Squishy Circuits

Overview: Understanding the characteristics of electricity, types of conductive and insulating materials, and basic circuitry are essential knowledge for students as devices that are powered by electricity become more and more prevalent in our daily lives as we move through the digital age. A great way for elementary-aged students to investigate and experiment with electricity in a safe, but hands-on way is through the creation and manipulation of conductive and insulating doughs, or "squishy circuits". Through this activity students will be exposed to how electricity flows, the effect of a closed versus an open circuit on the flow of electricity, and the resistive effect of different materials serving as insulators.

Procedure: Using the materials needed to make the dough, along with adult support and supervise as needed, have students measure and combine ingredients to create conductive dough following this recipe:

1 cup water
1 ½ cups flour (gluten-free can be used)
¼ cup salt
3 tbsp. cream of tartar
1 tbsp. vegetable oil
food coloring of choice

1. Mix water, 1 cup of flour, salt, cream of tartar, vegetable oil, and food coloring in a medium sized pot.

2. Cook over medium heat and stir continuously, as mixture will begin to boil and get chunky.

3. Keep stirring mixture until it forms a ball in the pot.

4. Once a ball forms, place the ball on a lightly floured surface **(IT WILL BE HOT!)**

5. Slowly knead the remaining flour into the ball until you've reached a desired consistency.

6. Store dough in an airtight container. If stored properly it will last for several weeks.

To make the insulating dough, students will need to combine the following ingredients:

1 ½ cup flour
½ cup sugar
3 tbsp. vegetable oil

½ cup distilled water
A different color food coloring than what you used with the conductive dough.

Have students follow this procedure to create insulating dough:

1. Mix solid ingredients, food coloring, and oil in a pot or large bowl, setting aside ½ cup flour to be used later.

2. Add a small amount of distilled water (about 1 tbsp.) and stir. Repeat this until the mixture absorbs a majority of the water.

3. Knead you mixture into a lump, adding water as needed until a ball with a sticky, dough-like texture is formed.

4. Finally, knead the remaining flour into your dough (a little at a time) until a desired textured is reached.

5. Store in an airtight container. If properly stored, your dough will last for several weeks.

Once your prepared dough is cool to the touch, you are ready to start building circuits! Take two pieces of conductive dough and roll them into long cylinders. Take a battery pack (easily purchased at Radio Shack) and place one output wire into one of the dough cylinders and the other output into the other dough cylinder. Using a LED light with positive and negative terminals, connect the two dough cylinders using the LED. The LED should illuminate.

Discuss with students how although the batteries are not coming directly in contact with the LED light, the electricity from the battery is being "conducted" by the materials in the conductive dough (salt, water, cream of tartar). This opportunity can also be used to show students about formation of the closed series circuit. Point our how the circuit that you've created forms a closed shape/circle. Much like a ring, it has no beginning and no end. Electricity only flows through closed circuits. Pull one of the output wires or break a piece of the dough cylinder so that there is a gap in the circuit. What happens to the light when the circuit is opened? What happens to the illuminated LED of the two dough cylinders come in contact with one another? (LED goes off/short circuit)

Repeat the experiment using the insulating dough. Does the LED illuminate using this dough? What is the difference? Demonstrate how a cylinder of this dough can be placed between two conductive dough cylinders to prevent a short circuit from occurring. Have students design and create their own working series circuits using both the conductive and insulating dough. Provide support in trouble shooting circuits that do not work. Have students describe/explain their designs through their primary modality.

ASOL Covered in this Activity:

5S-SI 2: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which

i)Inferences are made and conclusions are drawn.

5S-FME2: The student will investigate and understand the characteristics of electricity. Key concepts include

a) conductors and insulators;
b) basic circuits;

HSS-SI 1 : The student will plan and conduct investigations in which

e) variables are manipulated with repeated trials.

Materials Needed:

- Tap water
- Distilled water
- Flour
- Salt
- Sugar
- Cream of Tartar
- Vegetable Oil
- Food Coloring (Optional)
- Pot
- Stove
- Mixing Spoon
- Batteries
- Battery Pack
- LEDs, Motors, Buzzers, etc.

Instructional Setting: Classroom

Community Connections and/or Peer Interaction: Have students work with a peer to collaboratively design a larger or more complex circuit or object by combining their materials.

Have a students keep a visual or written log/scrapbook of different examples of items that have circuits or use electricity at home or in their community.

Have students create a model or piece of artwork using their dough and materials that they can take home to share with family/friends.

Functional Activity/Routine: Students will use measurement skills to properly identify and measure the ingredients from the recipes for the conductive and insulating doughs. Students will use sequencing skills to combine recipe ingredients and to follow the cooking/preparation procedure.

Strategies to Collect Evidence:

Create a task analysis checklist of steps needed to assemble a working circuit with a given set of materials. Evaluate a student's performance on completing these steps.

Take pictures/video of students assembling their circuits.

Have students sequence or match images of the steps of squishy circuit assembly into the correct order.

Have students illustrate closed and open circuit models.

Have student identify the dough/object that will conduct electricity and/or the dough/object that will insulate.

Keep student squishy circuit creations as artifacts of learning.

Specific Options for Differentiating this Activity:

- Provide assistive technology as needed for all aspects of this activity.
- Provide audio and/or video recordings of the steps needed to create the dough and assembly a working circuit for student review.
- Allow tactilely defensive students to draw, color, or otherwise illustrate the process for designing a working circuit.
- Use audible loads (such a buzzers) rather than LEDs for students with visual impairments.
- Provide assembly templates for visual learners to refer to when assembling circuits.

Extension Ideas: Have students experiment with different common objects to determine whether they are conductors and insulators of electricity.

Using alligator clip wires, batteries or battery packs, and LEDs have students insert objects into their circuits (pennies, paper clips, popsicle sticks, paper, foil, etc.) to see which objects allow the LED to remain illuminated when they are inserted into the circuit.

Using the concept of open/closed circuits, have students build their own light switches using brass brads and paper clips. Connect your alligator clip wires to two brads and use a paper clip to close and open the circuit.

References: http://courseweb.stthomas.edu/apthomas/SquishyCircuits/