Topic: Electrical Properties of Matter

Time allotment: 50 minutes

Overview: Electronics are everywhere in our society, but the inner workings of how their circuitry work are not apparent. Stripping away the bells, whistles, and LCD screens reveals the basic form of a circuit, consisting of an energy source connected to the versatile resistor of choice. Even more fundamental than a circuit, deconvoluting electricity as electrons flowing through a conductive medium is the foundation for our electronic world. In this lesson, students explore the ability of water and other materials to act as conductors to varying degrees of success, controlled by the electrical conductivity of different media.

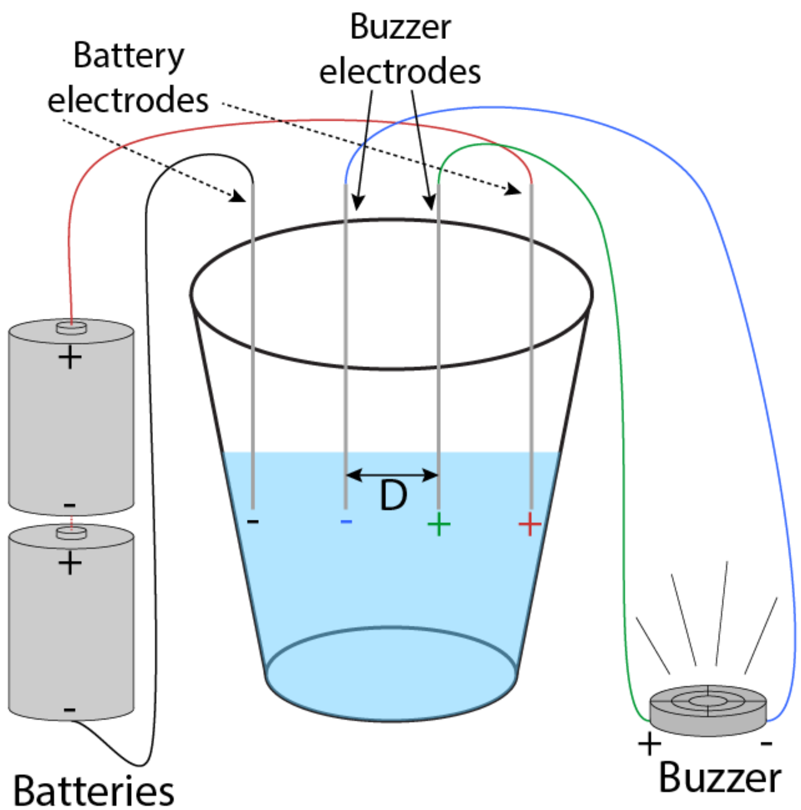

Figure 1. Experimental setup for student groups. The buzzer and battery electrode positions can be switched.

1) **Engage (5 min)**:
   - Instructor uses a clear container (fish tank) full of salty water as a conductor to complete a circuit
     - Materials:
       fish tank/clear container
       small buzzer
       2 D-cell batteries (or larger)
       4 conducting wires, alligator clips recommended
       2 electrodes (paper clips or tin foil wrapped on popsicle sticks)

- Keep salinity of water secret. Have students predict what will happen if the electrodes are inserted into the water. (light up = illuminate)
- With the light illuminated, move the electrodes around the container keeping the same spacing between the electrodes – the light should not change intensity.
- With the light illuminated, change the distance between the electrodes to change the light intensity.
- Do not explain how or why the light bulb illuminates or changes intensity until Explanation or Elaboration time.

2) Exploration (10-20 min):

- In groups of 3-6, the students create, experiment with, and test their own water circuits using tap water, distilled water, and distilled water with salt added.
    - Materials:
      Paper or plastic cup
      2 electrodes (tin-foil covered object or paper clip)
      4 conducting wires, alligator clips recommended
      small buzzer
      2 D-cell batteries (or larger)
      Distilled water
      small cup of salt (other solutes/mixtures could be used: sugar, oil, lemon juice)
      stir/mixing bar

- The students are not supposed to make the buzzer sound by having the electrodes touch
- Students draw their experimental setup/circuit in their notebook and record observations of how the three different solutions affect their water circuit.
    - How far do the buzzer electrodes have to be apart for the buzzer to sound (D in Fig. 1)?
    - How far do the buzzer electrodes have to be away from the battery electrodes?
    - Do different solutions give different distances for the electrodes?
    - What happens if you switch the order of the electrodes? There are many possible combinations
- Encourage thought on why the salt/water closes the circuit.

3) Explanations (10 min):

- Together as a group discussion, the students explain with teacher guidance:
    - How the electrical circuit was created using the materials given
    - How the light bulb was illuminated (looking for closed circuit)
    - Which solutions closed the electrical circuit and which did not
    - How adding salt changes the distilled water from an insulator to a conductor
- Throughout this discussion, contribute these formal statements:
    - The saltwater closes the electrical circuit that flows from the current source (battery), through the resistor (light bulb), and back to the source.
    - The electricity flows through the saltwater to close the circuit and is a conductor. The distilled water does not conduct electricity and, thus, is an insulator.
    - A current is the flowing of electricity through something

- Electricity flows because <u>electrons</u> move through the conductor (like water particles in a river)
- Salt in the distilled water <u>dissolves</u> into ions that pass the electrons through the water
- Distilled water has no (or very few) ions and acts as an insulator
- Tap water (and most natural water) has ions and is a conductor
- Depending on the size of the battery, electrolysis might cause tiny bubbles to form on the battery electrodes.
- Why does the distance between the electrodes matter? An electrical field is created in the medium of choice, and the electrical conductivity of the medium determines how quickly the voltage drops away from the battery electrodes. When the buzzer electrodes are spaced too closely together, the electrical gradient between the electrodes is too small. A more understandable analogy is that the electrons move downhill (electrically speaking), so when the buzzer electrodes are too close, the hill becomes too flat. Then, the electrons do not move in either direction because they do not have an obvious "downhill" direction. By moving the electrodes further apart, the hypothetical hill becomes steeper and steeper.

4) **Elaboration (15 min-1 hr, or if time allows)**:

- Students test the conductivity of sand, clay, or a mystery mixture using a similar procedure as teacher demonstration
    - Materials:
      3 opaque cups filled with: 1) sand, 2) clay, 3) soil, 4) sand/clay mixture, or 5) sand/saltwater mixture
      2 electrodes (tin-foil covered object or paper clip)
      4 conducting wires, alligator clips recommended
      buzzer
      2 D-cell batteries (or larger)

- Have the students use the buzzer as a surrogate voltmeter:
    - At what distance of buzzer electrodes does the buzzer no longer sound for each medium?
    - Approximately how loud is the buzzer as the buzzer electrodes move from touching the battery electrodes (ignores the surrounding medium) until their maximum distance apart? Can have the students plot a relative loudness vs. distance or make a table.
- Students order the mixtures from best conductor to best insulator

5) Evaluation (10 min):

- Model drawing with labels from Exploration (similar to Fig. 1)
- Graphical or written presentation of the order of conductors and insulators from Elaboration, but can be part of the normal (water only) lesson.
- Create a table or graph that relates the distance of the buzzer electrodes to the loudness of the buzzer.
- Draw the different configurations of the electrodes that were tested and explain why some worked and others did not.

- Answer the following questions:
  - Most water has ions dissolved in it. That makes most water a ____________.
  - What has to flow for electricity to exist?
  - Would you go swimming with a car battery? Why or why not? What is required for a closed circuit while you are swimming?
  - What would happen to the activity if more batteries or a car battery was used?
  - Extension: How fast do electrons move?

5th grade TEKS:

5.1A

5.2A,B,C,D,F,G

5.3A,C,D

5.4A,b

5.5A,C,D

5.6A,B