Day 2
Soft Circuits

Overview:

Soft circuits is a complicated but fun activity that mashes up circuitry and textiles. Instead of wires, we use conductive thread which is a special thread with metal woven into it to conduct the electricity. We use fabric as the circuit board, allowing us to wear our soft circuit creations. Sewn circuits open up possibilities for all sorts of technology integration and innovation into the more traditional fabric arts.

Materials

- Jeweler's pliers
- LEDs
- Sewable coin cell battery holder
- Coin cell (CR2032) batteries
- Alligator clips (for testing)
- Conductive thread
- Felt
- Adhesive velcro
- Conductive fabric tape
- Embroidery needles
- Needle threaders
- Embroidery floss
- Buttons
- Scissors
- Pencils
- Fabric markers
- Sharpies
- Pin backs
- Hot glue and glue guns for adding clasps and embellishments and gluing down loose parts.

Optional Materials

- Sewable LEDs
- Sew-on magnetic snaps
- Soft felt
- Loose weave fabric
- Scrap wire to practice looping the wire

Introduction/Discussion

Begin the discussion by reviewing the activity from the previous week. *What did we do? What tools did we use? How did we use them? What skills did we need to successfully complete our science journals?*

Helpful Hint: 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. This helps reinforce what they learned and affords them the opportunity to share what they learned with a peer.

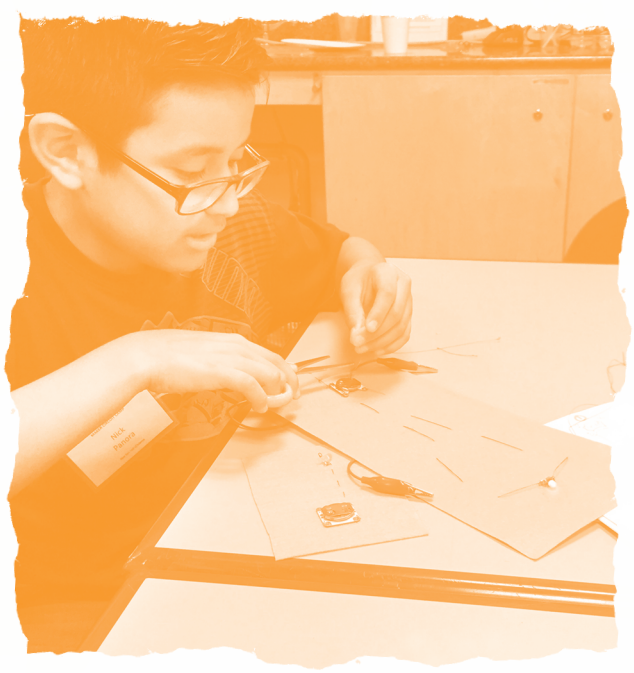
The Soft Circuits activity builds on the basic sewing skills learned from the Science Journal activity and combines it with circuitry. Sewing circuits can be challenging, yet the payoff is very rewarding. Plus it provides a platform for trial and error, an important aspect of the making process.

Prompts: *Does anyone know what a circuit is? Have you heard that word before? Show the group an example of a simple sewn circuit. What do you notice? What is this? How does it work?* This allows the kids to share any previous experience they may have with circuits. If they are unsure, encourage them to think outside the box and try to figure it out.

Hand out an LED and a coin cell battery to a few students in the circle and give them a few moments to make some observations about the materials. Have them pass the materials around so other students can see as well. *What do you notice about the materials? Have you ever seen anything like this before? Are there any special markings? Any physical properties that 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.

Show them the spool of conductive thread and explain that it is similar to the thread they used to sew their science journals, except there is a strand of metal woven into it that allows it to conduct electricity. This is how they're going to get the electricity from the battery to the LEDs on their soft circuits.



Start Making

Have plenty of samples of successful sewn circuits for learners to reference. Encourage them to figure out what is working and what isn't throughout the process in order to catch any mistakes when they happen. Everyone should test their LEDs and batteries to make sure they are working. The positive leg of each LED should be marked with a Sharpie to easily identify them once they've been curled. (*see step 5 below*).

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 thread, and the positioning of the LED. Remember, the LED has polarity and only works if it matches the polarity of the battery.
2. Cut two, arm-length pieces of conductive thread.
3. Thread one strand through the eye of the needle (using a needle threader if you need it).
4. Pull the thread through the eye until it is doubled, then tie off the end with a simple overhand knot.
5. If you are not using sewable LEDs, curl the ends of the LED around the nose of the jeweler's pliers to make it sewable. (Make sure you've marked the positive leg of the LED with a Sharpie first.)
6. Use the fabric markers to transfer your circuit diagram onto your piece of felt. Remember to mark where the battery holder and the LED are going to go.
7. Begin by sewing on ONE side of the battery holder. It helps to loop the thread through several times to make the battery holder secure. The more surface area the thread has with the battery holder, the better the connection will be. You can place a piece of masking tape or some hot glue on the other side of the battery holder to keep it in place while you sew.
8. Then, sew away from the battery holder toward where you've positioned the LED.
9. When you reach the LED, sew on the leg that matches the side of the battery pack you started sewing from. If you started sewing from the negative side of the battery pack, you need to sew on the negative leg of the LED. Remember, the positive leg has the Sharpie mark on it. Sew several loops of thread around the leg of the LED and into the fabric to make sure it is secure.
10. Tie a knot around the loop of the LED and cut the excess thread.
11. Test your circuit. Use an alligator clip from the other (not-sewed) side of the LED to connect it to the other (not-sewed) side of the battery. Does the LED light up? If it does, you can sew the other side of your circuit. If not, check to make sure you sewed the correct leg of the LED to the correct side of the battery. Or, look for short circuits. Sometimes they are on the back of the sewing piece and can be hard to see.
12. After you have successfully tested your circuit you can continue sewing. Start with sewing the second leg of the LED the same way you sewed on the first. Make sure to make several loops around the leg of the LED so that it is secure.
13. Then, sew away from the LED toward the battery following your circuit design.
14. Loop your thread through the battery holder several times to make sure it is sewn on tightly. Be sure you've sewed to the opposite hole on the battery holder so that it is connected and secured on both sides. Check the circuit to make sure it works.
15. When the circuit is complete, it is time to personalize. Decorate your soft circuit with felt elements or buttons, use the fabric markers to draw designs, or sew on a pin back so you can wear your creation.

Extension:

If someone is finished and wants an additional challenge, they can try adding a second light to their design. Parallel circuits can be added without adding a second battery. Check out the circuit diagram on page 6 for ideas.

Students can also add embroidery embellishments, clasps and buttons or add a switch to turn their LED on and off.

Note on Sewing Circuits

Sewing circuits can be challenging. If you encounter a learner who is struggling to the point of giving up, offer them the conductive fabric tape as an intermediate step. Conductive fabric tape works the same as the conductive thread, and learners should take the same precautions about shorting circuits, but it can be a good step up to the more challenging sewing if they're really struggling. Once they've gotten their circuit to work using the conductive tape, you can encourage them to try sewing again, by removing one piece of the tape at a time and sewing where the tape used to be.

Facilitator Notes

What Is a Circuit: We have noticed in the initial discussion of circuits that students often mention circles. This is a good opportunity to explain that a complete or unbroken circuit is similar to a circle. Like a circle, a complete circuit has no beginning and no end, allowing the electricity flow continuously. To have a complete circuit you need a power source, wires and something for the electricity to travel through, in this case an LED. You can demonstrate this for learners using the alligator clips, the LED and the battery. Even though the circuit might not be shaped like a perfect circle, it is continuous.

What function do the alligator clips serve in this circuit? Compare it to the soft circuit. What material in the soft circuit do you think correlates with the alligator clips?

Short Circuits: Explain that it is easier for electricity to flow through a wire than an LED. Short circuits are easy to make when working on soft circuits. Show the learners an example of a soft circuit that has a short in it, and try to light it up. When it doesn't work, ask them what they think might be happening. Be sure to explain that when the thread crosses, the electricity will flow through there, because it's easier, rather than through the LED, which means their light won't light up. Assure them there will be examples of good circuits and plenty of help, and that the circuits will be planned ahead of time to make sure the wearables work.

Room Set Up: Set up the materials in a designated place, allowing students to select their materials and return to their table to work on their project. This is a fairly materials intensive activity, and it is helpful to have a clear workspace free of clutter or excess materials.

Helpful Tool: It may be helpful to have a multimeter on hand to test circuits if learners are struggling and cannot figure out why their LED will not light. The multimeter will help test the circuit to determine whether electricity is flowing, and locate where the break might be.

Troubleshooting

- *Not enough thread to tie off stitch?*
  You can use hot glue or tape to secure thread. Make sure it doesn't get in between the thread connection to the battery or LED.
- *Ran out of thread mid-connection?*
  Tie one strand to the other and keep going.
- *LEDs not lighting?*
  Look for a short circuit (crossed conductive thread) and be sure to check the back of the project as well.
  Is the LED oriented the right way? If the charges aren't matching, the light won't light up.
  Use the multimeter to test your circuit in different places to see where the current is flowing.

Material Tips

Have needle threaders on hand for learners who have a hard time threading the needle.

Sewable LEDs are also available and they are generally easier to attach, but it can be harder to figure out how they work and they are more expensive.

Multimeters

Multimeters have a setting that lets you know if two points are making an electrical connection. Turn to the setting (usually the multimeter will have a 'beep' or a sound icon of some sort) and touch the two probes to a metal object. You should hear a beep. Now touch the probes to a non-conductive object. You should not hear anything. This is telling you that the two points the probes touch are electrically connected. This is very useful in trouble-shooting sewn circuits, as well as paper circuits. If an LED is not lighting up, you can put one probe on one leg of the LED and the other probe at different points in the circuit. If you hear beeps, that means the circuit is good and if you don't, that means there is a break in that circuit somewhere that needs to be fixed. This is a great tool to show kids how to use LEDs to investigate their circuits.

Documentation

Encourage students to take photos or videos of their projects. If they post to social media, have them use #tinkersewncircuits so all of our media will be collected in one place!

Journal Prompts

When designing:

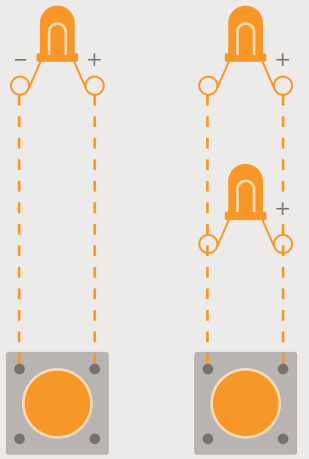
- Use your journal to plan your circuit. Mark where the battery will go and where the LED will go. Remember to mark the positive and negative sides of both the LED and battery.
- Plan your designs and embellishments in your journal.
- Had you ever sewn before? If yes, how did you learn and what did you make? If no, what did you learn about sewing today?

Post Activity Reflection

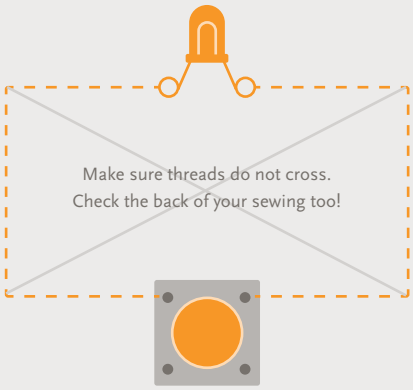
- What tools/materials did you use?
- What were some of the challenges? How did you overcome them?
- If a friend wanted to remake your project, what steps would they need to follow?
- What was new or interesting to you about making circuits? What was interesting about the materials we used?

Facilitator Debrief Prompts

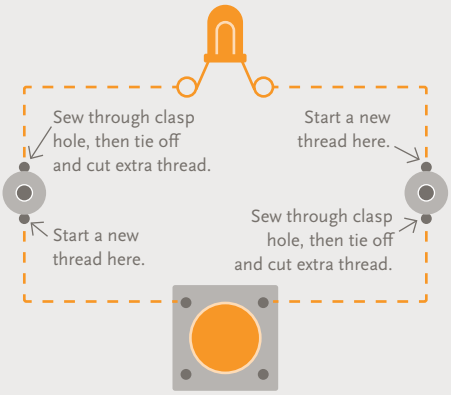
- What conversations about sewing did you overhear? What about circuits?
- What were learner reactions to being able to make a circuit they could easily wear?
- What instances of frustration or disappointment did learners encounter? What kind of facilitation support is helpful in these instances?



Basic Sewn Basic Parallel



Short Circuit



Clasp Switch