Day 3
Paper Circuits 1: LED Name Tag

Overview:

What is a paper circuit? A paper circuit is a fun and engaging way to explore the world of circuitry. We use simple everyday materials as well as conductive tape, LEDs and batteries to create our paper circuit name tags. This activity provides the opportunity for trial and error, making mistakes and starting all over again. Students of all ages are challenged in a variety of ways, resulting in a basic understanding of how circuits work.

Materials:

- Scissors
- Cardstock
- Scotch tape
- Small binder clips or paper clips
- Bone folders or pop sticks
- Pencils
- Markers
- Copper tape
- LEDs
- Coin cell batteries

Introduction/Discussion

Begin the discussion by reviewing the activity from the previous week. *What did we do? What tools/materials did we use? How did we use them? What skills did we need to successfully complete our project?* If one of the participants is new to the group or was absent last week, use this conversation to help fill them in on what the group has been doing. Have the returning students explain the experience from the previous session.

Additional Questions: What do you know about electricity? What do we use electricity for? Can we see electricity?

The Paper Circuits activity continues with an exploration of circuitry from the previous week and introduces new materials. The introduction discussion should cover the circuit basics from the Soft Circuits activity such as how circuits work and the basic materials: LEDs, wires and batteries.

Hand out an LED and a coin cell battery to each student, and give them a few moments to make some observations about the materials. *What do you notice about the materials? Have you ever seen anything like this before? Are there any special markings? Any physical properties you find interesting?* If they notice the markings on the battery, you can discuss the polarity – positive and negative. *What does this mean?* If they don't notice, you can point out the length of the legs on the LED – one is longer than the other. *What does this signify? Can you use the battery to light up the LED?*

Helpful Hint: Like batteries, LEDs also have polarity; the longer leg is the positive and the shorter one is negative. It will only work if you put the longer (+) leg on the positive side of the battery.

Have the students separate the LED from the battery, and place them on the floor at a short distance from each other (a couple inches is fine). *How can we connect the battery to the LED? What did we use for the Soft Circuits activity to connect the LED to the battery? Can we use anything else?*

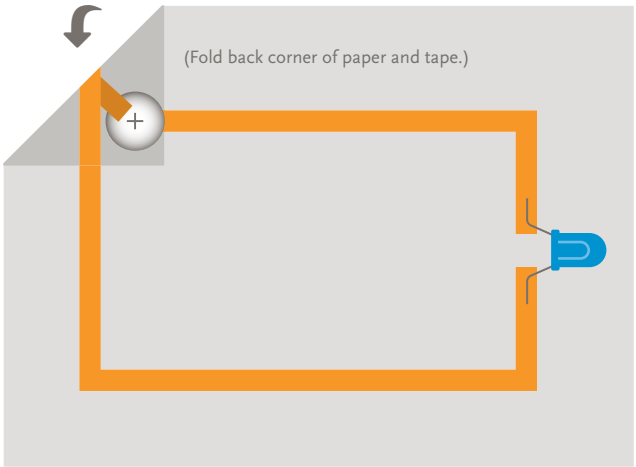
The conversation should be guided in a way that allows for the students to use the knowledge they learned from Soft Circuits and then introduce the conductive tape.

Show them a piece of the conductive tape. *What is this? Do you think it is conductive? Why?* Discuss the conductivity of the copper tape and that it can be used in the same way that we used the conductive thread.

Start Making

Put paper circuit examples at each table for the students to reference. Have them investigate what materials the name tag is made of and how it works. We recommend having the materials at the table in trays so when the students are ready, they can collect the materials they need and begin building their LED name tag. Each student should have a cardstock/index card, a small binder clip or paper clip, a craft stick, copper tape (you could pre-cut the copper tape into 8-inch strips and provide four per student), one LED and one coin cell battery. You should also include scissors, markers, masking tape and any other personalization tools you have.

1. Draw out the plan for your circuit in your science journal. It's a good idea to make a plan for your entire design, marking where the battery will go, the path of the conductive tape, and the positioning of the LED. Remember the LED has polarity and only works if it matches the polarity of the battery. *We have included this circuit diagram that we have found useful for certain students. Feel free to use it for clarification.*



2. Transfer your circuit diagram to the cardstock. Make sure to label where the battery and LED go and mark the polarity in the circuit diagram.
3. Place the conductive tape on the diagram and use the craft stick to smooth the tape down. The conductive tape is metal and can create sharp edges that may cut.

   Helpful Hint: It is best to keep the conductive tape as continuous as possible, meaning you only want a separation where it is necessary, i.e. for the LED and battery. The more segments of conductive tape, the more possibilities it may not work.
4. Place the LED where you want it and tape it down with scotch tape. Each leg should be touching conductive tape. Remember the polarity of the LED and mark which side is positive (+) and negative (-).
5. Position the battery according to the circuit diagram and test your circuit. Make sure the polarity of the battery matches the polarity of the LED.
6. Once you have successfully tested the LED, fold the paper over the battery completing the circuit, and use binder clip/paper clip to secure it in place.
7. Use markers, pencil, scissors, etc. to personalize your project and attach a pin back to complete the name tag.

   If a student finishes their name tag early, they can make another one. Challenge them by asking: *Do you think you can make a paper circuit with two LED lights? Or a switch?* You can have some examples of paper circuits with multiple LEDs or a switch on hand if you want to illustrate how it may be done.

Helpful Hint: The students can design the aesthetic aspect of the name tag prior to building the circuit. This allows them to plan out where the light will be according to their drawing and decoration.

Variation: The name tag offers students a chance to visually express their name. However, you can apply any theme to the personalization of the paper circuit. We have used "create your own superhero name and power" and "create a personal logo." Or, you can simplify and just focus on building the circuit itself.

Science Journal Prompts

- What tools/materials did you use?
- What were some of the challenges? How did you overcome them?
- If a friend wanted to remake your project, what steps would they need to follow?
- What was new or interesting to you about this project? What was interesting about the materials you used?

Facilitator Debrief Prompts

- Did you notice students using what they learned in previous circuit activities?
- What questions did students ask related to circuits and electricity?
- What was the vibe of the room? Were students engaging with each other?

Helpful Hint Facilitation: You may notice the students struggling with this project; this struggle is important to the learning process. Encourage students to test their circuits throughout the process to ensure they are able to find any mistakes as they happen. All connection points can be the culprit for a non-working circuit. Make sure the battery and LED are connected solidly and smooth out any points in the circuit where conductive tape is connecting.

Troubleshooting

Are battery and LED oriented correctly (polarity)? Double check that the battery and LED work.

Is the conductive tape making connections where they should?

Is there a short circuit? Does the (+) and (-) conductive tape overlap at any point?

Helpful Tool: Multimeter

A multimeter is a tool designed to measure electric current, voltage and resistance. You can use it to find out if two points of the circuit are making an electrical connection. You can use the multimeters metal probes to test the LED, battery and any points on the conductive tape to find the point in the circuit where electricity isn't flowing.