TRANSFER OF ENERGY AND ITS EFFECTS

Prep Time: 30 minutes
Teaching Time: 6 hours

INSTRUCTIONS
Grade 7

Science Teacher Education Program

Science Concept:

Solar radiation is transferred to Earth. (NOTE: This lesson requires a light sensor and associated software. The lesson was written based on use of Vernier software.)

Objectives:

The student will:

- describe transfer of energy;
- make a prediction; and
- make a labeled graph of data collected.

GLEs Addressed:

Science

[7] SB2.1 The student demonstrates an understanding of how energy can be transformed, transferred and conserved by explaining that energy (i.e. heat, light, chemical, electrical, mechanical) can change form.

[7] SA1.1 The student understands the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring and communicating.

Math

[7] G-8 The student demonstrates an understanding of position and direction by graphing or identifying values of variables on a coordinate grid.

Vocabulary:

absorption – the swallowing up or disappearance of things through their inclusion in or assimilation to something else; incorporation in something else

albedo – the proportion of the incident light or radiation that is reflected by a surface, typically that of a planet or moon

lux – a unit of illumination equal to the illumination of a surface all of which is one meter from a uniform point of light of unit intensity; one lumen per square meter

radiant energy – energy transmitted as electromagnetic radiation

reflectivity – the property of reflecting light or radiation, especially reflectance as measured independently of the thickness of a material

Materials:

- Computer with Logger Pro installed
- Tape
- Black paper (two sheets per group)
- White paper (two sheets per group)
- Sand
- Thermometers (two per group)
- Ring stand and utility clamp
- Water source
- Disposable cups (one per group)
- Light sensors (such as a Vernier light probe) (one per group)
- Vernier LabPro or LabQuest computer interface
- Aluminum foil
- Ice
- Light-colored leaf

- Dark-colored leaf
- Rulers (one per group)
- Blue food coloring
- Lamps and bulbs (one per group)
- Radiometers (one per group)
- Stopwatches or timers (one per group)
- Soil
- Data logger software, compatible with light sensor
- STUDENT WORKSHEET: "Explore"

Activity Preparation:

1. If necessary, install data logger software on student computers.
2. Prepare colored water for use in Activity Procedure 5.

Activity Procedure:

Please refer to the assessment task and scoring rubric located at the end of these instructions. Discuss the assessment descriptors with the class before teaching this lesson.

Gear Up

Process Skills: observing, inferring, and communicating

1. Divide the class into small groups. Distribute a radiometer that is covered to each group. Explain students must remain quiet during the entire observation period. When signaled, groups should uncover the radiometer and observe it for 1-2 minutes, keeping notes of all observations.
2. When the observation period is complete, ask groups to write their inferences on how the radiometer functions. Ask each group to share their inferences with the class.

Teacher's Note: A radiometer is a device used for measuring the radiant flux (power) of radiant energy.

Explore

Process Skills: observing, collecting data, describing, questioning, investigating, and measuring

3. Ask the class how color affects the absorption and transfer of energy from the sun to living and nonliving things.
4. Distribute the STUDENT WORKSHEET: "Explore," two thermometers, white paper, black paper, a stopwatch or timer, a ruler, and a lamp to each group. Instruct students to follow the procedures in Part A of the worksheet. Students should stop after Part A. Discuss student results as a class.
5. Explain students will use a light sensor and computer software to measure the reflectivity of various surfaces. Distribute the following items to each group: light sensor, clamp, ring stand, a dark-colored leaf, a light-colored leaf, white paper, black paper, aluminum, sand, soil, a cup of water (dyed blue), and ice. Students will also require access to a computer with data logger software installed.
6. Instruct groups to complete Part B of their worksheets.

Generalize

Process Skills: inferring, communicating, and describing

7. Ask students the following questions and discuss:
   a. Which item has the highest lux?
   b. Which item has the lowest lux?
   c. Which color paper had the greatest range (difference in beginning and ending temperature)?
   d. Which color paper had the greatest temperature?
   e. Explain the difference in temperature between the white and black papers.
   f. How did the color of paper affect the reflective value?

g. What materials in the natural world would have the highest reflective values?
h. How is the reflective value of an object related to the object's absorption of energy?
i. If you had a light and a dark colored sand, which would you expect to have the highest reflective value under the same light?

Apply

Process Skills: predicting, inferring, writing and making generalizations

8. Ask students to write a reflective paragraph about how energy is reflected off of surfaces and how this might affect Earth's climate.

Answers

Answers will vary based on materials used but should be consistent with overall class results.

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RUBRIC

Assessment Task

Using the information from the data collected during the Explore Part A, step 8, create a labeled graph including both sets of temperature data from the black and white paper. Use that information to help you answer the following:

Two students are walking in the Sahara Desert on a hot, sunny day. They are curious about the temperature and take out their science pack to find a thermometer. Using the thermometer, they find that the temperature is 39˚C (102˚F). One student is wearing a black t-shirt and the other is wearing a white t-shirt. In your science journal, predict which student would feel cooler. Include a reason for why you made that prediction. Also, using vocabulary introduced in the lesson, explain why there would be a temperature difference between the white t-shirt and the black t-shirt. Finally, include an example of where you find difference between light and dark surfaces in the natural world.

Rubric

Objective	GLE	Below Proficient	Proficient	Above Proficient
The student describes energy transformation and provides an example.	[7] SB2.1	The student provides an incomplete description of energy transformation or does not provide an example.	The student describes energy transformation and provides an example.	The student describes energy transformation and provides a real-world example.
The student explains the difference between light and dark surfaces as they relate to energy transfer.	[7] SB2.1	The student does not explain the difference between light and dark surfaces as they relate to energy transfer.	The student explains the difference between light and dark surfaces as they relate to energy transfer.	The student explains the difference between light and dark surfaces as they relate to energy transfer and provides a real-world example.
The student uses qualitative and quantitative observations to write his or her own inferences and/or predictions.	[7] SA1.1	The student makes no prediction and gives no reason.	The student makes a correct prediction but gives no reason for the prediction.	The student makes a correct prediction and gives the correct reason for the prediction.
The student graphs data.	[7] G-8	The student graphs data but is missing one or more parts of the graph or graphs data incorrectly.	The student graphs data and includes labels, title, and scale.	The student graphs data correctly and includes labels, title, and scale.

Part A
Materials:

- White paper
- Black paper
- Lamp
- Thermometers (two)
- Stopwatch or timer
- Ruler

Procedure:

STEP 1. Fold each piece of paper in half widthwise, and insert a thermometer between each half.

STEP 2. Place the pieces of paper next to each other on the table.

STEP 3. Place a lamp directly over the boundary between the two pieces of paper. The lamp should be at least 10 centimeters above each piece of paper. The lamp should be the same distance above each thermometer.

STEP 4. Turn on the lamp and record initial temperatures (in degrees Celsius) for both sheets of paper on the data table below.

Temperature (°C)	Initial	2 min	4 min	6 min	8 min	10 min
White Paper						
Black Paper						

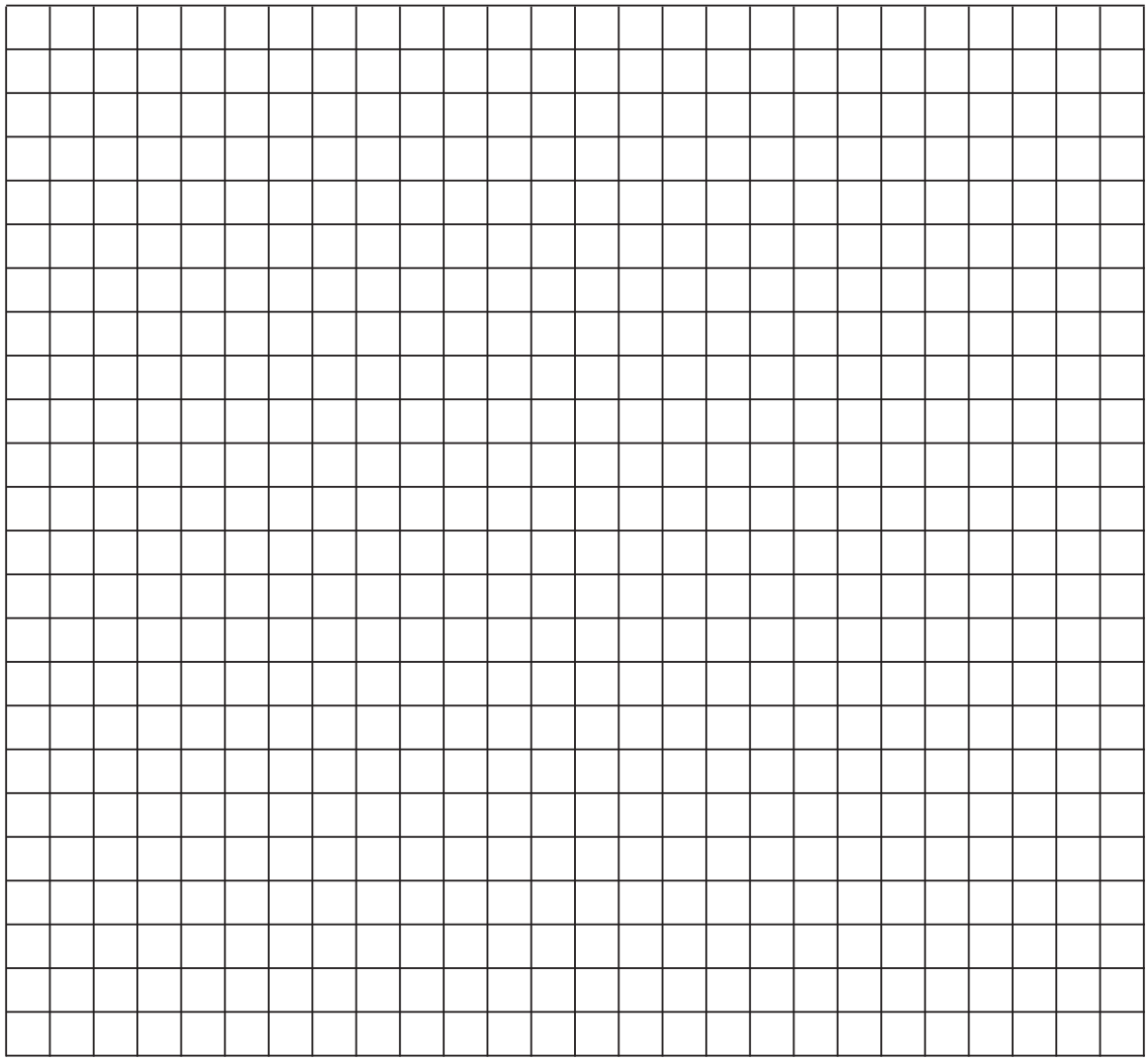
STEP 5. Record the temperatures (in degrees Celsius) every two minutes for ten minutes.

STEP 6. Turn off the lamp.

STEP 7. Calculate the temperature change (Δt) for each color by subtracting the initial temperature from the final temperature ($\Delta t = t_f - t_i$). Show your work below.

Δt for White: _____ Δt for Black: _____

STEP 8. On the grid below, create a line graph of time versus temperature for both colors of paper. Title the graph and label both axes.



Part B
Materials:

- Lamp
- Light sensor
- Clamp
- Ring stand
- Computer with data logger software
- Dark-colored leaf
- Light-colored leaf
- Ruler
- White paper
- Black paper
- Aluminum
- Sand
- Soil
- Cup of water with blue dye
- Ice

STEP 1. Fasten a light sensor to the ring stand with a clamp. Make sure the light sensor is 5 centimeters from, and perpendicular, to the test item.

STEP 2. Set the lamp 50 centimeters above the test item. Turn on the lamp.

STEP 3. Connect the light sensor to the computer and set it to the 0-6000 lux position.

STEP 4. When the reading stabilizes, record the reflected light value in lux for each test item.

Test Item	Reflected Light (Lux)
Aluminum	
White Paper	
Black Paper	
Sand	
Soil	
Cup of water with blue dye	
Ice	
Light-colored leaf	
Dark-colored leaf	

STEP 5. Use the following formula to calculate the percent reflectivity for each item, where aluminum remains constant. Record the data in the table on the following page.

$$\% \text{ Reflectivity} = \frac{\text{value for test item}}{\text{value for aluminum}} \times 100$$

Test Item	% Reflectivity
Aluminum	
White Paper	
Black Paper	
Sand	
Soil	
Water (colored)	
Ice	
Light colored leaf	
Dark colored leaf	

STEP 6. Graph results on the chart below. Be sure to label the graph.