What can temperature tell us about energy?

Plan Investigation 1

Note: This sequence assumes that students have completed the Motion Energy sequence.

This investigation introduces a new form of energy called thermal energy. Key energy concepts introduced in the Motion Energy sequence, such as energy transfer, energy transformation, and the pairing of energy gains with energy losses, continue to apply to thermal energy. Like motion and elastic energy, thermal energy cannot be directly observed. The indicator of thermal energy is temperature: as an object's thermal energy increases, its temperature increases, and vice versa.

In this session, a very short video introduces students to thermal energy. In the video, the stopper of an empty bottle shoots into the air after the bottle is placed in a tub of hot water. The question is posed, "If the stopper gained motion energy, what lost energy?" The thermal energy of the hot water is likely to be identified by students as the source. Next, students rub their hands together and sense the warming (gain of thermal energy). As an option, they can also rub an eraser against the desktop and sense the increase in temperature.

The main investigation today highlights gains, losses, and the transfer of thermal energy. After placing a room temperature rock into a cup of hot water, students use a thermometer to observe the cooling (loss of thermal energy) of the water, and then use their sense of touch to observe that the rock has become warmer (gained thermal energy) when compared with a control rock that has remained at room temperature. In their notebooks students describe gains, losses, and the transfer of thermal energy.

One challenge that will arise is understanding the difference between temperature (the indicator) and thermal energy. There are more opportunities in the two following investigations for students to clarify the distinction between temperature and thermal energy. More information about this can be found in the Thermal Energy Unit Overview.

By the end of this investigation students will have expanded their understanding of energy transfer, gains, and losses, and will start to understand the difference between temperature (the indicator) and thermal energy.

Learning Targets Introduced in this Investigation

- Motion energy can be transformed into thermal energy through rubbing.
- Temperature is the indicator of an object's thermal energy. If an object's temperature increases or decreases, its thermal energy has increased or decreased.
- Thermal energy can be transferred between objects through contact.

Sequence of Experiences		
1. Introduce Thermal Energy	All Class	20 Minutes
2. Explore	Groups of 4	20 Minutes
3. Make Meaning	All Class	20 Minutes

Materials

For the class:

- Pop the Stopper video (available on the Focus on Energy website, under Curriculum -> Thermal Energy -> Resource Quick Links)

For each student:

- Thermal Energy Student Notebook
- 1 rubber eraser (optional)

For each group of 4:

- 2 rocks in an 8-oz. plastic cup
- 1 plastic fork (for lowering the rock into the cup of water and later for removing the rock from the cup)
- 1 8-oz. plastic cup half-full of 110° F water
- 2 paper towels (for drying the rock after it is removed from the water)
- 1 alcohol thermometer

Materials for each group of 4 students

Preparation

- If you have not already done so, read the Thermal Energy Curriculum Unit Overview.
- Have a source of hot (110° F) water in the classroom. Depending on your situation, you may want the water to originally be warmer than 110° F so that it is approximately 110° F when students get it.
- Place the Model of Energy poster where all can see.
- If your students are not familiar with how to interpolate between temperature marks on a thermometer you should be prepared to address that topic with them.
- Watch the *Thermal 1: Setting Up and Using Equipment video* available on the *Focus on Energy* website on the Curriculum -> Thermal Energy -> Resource Quick Links page.

Thermal 1: Setting Up and Using Equipment Video

1. Introduce Thermal Energy

All class – 20 Minutes

Begin class in a discussion circle.

Review

Before starting the new Unit, review some of the ideas about energy that students may already have listed in their growing Model of Energy. Be sure to include the following ideas, which will help students as they investigate the new form of energy:

- *Energy cannot be directly seen, but indicators can inform us of its presence.*
- *Motion is an indicator that an object has motion energy.*
- *Speed is an indicator of the amount of motion energy. If an object's speed increases, its motion energy has increased.*
- *Energy can move from one object to another (this is called transfer).*
- *Whenever there is a loss of energy somewhere there is a gain of energy somewhere else and vice versa.*
- *One form of energy can be changed into a different form of energy; this is called energy transformation.*

See how students are introduced to a new form of energy.

Introducing New Forms of Energy video available in Resource Quick Links on the Focus on Energy website

Introduce evidence for another form of energy – thermal energy

The purpose of this discussion is to introduce another form of energy: thermal energy.

We have just reviewed some of the important ideas about energy that you worked with in the unit about motion energy and elastic energy. To start this new unit on energy, we will watch a video. After watching it twice, let's see how the energy ideas we have already worked with can help us learn about a new form of energy.

Play the video of "Pop the Stopper" twice.

Let's use the Energy Tracking Lens:

(On the board or a sheet of paper that all can see, record just the observations and claims that the students make. If there are no ideas about something, just record a question mark, or incomplete responses.)

What did you observe? (Remember, you can't observe energy.) (bottle stopper flew into the air; motion)

What's the energy story?

- *What are the system components?* (bottle, stopper, water, bucket)
- *What are the forms of energy?* (motion, …)
- *What gained energy?*

  ➔ The stopper changed from having no motion to have a lot of motion. The stopper gained motion energy.

Your Model of Energy says that whenever there's a gain of energy, there a loss of energy somewhere. What do you think lost energy? (the hot water? the air in the bottle?)

And what form was that energy? Was it motion energy? (no) *Was it elastic energy?* (no)

Note: The hot water first warms the air in the bottle, causing the air to expand and pop the stopper. If students have questions about this detail, you can share it, but otherwise we suggest that you just keep to the energy story: it was the hot water's thermal energy that was ultimately responsible for the movement of the stopper.

Introduce the term "thermal energy"

Explain (or confirm) that *the hot water has energy, and that form of energy is called **thermal energy**.*

Have you heard the word "thermal" before? Can you think of other words that begin with therm, or do you have any other ideas about "thermal"?

➔ Thermometer, thermos, thermostat, thermal underwear

All of those "therm" words have something to do with how warm something is.
***The warmer an object is, the more thermal energy it has.** Temperature is the indicator of thermal energy.*

What ideas do you have now about the energy story that we watched in the video?

➔ Students may mention transfer of energy from the water to the stopper, the loss of thermal energy and the gain of motion energy, and the transformation of thermal energy into motion energy. No need for them to describe the complete energy story at this point.

A quick activity that links motion energy and thermal energy

Rubbing hands

Rub your hands together vigorously.

Do you think your hands gained thermal energy? What makes you think so?

➔ My hands feel warmer so they gained thermal energy.

Reinforce the idea that an object's temperature increase is the indicator that the object's thermal energy has increased.

Remind students that in the video, thermal energy was transformed into motion energy. Ask if there is also a transformation as they rub their hands together. (Motion energy was transformed into thermal energy.)

Note: When you ask what made you think the object (hand or eraser) gained thermal energy, you are asking students to describe the evidence or indicator they use to "tell the energy story." The indicator of a change in thermal energy is a change in temperature.

(Optional) The eraser

Give each student a soft rubber eraser.

Put your finger on the area just above your upper lip and below your nose. This area is very sensitive to temperature changes. Touch the eraser to that area. How would you describe the temperature of the eraser?

➔ Response will likely be "Cool" for a room-temperature eraser.

Now rub the eraser back and forth very hard against the desktop about 40 times, then touch that part of the eraser that was rubbing against the desk to the area above your upper lip.

Do you think the eraser gained thermal energy? What makes you think so?

➔ The eraser felt warmer so it has gained thermal energy.

Note: Friction—in case someone mentions it in relation to warming hands or the eraser—is a *force*, not a form of energy. Friction is the mechanism that causes the eraser to warm or gain thermal energy, just as a force is the mechanism that causes a stationary ball to move after a collision. However, a detailed description of friction is beyond the scope of this investigation.

2. Explore

Groups of 4 – 20 Minutes

Ask the Question

Before students move into small groups, ask the question:

Now we come to today's investigation question: "What can temperature tell us about energy?"

Distribute materials

Have students move to small groups of 4.

Distribute the Thermal Energy Student Notebooks.

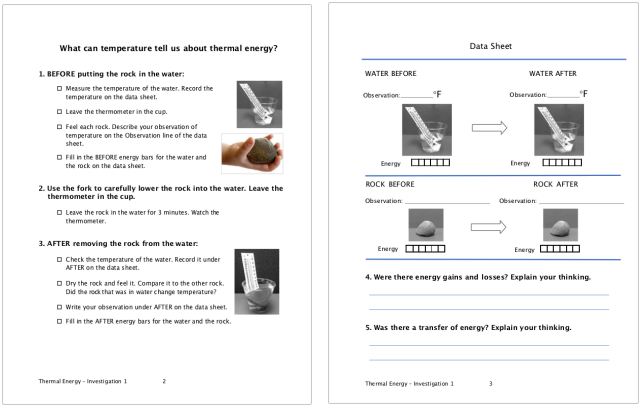
Give each group a cup with 2 room temperature rocks, 2 paper towels, a cup half-full of warm (110 degree) water, a plastic fork, and an alcohol thermometer.

You may need to show students how to read the alcohol thermometer, since they may be unfamiliar with interpolating between the scale marks. In the process, check the room temperature and announce it to the class.

Describe the simple investigation. It is outlined in the student notebook, on page 2, *What can temperature tell us about energy?*

Have students leave the dry rock in the empty cup. This will keep students from holding it, warming it in their hands, and possibly clouding the results of the investigation. Explain that students can decide if the rock in hot water changes temperature by comparing it to the dry rock. The dry rock hasn't been moved and is still surrounded by room temperature air. (Scientists would call the dry rock "the control.")

Tell students that **step-by-step instructions** are found in the Thermal Energy Student Notebook p. 2. They will also need to answer the questions on p. 3.



What can temperature tell us about thermal energy?

1. BEFORE putting the rock in the water:
- ☐ Measure the temperature of the water. Record the temperature on the data sheet.
- ☐ Leave the thermometer in the cup.
- ☐ Feel each rock. Describe your observation of temperature on the Observation line of the data sheet.
- ☐ Fill in the BEFORE energy bars for the water and the rock on the data sheet.

2. Use the fork to carefully lower the rock into the water. Leave the thermometer in the cup.
- ☐ Leave the rock in the water for 3 minutes. Watch the thermometer.

3. AFTER removing the rock from the water:
- ☐ Check the temperature of the water. Record it under AFTER on the data sheet.
- ☐ Dry the rock and feel it. Compare it to the other rock. Did the rock that was in water change temperature?
- ☐ Write your observation under AFTER on the data sheet.
- ☐ Fill in the AFTER energy bars for the water and the rock.

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Data Sheet

WATER BEFORE WATER AFTER

Observation:_____°F Observation:_____°F

Energy Energy

ROCK BEFORE ROCK AFTER

Observation: Observation:

Energy Energy

4. Were there energy gains and losses? Explain your thinking.

5. Was there a transfer of energy? Explain your thinking.

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Notebook pages 2 and 3

3. Make Meaning

All class – 20 Minutes

Have students come together in a discussion circle and bring their notebooks open to page 3. *What can temperature tell us about energy?* Data Sheet.

The purpose of this discussion is to reach consensus on how to answer the question: What can temperature tell us about energy and add this information to the Model of Energy chart.

Focus on the rocks.

What did you discover about the temperature of the rock that had been in the water?
➔The rock became warmer. Its temperature went up.

What evidence do you have that the rock became warmer?
➔I used my hands to compare it with the room temperature rock.

Did anyone have a different result for the rock?

What can you say about the thermal energy of the rock? Explain your reasoning
➔The thermal energy of the rock increased. I know this because its temperature increased, and temperature is the indicator of thermal energy.

Ask for some examples of how many energy bar boxes were filled in before and after.

Did anyone have an empty energy bar for the rock before it went into the water?

If so, ask if the rock could possibly become even colder? A "yes" means it must have some thermal energy to lose, so it must have some thermal energy at room temperature. This is a good time to introduce the idea that any object that can possibly get colder has some thermal energy. (In our classroom trials we found students are intrigued by this idea!)

Even an ice cube in your kitchen freezer has some thermal energy.
If you take that same ice cube to the North Pole, it could become even colder and lose some of its thermal energy.

If the rock gained thermal energy, what lost energy? Look in your notebooks. What did you write for item #4 in your notebooks?

Discuss the water data.

Do you have evidence that the water's thermal energy changed?

What did students have for water temperatures before the rock was put in to the water?
(Write responses on the board or a large piece of paper.)

What did they have for water temperatures after the rock was removed from the water?
(Write responses on the board or a large piece of paper.)

Even though there is some difference in the temperatures, everyone reports that the water temperature went down.

If you had not used thermometers today, would you be able to say for sure that the water lost thermal energy? Explain your answer.

Note: This question could launch an interesting discussion among students. Some may realize that the same evidence the rock gained thermal energy is the evidence that the water had to lose thermal energy.

Ask for some examples of how many energy bar boxes were filled in before and after.

What did you write for items #4 and #5 in your notebooks?
(This is an opportunity to hear different explanations about energy gains and losses and transfer from a number of students. Some may claim that the air in the room gained thermal energy.)

Return to the rock

Ask students to once again use their hands to compare the two rocks.

Has there been a change? Is the rock that had been in the water still as warm as it was earlier?

If the rock has lost thermal energy, what has gained thermal energy?

Again, students may claim that the air has gained, but what is the evidence?

Explain that students will be able to investigate this question of thermal energy possibly moving into the air by collecting more data in a future class.

Wrap Up

Ask students what answers they may now have for the investigation question, *What can temperature tell us about thermal energy?*

What can they add to the growing Model of Energy?

Possibilities include:

Temperature is the indicator of an object's thermal energy.

If an object's temperature increases, its thermal energy increases.

If an object's temperature decreases, its thermal energy decreases.

Also:

Motion energy can be transformed into thermal energy by rubbing.

Thermal energy can be transformed into motion energy (pop the stopper).

Thermal energy can't be seen.

Thermal energy can transfer from one object to another.