Heat Conduction

NC Standard 4.P.2.1

Grade 4 Physical Science

Throughout the guide, teaching tips are in red.

Activity Description & Estimated Class Time

This activity requires two 50-minute blocks. In Part 1, students experience heat moving from water to a piece of metal. In Part 2, students compare the speed of heat movement through different materials and decide whether those materials are conductors or insulators.

Objectives

Students will demonstrate knowledge and understanding of the following ideas and content:

- Physical properties of materials can be measured.
- Different materials conduct heat at different rates.

Students demonstrate this knowledge and understanding by measuring the amount of heat movement through different materials. They use the results of their measurements to classify the materials as either insulators, conductors, or something in between.

Correlations to NC Science Standards

4.P.2.1 *Compare the physical properties of samples of matter (strength, hardness, flexibility, ability to conduct heat, ability to conduct electricity, ability to be attracted by magnets, reactions to water and fire).*

Brief Science Background

When a spoon is put into a hot drink with its handle not touching the liquid, the handle remains cool at first, but after awhile, it starts to warm up. Heat moves from the spoon to the handle. This example of heat moving through a material is called heat conduction. Each kind of material conducts heat at its own rate, letting a specific amount of heat pass through in a given amount of time. Steel allows a large amount of heat to move quickly through it. Materials that behave in this way are called heat conductors. Styrofoam allows only a little heat to move slowly through it. Materials that behave in this way are called are called heat insulators. For each material, any sample of it and all parts of it will conduct the same amount of heat in the same amount of time. The amount of heat that a material will conduct is a property of the material.

Part 1 — Heat Moves –50 minutes

Materials

Materials for the whole class

- hot pot
- a dish pan containing hot water at about 120˚ F
- paper towels or rags for water spills (supplied by teacher)
- a "control" cup of hot water
- a "control" heat ring
- timer, watch, or clock with seconds (supplied by the teacher)
- a digital thermometer for demonstration purposes

Materials for groups of 2 students

- digital thermometer
- 8-ounce Styrofoam cup half full of hot water
- heat ring with white cable tie handle
- paper towels
- paper tray
- science notebook (supplied by teacher)

Preparation

1. About 20 minutes before the activity, begin heating water in the hot pot. When it is hot, mix this with cold water to make a supply of 120˚ F water in the dish pan. **This is hot water but it will not scald if spilled on someone.**
2. Fill a foam cup half full of hot water from the dish pan and set it aside. Also set aside a heat ring to be kept at room temperature; these will serve as classroom controls for the activity.
3. Prepare one cup half full of hot water for each pair of students.

Procedure

1. Give out the digital thermometers and show students how to turn them on and switch between degrees C and F. **Give an appropriate safety warning about sharp points and being careful with the instruments around people.** Ask students to set the thermometers on degrees F and hold the tip of the thermometer carefully between their thumb and forefinger. Ask them to watch the temperature reading, then ask them to watch what happens after they remove their fingers.
2. Place a "control" heat ring at the front of the room and take its temperature. Use the control heat ring to demonstrate how to determine its temperature. Hold the thermometer on it for 30 seconds then read the temperature to the class. Give out one room temperature heat ring per pair of students. Tell the teams to always hold and move the rings by the cable-tie handle. Ask students to record the temperatures of their heat rings.

Part 1 (cont.)

3. Place a “control” cup of hot water at the front of the room. Hold the thermometer in it to take its temperature. Record the temperature and tell the class what it is. Tell students that in a few minutes, you will ask them to put the heat ring in the hot water. Ask them to predict the temperature of the water *and* the heat ring in the cup a few minutes after they put the heat ring in. Ask students to read their predictions and accept all answers.

4. Ask students to write 0 seconds, 30 seconds, 60 seconds, 90 seconds, 120 seconds, 150 seconds, 180 seconds in their notebooks. Pass out cups of hot water. Ask students to take the temperature of their water and record it next to “0 seconds.” Proceed quickly to the next step.

5. Ask teams to use the cable-tie handle to completely submerge their heat ring in the hot water in their cup. Ask them to keep it submerged. **Do *not* put a heat ring in the control cup.** Begin timing when the students’ heat rings go in the water. Ask teams to record the water temperature (not the temperature of the heat ring) when you call out the time every 30 seconds for the next three minutes. Ask them to record their temperature measurements by the appropriate 30 second time interval written in their notebook.

6. After three minutes, ask students to take the heat ring out of the water, dry it off, measure its temperature, and record this temperature in their notebooks.

7. Take the temperature of the control cup of water (which does not contain a heat ring) and the temperature of the heat ring sitting out at room temperature (which was not put into hot water). Ask them to record these temperatures in their notebooks as “control water” and “control heat ring.”

Content Wrap-Up

Ask students to calculate the temperature change of the water in their cups and compare it to the temperature change that occurred in the control cup of water. Ask why they think the water temperature changed more in their cups than in the control. Likewise, have them compare the temperature changes in the heat rings. Ask what might explain the temperature changes they observed. Mention other examples of heat moving, such as a pan heating up and food getting hot, candle wax melting from the heat of a flame, or ice cream getting soft on a summer day. Ask students for other examples they can think of that are evidence of heat having moved. **By the end of the discussion, students should agree that heat moved from hot water in the cup to the heat ring. They should understand that heat energy can move from one object (water) to another object (the heat ring).**

Part 2 — Measuring Heat Movement in Different Materials
50 minutes

Materials

Materials for the whole class

- hot pot
- a dish pan containing water at 120˚ F
- 15 hot heat rings (in hot water) having black cable-tie handles
- 15 hot heat rings (in hot water) having white cable-tie handles

Materials for groups of 2 students

- 3 test item pieces marked with an x and a red dot: one each of aluminum, ceramic tile, and foam
- paper tray
- 1 black-handle heat ring (hot, to be given out when activity begins)
- 1 white-handle heat ring (hot, to be given out when activity is in progress)
- digital thermometer
- paper towels (supplied by teacher)
- science notebook
- access to the dish pan of hot water containing hot heat rings

Preparation

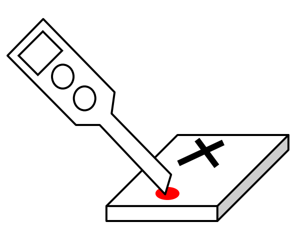
1. About 40 minutes before the activity, heat water as described in Part 1, mix it with cool water, and pour the 120˚ F water into the dish pan.
2. Place all of the heat rings in the dish pan (120˚ F) for 20 minutes before doing this activity. Be sure the cable-tie handles are sticking out of the water so that you can grab them without getting burned.
3. Place the test item pieces on paper trays to give out to groups.

Procedure

1. Remind students that in the previous activity, they saw heat move from one object to another. Then tell them that one of the properties of matter is how quickly heat moves through it.
2. Explain that students will use hot rings of metal as a source of heat. They will measure how much heat moves through different materials from the X by measuring change in temperature at the red dot. Demonstrate temperature measurement with the class gathered around or using a document camera.

   A. Show students the X and the red dot on the ceramic test piece.

   B. With the test piece on a paper tray, place the thermometer tip on the red dot for 30 seconds and record the temperature in degrees F.



Ceramic test piece

Heat ring

Part 2 (cont.)

C. Remove a heat ring from the hot water and dry it. Place it on the X on the ceramic test piece. Touch the thermometer to the red dot on the test piece and start the timer. Take temperature readings at 30 seconds, and another reading at 60 seconds. Record these temperatures. Return the heat ring to the water bath and dry off the ceramic test piece. **Note that the aluminum test piece begins to cool after 60 seconds. Heat conductivity allows heat to pass all the way through objects. This offers an opportunity to discuss the property of heat conduction.**

3. Ask students what they noticed. Accept all answers. Ask them to do a little mental math to calculate the temperature change.

4. Ask students to look at their test pieces and predict which one will allow heat to move the fastest and which will allow it to move the slowest.

5. Ask students to use the demonstrated technique to test their predictions.

- Have students do their first tests with heat rings having handles of one color. When they finish with these, put these rings back in hot water.
- For their second test, have students use the ring with a different-colored handle. Alternating in this way brings the rings back up to temperature for the next test.
- For their last tests, students will re-use their first rings.

Content Wrap-Up

1. Ask students for their most surprising result and discuss their responses.

2. Ask students what they think it means if the temperature of a material increases a lot? **It means that heat moves easily through the material.** Ask students what it means if the temperature of the material does not heat up much. **It means that heat does not move well through the material.** Tell students that the word for materials that move heat well is conductor and the materials that do not move heat well are called insulators.

3. Ask the students to look at their temperature data and record whether they think each of the three materials is an insulator or a conductor. Discuss the materials one at a time with the class comparing results and classifying them as conductors or insulators. **This could generate discussion about the ceramic test piece. Ceramic conducts heat; many casserole dishes and pie plates are made from it, so it conducts heat from the oven the food inside it. However, ceramic doesn't conduct heat nearly as quickly as aluminum, so it is better for keeping hot drinks hot while warming (but not burning) the drinker's hands.**

Guided Practice

Guided Practices are similar to typical tests, but require students to reveal their thinking about content. They serve as a practice before a test and should not be graded. They are intended to expose misconceptions *before* an assessment and to provide opportunities for discussion, re-teaching, and for students to justify answers. They are best given as individual assignments without the manipulatives used in the activity. In that context, pose the following "test items" to the class. Ask them to write responses in notebooks.

Moving heat is important in the kitchen for cooking. Some materials are used in specific kitchen items for their properties as conductors or insulators. Explain how you think the heat conduction properties of the following materials make them useful for the items listed.

A. Heavy iron skillet or frying pan

B. Ceramic tile lying flat on the table, upon which a cake just taken from the oven is placed

C. Wooden spoon used to stir boiling liquid

D. Plastic handle on a steel cooking pot

E. Cotton filling in an oven mitt

Answer Key

A. The iron conducts heat for even cooking.

B. Ceramic serves as an insulator to keep the hot pan from damaging the table.

C. Wood is a poor conductor of heat (insulator) so it stays cool as one stirs hot food.

D. Plastic is a poor conductor (insulator) so it stays cool enough to pick up when the pan is hot.

E. Cotton is an insulator that allows people to pick up hot pans without burning their hands.

Appendix

Common Student Preconceptions About This Topic

Many young children think of hot and cold as two distinct phenomena, with one being the opposite of the other, but by the time they are 10-12 years old they understand that hot and cold are points in a continuum. Distinguishing between the concepts of heat (a form of energy) and temperature (a manifestation of the amount of heat energy present) is difficult for people of all ages. Instead, many people think that heat is hot, but temperature can be hot or cold. Many children think temperature is a property of a material or object. For example, a metal spoon taken from the kitchen drawer is cold, and so is the porcelain bathroom sink. A blanket on the bed is warm, though, and so is the carpet.

With regard to movement of heat, children tend to view heat as a fluid-like substance that can flow into or out of solid objects. For example, when a long piece of metal is heated at one end and the other end eventually warms, students often think that excess heat in one spot "overflowed" to another place, like a liquid. Similarly, they think of the sensations of hotness or coldness as something entering or leaving the body. It is not until students are much older that they can accept the idea of cold as an absence of heat, and that heat always moves from warmer places to cooler ones.