlight.
7) Take the temperature of the cans every minute for ten minutes and record the temperatures in the data table.
8) Take the students outside to conduct the experiment.

Designing and Building a solar oven (45 min)

This activity provides students with the opportunity to apply the science content knowledge they have gained within a real world context. The list of building materials is only a suggestion and can be added to or modified as needed.

1) Present the engineering design challenge to the students.
2) Challenge: Your challenge is to construct a solar oven using only the materials provided to heat a marshmallow. The goal is to see which group can get their marshmallow the hottest.
3) Go through the list of materials with the students.
4) Pass out drawing paper and have each student sketch a solar oven design making sure that students label the materials in their design.

5) Have students share their designs with their design groups and then have design groups work together to create a final design plan.
6) Have students construct their solar ovens using only the materials in their group design.
7) Test the solar ovens by allowing them to sit in direct sunlight for a minimum of 20 minutes and then taking the temperature of the marshmallow. Heat lamps work well if it is not possible to test the solar ovens outside.
8) Share the final temperature results with the class.

While students are waiting for the marshmallows to cook, or as an extension, student groups can work together in pairs to create a Venn diagram to compare and contrast the design of their solar oven with that of their partner team.

If time permits, teachers can further implement the engineering design process by allowing students to make improvements to their original design.

Reflection

Create meaning by reflecting on the activities. Have students analyze observations or data, construct explanatinos, and make ties to content, as well as reflect on the learning. For the can experiments (part 1 and 2), after conducting the experiment guide the students through the process of interpreting the data.

- Have the students look for any patterns (increases, decreases, fluctuations).
- Have the students calculate the average temperature, or identify the median temperature for each can.
- Have the students rank the cans in order from warmest to coolest.

Using large white boards or chart paper, have the students create a representation of the data form their experiment (one per group). The representation should include:

- A data table (average or median temperatures only)
- A bar graph using average or median temperatures for comparison
- A statement of something interesting they discovered during the experiment

After completing the data representations, have the students sit in a circle with their white boards or chart papers. Guide the students through a discussion of their data by having them compare graphs and data tables, and discussing the interesting things they learned. Challenge students to confront differences in data and to work through to a common consensus of results and understanding of content. Provide the students with direct instruction about thermal insulators and thermal conductors.

For the solar oven, have students write a reflection about what went well with their oven and what they could improve.

Connect beyond the classroom (10 min)

Solar ovens are in use worldwide, providing fuel-free and smoke-free cooking, baking and water decontamination especially helpful in remote and poor regions.

Connect to solar and photovoltaic researchers conducting experiments.

Determine how well the ovens perform in winter. How important is the season? How important is the time of day? How important is the outside temperature?

Assessment Opportunities

Have groups make class presentations about their solar ovens. Require each student to participate. Require groups to describe how their ovens work and why they made certain material/design choices. In their explanations, students should use concepts learned, including vocabulary from the word bank (e.g. reflection, refraction, absorption, insulator, conductor).

Deepen your Knowledge

For direct instruction and a connection to Language Arts, teachers may wish to incorporate the book "Light Show Reflection and Absorption" by Jack Torrence.

Next Generation Science Standards

Grade 3-6

3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

5-ESS3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.

MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.