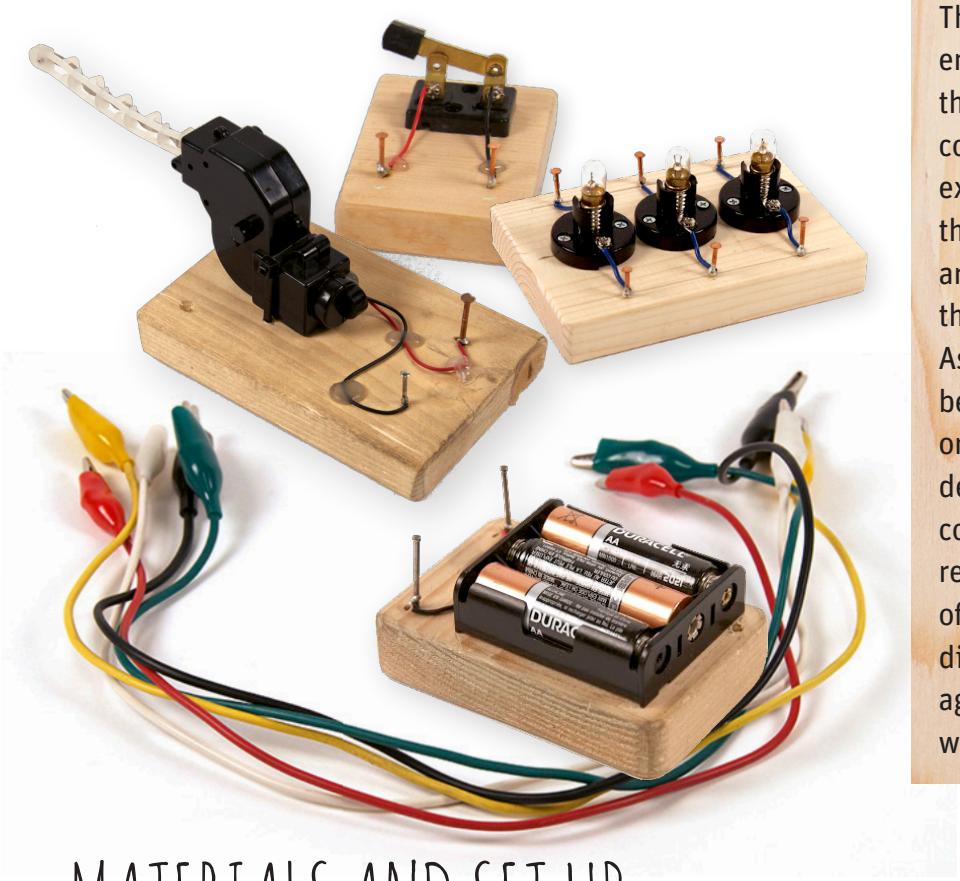
CIRCUIT BOARDS

AFTER-SCHOOL EDUCATOR GUIDE



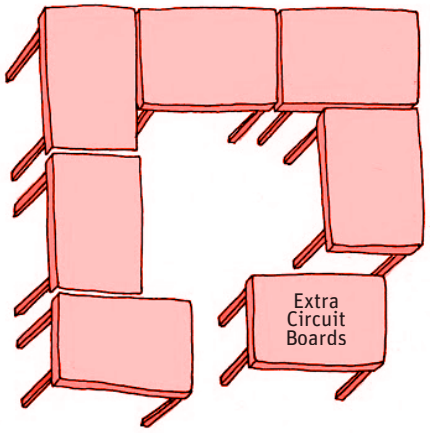
The Circuit Boards activity is designed to encourage young people to "complexify" their thinking over time. The variety of components and variables available for experimentation allows students to begin the activity at a starting point where they are comfortable, and then alter and refine their designs as they develop new ideas. As students test out the connections between the boards—either independently or in collaboration—they develop a deeper understanding of the electrical components while building on their relationships to one another. This activity often leads to multiple solutions and discoveries being made by people of all ages, regardless of their past experience with circuitry.

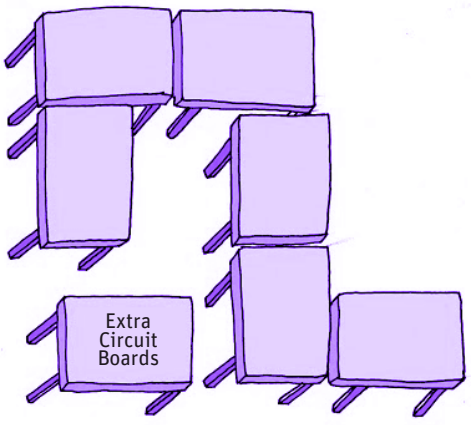
MATERIALS AND SET UP

For this activity, we like to keep the tables connected and arranged so that students and facilitators have plenty of space to work while also being able to see each other's work, especially when sitting at corners and across from each other.

We like to have the tables prepped with batteries, light bulb boards, and alligator clips. We start by giving students time to get started exploring simple circuits before adding more complicated components, such as switches and motors. We tend to keep these on a table off to the side, leaving it up to facilitators to gradually bring them in when it looks like students are ready to expand their explorations into more complex circuits.

Check out http://tinkering.exploratorium.edu/circuit-boards for more resources including a pdf guide for building your own circuit boards.





the tinkering studio

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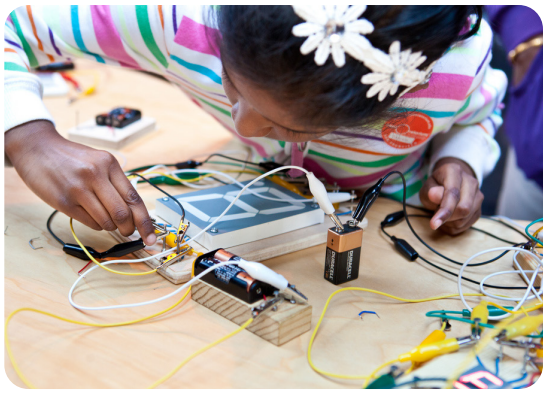
OPENING DISCUSSION PROMPTS

Here are a few example prompts we've used to introduce this activity. We usually sit in a circle and treat this time as a way to enter the activity together, as well as engage young people in a discussion about their questions, ideas, discoveries and plans.

We often begin by asking students to think about electricity and to share their questions about how it works. When the questions they pose about electricity are directly investigable with the circuit boards, we suggest students explore their questions during the activity. as mentioned in the 'safety tip' section to the right, these conversations also create an opportunity for talking about safety (after they share their thoughts and questions).

Safety Tip:
Free investigation is a key part of Circuit Boards. When wires are crossed batteries sometimes get hot and bulbs sometimes burn out, but these outcomes are the real and important consequences of the ideas students test out while exploring. We always discuss safety before starting circuit boards, reminding young people not to touch the wires of any appliances or electronics that plug into an outlet, or any wiring found in walls or ceilings. We let them know that touching these circuit boards are safe because they use low-voltage batteries.

We also find it generative to ask students to demonstrate connecting a simple circuit during discussion time. This can help the students acquire a basic foundation in circuitry and offers entry points into the activity. Once the circuit is connected, you might ask students to share their questions and ideas about how it works. This can provide a good bridge to their upcoming investigations. For example, we might say "So what we're going to do today is learn about how electricity works by playing with it. We'll experiment with different ways to connect things and see if we can come up with ideas for how to make different circuits. A circuit is any combination of things that use power to light up a light bulb or make a motor move. You can invent lots of different circuits that have different components to them." Since other upcoming activities (Scribbling Machines and Nature Bots) also involve electricity and circuitry, it might be helpful to let students know that building Circuit Boards is the beginning of an extended exploration.



It's important to encourage students to watch and observe during this activity. For example, we might say "I want to remind you to watch closely when you are exploring electricity, and see what you notice about what happens. If you have any trouble, it's really good to look closely and follow the wires to troubleshoot when things don't work."

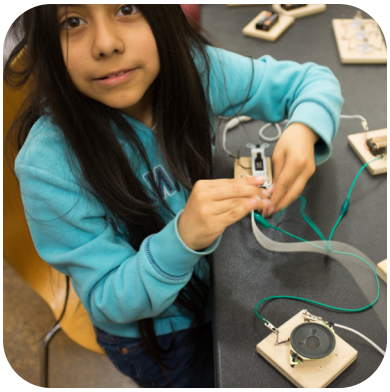
TRY IT!

Getting Started

As students get familiar with the materials and start experimenting, we often find ourselves moving wires so that their paths are more visible, helping students figure out how to use the alligator clips, and modeling troubleshooting methods through guided observation. Students often get excited to share their circuits once they make a light turn on. These moments of excitement can be leveraged as occasions for talking about what's happening, what they notice, and what they might want to try next.

Here are some of the rich learning moments we've noticed at this phase:

Alligator clips are finicky, and figuring them out can be a challenge for students. Slowing down to notice the thinking and experimentation that happens while small hands are learning to manage these slippery little clips can be just as rich as observing other, more complex moments. At the beginning of the workshop, students are getting a feel for both the materials and a new, physical way of exploring and learning about how those materials work.

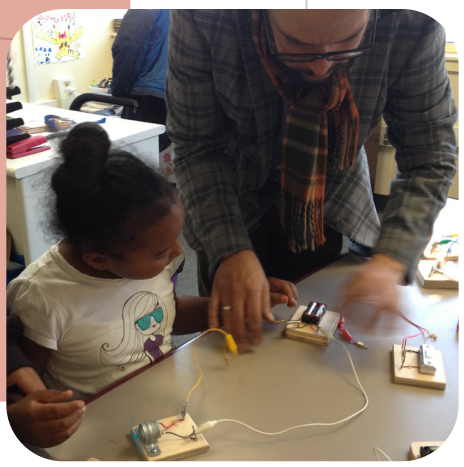


Cycles of Sharing

Young people love to share when they've gotten something to work, and we've found that substantive recognition of what they've done and worthy witnessing by other students or facilitators often sends them into their next investigations. These moments of recognition can become an important part of the iterative process: Once their accomplishments have been recognized, students often feel ready to take their circuit apart and try something else. It's helpful to consider your commentary in these moments, and how recognition or praise may be interwoven with deepening students' conceptual understanding, such as, "Let's see. Your lights are super bright, they must be getting lots of power."

Hands & Eyes

It can be important to be mindful of our own hands and interventions. Sometimes we have found that when adults' hands come forward to work on the boards, students' hands will move back or their eyes will move away from their circuit. This doesn't mean we shouldn't intervene, but rather we should notice and become intentional about the ways we intervene. We've found that keeping students involved by talking about what we're doing or by offering something as an option and then returning the wires or boards back to how they were before can help keep students actively engaged in the moment. (The authors of this guide discuss Hands & Eyes in depth here: http://bit.ly/HandsAndEyes)



Going deeper

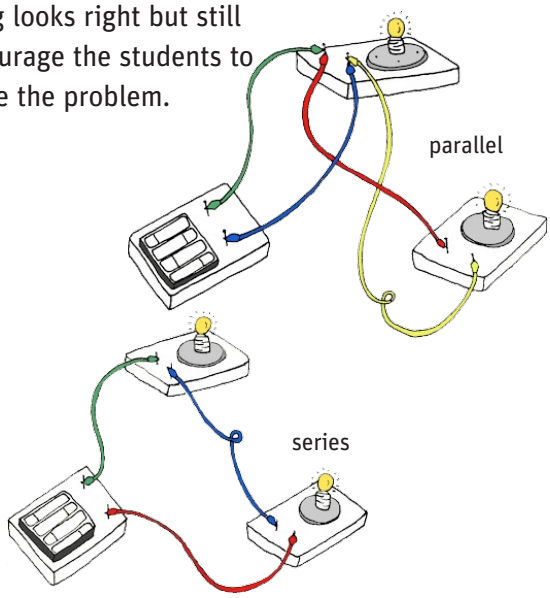
Some students may complexify their work by deepening investigations of one circuit, while others may benefit from adding new boards, so it's good to keep an eye on the room and consider when it would be generative to introduce new boards.

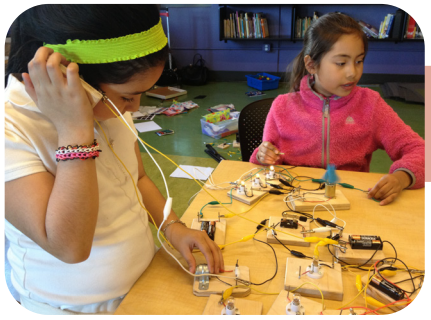
We often start by suggesting they try adding a switch, and then let them find new boards that interest them. We also encourage students to walk around the room and observe or notice others' investigations as a way to think about what they might want to try next, gaining inspiration from others. These moments can create organic opportunities for children to take on the role of experts and share their ideas and discoveries with one another.

As students dig into the process, they might say "It's not working!" or "Mine doesn't work!" These are also nice opportunities for helping them study the boards and think about where the electricity is flowing and what they might need to change or adjust to make it work. Helping them spread out the boards and clearing away unused wires makes the circuit easier to study. Sometimes this reveals a wire that is only connected on one side, or the presence of too many wires, which creates a short circuit. When everything looks right but still isn't working, we suggest testing and securing all the connections, or encourage the students to test their batteries with the battery tester if they think the battery might be the problem.

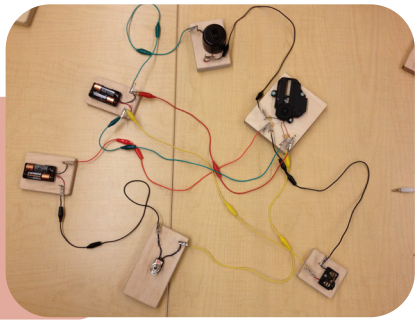
Beyond series and parallel

There are so many aspects of circuitry that emerge when we approach this activity with an intentional openness to the multiple pathways young people may choose to take. These explorations often lead to discoveries we never anticipated. Because the circuits that students create will all have parallel and series configurations, there will always be opportunities to identify and discuss them in context, together with the endless other principles and phenomena that reveal themselves along the way. Here are some fun discoveries our students have made:





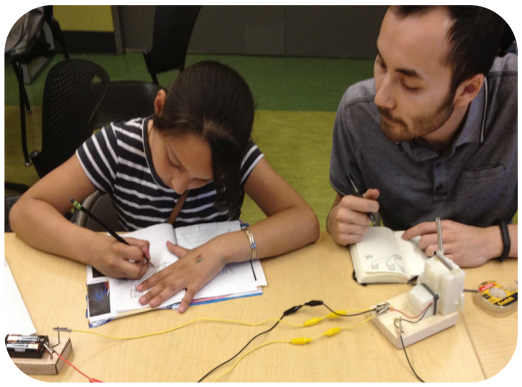
These girls discovered that if they put a motor in series with a small speaker, they could hear the current of the motor amplified in the speaker.



The board on the right is from the inside tray of a cd player. It has two motors—one that moves the laser lens and another that spins the disk drive. Our student spent about 30 minutes finding a way to create a circuit that could drive both motors. In the case of the laser lens, she also explored changing polarities with a switch in order to change directions.

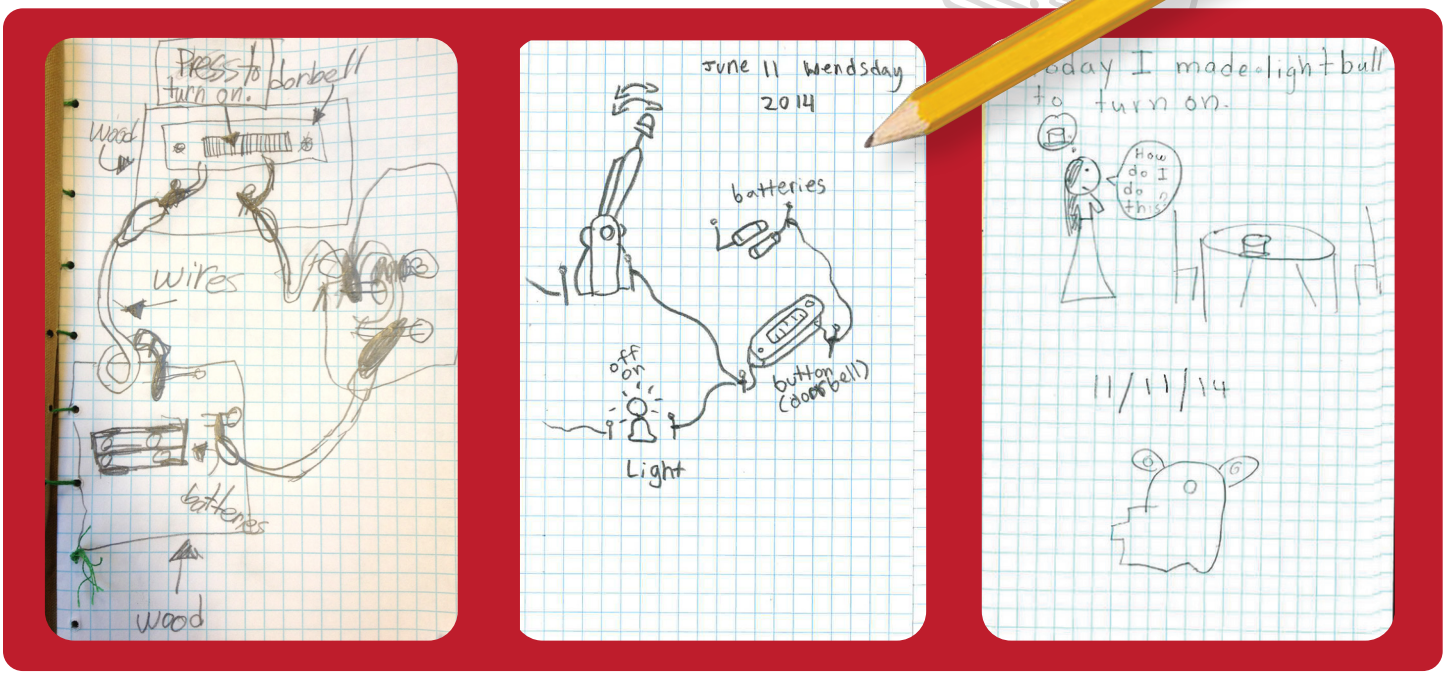
Science journal prompts

Consistent with the notion of science journals being a place to record the histories of ideas, Circuit Boards is a perfect opportunity for drawing or documenting circuits which will be disassembled at the end of the day. We often encourage students to draw or write about their work with questions such as:



- "If a friend or another tinkering student wanted to make this same circuit you made today, could you make a drawing that would help them know what to do?"
- "Draw your circuit in your science journal so that next time you can expand on those ideas—and explore new ideas."
- "You all spent a lot of time on these creations. Try drawing them or writing about what you were thinking about while you made them."
- "What do you understand now about circuits that you didn't earlier today? What new questions do you have about circuits or electricity?"

SCIENCE JOURNALS IN ACTION



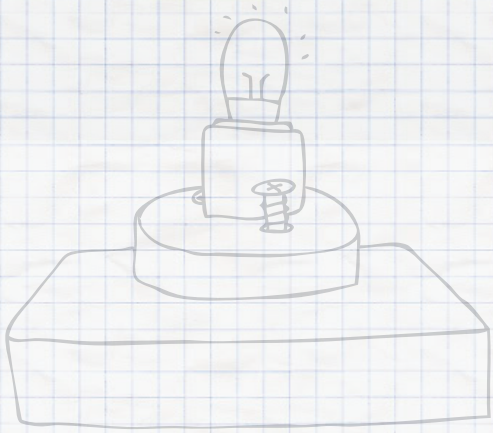
Noticing Learning in Science Journals

These images reflect the care with which students documented their circuits, including the details of the mechanisms, batteries and wires. We have often found that students are invested in illustrating these details, both as a way to document their creations (which will be taken apart at the end of the day) and as another context for reflection and meaning making. The labels attached to different components also suggest the growing confidence and sense of membership that can come with acquiring new words within the context of the activity. In this way, science notebooks provide an additional space in which a student grows into the role of an expert who can share her newfound insights with others.

FACILITATOR DEBRIEF PROMPTS

Taking time for reflection after a workshop can be a powerful way to share or record the moments of learning you noticed and to brainstorm new ideas to try next time. Here are a few prompts to get you started:

- Describe some of the most interesting circuits being explored by students today.
- What questions did students ask related to circuits and electricity? Were you able to seek the answers using the boards themselves?
- Were there any students that seemed to hang back or not be as engaged as others? What about their surroundings could have contributed to that and what strategies might help deepen their engagement
- What surprised you or stood out the most about the general energy in the room?



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