UTAH OFFICE OF
ENERGY DEVELOPMENT

Using Geothermal Energy

Grade/Subject: Physics

Strand/Standard Physics 2.2 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system. Emphasize that uniform distribution of energy is a natural tendency. Examples could include the measurement of the reduction of temperature of a hot object or the increase in temperature of a cold object. (PS3.B)

Lesson Performance Expectations:

- Students will design a system to deliver hot water through a system and deliver it at a defined temperature.

Materials: (per group)

- Empty two-liter soda bottle with bottom cut out
- Adaptable stopper spouts
- Plastic tubing (surgical) and connectors (some Y shaped)
- One hole rubber #4 stopper
- Insulating materials (packaging, paper towels, bubble wrap)
- Digital thermometer
- Hot pads
- Ring stands with a ring large enough to hold a 2 liter bottle, 4 inches.
- Plastic hose clamp, ie Hoffman Screw-Compressor Clamp
- 2 500-2000 mL plastic beakers

Time: 45 minutes

Teacher Background Information:

1. The easiest way for students to access 80℃ water is for you to have a large container of water kept at a constant 80℃ temperature.
2. Students may figure out how to dilute the hot water with cooler water. The important aspect is that they can document where the heat loss and gain is.
3. Students also may use their tubing to create a cool water bath to cool the water as it passes through. The tubing may lose a surprising large amount of heat.
4. Students may surprise you with the ideas they have.
5. For students to calculate the heat change in the system, they will need to be introduced to the math: $q = mc\Delta T$, where m is the mass of the sample (1mL =g), c is the specific heat (1 C), and ΔT is the temperature change
6. Students may figure out to insulate their pop bottle to reduce heat loss.

https://geology.utah.gov/docs/emp/geothermal/geothermal_in_utah.pdf

Student Background Knowledge:

1. Students should have used the formula $q = mc\Delta T$ on some simple calculations.
2. Students should understand basic insulation properties. They have done several activities in previous grades to create insulated systems.

Teacher Directions: A standards-based lesson engages students' curiosity, interest and motivation to learn more. Time and space for the students to experience the phenomenon and ask questions is essential. The student sheet provided below provides guidance but is only one example of how students might respond.

1. Start heat water to 80℃ and determine how to maintain that as closely as possible.
2. Allow students time to read the information on the website provided. It might be easiest to project the information. The website has only two pages.
3. Read the intro with students and describe the materials and their locations. Students may be unfamiliar with the term "hot water heaters" as they are less common in Utah. They work by running hot water through radiators, usually located near the floor. High end homes may have them embedded in floors.
4. Define student groups if necessary.
5. Give students time to design on paper and to decide what information they will collect on their data table. You may wish to check the data table before they begin. If they do not indicate volumes of water used and start and finish temps, they will be unable to do the calculations needed.
6. Allow time for testing and retesting.
7. If you wish to make this a "contest", the winner would be the group that meets the criteria with the least heat loss.

Assessment of Student Learning.

1. Which method conserves heat energy while lowering temperature?
   A. Allowing warm water to cool in the air.
   B. Allowing warm water to cool wrapped in an insulator.
   C. Allowing warm water to mix with cooler water.*
   D. Allowing warm water to remain very still.

2. Use the formula $q = mc\Delta T$, where m is the mass of the sample (1mL =g), c is the specific heat (1 C), and ΔT is the temperature change to calculate the change in energy (KCal) for 500 mL of 80℃ water cooled to 50 ℃.
   a. 30 c
   b. 80 c
   c. 500 c
   d. 1500 c*

3. What determines where the heat loss goes when water cools?
   A. The amount of water.
   B. The initial amount of water.
   C. The specific heat of the water.
   D. The environment the water is in.*

4. Why does adding cool water to warm water reduce heat loss to the atmosphere?

A. The cool water absorbs the heat.* B. The hot water heat loss is reduced. C. The cool water insulates the hot water. D. The total volume of the water is unchanged.
Extension of lesson and Career Connections: Ask students to access the Utah Forge Project at: https://utahforge.com/ and report on this Utah geothermal project. Access https://www.energy.gov/eere/jobs/find-clean-energy-jobs for students to see what types of employment are found in alternative energy development.

Title: **Using Geothermal Energy**
Name______________________________

Introduction: Begin this activity by opening this webpage and reading the information. Look for the location of your home and school on the map.
https://geology.utah.gov/docs/emp/geothermal/geothermal_in_utah.pdf

Imagine in this activity that your home sits on rock with hot water in fissures below. The hot water can be piped out at a temperature of 80℃.

Your challenge is to deliver the underground water to hot water heaters in your home at a temperature of 50℃ (warm enough to change air temperature to about 20℃) without a significant net loss of energy. You will have a variety of materials to work with and do not need to use all of them.

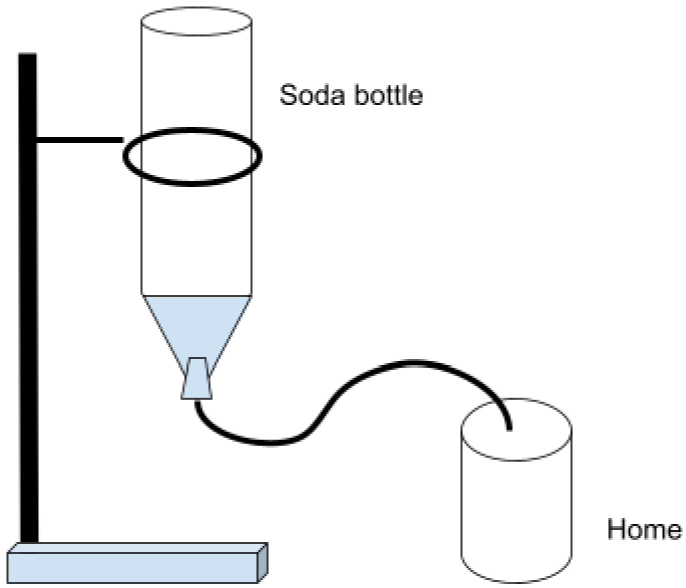
Materials: 2-liter soda bottle, plastic tubing, tubing connectors and clamps, stoppers, stopper adapters, insulating materials, 2 liter plastic beaker, hot pads, hot water, digital thermometer

Safety information: Water at 80℃ can cause discomfort to your skin. Handle the hot water with hot pads and pour carefully.

Criteria: Water is delivered out the end of the tube at 50℃. It must remain at this temperature for 30 seconds or more. The heat loss is captured and measured and as little as possible is released to the environment.

Constraints:
1. The system should seem possible for a home. (no ice cubes)
2. 500 mL at a time can be tested. Additional tests are allowed.
3. Any heat loss or gain must be identified and measured.
4. Heat loss must be prevented or reclaimed at least partially.
5. Careful documentation of the amounts of water used and its temperatures must be made. Your results may have to be verified.

Design your first attempt. The set-up for delivering the hot water is as shown:



Data: Record your results. Add titles to the columns.

Re-test. What will you do differently a second time?

Re-test. What will you do differently a third time?

Analysis:

1. Did you achieve 50℃? For how long?

2. How was heat lost from the hot water? How much heat was lost?

3. Where did the heat go?

4. What is the total heat change in your system? (use $q = mc\Delta T$) How much was lost to the environment?

5. From the map on the website, how likely are people living in your area to have a source of geothermal energy?

6. What are the benefits of geothermal energy?

7. What are drawbacks?