Teacher's Guide for "No pots. No pans. No problem!"

Overview

This heat transfer activity highlights the Native Americans use of fire-heated stones to boil water. It provides students with an interesting application of heat transfer by conduction, and an introduction to how scientists can determine the amount of heat that has been transferred. By doing the activity, students should gain a better understanding of heat transfer and a greater appreciation for how Native Americans used available resources to accomplish tasks. (This activity was created by Rod Benson, Earth Science Teacher at Helena High School)

To learn more about this topic . . .

A PowerPoint presentation that goes with this activity is available on my web site. To download it and obtain a student handout, go to

www.formontana.net/bones.html

Pre-Activity Questions (to be discussed/completed together before the activity)

1. What are the three ways that heat is transferred from one material (or place) to another? Examples?

Conduction, convection, and radiation . . . have students come up with examples.

2. Before trade relationships with Europeans resulted in ownership of metal goods, Plains Indian Tribes did not have metal pots and pans, yet they did boil water to cook certain foods. What did they use for containers?

Allow students to suggest ideas, before explaining how Native Americans in the Montana area dug a small pit and then lined it with a hide(s). Some tribes in other regions used tightly woven baskets.

3. What are some ways you might bring the water in such a container to a boil?

Again, allow students to make suggestions. Native Americans heated stones in a campfire until they were glowing hot. Some tribes used antlers to pick up and place the stones into the pit. One way that boiling was used was to obtain grease to make pemmican, a mixture of pulverized jerky and dried berries held together by the grease. Evidence of numerous boiling pits at the Head-Smashed-In Buffalo Jump in Alberta, Canada indicates that large leg bones were smashed to remove the nutritious marrow, and then boiled to render the grease.

4. In this activity you will be determining how much heat has been added to water. What measurements will you need to make?

Now is good time to explain (general overview) the activity.

Measurements that will be needed include the mass of the water, and the temperatures of the water before and after the heat is added.

5. The specific heat of water is 1 calorie/gram x °C. What does this mean?

This means that it takes one calorie of heat to raise the temperature of one gram of water by 1 ℃. Ask student how many calories it would take to raise the temperature of 50 g of water from 50 ℃ to 75 ℃. . . . Answer: 1,250 calories

6. The unit that will be used to express your answer is "calories". What is a calorie?

A calorie is an amount of energy. It is the amount of energy needed to raise one cubic centimeter of water by one degree C. Nutritionists use kilocalories (equal to 1000 calories), and typically label them either as "kcal" or as "Calories" with a capital "C".

Procedures

Students will need the following materials:

goggles, 16 oz. paper cup suitable for hot drinks, thermometer (I use plastic alcohol thermometers with metal backing that go up to 100 C.), Bunsen burner, metal tongs, room temperature water, beaker or graduated cylinder for measuring water, stop watch, samples of quartzite (30-100 g. samples work best)

1. Put your goggles on now and keep them on until you have completed the activity.

2. Add 200 ml of room temperature water to the cup. Insert a thermometer and set it aside for now.

3. Obtain a stone (quartzite is the type of rock used in this activity).

4. Check the temperature of the water now. Record the temperature (°C) on the data table. Remove the thermometer and set it aside for now.

5. Light your Bunsen burner. Using tongs (and wearing goggles!), hold the stone above the tip of the flame for three minutes.

6. Use tongs to gently set the hot stone into the cup of water (don't splash!). Put the tongs aside and do not touch them. They end of the tongs that held the stone will remain hot for several minutes.

7. Put the thermometer back into the cup of water so that it is not touching the stone. Watch what happens to the temperature of the water. When the temperature stops rising, record it on the data table.

8. Use your data and the formula to determine how many calories of heat were transferred from the stone to the water.

Data Table (sample results in italics)

C . . . Specific Heat of water is 1 calorie/gram x °C

m . . . Mass of water: 200 g

Temperature of water before: ***24*** ***°C (example)***

Highest temperature of water after the hot stone was added: ***42*** ***°C***

ΔT . . . Change in Temperature of water: ***18*** ***°C***

Formula

C x **m** x **ΔT = Heat transferred in calories**

1 cal/g °C x 200 g. x 18 °C = 3,600 calories . . . or 3.6 food Calories

Follow-Up Questions

1. How would the final temperature of your water have been different if the cup had contained 100 ml of water instead of 200 ml?

   The 100 ml of water would have gotten hotter.

2. How would the final temperature have been different if the rock that you had placed into the 200 ml of water had been twice as massive? (Assume that the larger rock was the same temperature as your rock.)

   Since a more massive rock (at the same temperature as a less massive rock) would have contained twice as much heat, it would have caused the change in temperature to be twice as much .

3. If some water splashed out of the cup when you put the hot stone in, it would have affected your results. Explain why.

   It would have increased the temperature of the water in the cup. The smaller amount of water (that did not splash out) would become hotter as heat is added to it.

4. How was the heat transferred from the stone to the water? (conduction, convection, or radiation)

   Conduction . . . heat was transferred from the hot rock to the water by direct contact.

Not all of the heat in the stone ended up in the water. Fill in the blanks with the appropriate term (conduction, convection, or radiation).

5. radiation: As the rock was being moved from the flame to the cup, the rock gave off infrared waves, transferring heat to its surroundings.

6. conduction: As the rock was being moved, heat was transferred to air molecules that collided with the rock.

7. conduction: As the hot rock sat in the cup, both the rock and the water transferred heat to the cup.

8. convection: As the hot water warmed the air above it, this air began to rise, taking heat toward the ceiling.

9. conduction: If you dropped the fire-heated stone and then picked it up with your fingers, heat from the stone would have caused major discomfort to your fingers.

10. radiation: A heat lamp shines down on food at a restaurant buffet, keeping the food warm for customers.

11. radiation: The Sun transfers heat to the Earth.

12. convection: Unfortunately much of the heat produced by burning wood in a fireplace goes up the chimney.

13. radiation: You feel warmth as you put your hand near someone's face.

14. convection: This is why people sometimes say, "heat rises." (a statement that isn't always true)

15. convection: This is the reason your house loses heat every time you open a door to let the dog out (or in).

16. In the days before they were able to trade for pots and pans, American Indians must have done a lot of experimentation as they sought ways to boil water more efficiently. List 5 things (materials, methods, etc.) they may have experimented with. (5 points)

    a.

    Answers will vary.

    b.

    c.

    d.

    e.

Possible Extensions

For more information about Native American historic uses of metal to enhance your discussion of pots and pans, look up "metallurgy" in The Encyclopedia of American Indian Contributions to the World by Keoke and Porterfield.

These "extensions" listed below are optional learning activities to do in the days following the "No Pots? No Pans? No Problem" activity. They can be used as discussion topics, lab activities, or as projects for individual students or small groups of students.

Extension #1
Like individuals within all societies, some American Indian people experimented with methods and materials to find the most efficient way to accomplish tasks. List up to three methods or materials people of the Plains Indian Tribes may have experimented with as they sought ways to boil water more efficiently prior to Colonization.

Extension #2
Design an experiment to determine which type of rock (basalt or quartzite) transfers heat better when used as a boiling stone. Do the experiment and make a graph to show your results.

Extension #3
Design an experiment to determine whether there is a correlation between the mass of the stone and the amount of heat that is transferred. Do the experiment and then make a graph to show your results.

Extension #4
An important spiritual practice for some American Indian people of many tribes is the use of sweat lodges. These lodges are steam-filled enclosures with room for several people. There is no fire inside. Design a plan to build a simple enclosure and fill it with steam, using resources that would have been available 300 years ago. Describe your plan (step-by-step) and include a list of resources that would be needed.

> NOTE: One resource for information about sweat lodges is a book titled The Native American Sweat Lodge, History and Legend by Joseph Bruchac (Abenaki), a respected author.