IDIN Skill Builder: Smart Light Instructor Guide

Time Needed:

6 hours, or 2 x 3 hour sessions

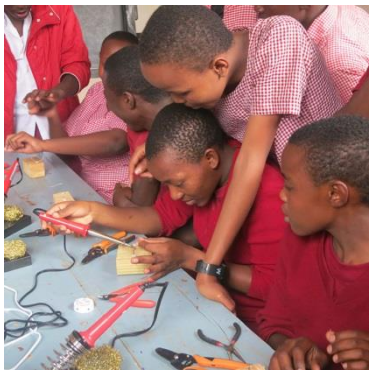
Number of People Needed to Run the Session:

1 instructor per 3-5 participants. Heavily dependent on the soldering ability of the participants.

Space Set-Up:

Well illuminated tables with access to relatively high amperage electrical outlets in order to use at least 2 soldering stations for every 3-4 participants and 1 hot glue gun for every 2-3 participants. Tables should not have easily flammable materials (wood is ok, cloth and straw are not). There should also be space in the room so that each person has room when using the soldering iron.

1. Introduction



PHILOSOPHY

Many people around the world go through their lives rarely using their inherent creative instincts to make a useful object with their own hands. However, a belief in one's individual ability to create technology can lead to a sense of agency and a belief that one can create positive change in the world. This idea embodies the purpose of a Skill Builder.

Those who participate in a Builder leave believing they can be creative, work with technology, and build tools to solve problems present in their own lives or in the lives of others. The experience provided is transformative; if they can successfully build this device, then by extension, they can build another. For example, creating light is a magical experience, endowing a person with the ability to replicate the power of the sun. As a person said in Zambia following a Builder, "I was a dull knife and you sharpened me."

This kind of transformation is only achieved by having participants build on their own terms, exploring the use of tools with guidance from an instructor. It is important that their devices work so they are successful and feel a sense of accomplishment; but even more important is that they felt they did it themselves and believe they could do it again.

Skill Builders are the building of a piece of technology as a means to acquiring fabrication skills, working with materials, and learning physical principles. This can range from using wire strippers and a soldering iron to create an LED light to using a hammer and chisel to shape wood into a spoon. The key to inspiring change in participants does not lie within the device created; it lies in the skills gained and the newfound sense of ability felt by participants.

For those who have never used the tools before, the initial stages of the Builder will feel awkward. Participants may "fail" at steps in the process. They should be guided out of these stumbles, not have the stumbles solved for

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them. Struggling with the process and resolving issues on one's own are important in building the feeling of agency that is necessary to use these skills to address problems in the world.

Skill Builders are also a powerful experience for the instructors. When the participants have successful devices, the pride they have will be reflected in the pride instructors feel. The instructors are the first link in passing along the philosophy and skills transmitted. If the instructors are steeped in these principles, the participants will carry the philosophy and skills forward in their lives and will share with those around them.

GUIDELINES

To be an effective instructor and create a valuable experience for the participants, keep the following ideas in mind while delivering the Skill Builder.

- Allow participants to work through the steps at their own pace. It is important that everyone gets to practice using each of the tools. Since this is the first time most people have used them, it will take longer than you might expect. The length or number of sessions should account for this. If you find you still go over, arrange for more time.
- Encourage participants to form pairs and help each other through the activity. Ensure there is not a dominant person in each pair who does all of the tooling and machining.
- If a participant is having trouble, encourage those around him or her to provide help so the participants can learn from each other. When a participant has solved a problem, have them demonstrate the solution to the group so they can take credit.
- If a participant makes a mistake, help them to diagnose the problem and fix it. This should be done by encouraging them to share their thoughts on the problem and the solution, before offering your own diagnosis and solution. Avoid correcting the mistake for the participant except in extreme situations.
- It is important to practice showing, instead of telling. A visual demonstration goes much farther than an oral description of the task. During the Skill Builder, be vigilant to ensure there is more showing than speaking.
- Encourage participants to use spare materials to practice the skills before using the tools to make the final product.
- Observe and advise the participants on their technique in using the tools so they have the opportunity to improve.
- Complement the participants as they successfully complete steps in the construction process, emphasizing that they are responsible for accomplishing the task.
- Promote a sense of camaraderie in the group. Ways to do this can include a group picture, having each person sign each other's device, or taking time for each person to demonstrate their functional device. Place emphasis on each participant's success in creating a working device to increase their confidence.
- Keep the guiding principles described in the philosophy section in mind as you deliver the curriculum.

PREPARATION

To set the Skill Builder up for success, do the following ahead of time:

- Make the device yourself to discover what steps participants might find difficult and to ensure all tooling and machinery is functional.
- Set aside one set of Skill Builder parts for yourself and subassemblies to show key steps. As you lead the participants through the Skill Builder, you can demonstrate steps using your own set of parts.
- Set up at least one completed device that participants can reference as they complete the activity.
- Prepare extra material that the participants can use to practice skills.
- Print one 'Participant Skill Builder Photo Guide' per participant.
- Print one 'Skill Builder Module User Evaluation Sheet' per participant.
- Prepare supplies and tools at the work stations.
- Ensure a first aid kit is available.

- ☐ Ensure there are enough safety glasses for you and all participants to each have a pair throughout the activity. Ensure other personal protective equipment is available where necessary.

SAFETY

Below is a list of safety concerns relevant to this Skill Builder.

Soldering iron:

- Soldering iron tips are very hot and can easily cause minor burns from accidental contact with the skin.
- Likewise, the tips can also easily burn through the insulation of power cables, leading to short circuits. Short circuits usually spark momentarily and trip breakers or fuses. Very rarely, if a short circuit is not protected, it can get hot to the point of melting material and may have the possibility of starting a fire.
- Even though it is tempting to use the iron tip to melt plastic and make holes, doing so will destroy the surface of the tip, making soldering difficult to impossible.
- Even when the soldering iron is safely resting in the provided metal cradle, the tip of the iron can burn wires and other tools. Be sure to move any materials away from the tips of the irons to prevent melting.

Hot glue gun:

- As in the case of the soldering iron, the tip of the glue gun may also cause burns, although there is much less exposed surface, and the temperature is lower.

2. Overview

LEARNING OBJECTIVES

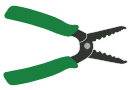
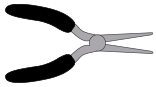
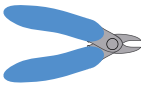
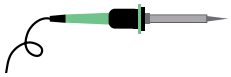
- ☐ Participants will learn about basic electrical circuit theory.
- ☐ Participants will learn how to successfully strip wire.
- ☐ Participants will learn how to properly solder.
- ☐ Participants will learn about the use of microcontrollers.
- ☐ Participants will learn how to troubleshoot a circuit.
- ☐ Participants will build a working LED lantern.

LESSON PLAN

1. Review what the technology is, including the supplies and tools needed. *15 min*
2. Complete pre-questions in the ‘Skill Builder User Evaluation Sheet’. *5 min*
3. Body storming activity. *40 min*
4. Solder the LEDs, button and battery pack to wires. *1 hour, 15 min*
5. Solder components to the circuit board. *2 hours*
6. Assemble the lantern. *1 hour*
7. Reflection and feedback. *30 min*
8. Complete the post-questions in the ‘Skill Builder User Evaluation Sheet’. *15 min*

3. Materials

TOOLS

	Item	Quantity Per 4 Participants
	Wire strippers	4
	Needle-nose pliers	4
	Wire cutters	4
	Drill and 3/16” drill bit	2
	Soldering iron	4
	Hot glue gun and glue sticks	2
	Putty	thumb-size per person
	Wooden block (minimum size of 10cm x 10cm x 5cm, 4” x 4” x 2”)	4
	Mutlimeter	1 for the session

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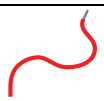
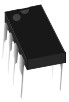
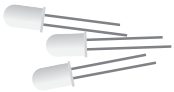
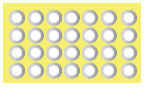
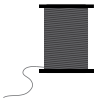
SUPPLIES

	Item	Amount	Cost
	Wire (26 AWG standard, 4 different colors)	10cm x 10 pieces	$0.35
	1.5V AA batteries	2	$0.49
	AA double battery holder	1	$0.75
	PIC 10F200 microcontroller (pre-programmed)	1	$0.43
	Push button switch	1	$0.19
	LEDs	3	$0.60
	8 pin DIP socket	1	$0.11
	Plastic container (ex. medicine bottle, at least 8cm long x 4cm diameter)	1	variable
	Perforated board (4 x 7 holes)	1	$0.14
	Solder	~30cm per person	variable
		Total Cost	**$3.03**

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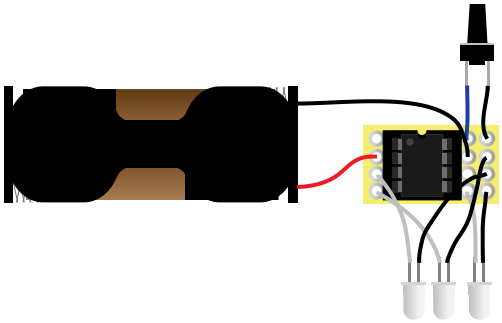
4. Teaching Notes

INTRODUCTION TO THE SESSION

The smart lantern uses a microcontroller to dim the perceived brightness of three LEDs using pulse-width modulation. Participants may use any container of the appropriate size as an enclosure. The circuit is powered by two AA batteries.



The ability to manipulate the brightness, shape and location of the lantern makes it adaptable to be used as handheld, reading, working, or home illumination. Customizing the brightness also results in reduced battery consumption and compatibility with low-light environments where stark differences in illumination can be inconvenient and dangerous.

BODYSTORMING

Traditionally, bodystorming is a method used in interaction design to physically experience a situation in order to derive new ideas. In this context, bodystorming is a teaching and learning strategy that helps communicate a theoretical concept. With electronics, it can be difficult to understand what is happening within a given circuit because current is not visible. This lack of understanding can form a barrier, especially to people who have not had formal education. Modeling elements of circuits using people, or bodies, allows the participants to engage in a hands-on way with the theoretical concepts presented while simultaneously providing a physical representation of what is happening. Suggestions for specific bodystorms related to this Builder are:

- Simple circuit with a battery and LED. This is a good moment to discuss the polarity of an LED and show how current comes out of one side of a battery while the other is ground. This is also a good moment to demonstrate the difference between an open and closed circuit.
- Add a switch to the circuit and explain how the switch can be used to interrupt the circuit.
- Introduce additional LEDs to the circuit and explain how current passes from one to the other.
- If there are enough people in the room, introduce a microcontroller into the circuit and act out its functionality.
- Depict soldering and explain what is occurring in the process.

Bodystorming is a fun, interactive activity. Make sure to get all participants involved as parts of the circuit. Make changes to the circuit and ask the participants to guess the outcome in order to encourage their learning. This is a moment to be silly and engaging and help participants feel comfortable approaching circuits and electronics both in the Skill Builder and in their life.

LEARNING OBJECTIVES ACCOMPLISHED:

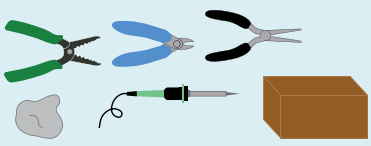
- ☐ Participants will learn about basic electrical circuit theory.
- ☐ Participants will learn about the use of microcontrollers.

SOLDER THE LEDs, BUTTON, AND BATTERY PACK TO WIRES

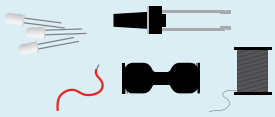
Skills

soldering

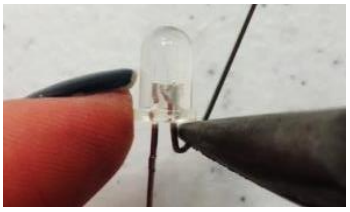
Tools



Supplies



1. Use the needle-nose pliers to bend the legs of the LEDs into a u-shape. The bends should be close to the top of the LED.



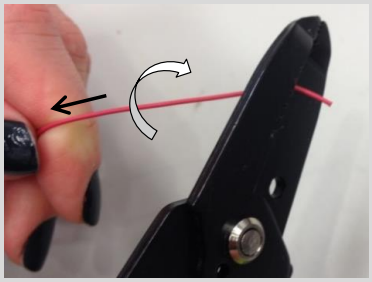
2. Strip a piece of wire selected for ‘ground’ and a piece of wire selected for ‘current’. Twist the multi-stranded wire so that the strands have more physical integrity. Bend the stripped ends of these wires into u-shapes and connect them with the u-shaped bends made on the LED.

   Teaching note: Explain that in building a circuit, it helps to keep all of the ground wires consistently one color while the current wires are consistently a different color.

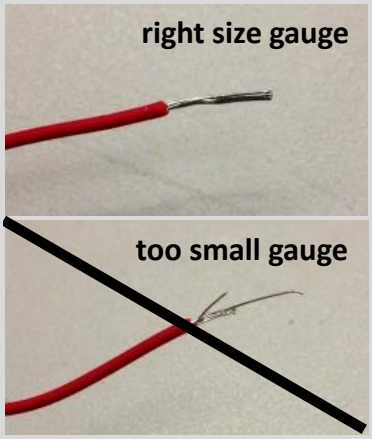
TEACHING NOTE: *DEMONSTRATE PROPER WIRE STRIPPING*

Find the right gauge. Wires are often covered in an insulating sheath. To allow current to flow from one component to another, their conductive parts must touch. To expose the metallic conductive wire underneath the sheath, we must strip the wire. Grasp the wire stripper in your dominant hand. Determine the proper gauge of the wire and clamp it between the notches labeled with the gauge, leaving about a centimeter of wire to be stripped.

Strip the wire. Using your free hand, twirl the wire in a few circles while tugging gently until the colored casing has become separated from the silver wire inside. Continue to pull on the wire until it has been stripped.



Check the result. Your resulting wire should look clean, as in the figure to the right. Be careful not to cut the inside silver wire or any of the individual strands of silver wire if you are using stranded wire. This happens when you use too small of a gauge. If you use too large of a gauge, the colored casing will not be cut all the way through. When in doubt, cut away the stripped wire and try again



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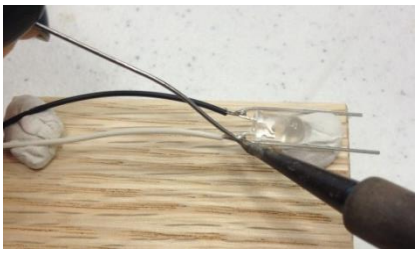
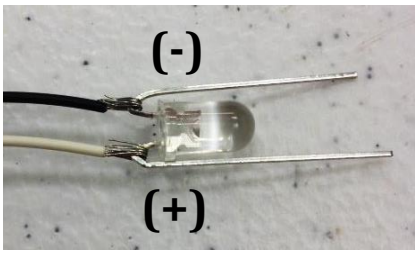
3. Secure the LED and the two wires to the wooden block using the putty. Solder a wire to each of the legs of the LED.

   Teaching note: Explain that the LEDs are polarized and must be attached so that the long leg (LED +) is connected to power and the short leg (LED -) is connected to ground.





TEACHING NOTE: *DEMONSTRATE PROPER SOLDERING OF FLOATING COMPONENTS*

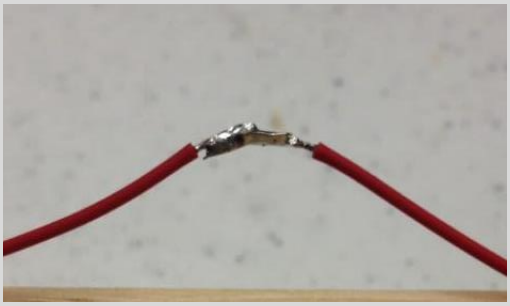
Hook ends of wires. Solder is used to create strong, permanent electrically conductive connections between metal components and wires. Before you can create this electrical connection, however, you must first create a physical connection. This is done by taking the component and the wire (or second component) and bending both ends of the sides you are planning on soldering into hook shapes. Once you have both hooks, put them together. When you tug on the components or wires, they should stay together.

Apply solder. Solder is like metal "glue." Just as with normal glue, you do not need to use a lot to get things to stick. The soldering process should only take 4 seconds. Think of it this way:

- heat the components by placing the soldering iron on the pieces you wish to solder-COUNT ONE
- touch the solder to the components and watch the solder flow -COUNT TWO, THREE
- lift the soldering iron off the piece first, and then remove the solder-COUNT FOUR

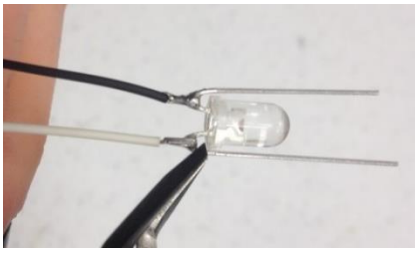
Always put the solder on the component, not directly on the soldering iron, as this will cause more solder to be burned without actually attaching anything. You want to see the solder glide quickly across the metal.

Check the result. Your soldered area should look smooth and evenly covered. If you can still see/wiggle the individual components, you may have too little solder. If your soldered area is chunky, you may have applied too much solder.



Avoid overheating. Make sure to not leave the soldering iron tip on any one component for too long, as it can burn components and cause them to stop functioning. If something still isn't attached after the four second rule, stop, allow the components to cool down, and begin again. All of the components are susceptible to intense heat, so be careful not to overheat them. The battery packs in particular are very easy to melt, so follow the four second rule closely.

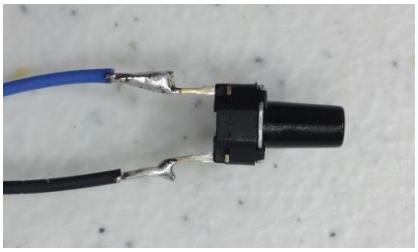
4. Use the wire cutters to snip off the legs of the LEDs close to where they have been soldered.



5. Repeat the steps above for the two remaining LEDs.

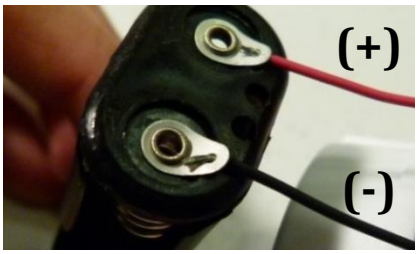
6. Repeat the soldering technique from above to attach wires to each of the legs of the button.

   Teaching note: Explain that the button is not polarized, so it does not have a (+) or (-) side defined.



7. To solder wire connections to the battery pack, thread the stripped ends of the wires through the holes in the battery terminals. The ground wire should be connected to the terminal with the spring (-) side, while the current wire is connected to the flat (+) side.

   Teaching note: Explain that the battery pack is polarized. Here, it is important to keep the wire coloring consistent.



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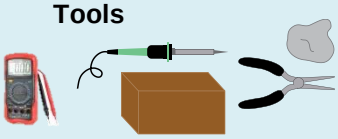
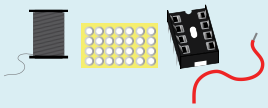
LEARNING OBJECTIVES ACCOMPLISHED:

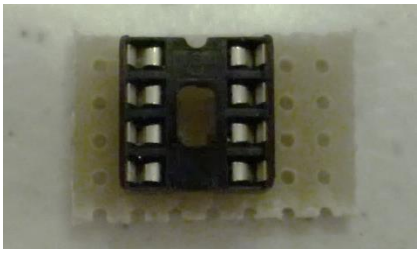
- ☐ Participants will learn how to successfully strip wire.
- ☐ Participants will learn how to properly solder

SOLDER COMPONENTS TO THE CIRCUIT BOARD

Skills	Tools	Supplies
soldering troubleshooting		

8. Place the socket into the perforated circuit board. Leave one column open on the left, and two on the right. Also make sure that the half-circle indentation of the socket is on top.

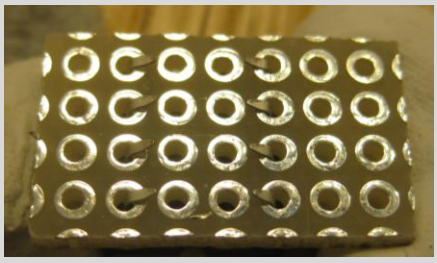
   Teaching note: Explain that the socket should be placed onto the non-metallic side, so that soldering will be done on the metallic side. Also, explain that when applying solder to the socket, they should make sure that the microcontroller is not inserted, as microcontrollers are very sensitive to heat.



9. Carefully flip it over, so that the metallic side is on top. Press the socket and board into the putty to secure it in place. Make sure to keep the socket legs in the holes of the circuit board while you flip it. Carefully bend each leg toward the center of the board to keep it in place. Solder each leg of the socket to the board.

TEACHING NOTE: *DEMONSTRATE PROPER SOLDERING TO THE CIRCUIT BOARD*

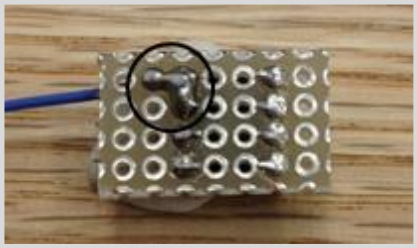
Secure the object to the circuit board. Bend the legs of the socket or ends of the wires inward to secure them mechanically to the circuit board before soldering. Make sure that the legs of the socket or the ends of the wires are on the metallic side of the board, because this is where the soldering will take place.



Apply the right amount of solder. Using the 4-second rule, solder the component to the metallic ring that it comes out of on the circuit board. Apply just enough solder to fill the hole. If connecting two things on the circuit board, solder the second component to the metallic ring first. Then, touch the soldering iron to the portion of the second component resting on the already soldered component. This will re-melt the area and allow the components to connect.

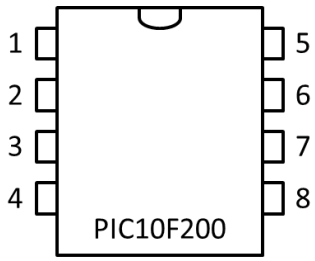
If your soldered connections are overlapping in places that aren't supposed to be connected, you probably applied too much solder and the circuit will short.

If the metallic holes aren't filled with solder, and you can wiggle your wires loose, you probably haven't applied enough solder.

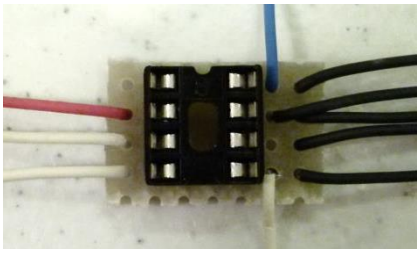


If the metallic ring slips off of its hole, you've probably applied too much heat to the area and should start with a new circuit board.

10. Turn the board, with the socket soldered on, back over. The pins of the microcontroller are numbered counterclockwise from the top left. No wires will be connected to pins 1 and 6.

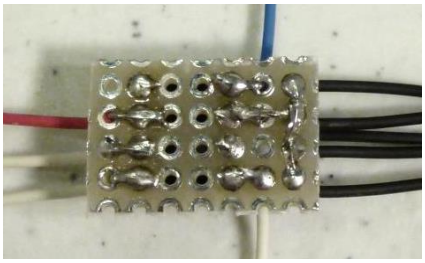


11. Insert the wires as follows:
    - (+) side of the battery next to pin 2.
    - (+) side of each LED to pins 3, 4, 5.
    - One side of the switch to pin 8.
    - (-) side of each LED, (-) side of the battery and other side of the switch to pin 7 as shown in the diagram. Pin 7 will represent ground.



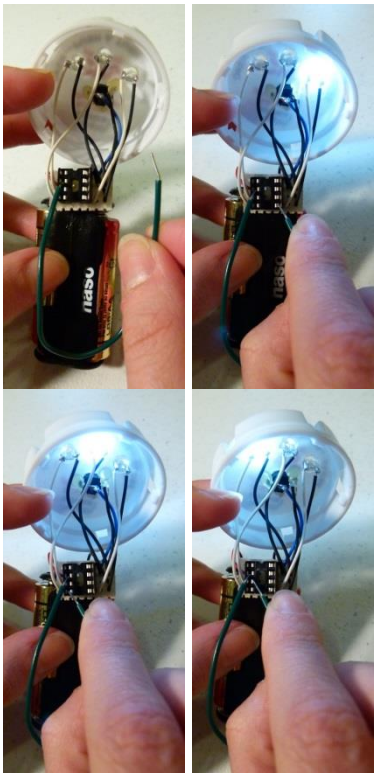
12. With the wires in place, turn the circuit board over and secure it to the putty and block. This can be done after all of the wires are in place or one at a time. Bend the ends of the wires to touch the pins they correspond to. With the grounded wires, bend first the end of the wire that is closest to pin 7 to touch the pin, then bend the other grounded wires to connect to each other in the black "T" shape shown in the figure.

    Solder each of the wires to its corresponding pin.



13. After everything is soldered, test the circuit to make sure it works. Insert the batteries, lining up the (+) terminal of the battery with the flat end of the battery holder and the (-) terminal of the battery with the spring end of the battery holder. Use a piece of wire to bridge the connection between current (pin 2) and the positive end of each LED (pins 3, 4, 8). The LEDs should each light up.

    Teaching note: In the image to the right, this is done after the components are attached to the container. We suggest testing at this step rather than later so that it is easier to make corrections to soldered joints



14. If the circuit does not work, use the multimeter to troubleshoot.

TEACHING NOTE: *DEMONSTRATE PROPER TROUBLESHOOTING TECHNIQUE*

Test early and often. The best method for identifying errors in the circuit is to test as the circuit is being constructed, where possible. That way, one is able to identify when the error was introduced and isolate it to a particular subsystem. In this device, soldering the battery to the board first allows one to pass current through the system and test each LED as it is soldered to the board. Also, although a system may have worked when it was first attached, it should be retested if it is manipulated to ensure no connections were broken.

Test components individually. Again, dividing the circuit into discrete components allows one to test each individually to narrow down where the error in the circuit may be. Otherwise, one is only guessing at what the problem could be rather than using deductive reasoning to isolate the issue.

Testing for breaks in the circuit. If one finds a problem in the circuit, a multimeter can help diagnose where the break in the circuit may be. Place the multimeter in 'continuity' mode. In this mode, the two probes will beep when a circuit has been completed. Test that the multimeter is working by touching the two probes together and listening for the beep. Then, place the probes on either end of each of the soldered joints and/or across each component in the circuit to see where current is flowing and where it is not.

LEARNING OBJECTIVES ACCOMPLISHED:

- ☐ Participants will learn about basic electrical circuit theory.
- ☐ Participants will learn how to properly solder.
- ☐ Participants will learn how to troubleshoot a circuit.

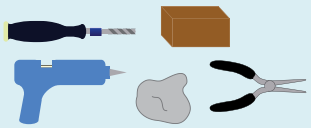
ASSEMBLE THE LANTERN

Skills

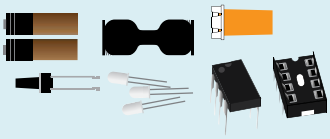
manual drilling

hot glue

Tools



Supplies



15. Use the putty to attach the lid securely to the block. After determining where you would like to place your three LEDs and button, drill the corresponding holes into the lid of the container.

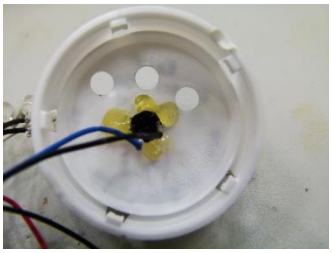
TEACHING NOTE: *DEMONSTRATE PROPER USAGE OF A MANUAL DRILL*

Mount the item. Secure the item to be drilled on to a block of wood using pieces of putty. This prevents you from damaging your work surface and allows you to have your hands free to drill.

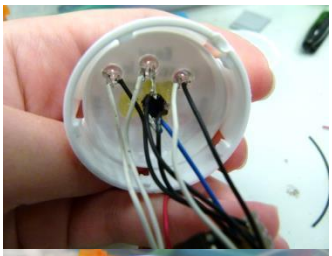
Appropriate technique. After deciding where you want to drill your hole, place the drill at a 90 degree angle from the surface. Apply pressure and twist the drill until you feel the wood underneath. To clean up the edges of the hole, remove the object from the wood and drill from the other side of the hole.

16. Secure the button using hot glue. Use three small dots of glue equally spaced around the base of the button. Make sure to put the glue on the inside of the bottle, on the side of the button where the wires are.

    Teaching note: Explain that care is needed to avoid getting glue in the moving part of the button, as this can prevent the button from being pressed and cause it to function improperly.



17. The LEDs will press-fit into the drilled holes. Line the tip of the LED up with the hole and press gently until the LED is fit snugly in the hole.

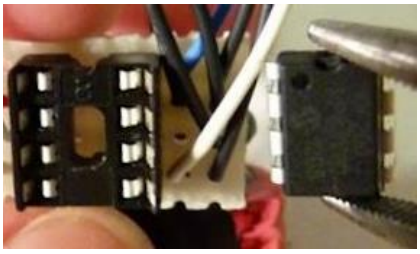


18. Insert the batteries into the battery holder.

    Teaching note: Explain that the batteries each have a (+) and (-) terminal. The raised (+) side of the battery goes to the flat side of the battery pack, and the flat (-) side of the battery contacts the spring of the battery pack.

19. To insert the microcontroller, line up the notch on the top of the microcontroller with the notch on the socket. Gently press the microcontroller into the socket, applying equal pressure to each of the legs to make sure they line up.

    Teaching note: Explain that putting the microcontroller in the socket should be the last step, as it is fragile and easily damaged by heat (from soldering irons or hot glue guns). Also, explain that the microcontroller should be inserted and removed with pliers, as it is very easy to bend the legs of the microcontroller.



20. Gently push the circuit into the bottle, watching the wire connections to make sure there is no excessive strain on them.

    Teaching note: Explain that the connections between the wires and components are fragile and can easily be broken at this step.

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21. Carefully twist the bottle closed.

    Teaching note, explain that after enclosing the circuit, it is best to leave the bottle closed unless absolutely necessary. Each time the circuit is taken in and out of the bottle, the wires weaken, which can cause them to break.

LEARNING OBJECTIVES ACCOMPLISHED:

- ☐ Participants will learn about basic electrical circuit theory.
- ☐ Participants will learn about the use of microcontrollers.
- ☐ Participants will learn how to troubleshoot a circuit.

REFLECTION AND FEEDBACK GROUP DISCUSSION QUESTIONS

- What physical dimensions of the lantern can be changed? What other device shapes can this lead to? What other uses can those devices have?
- What other switches can be designed? Are they limited in size and location relative to the rest of the device? Does a single person have to be the one controlling the switch? Does it have to be with the hand?
- What about combining switches in series or in parallel? What behavior can be achieved if the device can respond when switch 1 *and* 2 are activated? What about switch 1 *or* 2? What about 1 *and* 2 *or* 3 (yes, it can be interpreted in different ways)? What about switch 1 after some specified time and then switch 2 (microcontrollers have timers)?
- Once the basic behavior of the microcontroller is understood, how can changing inputs and outputs be used? What devices can be built if the light flickers, changes brightness, or respond intelligent to one or more switches that may be controlled in various locations and at various distances?
- Besides another lantern, what would you make with the new skills you've acquired?
- Which skill that you learned are you most excited about?
- Which skill that you learned would you like to have spent more time practicing?

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This document has been created by support from the following members of the IDIN network:

List individual names and the organizations/institutions they are associated with.

Mika Ichiki-Welches	*Olin College of Engineering*
Anna Konstantinova	*Olin College of Engineering*
Benjamin Linder	*Olin College of Engineering*
Megan McCauley	*Olin College of Engineering*
Jose Oscar Mur-Miranda	*Olin College of Engineering*
Erin Pierce	*Olin College of Engineering*

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