ACTIVITY 19

Designing a Solar Collector

BROWARD COUNTY ELEMENTARY SCIENCE BENCHMARK PLAN

Grade 5—Quarter 2
Activity 19

SC.B.1.2.2
The student recognizes various forms of energy (e.g., heat, light, and electricity).

SC.B.1.2.3
The student knows that most things that emit light also emit heat.

SC.B.1.2.4
The student knows the many ways in which energy can be transformed from one type to another.

SC.B.1.2.5
The student knows that various forms of energy (e.g., mechanical, chemical, electrical, magnetic, nuclear, and radiant) can be measured in ways that make it possible to determine the amount of energy that is transformed.

SC.B.1.2.6
The student knows ways that heat can move from one object to another.

SC.H.1.2.1
The student knows that it is important to keep accurate records and descriptions to provide information and clues on causes of discrepancies in repeated experiments.

SC.H.1.2.2
The student knows that a successful method to explore the natural world is to observe and record, and then analyze and communicate the results.

SC.H.1.2.3
The student knows that to work collaboratively, all team members should be free to reach, explain, and justify their own individual conclusions.

ACTIVITY ASSESSMENT OPPORTUNITIES

The following suggestions are intended to help identify major concepts covered in the activity that may need extra reinforcement. The goal is to provide opportunities to assess student progress without creating the need for a separate, formal assessment session (or activity) for each of the 39 hands-on activities at your grade.

1. Inform the students that they have been acting as engineers by designing the solution to a problem. Ask them what problem they were trying to solve. (We were trying to build a solar collector that was efficient and could heat a measured amount of water.) Tell them

that engineers are constantly trying to improve their designs and products. Ask, *After you saw the designs of the other groups, what could you have done to improve your results?* (Answers will vary but may include changing the tilt of the tray or adding a cover.)

2. Use the Activity Sheet(s) to assess student understanding of the major concepts in the activity.

In addition to the above assessment suggestions, the questions in bold and tasks that students perform throughout the activity provide opportunities to identify areas that may require additional review before proceeding further with the activity.

Activity 19: Designing a Solar Collector

OBJECTIVES

Students apply what they have learned in previous activities to design and construct the most efficient solar collector.

The students

- design and build efficient solar collectors based on data from previous experiments
- test the solar collectors to see which produces the greatest increase in temperature
- review the winning design and the variables that made it so efficient

SCHEDULE

About 1 hour

MATERIALS

For each student

1	Activity Sheet 19, Parts A and B
1 pr	safety goggles*

For each team of two

1	solar tray, black
1	solar tray, white
1	solar tray cover
1	thermometer, Celsius
1	tumbler, large

For the class

2	containers, 6-L
	props (see Preparation)*
1	ruler*
1 roll	masking tape
12 L	water, tap*

*provided by the teacher

PREPARATION

1. Make a copy of Activity sheet 19, Parts A and B for each student.
2. Select an area outdoors where 16 solar collectors can be left undisturbed for 30 minutes in direct sunlight.
3. At least two hours before the start of the activity, fill two 6-L containers with tap water and place them in the shade near where the students will conduct their experiments.
4. Each team of two will select their own materials. In general, each setup will include one solar tray, one tumbler, and one thermometer. Students will need access to the following materials should they decide to use them: a ruler, solar tray cover, white solar tray, props (like those used in previous activities), and a roll of masking tape.

BACKGROUND INFORMATION

In this activity, the students will apply what they have learned about solar energy to design and construct a solar collector that they think will capture the most solar energy (produce the greatest increase in temperature).

Students will use data from previous experiments to help them decide which variables to incorporate into their design. For example, they may angle their tray or leave it flat. Certain conditions will remain the same for each team. For example, every team will use the same volume of liquid, and every team will leave their tray in the Sun for the same length of time.

▼ **Activity Sheet 19, Part A**

Designing a Solar Collector

Starting Time ________		Ending Time ________
Starting Temperature (°C)	Final Temperature (°C)	Change in Temperature (°C)
20°C		

1. Record the starting temperature of the liquid and the starting time.
2. Draw and describe the solar collector that you and your teammate designed. Include details such as the angle or tilt of the tray, the amount of liquid used, and so on.

▼ **Activity Sheet 19, Part B**

Designing a Solar Collector

3. After 30 minutes, record the final temperature of the liquid and the ending time. Calculate and record the change in temperature for each tray.
4. How did the efficiency of your collector compare with that of other teams' collectors?
5. Draw and describe the winning design (if another team's). Point out how their design was different from yours and why you think those differences may have made their collector more efficient.

Guiding the Activity

1 Explain to the students that the experiment they are about to conduct is not a controlled experiment. Instead, they will try to build the best (most efficient) solar collector that they can. Each team is to design and construct a solar collector in such a way that after 30 minutes in the Sun the temperature of the solution in their collector will have risen higher than any other team's solution.

2 Distribute a copy of **Activity Sheet 19, Parts A and B,** to each student. Divide the class into teams of two. Place all the materials at a central distribution station.

Tell students that they can use any of the materials that they have used so far, in any combination, to achieve the greatest possible temperature change in the solution in their collectors. Also tell them that certain conditions will remain constant for every team: Exposure time will be 30 minutes, and everyone will use one tumblerful (1 cup) of liquid.

Additional Information

Remind the students of their results from previous activities. Suggest that they refer to the data on those activity sheets, as necessary.

Guiding the Activity

Additional Information

3 Allow 10 minutes for team members to confer and design their setups and decide which materials to use. Then have them draw and describe their designs on Activity Sheet 19, Part A. After students have finished, take them to the predetermined area outdoors.

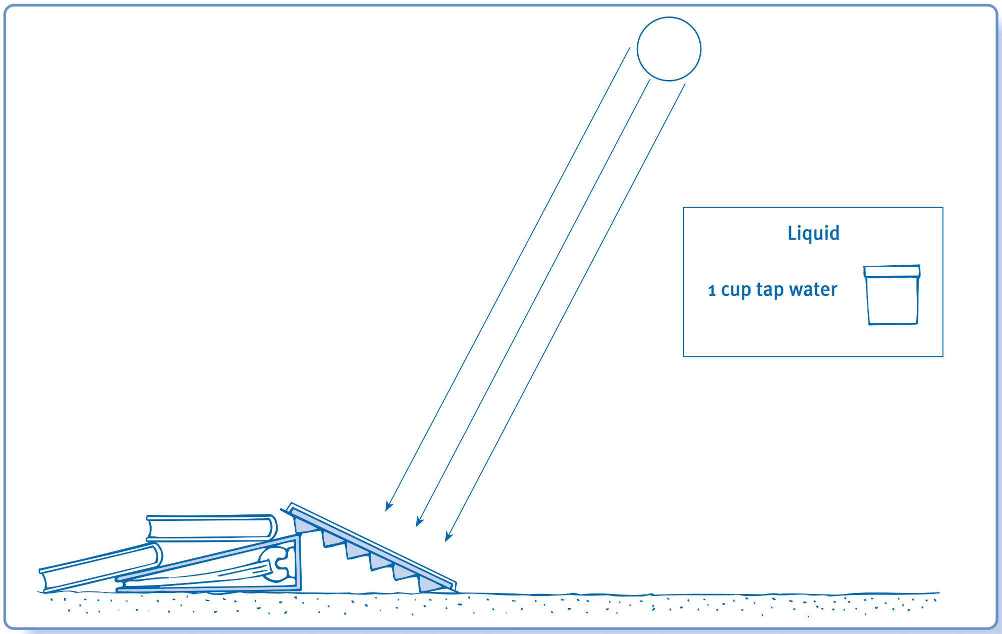
Students should take any items with them that are necessary to execute their designs. These items may include a roll of tape, solar tray, solar cover, objects with which to prop up the solar trays, and a ruler to measure the incline. They should also bring their activity sheets and a pencil with them.

4 Have teams fill their tumblers with water from the 6-L containers, measure the starting temperature of the water in each tumbler, and record this information on the activity sheet.

Allow students time to prepare their setups. Have each team add the liquid to their solar tray, put the cover on (if they choose to use one), and position the tray as planned. Have the students enter on their activity sheets the time at which the covers were placed on the trays (starting time).

Make sure each team has the same starting time.

Tell students that they will return to the site in about 30 minutes to measure the temperature of the water in the trays. Return to the classroom. Remind students to bring with them all materials that aren't currently being used.



▲ ***Figure 19-1.*** *An efficient solar collector.*

Guiding the Activity

Guiding the Activity	Additional Information
5 Once back in the classroom, begin a discussion of the different solar collector designs. Ask, **Why do you think your team's design will work the best?**	*Discuss all explanations.*
6 Return to the site about 30 minutes after setting up the experiments. Tell the students to bring their tumblers, thermometers, the 6-L containers, and the activity sheets with them. Tell each team to pour the contents of their tray into a tumbler and measure the temperature. Have teams record on their activity sheets the final temperature and the time at which it was taken (ending time). After the temperatures have been measured and recorded, have the students disassemble their setups and return to the classroom.	
7 Once back in the classroom, tell students to complete the chart on Activity Sheet 19, Part A. Ask each team to tell you the change in temperature of the liquid in their tray. Record each team's temperature on the board. After you have determined which team achieved the greatest change in temperature, invite that team to describe their setup to the rest of the class. Tell students to complete Activity Sheet 19, Part B.	*Encourage the team members to explain why they chose the various aspects of their design.*

REINFORCEMENT

Students may experiment further with solar collector designs. Encourage them to choose aspects of their design that were the most effective and to add any others that they think will make their collector even more efficient. To make this a controlled experiment, have them set up a control tray that sits on level ground, contains plain tap water, and has no other modifications. Students should compare the temperature of the water in these two trays after 30 minutes in the Sun.

CLEANUP

Pour all liquids down the sink drain. Rinse and air-dry the 6-L containers, solar trays and covers, tumblers, and thermometers, and return all materials to the kit.

Connections

Science Challenge

Ask students to investigate the types of solar collection systems that are used in homes to produce hot water or to heat the building. Then challenge teams to design and build a working model to demonstrate how one type of system operates. Tell students that they may use water, stone, or any other material as the collection and storage medium. Encourage them to make creative use of other materials to model the actual system's design—for example, cylinders of water to capture and store heat. Give each team an opportunity to demonstrate and explain its model to the rest of the class.

Science Extension

Divide the class into cooperative learning groups to research and report on the three basic types of solar collectors in use today: flat-plate collectors, focusing collectors, and parabolic trough collectors. In each group, some students could be responsible for doing library research; other students could create diagrams showing how each type works; and the remaining students could prepare a written report or notes for an oral report. Ask students to find out whether there are any solar thermal power plants or solar heating systems in operation in your area. If there are, try to arrange a class visit so students can see the plant or system in operation.

Science and Language Arts

Challenge students to list as many song titles and lyrics as they can that refer to the Sun. Encourage them to ask older family members and friends to suggest additional titles and lyrics that they may not be familiar with themselves. For phrases in which the reference is figurative, such as "You are the sunshine of my life," ask students to explain what the phrase means. Keep a class master list, and have students add new titles and lyrics as they discover them.

Science and Social Studies

In the early 17th century, Solomon de Caux, a French scientist, invented a solar-powered machine to pump water. In 1826, Swedish-born US inventor John Ericsson—best known for designing the Union Navy's ironclad ship the *Monitor*—built a solar-powered hot-air engine. In the late 1800s, Abel Pifre, another French inventor, built a solar-powered engine that ran a printing press to print a newspaper called *le Journal Soleil* (the *Sun Journal*). In 1912, an American engineer, Frank Shulman, set up a solar-powered irrigation project in Egypt. Encourage interested students to research these and other examples of the development and use of solar-powered machines.

Science, Technology, and Society

In the extreme heat of the Sun's core, hydrogen is changed to helium through nuclear fusion. Scientists have tried to replicate this process as a way of generating our own solar power, but the extremely high temperatures required cannot be contained by ordinary materials. The Tokamak reactor, invented by scientists in the former Soviet Union, uses powerful magnetic fields to contain the heated material. Encourage interested students to research the development of Tokamak reactors and their current use in the United States, Britain, and Japan.