Robotics in Manufacturing Camp - Little Bits Curriculum

Station Overview

Golden Rule: Do not build circuits for the students. Little Bits are simple enough that even the youngest students are capable of building them for themselves. If you *must* demonstrate putting something together for a student, take it back apart again before giving it to them. Make them engage and do the activity. Caveat: help students experiencing significant difficulties when time is limited.

Station Management

- **Passing out pieces**
  - It is recommended that the station Instructor passes out **all** bits to students as required by the lesson
  - If students have bits in front of them, they will be focused on them and NOT you
  - Pass out bits as you go, not all at once
- **Recollecting pieces at the end of the lesson**
  - A good method is to have all students sort and organize their bits at their tables
    - e.g. All buttons are grouped together, all batteries are grouped together
  - Students do the deconstruction and sorting, saving you time
  - Instructor should recollect the pieces and return them to a distribution/sorting table or to their boxes
    - Please refrain from having students do this as this will likely contribute to a breakdown of organization in the parts boxes
- **Build platforms**
  - Unless necessary, it is recommended that you refrain from handing out these
  - It is difficult for most students to quickly make changes to their circuits on the platform as it requires pulling them up out of the boards and then pushing them back down
  - These can lead to the connector ends of bits getting bent
- **Keep it on the table**
  - Kids tend to pick up their bits and wave them around
  - The magnets are not strong enough to keep the bits together
  - Remind students that they are “table bits”
- **Power Bits**
  - There are two different types of power bits
  - The one for the rechargeable batteries features a micro-usb port and is always on, indicated by a red LED
  - The one for 9V batteries steps down voltage to 5V to work with the bits and features an on/off switch
  - These two bits are nearly identical (issues can arise when working with servos)
- **Buzzers**
  - Kids’ favorite bit
  - Very very annoying
  - Do yourself, any camp staff, and others in the vicinity a favor and don’t pull these out until the end of the last day. You can refer to these as a “super special secret bit” that you only give out to well behaved students

Day 1

Objective

Students will be introduced to the four types of bits — power, input, output, and wire — and learn to connect different bits together to build a working circuit.

Materials

- Battery
- Power cord + power bit
- RGB LED
- Button
- Latch
- Bargraph
- Slider
- Fork
- Long LED
- Pulse

Warm-up

Instructor should introduce themselves to the students.

Explain that in the Little Bits station we will be working with electricity and circuits.

Ask students if anyone thinks they know what electricity is.

- Common responses: Electricity lets us run the lights. Electricity powers our computers and phones. Lightning. Static electricity.
- Explain to students that those are examples of what electricity does, not what it is.
- Prompt students again and see if they can come up with what electricity is.

After several responses, conclude the discussion by giving a definition of electricity.

- For young students, an acceptable definition can be “a form of energy”
- For older students (4^{th}/5^{th} grade and up) you can briefly explain that electricity is “a form of energy resulting from the movement of charged particles, such as electrons”

Remind students that they will be working with circuits. Ask if anyone thinks they know what a circuit is.

- One common response is *no* response, especially at younger ages. This is okay.
- Common responses: Racing circuits (e.g. a track)
- Ask students what the word “circuit” sounds like.
    - Common responses: Circus
        - A good response to this remark is “you’re correct, circus does sound like circuit, but it’s not the word I’m looking for”
    - Guide students to the word “circle”
        - If students cannot get it within ~30 seconds, prompt: “Think of a shape”
    - Explain that a circuit is like a circle because electricity needs a complete loop to follow around.

Explain that all of our circuits will have a bunch of different components in them. Hold up the power cord (cord connecting battery to power bit) and ask students if they think there is electricity in the wire.

- Generally, there will be at least one kid per vote type (yes/no)
- Put it to a vote, ask all the students who think there is electricity in the wire to raise their hand. Have them put their hands down. Ask all the students who think there isn't electricity in the wire to raise their hands. Have them put their hands down.
- Explain that there is not electricity in the wire at the moment. Let students theorize reasons.
    - **Common responses**: It's not plugged in
- Explain that until it's connected to a power source, there isn't electricity in the wire

Show all students the two battery types. Not all students have seen either type.

Sample Dialogue:

> *"The power source for our circuits is going to come from a battery. I've got two types of batteries here, a 9V battery and a rechargeable one. The rechargeable one is kind of like one of those things you use if your phone can't make it through the entire day and you need to charge it."*

Use portions of the above dialogue relevant to the battery type you are using if only using one type.

Pass out batteries to students.

Sample Dialogue:

> *"I'm going to give everyone a battery. Both types work the same, so it doesn't matter what type you get."*

Lesson

Set-up note: Power-bits should be pre-attached to their appropriate cords.

Sample Dialogue:

> *"Now that everyone has a battery, it's time for us to start building some circuits. I'm going to come around and pass out power cords to you. They can only connect one way to your battery. Go ahead and try to get them connected."*

Allow students time to get this figured out. As you walk around, tell students you are looking for red lights. When the red light on their power-bit comes on, they have completed this step successfully.

Common trouble points:

- Younger students sometimes struggle with 9V battery connectors, as many have never seen them before. Explain that big goes with small and that should help them get it turned the right way around.
- Power-bits for 9V batteries have a small on/off toggle switch, help students find this if they are having difficulties

Once everyone has their cords plugged in and the red light on, tell them that they have made their first circuit.

Sample Dialogue:

> *"Congratulations everyone, you have just made the world's most boring circuit."*
>
> And, depending on your sense of humor and delivery:
>
> *"Alright, that's it, we're done, now we can go home."*

Hold up an RGB LED Bit for everyone to see.

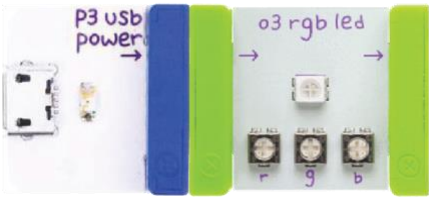
Explain that we will be adding bits to our circuit. The first type of bit is an output bit. Explain what an output is. Have them note the color of the bit.

Sample Dialogue:

> *"We are going to make our circuits more interesting. We can add bits to them that do different things. This first bit is called an output bit. An output is something we can observe with one of our senses. We can see it, hear it, feel it, but hopefully not smell it. Electronics generally don't work very well anymore if we can smell them. You can see that this bit is green, in fact, all output bits are green. When I give you the bit, your job is going to be to figure out how to attach it to your power-bit. It only goes on one way, so keep trying until you see the output doing something."*

Allow students time to figure out this procedure. Once one student gets it, more will follow shortly thereafter. Assist any students still struggling after ~75% of students have got it.

The circuit should resemble:



Get the students' collective attention again.

Discuss how this light is similar/different to lights they've seen before. For example:

- It's a light
- It's like a flashlight
- How is it turned on/off

Sample Dialogue:

> *"Now that we've all got our lights running, I've got a question for all of you. How do we turn this light off?"*

Allow students to respond. Common responses will include: Unplug the cord from the battery, detach the output bit

Ask students to compare this to lights they have in their house and ask if this is similar.

Sample Dialogue:

> *"With most of the lights in our house, do we have to unplug them to turn them off?"*
>
> The "most" here is important so you can avoid students telling you all about those one specific lights in their houses that are, in fact, only plugged in and don't have a switch.

Sample Dialogue:

> *"So how do we turn off those lights?"*

Common responses will include: Switch, dimmer, button, clapper

Sample Dialogue:

> *"Those are all great ideas. We're going to add one of those to our circuits.* [Hold up a button] *What do I have?* [Wait for responses]*. This is indeed a button. A button is a type of input, a pink bit. Inputs can control outputs that come after them. Here's how it's going to work. I'm going to give you the button and you are going to have to figure out where it should go. If you've put it in the correct spot in your circuit, the light should come on when you push the button. If it doesn't, you need to try something else."*

Pass out buttons to each student and allow them time to work.

Sample prompts for students who may struggle:

- *"Remember, an input affects things that come after it."*
- *"You may need to take things all the way apart and put them back together again in a different order."*

The circuit should resemble:

Get the students' collective attention again.

Ask students to again compare this circuit to lights in their house. Are they the same? What are the differences?

- Students should be able to identify that their lights stay on when a button is pushed or switch flipped.

Sample Dialogue:

> *"What happens when I push the button [on your circuit]?* [response: the light comes on] *What happens when I let go?* [the light goes out] *That's still not how*

the lights in my house work, is it? Darn. Do you guys think there's a way for me to do that?"

Acquire a latch (wire bit). Hold this up for students to see.

Explain that this is a wire bit. Wire bits connect things in our circuit together and do a bunch of different jobs. This wire bit is called a latch. Ask students if they know what a latch is. Younger students likely have not. A door latch is a good example to use to define the term. It holds the door open or closed. A circuit latch will do the same thing, holding it open or closed.

Describe how the latch should work in the circuit when properly installed, but do not tell them where to put it. They will have to figure that out.

Sample Dialogue:

"I'm going to give you a latch for your circuit. When you put it in the correct spot, here's what should happen. When you push the button, the light should come on. When you let go of the button, the light should stay on. When you push the button again, the light will turn off. If your button doesn't do that, you will need to try something else."

Pass out latches to every student.

The circuit should resemble:

Explain that you will be handing out another bit [bargraph]. Hold it up for everyone to see. Ask students what type of bit you are holding. Remind them that green bits are outputs and that outputs are things they can observe with their senses (see, hear, feel).

Pass out the bit to the students and instruct them to put it on the end of their circuit.

The circuit should resemble:

Tell students that you have a challenge for them.

Sample Dialogue:

> *"I want you to build me a circuit that has one light always on. When the button is pressed, the other light should turn on and stay on. When the button is pressed again, the light will turn off."*

The circuit should resemble: [bargraph and RGB LED can be switched]

Once all students have figured out the answer, explain that you have another challenge for them.

Sample Dialogue:

> *"For your next challenge, I want you to build me a circuit that can do the following. When the button is pressed, both lights turn on. When you let go of the button, one light turns off and the other stays on."*

The circuit should resemble: [bargraph and RGB LED can be switched]

Explain that you are going to hand out another bit. Hold it up for students to see. Ask what type of bit it is. Wait for student responses. Repeat that pink bits are inputs and that they allow us to control our circuit. Explain that this bit is called a slide dimmer, or a slider.

Instruct students to learn how the slider works by only using it and one of their outputs (blue+pink+green only in the circuit). Once they have explored this, have students assemble their circuits with the inputs first, then the latch, then the outputs.

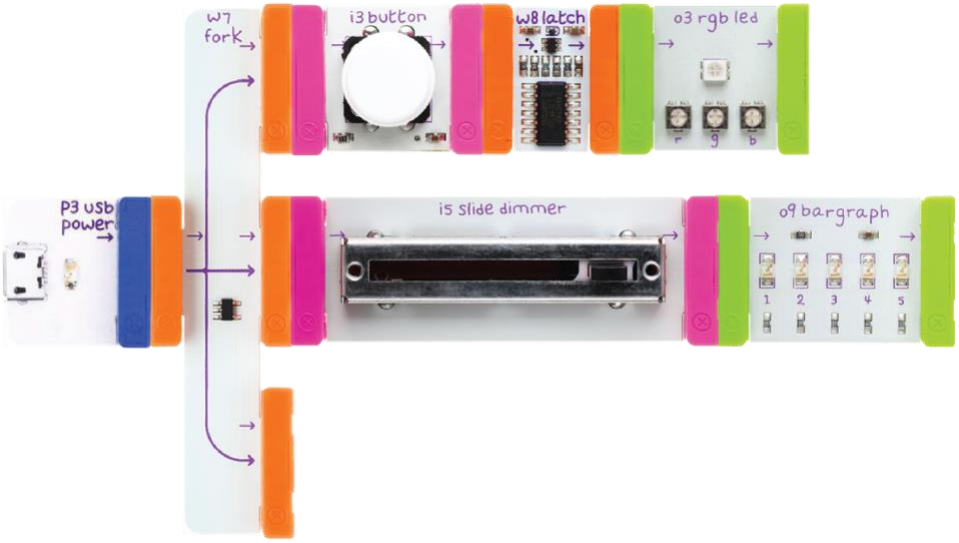
The circuit should resemble:

Explain that you are going to hand out another bit. Hold it up for students to see. Ask them what type of bit it is. After getting responses, remind them that orange bits are called wire bits and that wire bits connect things together in different ways.

This new bit is called a fork and that it divides power into three different paths. It's like having three different batteries in your circuit.

Hand out the fork to the students and have them explore using the bit. After 1-2 minutes, encourage students to pair an input and an output together on the paths of the fork.

The circuit should resemble: [What inputs are paired to which outputs does not matter]



Explain to students that you will be handing out another bit [long led]. Hold it up for students to see and ask them what it is. Students will likely say that it is a wire, since it contains one. Explain that the bit does have a wire, but it isn't a wire bit. Point out the color of the bit. Once students have identified it as an output, remind them that outputs are things we can observe with our senses.

Instruct students to put this bit on its own on the fork.

The circuit should resemble: [Exact bit positioning does not matter much]

Explain to the students that you have one more bit [pulse] to hand out and that it’s a really cool bit. Hold it up for students to see. Ask them what type of bit it is. After waiting for responses, remind students that pink bits are the input bits and allow us to control our circuits.

Instruct students to put the bit in their circuit before an output and hand out the bit to the students.

The circuit should resemble:

Allow students to use the remaining time to make changes with their circuit as they want. They should explore different combinations of inputs/outputs.

When there are approximately five minutes left in the session, get the students' attention again. Explain that we will begin cleaning up now. Explain the method students will use to do this.

Sample Dialogue:

> *"I want you to sort the bits at your table with everyone else at your table. All buttons go together, all forks go together, all batteries go together, and so on."*

Students should be sorting together all their pieces. If a piece is identical, they can magnetically connect them together; otherwise, discourage them from doing so.

Once all the pieces are sorted, the students are done for the session.

The instructor will collect all the bits and return them to the appropriate spots in the boxes.

Day 2

Objective

Students will use multiple inputs together and learn about the branch wire bit and the proximity sensor, an input that reacts to distance rather than touch.

Materials

- Battery
- Power cord
- Power Bit
- Branch Bit
- Button Bit
- (2) Slider Bit
- Proximity Bit
- RGB LED
- bargraph

Warm-up

Welcome students back to the Little Bits station. Ask them what they remember from yesterday.

After a brief discussion, pass out batteries to students. Then, pass out the power cord/power bit assemblies. As you pass them out, instruct students that they may connect them to their batteries.

Once all students have successfully connected their systems [check for red lights on the power bit], tell students that you will be giving them a bit. Hold up the bargraph for everyone to see. Ask students what this bit is.

Common responses: A light, an output

Be sure to make the connection between the color of the bit and the fact that it is an output. Remind students that an output is something you can observe with one of our senses (we can see, hear, or feel it).

Pass out the bargraph to the students and instruct them to connect it to their circuit. Wait for all students to have it connected to their power bit.

The circuit should resemble:

Ask students how they can turn their light on/off. Students should remember from the day before and be able to respond with button/slider. Reinforce this response and remind students that we can control outputs with inputs. Ask students what color the input bits were. After waiting for responses, reiterate that the pink bits are inputs.

Pass out sliders to the students. Instruct them to connect the bit to their circuits.

Sample Dialogue:

“Remember, when you connect your sliders, you should be able to control the output. If you can’t control your light, the slider is in the wrong spot.”

The circuit should resemble:

Hold up the next bit [button]. Ask students what the bit is. Make sure that they get to the response of input. Repeat that inputs allow us to control our circuits.

Pass out buttons to the students and instruct them to add them to their circuits. Instruct them to explore using both inputs together.

The circuit should resemble:

Ask the students if they think it’s possible for them to construct the circuit so that the light turns on and off with only three of the bargraph LEDs coming on.

Allow students to discuss their ideas. Reinforce after discussion that multiple inputs can be used.

Students should manipulate their sliders such that only three of the bargraph lights illuminate when the button is pressed. Explain that this allows us to use the bargraph as a setting and the button as an on/off tool.

Lesson

Hold up the next bit [branch]. Ask students what type of bit it is. Reinforce after discussion that it is a type of wire bit and is similar to the bit they used yesterday. Give the bit name and explain that it works the same as the fork, but in a different shape.

Pass out the branch to students and instruct them to add it to their circuit. Mention that it should go after the power bit and that they should pair one input with one output.

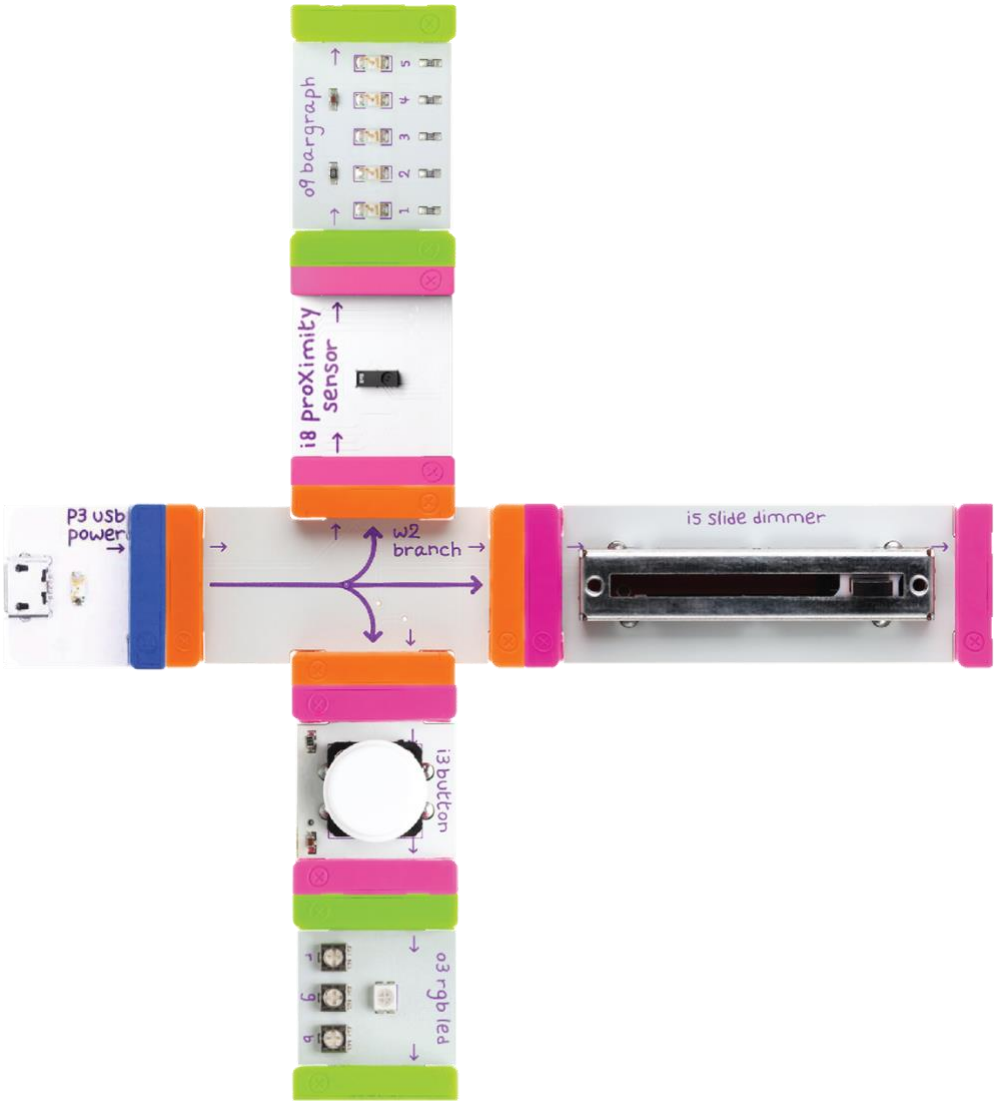
The circuit should resemble: [Which input/output bit is paired is immaterial]

Hold up the next bit [proximity bit]. Ask students what type of bit it is. Reinforce the connection between the fact that it is pink and an input. Remind students that inputs are things we use to control things in our circuit. Ask if any students know what proximity means.

Some students might make the connection to ‘proximity chat’ (from video games). Ask them what that is and what happens in proximity chat.

Pass out the proximity bits and instruct students to pair it with the bargraph bit and to put them on their own side of the branch. It is okay at this stage to not have the slider or button connected to anything.

The circuit should resemble:



When there are approximately five minutes left in the session, get the students' attention again. Explain that we will begin cleaning up now. Remind students of the method they will use to do this.

Sample Dialogue:

> *"I want you to sort the bits at your table with everyone else at your table. All buttons go together, all forks go together, all batteries go together, and so on."*

Students should be sorting together all their pieces. If a piece is identical, they can magnetically connect them together, otherwise, discourage them from doing so.

Once all the pieces are sorted, the students are done for the session.

Day 3

Objective

Students will learn more about inputs and types of outputs. The seven-segment display will be used, as well as the matrix display.

Materials

- Battery
- Power bit
- Power cord
- Fork bit
- 2 slider bits
- Inverter bit
- Button bit
- Seven-segment display bit
- Bargraph bit
- RGB LED bit
- Wire bit
- Matrix display bit (make sure that the slider on the bit is set to signal)

Warm-up

Welcome students back to the Little Bits station. Ask them what they remember from yesterday.

After a brief discussion, pass out batteries to students. Then, pass out the power cord/power bit assemblies. As you pass them out, instruct students that they may connect them to their batteries.

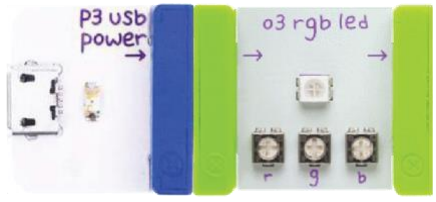
Once all students have successfully connected their systems [check for red lights on the power bit], tell students that you will be giving them a bit. Hold up the RGB LED for everyone to see. Ask students what this bit is.

Common responses: A light, an output

Be sure to make the connection between the color of the bit and the fact that it is an output. Remind students that an output is something you can observe with one of our senses (we can see, hear, or feel it {but hopefully not smell it}).

Pass out the RGB LED to the students and instruct them to connect it to their circuit. Wait for all students to have it connected to their power bit.

The circuit should resemble:



Ask students how they can turn their light on/off. Students should remember from the days before and be able to respond with button/slider. Reinforce this response and remind students that we can control outputs with inputs. Ask students what color the input bits were. After waiting for responses, reiterate that the pink bits are inputs.

Pass out buttons to the students. Instruct them to connect the bit to their circuits.

Sample Dialogue:

> *"Remember, when you connect your buttons, you should be able to control the output. If you can't control your light, the button is in the wrong spot."*

The circuit should resemble:

Once students all have functioning circuits, regain the group's attention. Ask the students to think of ways they could have their lights behave the opposite of how they are working now.

Sample Dialogue:

> *"Do you guys think it would be possible to build a circuit so that the light is always on, and the button turns the light off?"*

Allow students to formulate possible answers.

Common responses: Yes, no, there's a bit for that

If anyone responded thinking that there might be a bit to do this, congratulate them and tell them that they are right. Explain to them about the inverter bit, using the following suggested sequence. Hold the bit up so they can see it.

Sample Dialogue:

> *"I have the special type of bit that will allow us to do what we want. Can any of you tell me what type of bit this is?"*

Students should be able to identify the bit by its color. If students are having trouble identifying the bit, prompt them about the color of the bit.

Reinforce that orange bits are wire bits and introduce the bit.

Sample Dialogue:

> *"Wire bits allow us to connect other bits together and perform special tasks. This wire bit is called an inverter. Has anyone heard of that word before?"*

Allow students to provide responses. If students are unfamiliar with the term, explain that an inverter causes things to work opposite of how we expect. Yes becomes no, on becomes off, off becomes on.

Hand out the inverter bits and challenge the students to place them in their circuits so that the RGB LED turns off when the button is pressed.

Sample Dialogue:

> *"I am going to give you all an inverter bit. I want you to place them in your circuit so that when we press the button, the light turns off. When we let go of the button, the light should turn on."*

Allow students time to construct their circuits.

The circuits should resemble:

Regain the group's attention.

Inform them that you will be passing out another bit. Hold up the bargraph for them and ask them what type of bit it is.

Common responses: a light, the bargraph, an output

If students do not provide the output response, ask them what type of bits green bits are, and more specifically target that response.

Pass out the bits and instruct them to add it to their circuits so that it works just like the RGB LED.

The circuit should resemble:

Regain the group's attention.

Inform the students that you are giving them a challenge. Tell them that you would like for them to create a circuit where the lights alternate which one is on.

Sample Dialogue:

> *"For you next challenge, I want you to modify your circuit so that it can do the following. When the button is pressed, one of the lights turns on and the other turns off. When you let go of the button, the light that was on should turn off, and the light that was off should turn on."*

The circuit should resemble:

Lesson

Before proceeding with the lesson, take the inverter bits from the students. [If placed in the wrong location, the inverter can cause headaches for the next few activities, do not leave it with students.]

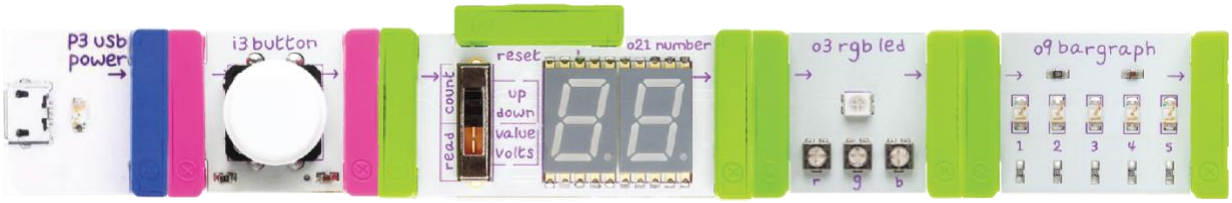
Hold up the number bit for the students and ask them to identify the type of bit. They should be able to identify it as an output (reinforce that an output is something we can see, hear, or feel). Tell the students that this type of bit is one we can see.

Show the bit display (unpowered) to students and ask if they've seen anything like it before. Students might give suggestions such as a clock, scoreboard, etc.

Explain to them that it is just like those examples. Pass out the number bits and instruct them to add it to their circuits before the other outputs.

Instructor Note: As you pass them out, verify that the slider on the number bit is set to count, either up or down.

Their circuits should resemble: [output order **does** matter, the number bit must come before the other outputs for the effect to work properly]



Allow the students time to explore pressing the button and seeing what happens to the outputs.

The following effects can be observed when the slider is in the count-up position: the numbers on the number bit's display will increase, the brightness of the RGB LED will brighten, the LEDs on the bargraph will turn on sequentially as the numbers rise

During the free exploration, allow students to move the slider to count-down (assist if they slide it too far to the read settings)

Regain the group's attention after a few minutes.

Hold up the fork bit and ask students to identify the bit. After they have successfully identified it as a wire bit and as the fork (which allows them to have three different paths for current to flow).

Hold up the slider bit and ask students to identify the bit. After they have successfully identified it as an input (allowing them to control outputs), pass it and the fork out to students.

Instruct the students to assemble their circuits such that the slider controls the number bit and the button is on a different leg of the fork.

The circuit should resemble: [the button needs to be on a different leg than the slider and number bit. The bargraph should be after the number bit. The placement of the RGB LED is immaterial]

Instruct the students to move the slider switch on the number bit to the read section. Allow them time to explore the effects of the slider on the number bit.

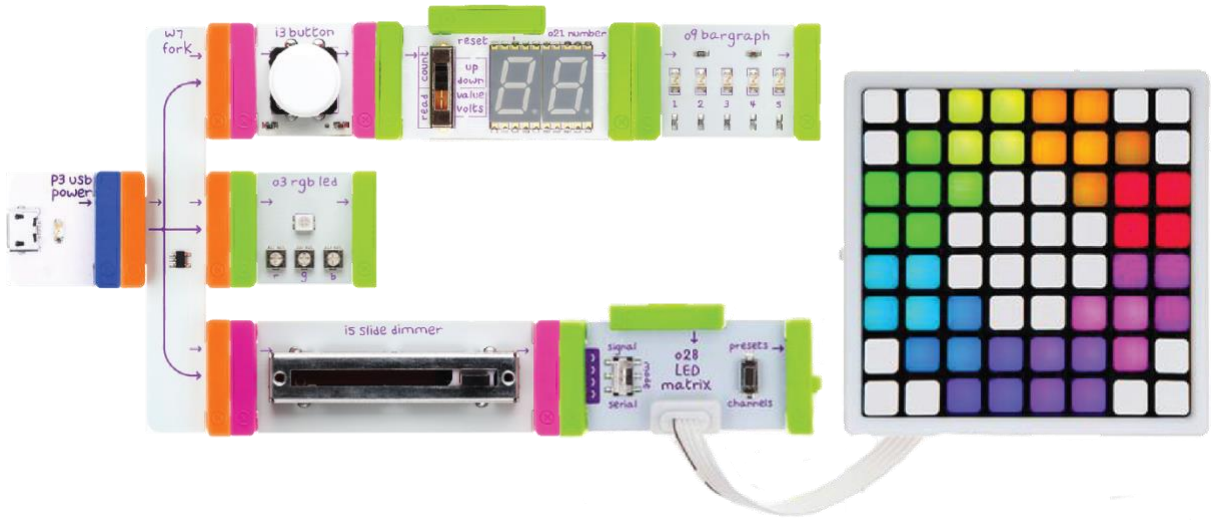
Regain the group's attention.

Instruct the students to move all outputs off the slider so that it is alone on a leg of the fork.

Inform the students that you will be giving them a new bit. Hold up the matrix display so they can see the green section. Ask students to identify what type of bit it is [output].

Pass these out to students and instruct them to add it after their sliders.

The circuit should resemble:



Allow students time to explore the slider's effect on the matrix. During this time, go around and show students the button they can press to change the program on the matrix.

These modes are:

- COLOR PRESET: the input bit controls display brightness and the top bit controls the color of all the LEDs
- X,Y PRESET: the input bit controls the x-location of the illuminated pixel, and the top bit controls the y-location of the illuminated pixel
- DRAW PRESET: the input bit controls the location of the illuminated pixel, and the top bit controls the color of the illuminated pixel
- SPECTRUM PRESET: the input bit controls the display like an equalizer, and the top bit controls the color scheme
- SCOREBOARD PRESET: low-to-high transitions on bit will increase each digit displayed from 0-9. The input bit controls the left number, and the top bit controls the right number.

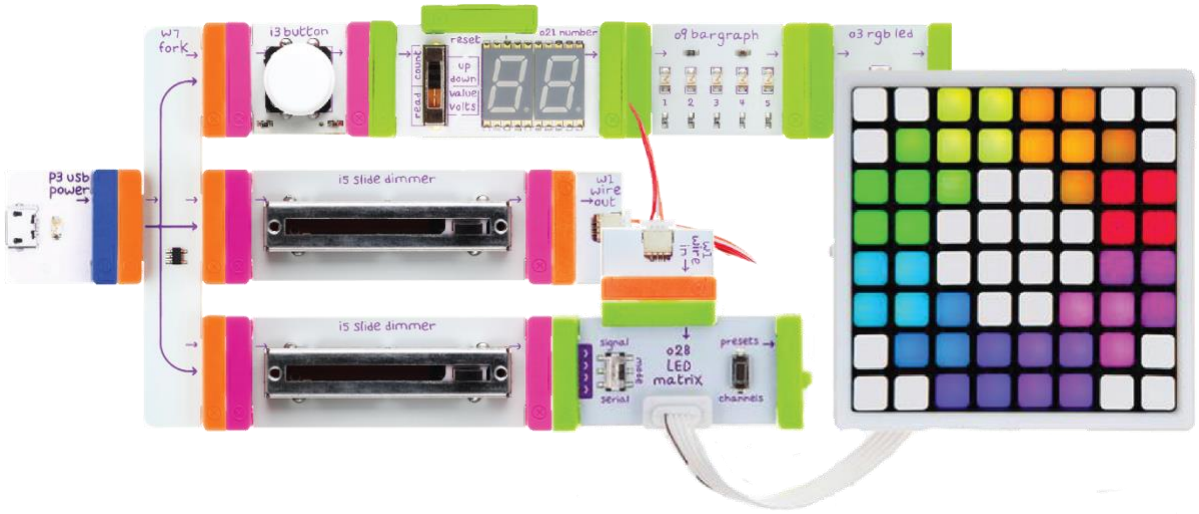
Instructor Note: The matrix truly needs two inputs to run properly. Only using one at this time is ***intentional***. Additionally, make sure that the slider on the matrix bit is set to signal.

Regain the group's attention after they have had a few minutes to explore.

Ask the students if they think their matrices are working as well as they can. Has anyone tried attaching the other side of the matrix bit to the slider? What changed?

Explain that the matrix bit is so cool, that it actually needs two inputs to work properly. Inform the students that you will be passing out a slider and wire bit to them. Instruct them to add these to the last leg on the fork and connect them to the other port on the matrix.

The circuit should resemble:



When there are approximately five minutes left in the session, get the students' attention again. Explain that we will begin cleaning up now. Remind students of the method they will use to do this.

Sample Dialogue:

> *"I want you to sort the bits at your table with everyone else at your table. All buttons go together, all forks go together, all batteries go together, and so on."*

Students should be sorting together all their pieces. If a piece is identical, they can magnetically connect them together, otherwise, discourage them from doing so.

Once all the pieces are sorted, the students are done for the session.

Day 4

Objective

Students will use a DC motor as a controllable output — setting its spin direction and using an input to vary its motion.

Materials

[Listed per student]

- Battery
- Power cord
- Power bit
- Button bit
- Latch bit
- Bargraph bit
- Dimmer bit
- RGB LED bit
- Fork bit
- Inverter bit
- 2 DC motor bits
- Wire bits

Warm-up

Welcome students back to the Little Bits station. Ask them what they remember from yesterday.

After a brief discussion, pass out batteries to students. Then pass out the power cord/power bit assemblies, instructing students to connect them to their batteries.

Once all students have successfully connected their systems [check for red lights on the power bit], tell them you will be giving them a bit. Hold up the bargraph for everyone to see. Ask students what type of bit it is.

Common responses: a light, an output

Make the connection between the color of the bit and the fact that it is an output. Remind students that an output is something we can observe with one of our senses (we can see, hear, or feel it {but hopefully not smell it}).

Pass out the bargraph and instruct students to connect it to their power bit.

The circuit should resemble:

Ask students how they would turn their lights on and off. Students should remember the button from previous days. Reinforce that pink bits are inputs and that inputs control the outputs after them.

Pass out the button and instruct students to add it to their circuits.

The circuit should resemble:

Ask students if there's a way to make the light stay on after they let go of the button. Guide them to the latch [orange wire bit]. Remind them a latch holds something open or closed — push on, push off.

Pass out the latch and instruct students to add it to their circuits.

The circuit should resemble:

Lesson

Get the students' attention. Hold up the DC motor for everyone to see. Ask students what type of bit it is.

Common responses: a motor, a fan, an output

If students don't reach "output," prompt them with the color. Reinforce that green bits are outputs — but explain this one is special: instead of something we see or hear, it gives us **motion**.

Sample Dialogue:

> *"All our outputs so far have been lights. This one's different. It doesn't light up or buzz — it moves. That makes it really useful, because motion is how we get things like cars, fans, and robots to do their jobs."*

Before passing it out, point out the direction switch on the motor: **CCW – VAR – CW**. Tell students to leave it on **CW** for now.

Pass out the motors and instruct students to add them to the end of their circuits.

The circuit should resemble:

Allow students time to make the motor spin with their button. Once roughly 75% have it, get their attention and have them slide the direction switch from **CW** to **CCW**. Ask what changed.

Common responses: it spins the other way, it goes backwards

Reinforce that CW and CCW just pick which way the motor spins.

Next, tell students you'll give them a bit to control the motor more precisely. Hold up the dimmer. Ask what type of bit it is. Reinforce that it's an input — like the slider they know, but a knob instead of a slide.

Pass out the dimmer and instruct students to add it to their circuits. With the motor still on **CW**, have them turn the knob and watch what happens.

The circuit should resemble:

Students should discover the dimmer controls the motor's **speed**, and that the bargraph rises and falls with it.

Sample Dialogue:

> *"Notice the bargraph is doing something useful here — it's showing you how strong the signal is. More lights, faster motor."*

Tell students you have a challenge for them.

Sample Dialogue:

> *"I want you to set your motor to run at about half speed. Use the bargraph to check — when about 3 of the 5 lights are on, you're close."*

Once students have managed this, get their attention for the key move of the day. Have them slide the direction switch to **VAR**. Tell them VAR stands for "variable" and that it changes what the dimmer does. Let them explore before you explain.

Students should discover that in VAR mode the dimmer acts like a joystick: turned all the way one direction the motor spins one way, in the middle it stops, and turned the other way it spins the opposite direction.

Sample Dialogue:

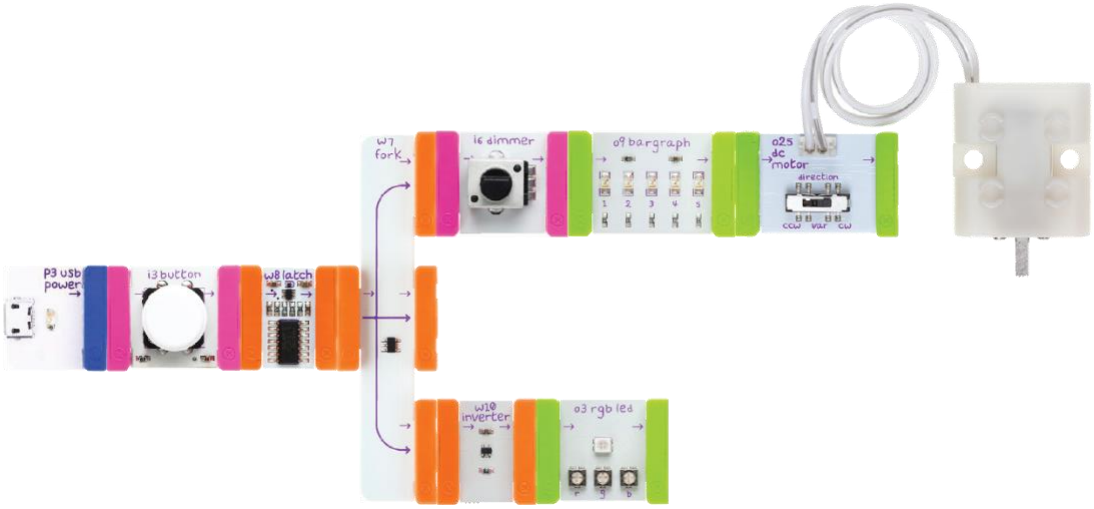
> *"In VAR mode, your dimmer isn't just speed anymore — it's a steering wheel. All the way down, one direction. Middle, stopped. All the way up, the other direction. Hold onto that — it's going to matter a lot tomorrow."*

Now add a second output. Hold up the RGB LED, confirm it's an output, and have students add it to the circuit.

The circuit should resemble:

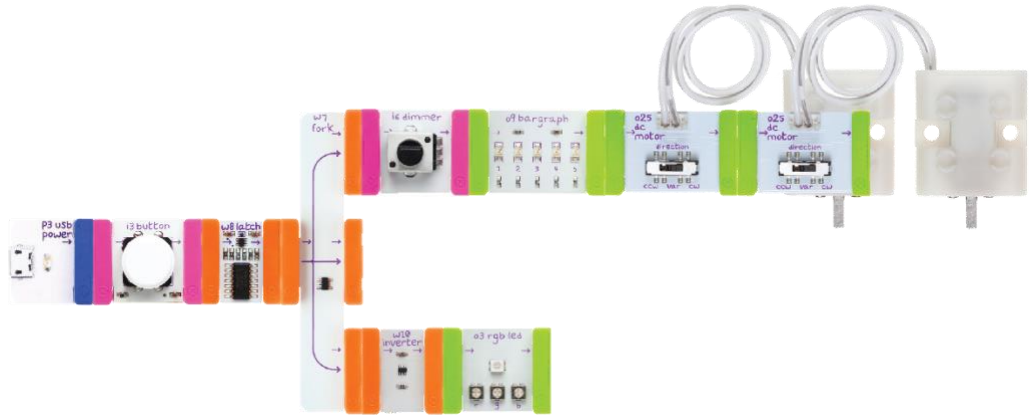
Finally, bring back the fork [orange wire bit] from earlier in the week. Remind students it splits power into separate paths. Have them rebuild so one path drives the motor through the dimmer and bargraph, and a second path runs an inverter into the RGB LED [recall the inverter from Day 3 — it makes things behave opposite].

The circuit should resemble:



For the last build, hand out a second motor. Have students place **two** DC motors on the fork, each with its own direction switch, both set to **VAR**.

The circuit should resemble:



Instructor Note: This two-motor, VAR-mode circuit is the electrical heart of tomorrow's car — two independently controlled motors. You don't need to say much, but it's worth a small teaser: "Remember this one."

When there are approximately five minutes left in the session, get the students' attention again. Explain that we will begin cleaning up now. Remind students of the method they will use to do this.

Sample Dialogue:

> *“I want you to sort the bits at your table with everyone else at your table. All buttons go together, all forks go together, all batteries go together, and so on.”*

Students should be sorting together all their pieces. If a piece is identical, they can magnetically connect them together; otherwise, discourage them from doing so.

Once all the pieces are sorted, the students are done for the session. The instructor will collect all the bits and return them to the appropriate spots in the boxes.

Day 5

Objective

By following a circuit diagram, students will build and connect a working remote-controlled vehicle, then test that it responds correctly to their controls.

Materials

[Listed per student]

- 1 Battery
- 1 Power cord
- 1 Power bit
- 1 Fork bit
- 10 wire bits
- 2 slider bits
- 1 Bargraph bit
- 1 Buzzer bit
- 1 Button bit
- 2 motor bits
- 2 twist ties
- 1 large build platform
- 1 small build platform
- 2 wheels
- 1 caster wheel
- 1 circuit diagram

Setup

The following tasks must be accomplished prior to students arriving at the station:

- Cars must be assembled – see Resource 1 for guidance
    - Make sure to use the twist ties to secure the motors to the large mounting board
- Wire bits should be sorted into groups of 10. Make as many groups as you have students.
- Power bits should be connected to the power cords
- Have printed out copies of the following. One per student.
    - Remote Control Circuit Diagram (Resource 1)
    - Performance Checklist (Resource 2)

Warm-up

Welcome students back to the Little Bits station. Ask them to review what was done the day previous. Allow time for student responses.

Reinforce the goal for today. Inform students that they will be making the remote controls for the cars that they built yesterday.

Pass out batteries to all students. Pass out power cord+power bit assemblies to students. Instruct students to go ahead and connect their wires when they get them.

After verifying all students have their systems setup, move on.

Hold up the bargraph bit for all students to see. Ask them what it is. Allow for student responses. After, reinforce correct remarks.

Sample Dialogue:

> *"As you can see, this is a green bit, which means it's an output. And remember, outputs are things we can observe with one of our senses. We can see it, hear it, feel it, but hopefully not smell it."*

Pass out the bargraph bit to all students and instruct them to connect them to their circuits. Visually scan the room and verify that all students have this connected. This should not take much time, the students should be very experienced at this task by now.

The circuit should resemble:

Ask students how they would turn on/off their lights. Connect the concept to the lights in their homes.

Sample Dialogue:

> *"Can anyone tell me how you would turn this light off?"*
>
> [Student responses, reinforce correct ones, acknowledge incorrect attempts]
>
> [In response to incorrect answers]: *"I don't think that would work, but thanks for trying."*
>
> [In response to correct answers]: *"Absolutely. I don't just unplug lights at my house. I [reference student response]"*

Hold up the button bit and ask students to identify it. Students should be able to identify the name (button), type (input), and how it works.

Sample Dialogue:

> *"What bit do I have?* [wait for responses]
>
> *"What type of bit is a button?"* [wait for responses]
>
> *"Remember that an input is something we can use to control outputs on our circuit."*

Pass out the button to students and instruct them to connect it to their circuits. If they experience difficulty controlling the light with the button, offer hints, but do not modify the circuit for them.

Sample Dialogue for hints:

> *"If you're having trouble, remember that every input needs an output."*
>
> *"You may need to take apart your circuit and put it back together differently."*

The circuit should resemble:

Ask students if we're limited to having one input for our outputs. Reinforce that we can have as many inputs as we want.

Ask students what would be a good input to use with the bargraph. The slider should be one of those suggested.

Pass out the slider to students after they have identified it. Instruct students to add it to their circuits so they can control the bargraph with it.

Allow students time to do so.

The circuit should resemble: [slider and button can be switched]

After, prompt students with a challenge. Tell them that you want them to use the slider as a setting so that when they push the button, only 2 of the 5 bargraph LEDs light up.

Solution: The slider should be advanced approximately 40% of the way up.

Lesson

Get the students' attention. Inform them that they will begin working on their remote controls now. Hold up the circuit diagrams (Resource 1). Explain that unlike the other things we've created, we need to follow a guide for this part.

Instruct them they will place their pieces on top of the diagram, matching the type of pieces.

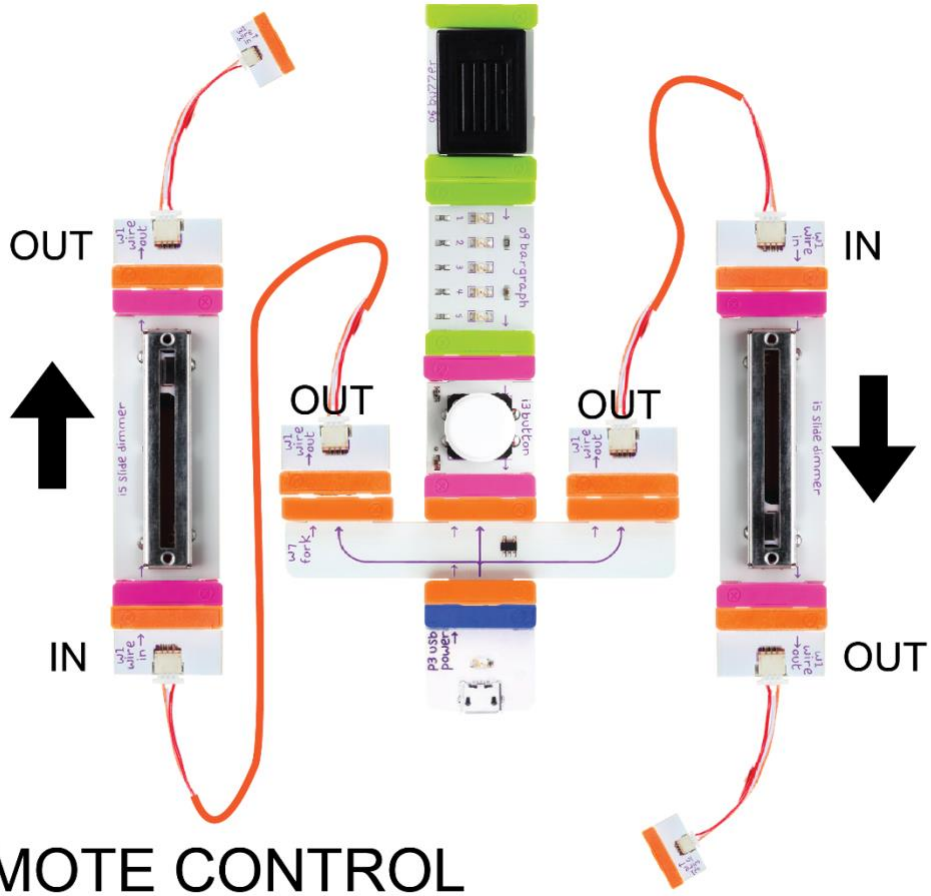
Sample Dialogue:

> *"We're going to start working on our remote controls. Now, because these are so complicated, we actually need to follow a guide to do so. Each of you will get your own and we're going to use them to help build our remotes. When you get*

yours, you should match the pieces you have to those on the diagram and lay them on top."

Pass out the diagrams to every student.

The diagrams look like the following:



Students should have their bits moved to be on top of the matching bits on the diagram. They should no longer be directly connected, except the button and bargraph.

Ask students what bit they think we need next. Students will likely name many of the bits they don't have. Refine the question to ask what piece should go after their power bit.

If students struggle to name the bit [fork], point out to them that the name of the bit is located on the diagram, they just need to look closer.

Once the bit has been identified, pass the forks out to the students.

Ask students what bit comes next. Students should be able to identify the wire bits. Once identified, pass out wire bits to each student. Pass out all the wire bits needed for each section and inform the students that you are giving them more than they need at this moment.

Monitor the room and assist students as needed. When >80% of the students are ready for the next step, ask students what bit comes next. If desired, this can also be done on an individual basis with students, so high performing students can move through the activity faster.

When students respond with the next bit, slider, pass this out to students.

Students will also ask about the top green piece. Passing out this bit, the buzzer, to students at this time is up to instructor discretion. It is recommended that you refrain and tell students that it's a "super special secret bit" that they only will get in the last five minutes of the activity if they work hard for the remainder of the time.

After attaching the sliders, prompt students for what piece comes next. Reaffirm that there are wire bits that need to be attached next. Instruct students to connect them.

Once students have finished their remote control circuits, hand out the small mounting boards and instruct students to mount the circuits to their boards. It is recommended that the battery be mounted on the back. Offer this hint to students.

Once all remotes are completed, get the students' attention. Inform them that you will be giving them their cars and that we need to lay them on the table in a particular way.

Place all of the cars out for the students. Instruct them to leave them where you put them. While you do so, take their remotes and orient them such that the left side of the remote is in alignment with the left wheel.

After passing out all the cars, get the students' attention. Instruct them to disconnect their power cords from their batteries. Explain to students this is because we don't want to accidentally drive our cars off the table.

Then, instruct them to use their remaining wires to connect the left side of the remote to the left side of the car. Inform them that they should use four wire bits. After students have completed this, they can move on to the right side of the car.

Once the car and remote are connected, ask students to verify that their motors are in 'VAR mode. This will allow the sliders to act as joysticks enabling those motors to run forwards and backwards.

Students who are finished with all these steps may move their devices to the ground and test their vehicles. Continue to assist with students who may still be struggling.

When all students have their vehicles driving, monitor the room and provide assistance where needed. As you do so, administer performance checks of student vehicles using the provided checklist (Resource 2).

As time permits, challenge students to demonstrate various driving skills. Such as, driving around obstacles, racing each other, or any other ideas you may come up with.

When there are approximately ten minutes remaining in the station, pass out buzzers to students and allow them to connect them to the button leg of their forks. If a student asks what the bit does, tell them that they will need to test it to find out.

When there are approximately five minutes remaining in the station, get the students' attention. Ask students to return to their seats with their vehicles.

Have the students sort and organize their pieces with their peers at the table. All like items should be grouped together.

If it is not the last station of the day, make sure to instruct students to **not** disassemble the vehicles.

After this is completed, thank the students for working hard and wish them a great day.

Return all bits and accessories to their proper storage locations.