



# ASPECT

Assessing Students' Progress on the Energy Concept

## Sunlight experiment: AP07-7

Elementary School - Thermal Energy Transfer

### TASK OVERVIEW

Motivated by the observation that a pool in sunlight has warmer water than a pool in the shade, students are provided with an experimental procedure and asked to analyze it to determine how it will help figure out whether light from the sun transfers energy. Students are then provided with data from the experiment and asked to evaluate whether the experiment was fair. Students are then asked to write an argument supporting or refuting the claim that light from the sun transfers energy.

### TARGETED DCIs, SEPs, AND CCCs

#### Disciplinary core ideas

- PS3.A-4.2: Energy can be moved from place to place by moving objects or through sound, light, or electric currents.
- PS3.B-4.1: Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- PS3.B-4.2: Light also transfers energy from place to place.

## Science & engineering practices

- SEP3-E.2: Evaluate appropriate methods and/or tools for collecting data
- SEP3-E.4: Make predictions about what would happen if a variable changes.
- SEP3-E.1: Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
- SEP7-E.4: Construct and/or support an argument with evidence, data, and/or a model.

## Crosscutting concepts

- CCC1-P.1: Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.
- CCC1-E.3: Patterns can be used as evidence to support an explanation.

## Related Performance Expectations

- 4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [Assessment Boundary: Assessment does not include quantitative measurements of energy.]

## TASK PERFORMANCE EXPECTATION

*Explain how* the measurements made during an experiment involving sunlight address the experiment's purpose. *Evaluate the fairness of the experimental design.* Identify patterns in temperature data and *use the data to support an argument* for the idea that sunlight transfers energy.

## LINK TO ONLINE VERSION

<http://assess.bscs.org/i/test/595>

## Task

A family is getting a pool in their backyard. They want to use the least amount of energy to keep the water in the pool warm. They can put the pool in the shade under some trees or in the open where sunlight will shine on it.

One family member thinks that they should put the pool in the sunlight. They think the sunlight will transfer energy to the pool so that they won't need to use an electric heater to keep the pool warm. Another thinks it doesn't matter where the pool is placed because the sunlight does not transfer energy. They decide to do an experiment to see whether sunlight transfers energy to the pool.

Below is a list of steps they take in the experiment.

### Experimental Procedure

Step 1: Fill two cans with the same amount of water.

Step 2: Place one can in the backyard so sunlight shines on the can.

Step 3: Place the second can under an umbrella in the backyard so no sunlight can shine on it.

Step 4: Measure the temperature of the water in each can every hour using a thermometer.

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1. Why will measuring the temperature of the water in the two cans help them figure out whether sunlight transfers energy to the water?

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2. If sunlight does transfer energy, what do you think would happen to the temperature of the water in both cans during the experiment?

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The family does the experiment twice. They measure the temperature of the water in each can every hour. The table below shows the data from their first experiment.

Experiment 1: Temperature Measurements

	Can with sunlight	Can without sunlight
Start	15 °C	15 °C
Time: 1 hour	16 °C	16 °C
Time: 2 hours	20 °C	16 °C

The second time they forget to make all the measurements. They measure the temperature of the water in the can in the sunlight after one hour and the temperature of the water in the can without sunlight after two hours. The table below shows the data from their second experiment.

**Experiment 2: Temperature Measurements**

	Can with sunlight	Can without sunlight
Start	15 °C	15 °C
Time: 1 hour	16 °C	No measurement taken
Time: 2 hours	No measurement taken	16 °C

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3. The family isn't sure whether the second experiment is a fair comparison of the two cans. Explain why the second experiment is or is not a fair comparison.

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4. Next, the family looks at the data from Experiment 1 to see if they can find patterns that would help them figure out whether sunlight transfers energy. What patterns do you notice in the temperature data from both cans of water in Experiment 1?

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5. Now, think about the patterns you found in the data from Experiment 1 and what you know about energy. Do you think energy was transferred by sunlight to the water?

- A. Yes, energy was transferred by sunlight to the water.
- B. No, energy was not transferred by sunlight to the water.

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6. Write an argument to support why you think energy was or was not transferred by sunlight to the water. Be sure your argument includes evidence from the family's experiment and uses what you know about energy.

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# Alignment to Targeted DCIs, SEPs, and CCCs and Scoring Rubrics

## QUESTION 1

Why will measuring the temperature of the water in the two cans help them figure out whether sunlight transfers energy to the water?

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### LEARNING GOAL

#### Learning Performance

- Explain why the measurements made in the experiment would address the experiment's purpose.

#### Targeted DCIs, SEP, and CCC

- PS3.B-4.1 Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
  - SEP3-E.2 Evaluate appropriate methods and/or tools for collecting data
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### SCORING RUBRIC

#### Ideal Response

Measuring the temperature of the water will help him figure out if sunlight transfers energy because an increase in the temperature of an object means that energy was transferred to the object.

## Elements of a Correct Response

Categories	Elements
Student states or uses general science ideas	<ul style="list-style-type: none"> <li>Changes in the temperature of an object are associated with energy being transferred to or from the object (i.e., if the can in the light increases in temperature, then energy was transferred to the can, or if the water in the can gets warmer, you can assume the sun transferred energy to the water). [links changes in temperature and energy transfer]</li> </ul> <p><u>Note:</u> The student must use the word “energy” in their response and link it to a change in temperature (getting warmer is ok).</p>

## Sample Student Responses

Student response	Scoring description
“Yes it will because if the sun is strong enough it will heat up at least one of the cans if the can is out long enough.”	Score = 0 The response does not make the connection between energy transfer and temperature changes.
“The temperature of water will change if sunlight transfers energy so a temperature change means energy was transferred.”	Score = 1 The response links temperature changes to energy being transferred to the water.

## QUESTION 2

If sunlight does transfer energy, what do you think would happen to the temperature of the water in boths cans during the experiment?

### LEARNING GOAL

#### Learning Performance

- Predict what the outcome of the experiment would be if sunlight does transfer energy.

#### Targeted DCIs, SEP, and CCC

- PS3.B-4.1 Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- SEP3-E.4 Make predictions about what would happen if a variable changes.

### SCORING RUBRIC

#### Ideal Response

I would expect the temperature of the water in the sunlight to increase and the temperature of the water without sunlight to stay the same.

#### Elements of a Correct Response

Categories	Elements
Student makes the correct prediction	<ul style="list-style-type: none"><li>• The temperature of the water in the sunlight will increase AND the temperature of the water without sunlight will not increase or will increase less than the water in the sunlight.</li></ul> <p><u>Note:</u> Student must reference both cans.</p> <p><u>Note:</u> It is acceptable to not specify which can is which. For example, “the temperature of one will increase and the temperature of the other will not.”</p>

## Sample Student Responses

Student response	Scoring description
"The can outside should be hotter because it received more energy."	Score = 0 The response does not reference both cans so it is unclear whether the student thinks the can in the sun will be hotter than the can in the shade or will be hotter than it was at the beginning.
"If sunlight does transfer energy then the water out in the sun will have a higher temperature and be warmer while the water in the shade will stay the same since it doesn't have any source of heat or something cold to change its temperature in either direction."	Score = 1 The response describes the correct predictions about the temperatures of the water in the sun and the water in the shade.

### QUESTION 3

The family isn't sure whether the second experiment is a fair comparison of the two cans. Explain why the second experiment is or is not a fair comparison.

### LEARNING GOAL

#### Learning Performance

- Explain why an experiment's design makes it difficult to make valid inferences from the experimental data.

#### Targeted DCIs, SEP, and CCC

- SEP3-E.2 Evaluate appropriate methods and/or tools for collecting data
- SEP3-E.1 Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.



## SCORING RUBRIC

### Ideal Response

The boy did not take the temperature measurements of the two cans at the same time in Experiment 2. Taking the measurements at different times isn't a fair test because a fair test requires variables like time to be controlled.

### Elements of a Correct Response

Categories	Elements
Student uses the practice of planning and carrying out investigations	<ul style="list-style-type: none"><li>Fair tests require variables to be controlled (i.e. In order for the experiment to be a fair test, the temperature measurements of both cans must be made at the same time intervals. OR It's not a fair test because they are missing two data points.)</li></ul> <p><u>Note:</u> Just stating "it's not a fair comparison" or "it's not a good test" is not acceptable.</p> <p><u>Note:</u> Discussing how the amount of energy transferred from the sun changes during the day is not acceptable.</p>

### Sample Student Responses

Student response	Scoring description
"The second experiment is not fair because the experiment wasn't executed properly."	Score = 0 The response does not describe what wasn't done correctly.
"it isn't a fair comparison because they were sitting out for different times, during an experiment the variables need to be equal for the results to be dependanble".	Score = 1 The response correctly describes why the second experiment is not a fair comparison.

## QUESTION 4

Next, the family looks at the data from Experiment 1 to see if they can find patterns that would help them figure out whether sunlight transfers energy. What patterns do you notice in the temperature data from both cans of water in Experiment 1?

### LEARNING GOAL

#### Learning Performance

- Identify and compare patterns in temperature data.

#### Targeted DCIs, SEP, and CCC

- CCC1-P.1: Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

### SCORING RUBRIC

#### Ideal Response

The temperature of the water in can in the sunlight increased over time, while the temperature of the water in the can without the sunlight remained somewhat the same.

#### Elements of a Correct Response

Categories	Elements
Student identifies patterns	<ul style="list-style-type: none"><li>• The can in the sunlight increased in temperature while the can in the shade remained the same.</li></ul> <p style="text-align: center;">OR</p> <ul style="list-style-type: none"><li>• The can in the sunlight increased in temperature more than the can without sunlight.</li></ul> <p><u>Note:</u> The student must indicate an increase in temperature not simply a change in temperature. They must also reference both cans.</p> <p><u>Note:</u> The student should indicate which can has which pattern. So “one is hotter than the other” is not acceptable. Citing the</p>

	data is acceptable. For example, "One increased from 15 to 20 and the other only increased from 15 to 16."
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## Sample Student Responses

Student response	Scoring description
"They increase in temperature."	Score = 0  The response describes that the temperature of the water is increasing but it does not include a pattern, i.e., that the one in the sun increases more than the one in the shade, that will help the family figure out whether sunlight transfers energy.
"I noticed that the can with sunlight is getting hotter each hour but after the first hour the can without sun light didn't change at all."	Score = 1  The response describes the different patterns in temperature change for both cans of water.

## QUESTIONS 5 & 6

Now, think about the patterns you found in the data from Experiment 1 and what you know about energy. Do you think energy was transferred by sunlight to the water?

- A. Yes, energy was transferred by sunlight to the water.
- B. No, energy was not transferred by sunlight to the water.

Write an argument to support why you think energy was or was not transferred by sunlight to the water. Be sure your argument includes evidence from the family's experiment and uses what you know about energy.

## LEARNING GOAL

### Learning Performance

- Write an argument supporting or refuting a claim that light transfers energy based on patterns in temperature data.

### Targeted DCIs, SEP, and CCC

- PS3.B-4.1 Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.
- PS3.B-4.2: Light also transfers energy from place to place.
- SEP7-E.4 Construct and/or support an argument with evidence, data, and/or a model.
- CC1-E.3 Patterns can be used as evidence to support an explanation.

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## SCORING RUBRIC

### Ideal Response

Yes, energy was transferred by sunlight to the water. The can in the sunlight increased 5 °C while the can without the sunlight only increased by 1 °C. If an object gets hotter, energy must have been transferred to it. This means that the water in the sunlight got energy but the water without the sunlight did not have energy given to it. The only difference between the cans was sunlight so the difference in energy transfer must have been caused by the sunlight.

### Elements of a Correct Response

Categories	Elements
Student selects the correct claim	A. Yes, energy was transferred by sunlight to the water
Student cites evidence to support their claim	<ul style="list-style-type: none"><li>• The temperature of the water in the sunlight increased</li><li>• The temperature of the water without sunlight stayed the same [or increased a little].</li></ul>

Student either states or uses a general science idea	<ul style="list-style-type: none"> <li>Changes in the temperature of an object indicate that energy was transferred to it (i.e., energy must have been transferred to the water in the sunlight because it got hotter). [<i>links increase in temperature and energy transfer</i>]</li> </ul>
Student uses reasoning to draw the correct conclusion from the experiment	<ul style="list-style-type: none"> <li>The only difference between the cans was sunlight, so the difference in energy transfer must have been caused by the sunlight. [<i>Science idea-based reasoning</i>]</li> </ul> <p style="text-align: center;">OR</p> <ul style="list-style-type: none"> <li>The can in the sun increased in temperature and the can in the shade didn't, therefore the sun must have transferred energy. [<i>Evidence-based reasoning</i>]</li> </ul> <p><u>Note:</u> Students can only receive the reasoning point if they mention the temperature changes in both cans.</p>

## Sample Student Responses

Student response	Scoring description
Student selected B and wrote "Energy was not transferred by sunlight to the water. My evidence for this claim is in the experiment for the first trial the temperature didnt change when exposed to the sunlight."	Score = 0  The student did not select the correct claim.
Student selected A and wrote "The family should move their pool into the sunlight because the sun does transfer energy to keep the pool warm."	Score = 1  The student selected the correct claim but did not include the other elements in the rubric, i.e., evidence from the experiments or science ideas.
Student selected A and wrote "[Energy] can be transferred form the sun to the can because it's hot and warm. Some evidence to support this was in one hour the	Score = 2  The response includes evidence about the temperature changes, but it does not include science ideas linking an increase in temperature and energy transfer.

<p>temperature was one degree warmer and hour 2 got 4 degrees even more warmer.”</p>	<p>The response did not receive a reasoning point because they did not reference the temperature change in both cans.</p>
<p>Student selected A and wrote</p> <p>“I think that energy was transferred by sunlight to the water because when the family did the experiments with two cans, in the first hour the can with the sunlight and without were the same but by the second hour they have changed temperatures to the can with the sunlight which was 20° And the can without, 16°. The evidence proves that by 2 hours the cans have different temperatures in which the one in the sunlight had increased in temperature.”</p>	<p>Score = 3</p> <p>The response includes a claim, science ideas, and evidence, but it does not use reasoning to link the components of the explanation.</p>
<p>Student selected A and wrote</p> <p>“I believe that sunlight does transfer energy. This is shown through the family's experiment. The can of water sitting in the sunlight had an increase of five degrees Celsius in two hours, while the can of water in the shade increased only one degree in two hours. This shows that the can of water sitting in the sunlight is receiving energy from the sun, resulting in an increase in temperature.”</p>	<p>Score = 4</p> <p>The response includes all the elements in the rubric.</p>

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