Experimenting With Solar Heaters Part 2: Manipulating Design Variables on Solar Heaters

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DESCRIPTION: Part 2 builds on part 1, asking students to design a solar heater that more effectively collects solar energy. Students are provided with various building supplies and are asked to change one variable from the standard to construct a new, more effective solar heater.

GRADE LEVEL(S): 6-8

SUBJECT AREA(S): Physical science

ACTIVITY LENGTH: 1 hour, 20 minutes

LEARNING GOAL(S):
In this activity students demonstrate the ability to evaluate competing solutions to the problem of increasing the heat energy transferred to a vial of water.

STANDARDS MET:
Next Generation Science Standards:

- MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impact of people and the natural environment that may limit possible solutions
- 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.

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Student Background:

Students should already be familiar with the ideas of energy transfer and energy transformation. They should be familiar with the concept that the kinetic energy of an object changes as energy is transferred to or from an object and that temperature is the average thermal kinetic energy of

an object. Students should also be familiar with the concept that energy can take different forms and that it can be transformed from one form of energy to another. Familiarity with the scientific or engineering process is also helpful.

This lesson assumes that students have already completed Experimenting with Solar Heaters Part 1.

Educator Background:

Educators should be comfortable with the ideas of energy transfer and transformation and kinetic energy. Educators should also be familiar with how solar heaters work.

Other Materials List:

1 set per class:
- 2-3 liters of room temperature water
- Several graduated cylinders or syringes for measuring 30ml of water
- Multiple colors of construction paper
- Cardboard scraps
- Rolls of aluminum foil
- Tape/glue
- A sunny day

1 set per group of 2-4 students:
- Part 2 “Student Worksheet”
- 2 vials, clear 12 dram vials work
- 2 thermometers
- 2 Styrofoam plates
- 1 piece 30cm x 30cm piece of aluminum foil
- 1 soup bowl to be used as the solar heater mold

Vocabulary:

- Solar heater
- Heat transfer
- Kinetic energy
- Temperature
- Energy transformation
- Variable

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Lesson Details:

This is a step-by-step guide to the lesson. Feel free to make it your own in order to better match the needs of your students.

Part 2 builds on part 1, asking students to design a solar heater that more effectively collects solar energy. Students are provided with a number of different materials that they may use to create their new solar heaters. If students are not familiar with the engineering design process, have them research it as homework. There are several engineering design loops easily found in a Google search. Have them print one or copy one down to compare in class before beginning part 2.

1. Focus Question: How can we use engineering design to create a better solar heater?

2. Inform students that each group will be given a chance to change one variable in the design of their solar heaters. Their goal is to maximize the effectiveness of their solar heaters.

3. Have a brainstorming session in which students think of variables they might change in the solar heater standard design to achieve best results.
   - Possible changes include: wrapping the vials in construction paper of various colors, changing the size of the solar heater, changing the shape of the solar heater, changing the location of the vial within the heater, etc.

4. After brainstorming, assign or let each group choose a variable they will test. Some overlap in variables is okay, but it is important that a variety of different variables are tested.

5. Allow five-ten minutes for students to describe in a drawing and writing the design of their new solar heaters. What variable will be changed and how?

6. Allow 10-15 minutes for students to design/build their new solar heaters.

7. Take students outside to test their new designs. Setup one standard solar heater and vial as a control. 10-15 minutes should be enough to show a difference depending on weather. Shop lights may be used inside as well.

8. Create the following data table on a large sheet of paper or the white board for students to record their design changes and the data from their experiments:

Group #	Design	ΔT (Celsius))	Heat energy transferred $q = mc\Delta T$ (Joules)	Effectiveness (as compared to the standard)
Control	Solar heater in direct sunlight			
1				
2				
etc.				

9. After all data has been recorded have students briefly present their findings to the class. Have students present the design change they made and how it affected the effectiveness of their solar heater compared to the control.

10. During presentations students should take notes on any changes they think will be useful for constructing the final solar heater.

11. Possible extension questions:
    a. What are the similarities and differences between the other design solutions and your own?
    b. Which designs didn't increase the efficiency of solar heaters? Use scientific principles to explain why you think this is the case.
    c. Which designs best increased the efficiency of the solar heaters? Support your answer with evidence from the data.