Activity: Modeling Geothermal Exchange

Instructor Background

Objective

Students will model how heat transfers between the ground and water in a geothermal exchange system and explain how this process can be used to heat or cool buildings.

Materials

- small cups
- baking pans (at least 3" deep)
- thin, flexible tubing (at least 1.5 x length of the pan)
- scissors
- tape and/or modeling clay
- digital thermometers
- containers of warm and cold water (at least 20°F difference)
- Syringes (needleless)
- goggles
- tongs
- towel
- ring stand (optional)

NGSS

DCI: Earth's Materials and Systems, Natural Resources, Conservation of Energy and Energy Transfer
SEP: Developing and Using Models, Analyzing and Interpreting Data
CCC: Systems and System Models, Cause and Effect, Energy and Matter

SDGs

7: Affordable and clean energy
11: Sustainable Cities and Communities

Credit: L. Mossa, AGI

Steps

1. **Introduction Discussion:** Begin by asking students to think about how heat moves in everyday life. For example, "Why does the ground feel cool when you dig into it, even on a hot day?" or "How does a spoon left in a cup of hot chocolate become warm?" Facilitate a short discussion about how energy moves between warm and cool materials. On the board, draw diagrams with arrows showing the direction of heat flow.

2. **Prepare the Model:** Have students make a "drip cup" by cutting a hole in the bottom of a cup just large enough to insert the flexible tubing, and a "drain cup" with a hole in the side (toward the top) large enough for the tubing. Students will then place each end of the thin, flexible tubing in the bottom of the "drip cup" and side of the "drain cup." As needed, add more cold water to the "drip cup" so the water level stays above the tubing to facilitate draining. Have them hold or secure the drip cup a few inches above one end of the pan and place the drain cup just outside the other end, with the tubing running along the bottom of the pan. They may use tape and/or

modeling clay to secure the tubing to the cups and/or pan.

3. **Make Predictions:** Go through the procedure with students, then have them make predictions about what they expect to happen using words and diagrams.

4. **Set Up the Model:** Have students measure and record the temperature of the cold water and set it aside. Pour warm water into the pan until it at least covers the tubing. Students then will measure the temperature of the warm water.

5. **Run the Model:** Fill the "drip cup" three quarters full with the cold water and allow it to flow through the tubing and into the "drain cup". Once the water has reached the drain cup, measure and record the temperature. Empty the drain cup using the syringe. Repeat the procedure two more times.

6. **Analysis:** Have students calculate the averages for their initial cold-water temperatures, warm-water temperatures, and drain-cup temperatures, in addition to calculating the temperature differences between the initial cold temperatures and the drain cup temperatures. Ask students to draw a diagram explaining what happened as cold water flowed through the model.

7. **Discuss:** Facilitate a class discussion about the model and results:

- How did the temperature change as the water moved through the tubing? Consider individual trials and average results.
- Where did the heat transfer occur in the model, and in what direction?
- If this model depicted part of the Earth, what might the warm water, cold water, and tubing represent?
- How could a system like this help people heat or cool buildings?
- What factors in this model might change how much heat is transferred?

8. **Extension:** Have student groups brainstorm one modification (e.g., tubing length, different materials, or water depth) to improve heat transfer. If time allows, test their revised designs and compare results.