littleBits education

NYCDOE STEM SUMMER IN THE CITY 2018 PROGRAM

TEACHER WORKBOOK

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Dear Educator,

I am truly delighted that you've chosen to partner with littleBits to bring STEAM to your students. We, like you, are incredibly energized and committed to the mission of inspiring the next generation of inventors, and helping them supercharge their skills of problem-solving, creative thinking and collaboration.

Today students are extremely tech savvy, but much of their relationship with technology is one of consumption. We believe we need to encourage them to be creators, so they can thrive in a complex, fast-moving and rapidly changing technical world. We believe it is not enough to know how circuits (or for that matter any technologies) work; it is even more important for students to be able to identify a problem in their lives and work to solve it creatively. For this reason, we have built the STEAM Student Set and all of our upcoming educational programs and products on the ethos of invention-based learning. Through inventions and challenges, we can engage students in very important topics that they could otherwise perceive as dry or archaic. Students engage with invention-based learning by moving through the littleBits Invention Cycle: a student- and teacher-friendly framework for approaching the engineering design process that is woven throughout our challenges and companion lessons. Over the past months and years we have seen students' eyes light up time and time again when they create these inventions, and we are thrilled to see it translate to engaging learning experiences that are also rigorous.

We are also proud to be focused on the next generation of STEM, known as STEAM, a term coined by the former President of the Rhode Island School of Design, John Maeda, that adds Art (and Design) to Science, Technology, Engineering, and Math. Art and Design help broaden the horizons of students, encourage them to pool ideas from different disciplines, to try and fail, and most importantly, to build their creative confidence.

On a personal note, I was trained as an engineer in a very traditional way – rigid, by-the-book learning for learning's sake – and it almost drove me to leave the field. But once I started to use technology as a creative tool to solve real-world problems in interdisciplinary ways, I fell in love with engineering again. Our goal for the littleBits STEAM Student Set is to inspire your students to fall in love with STEAM the same way I did, and to gain the 21st-century skillsets and mindsets that will help these future leaders shape the world and prepare for careers that haven't even been invented yet.

I am in awe of educators like you who tackle learning with enthusiasm and creativity. Thank you for bringing us along on your - and your students' - journey into invention. Please send us your honest feedback to education@littleBits.com, and I invite you to join our active community of educators at littleBits.com

Cheers,

Ayah Bdeir
CEO and Founder, littleBits

MATERIALS LIST

Welcome NYCDOE STEM Summer in the City Educators!
Over the next five weeks you and your students will be diving into littleBits invention-based challenges. To help you along this journey we've provided the following materials:

YOUR STUDENTS' KIT

- STEAM Student Set (1 per group of 3 students)
  - Contains 19 re-usable Bits, accessories and a detailed Student Invention Guide
  - See "Getting to Know Your Kit" pg. 9 – 15 for more detailed information
  - Note that the USB power Bit and adapter is a great backup for drained batteries.
- Student Workbooks (1 per student)
  - Every guided and open challenge will pair with an Invention Log; your students will have at least one copy per lesson in their binders. Additional Remix sections and scratch paper are also included. This binder should be passed out when you begin Guided Challenges.

YOUR TEACHER KIT

- STEAM Student Set (3)
  - Your go-to toolbox for invention-based learning. Spend time exploring your Kits, create inventions for class examples and loan out Bits and accessories with students as needed (for replacements or extra materials).
- Teacher Workbook (1)
  - This binder contains all the lessons and resources you need to run a fun and engaging 5 week summer program.

CLASSROOM MATERIALS

- Recycled Materials
  - You will receive a collection of craft materials and tools (detailed below), but collecting additional recycled materials throughout the summer is highly recommended. Some of our favorite materials include:
    - Empty containers (paper cups, milk jugs, water bottles)
    - Cardboard (cereal, granola, shipping, clean pizza boxes)
    - Bottle caps
    - Container lids
    - Paper towel and toilet paper rolls
    - Scrap paper
- Craft Packs
  - Every classroom will receive a box full of building materials and tools. You may chose to hand out materials that each group/student will be responsible for throughout the summer, or have a central materials station within the classroom.

WE'RE HERE TO HELP!
If you have any questions, please contact our customer support team at support@littlebits.com. Please include your site location in the email.

MATERIALS LIST

CRAFT LIST

ITEM	QTY PER CLASSROOM
Rubber Bands, ~300pcs, in reclosable plastic bag	1
Assorted Color Construction Paper, ~300 Sheets	1
Duct Tape, 2in x 30yd Roll	3
Ball of String	5
Glue Dots, 0.5"	~1000
12" Ruler, wood or plastic	10
Scissors - child-sized, blunt end	10
Scissors - adult-sized, blunt end	2
Glue Stick	12
Tissue Paper	~300
Felt	42
Masking Tape, 0.75in x 60yd roll	15
Wound Paper Tubes, various diameters and lengths	~75
Markers, Assorted Primary Colors - blunt tip	~100
Wood Pencils, #2, pre-sharpened, various colors	50
Corrugated Cardboard, Kraft, ~1 sqft	120
Paper Cups, 5oz	100
Chenille Stems/Pipe Cleaners, assorted colors	200
Wood Craft Sticks	300
Googly Eyes	200
Post-it pads, assorted colors, 3"x3" pad of 200 sheets	10
Cardboard boxes, assorted sizes	~25
Student Workbooks, 3 ring binders	24

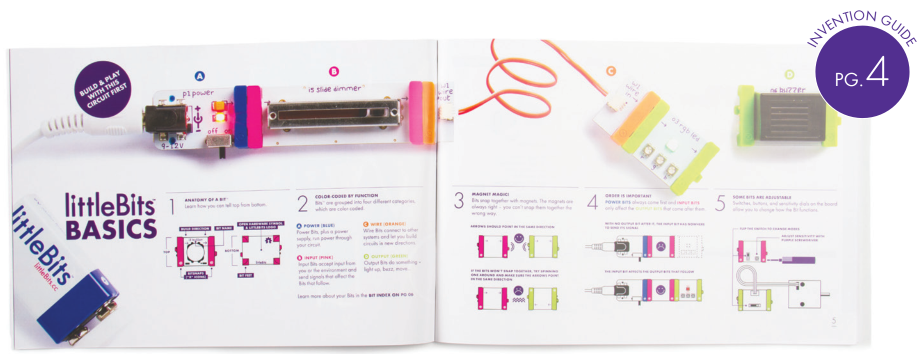
GETTING STARTED WITH YOUR KIT

Each littleBits STEAM Student Set comes with:
- 19 Bits
- 39 accessories
- 1 Invention Guide with 8 challenges, information about the Bits, troubleshooting and more.

littleBits STEAM Student Set online resources include:
- The Teacher's Guide with 10 lessons, curricular connections, classroom management tips, and more.
- Invention Log for students to document their invention progress. This document also serves as a formative and summative assessment tool. Download it for free at littleBits.cc/student-set

WHAT IS IN THE INVENTION GUIDE?

The Invention Guide is a 72-page printed handbook included in each littleBits STEAM Student Set that accompanies the Bits and accessories in the box. The guide walks students through invention challenges they can do independently, or it can be used as a reference tool during a lesson led by an educator. On the next page, you'll find a summary of what is included in the Invention Guide, along with some tips to get started. It's time to roll up your sleeves and dig in!



INVENTION GUIDE PAGES 4–5: BIT BASICS

The best way to learn about the Bits is to start playing! Go to pages 4 & 5 in your Invention Guide to learn the 5 basic Bit concepts. Take a few Bits out of your set and start exploring what the colored connectors mean, how the magnets work, and all of the exciting features. Then you'll be ready to move on to the "Bit Index" section.

INVENTION GUIDE PAGES 7–27: BIT INDEX

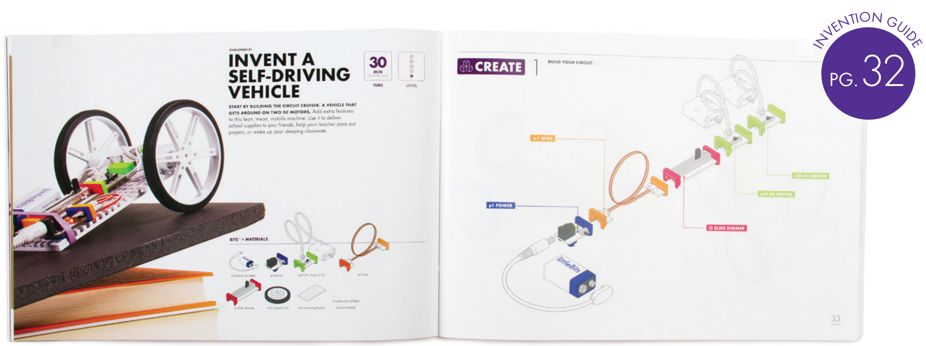
This section of the Invention Guide is designed to teach you and your students how the included Bits and accessories work. We recommend doing some hands-on exploration through this section of the Invention Guide prior to introducing the STEAM Student Set to your students.

When you are ready to introduce the set to your class, turn to the "Introducing littleBits" lesson (pg. 51) to make this process easy and fun.

For every Bit, there is one page dedicated to teaching the student about its functionality. The "Meet the Bit" content is a simple 1–2 sentence explanation of what the Bit does. The "How it Works" description dives deeper and explains how the electrical signal (glossary pg. 145) is affected. The "Real World Analogies" provide students with context of how these Bits appear in everyday objects around them. The "Sample Circuit" is a great way for students to play with and test out the Bit for the first time. The "mini-challenge" helps students take their understanding of that Bit to the next level, and helps educators assess how much they have learned.

INVENTION GUIDE PAGES 28-29: THE LITTLEBITS INVENTION CYCLE

The littleBits Invention Cycle is a roadmap for your students' invention. The Invention Cycle is made up of four phases: Create, Play, Remix, and Share. Each phase is full of activities and questions that help students explore their ideas and develop their inventions.



INVENTION GUIDE PAGES 32–58: GUIDED CHALLENGES

Guided Challenges are the easiest way to get started with littleBits challenges. These challenges walk you through step-by-step instructions, and challenge students to put their own twist on each invention. We recommend students complete at least one of these Guided Challenges before moving on to the Open Challenges. We also encourage you to try at least one Guided Challenge yourself! Who knows, you may create an innovative prototype that you can show off to your class. The Invention Guide includes four Guided Challenges:

- Challenge 01: Invent a Self-Driving Vehicle
- Challenge 02: Invent an Art Machine
- Challenge 03: Invent a Throwing Arm
- Challenge 04: Invent a Security Device

The Guided Challenges follow the littleBits Invention Cycle format of Create, Play, Remix, and Share. The Create phase starts with instructions for a simple invention. For example, the "Invent a Self-Driving Vehicle" challenge starts out with the instructions to make a "Circuit Cruiser." Once you have created the invention, the challenge moves into the Play phase, where you use your invention and evaluate whether it's successful or not. Then, once in the Remix phase, you are prompted to try different Bits, shapes, and materials to improve your prototype. At the end you enter the Share phase, where you are asked to present what you have invented in a creative and critical way.

INVENTION GUIDE PAGES 59–70: OPEN CHALLENGES

Open Challenges are designed for students who have used littleBits before and have a good understanding of how the individual Bits work. They start by presenting an open-ended problem, and challenge students to explore all the ways they could use Bits to create an invention that solves that problem. The Invention Guide includes 4 Open Challenges:

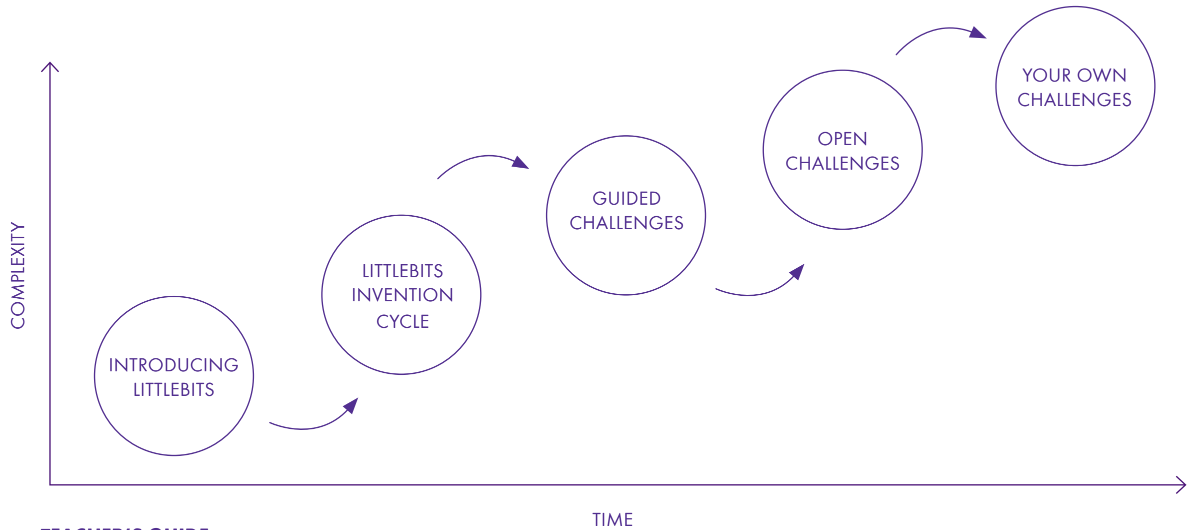
- Challenge 05: Hack Your Classroom
- Challenge 06: Invent for Good
- Challenge 07: Invent a Chain Reaction Contraption
- Challenge 08: Hack Your Habits

The Open Challenges also follow the littleBits Invention Cycle format of Create, Play, Remix, and Share. Unlike Guided Challenges, they do not start with instructions for a simple invention. In the Create phase, students will brainstorm ways to solve a problem and then create their own first prototype of an invention using littleBits. The Invention Cycle and Invention Log will help students move their invention through several sessions of experimentation and feedback so that it is better able to meet the designated criteria for success.

INVENTION GUIDE PAGE 71: TROUBLESHOOTING

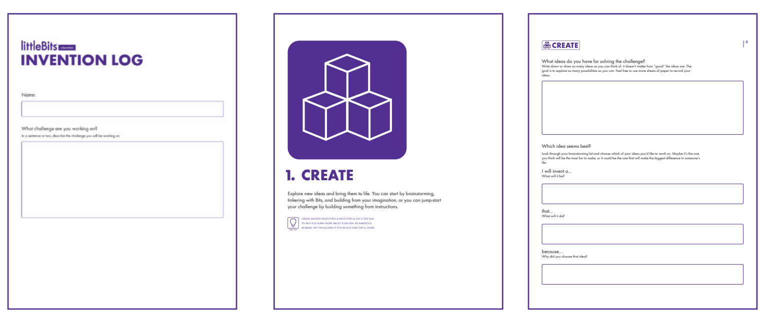
If you or a student are having trouble with a littleBits circuit, check out the troubleshooting guide. We've included some helpful tips to make sure your experience is a success. You can also visit littleBits.com/faq or contact our customer service team at support@littleBits.com

YOUR STUDENTS' JOURNEY WITH LITTLEBITS



TEACHER'S GUIDE

That's where you are now! We've compiled our very best implementation strategies and educator resources into this handy guidebook. The Teacher's Guide walks you through 10 lessons in total. Two introductory lessons will help your students develop foundational knowledge of the Bits and the Invention Cycle, while the remaining lessons provide companion materials for using the Invention Cycle in practice to execute the Invention Guide challenges in formal learning settings. Additional curricular connections for these lessons are available on pg. 169.



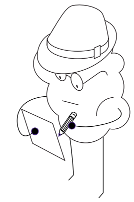
INVENTION LOG

The Invention Log is a workbook that students can fill out to document their invention process. It contains questions that help them reflect as they work, and record their experiences. Learn more about the Invention Log and how to use it for formal assessment on pg. 28. Your students will receive copies of the Invention Log in their workbooks.

MORE RESOURCES

Visit littlebits.cc/education/resources for more educator resources. We've assembled guides, project booklets, case studies and more to help you get started or extend your use of littleBits in the classroom, library, makerspace or other learning environment.

PACING GUIDE



Your littleBits summer curriculum is divided into three sections:
1. Introduction to littleBits
2. Guided Challenges
3. Open Challenges

The suggested pacing and flow of the activities is below, but feel free to customize to meet the needs of your schedule and student's abilities. If you would like to expand your littleBits activities beyond the core curriculum, additional challenges can be found on pg. 147 of your Teacher Workbook or you can browse lessons at littlebits.com/lessons.

1. INTRODUCTION TO LITTLEBITS

Each introductory lesson can be completed in 2 hours.

Students will need their STEAM Student Set Invention Guides (found in the Kit boxes) for these activities.

- INTRO TO LITTLEBITS
  Learn littleBits basics through a guided or exploratory introduction.
- MINI-CHALLENGES
  Continue the Intro to littleBits lesson by going through the Mini Challenges provided on each Bit Index page in the STEAM Student Set Invention Guide.
- INTRODUCING THE INVENTION CYCLE
  Explore the Create, Play, Remix and Share phases of the Invention Cycle through a competitive paper ball challenge.
- INTRODUCTION TO GUIDED CHALLENGES
  Choose any of the guided challenges from the STEAM Student Set Invention Guide (Circuit Cruiser, Art Bot, Throwing Arm, Backpack Alarm) to practice the Invention Cycle.

2. GUIDED CHALLENGES

Guided challenges can be completed in 2–3 hours. Additional remixes or extensions can be chosen to extend the activity.

If you need to break up an activity over 2 sessions, the following flow is suggested:

- Session 1: Create, Play, Remix*
- Session 2: Remix, Share, plus Optional Extensions

*Be sure to store inventions in a safe place

Students will refer to the relevant guided challenge instructions and guided Invention Logs in their Student Workbooks.

For students and teachers that have prior experience with littleBits, use the design challenge prompt to turn the lesson into a more open-ended experience. See lessons for more detail.

- SMART SIGN
  Create an eye catching spin that helps playground visitors enjoy the space.
- CONSTELLATION VIEWER
  Create a hand-held constellation viewer that can display stars, or a design of your choice.
- FORTUNE TELLER
  Create a toy/game that "predicts" the future.
- HAND RAISER
  Create a hand raising invention for an injured classmate.

OPEN CHALLENGES

Open challenges can be completed in 4–8 hours. Additional remixes or extensions can be chosen to extend the activity.

Depending on how deeply you want to engage in the material, you may choose to break up your lesson into 2–4 sessions, with each session being 2 hours:

TWO SESSIONS (4 hours = Ideal for Illumination or Make it Move)
- SESSION 1: Create (Ideas and Prototypes), Play, Remix*
- SESSION 2: Continue Remixing (fine tune prototypes), Share

FOUR SESSIONS (8 hours = Ideal for Carnival Games or Inventing to Improve NYC)
- SESSION 1: Create (Ideas and Prototypes)*
- SESSION 2: Play and Remix*
- SESSION 3: Fine tune prototypes and plan out presentations*
- SESSION 4: Finalize presentations and host a showcase

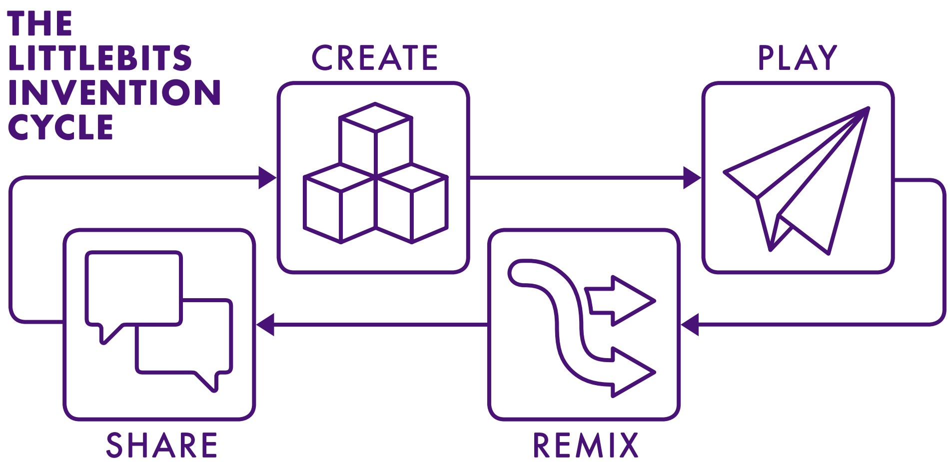
*Be sure to store inventions in a safe place between session

Students will refer to the Open Invention Logs in their Student Workbooks.
- ILLUMINATION
  Create an invention that glows.
- MAKE IT MOVE
  Create an invention that moves.
- CARNIVAL GAMES
  Create a game that others can play.
- INVENTING TO IMPROVE NYC
  Create an invention that has a positive impact on your neighborhood or city.

ADDITIONAL LESSONS

Explore additional open challenges to extend your littleBits learning experience:
- INVENT FOR GOOD
  Create an invention that makes a positive difference in someone's life.
- BITOLYMPICS
  Create an Olympics inspired invention or game.
- MAGIC OF INVENTION
  Create a Harry Potter inspired invention.

THE LITTLEBITS INVENTION CYCLE



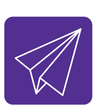
The Invention Cycle is a framework for approaching an engineering or design process. Each of the four phases is full of activities and questions that help students explore ideas and develop their inventions.

The phases work well in order, but the design process is always a little messy. A student's path through the Invention Cycle can be flexible. Each phase represents a different way of thinking and making and sometimes it's good to mix these things up. For example, students may want to share their work and gather feedback before they begin remixing. It can also be helpful for students to play with and evaluate a previously made invention before creating their own.

CREATE

DEFINITION: Explore new ideas and bring them to life. You can start by brainstorming, tinkering with Bits, and building from your imagination, or you can jump-start your challenge by building something from instructions. Don't worry if it doesn't work or if it isn't perfect. The important thing is to create your first model so you have something to experiment with.

IN THE CLASSROOM: The Create phase is the launch pad for an invention journey. It's where students explore problems and opportunities, create lists of ideas, evaluate available resources, and Create their first prototype to test.



PLAY

DEFINITION: Use it! Playing with what you've created is fun, but also an important part of inventing. Playing is like a test run. It's a chance to see how well your invention works and look for ways you can make it better.

IN THE CLASSROOM: Play is a natural way for students to explore and evaluate their creations without worrying too much about perfection. In this phase, students are reflective about their play, and gather information about their prototype's first test run and the circuits they've created.

REMIX

DEFINITION: Improve your invention. Keep experimenting! Add new Bits, swap parts with other inventions, or take all the pieces apart and put them together in a different way.

IN THE CLASSROOM: Remix is where students kick their experimentation into high gear. They are encouraged to test as many variations and improvements as they can, based on their reflections during Play. This phase is often when kids become more comfortable with the uncertainty of exploration and experimentation. When an idea doesn't work, it hasn't really failed. It's succeeded in showing them something new about how things work. Encourage students to try at least a few weird or wacky things. Sometimes really wonderful ideas are hidden in unexpected places.

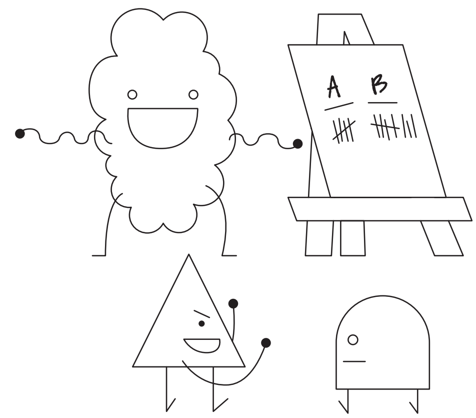
SHARE

DEFINITION: Inspire others. Show the world what you've created. Get inspired by exploring what others have shared. Create, play with, and remix other inventions. This is how awesome new inventions are born.

IN THE CLASSROOM: The Share phase is where students reflect on their whole invention process, figure out how to best tell their story, and share it with others. This reflection on the process helps them develop their skills as inventors, like critical thinking and creativity. Figuring out how to tell their story to others hones communication skills, and sharing that story provides a valuable opportunity for feedback. Learning from other students' stories and interacting with their inventions will also help to deepen this active learning process.

The four phases form a cycle because the process doesn't need to end with sharing. What they learn through sharing can be great fuel for another run through creating, playing, remixing, and sharing. It also serves as a reminder that an invention is never perfect or complete. There is always room for more exploration and improvement.

BEING AN INVENTION ADVISER



Anyone can be an Invention Adviser - whether you're a seasoned STEAM expert, or are just getting started teaching the concepts. We've put together our best tips to help you guide students and inspire them to create inventions with littleBits and the littleBits Invention Cycle. Use this section to supplement your lessons, add constraints to a challenge, or swap out brainstorm and remix prompts.

CREATE

The Create phase is about brainstorming and creating a prototype of your idea. In the Invention Guide, Guided Challenges have a different Create phase than the Open Challenges.

- In Guided Challenges, step-by-step instructions for an invention are provided. This gives students a jump start on the invention and is helpful for those new to littleBits.
- In Open Challenges, students create a prototype of an invention from an idea they brainstorm.

BRAINSTORMING WITH LITTLEBITS

- DON'T WORRY ABOUT THE BITS YET. The goal of a brainstorm is to collect as many ideas as possible around a topic. If the students are thinking about what they can realistically make with Bits vs. the topic at hand, they may miss out on some really great ideas. Adding Bits will come later and your students may surprise themselves by what they are able to accomplish with them.

- DON'T WORRY ABOUT "GOOD" IDEAS. In the early stage of the Invention Cycle, all ideas are relevant. Encourage your students to let their imaginations run wild. Wacky and weird ideas are great for getting the brain juices flowing.

- DON'T LET STUDENTS JUDGE OR MAKE FUN OF IDEAS. All ideas should be given the same respect as others. This helps create a more supportive and collaborative space for creativity to flow. When ideas are rejected, creativity can be stifled.

- BUILD OFF OF OTHERS' IDEAS. When brainstorming, one idea can trigger a bunch of other ideas in other people. Make sure to capture these ideas. This can help add perspective to or round out the original idea. For example, in the Hack Your Habits challenge, if a student has an idea to track each time they raise their hand in a class period, another student might be inspired to test which hand they raise more often.

- DOCUMENT IDEAS. Your students will be coming up with lots of ideas to push their inventions forward. Have them keep a record of these ideas. It can be in the form of a list, drawings, or whatever is easiest for the student to communicate. This visual reference will be a helpful guide as they begin to build with the Bits.

- DEFINE CONSTRAINTS. Define the user or issue, time, cost, environment, materials, or weight. Constraints help students focus and stay on track towards a goal. When the challenge is too broad, it's easy to get stuck because there are too many options. You can also try adding Bit constraints like limiting the number that can be used to complete the invention (i.e. you can only use four Bits). Another option is to give students a "budget" for what they can spend on their invention. You can assign a price tag to each Bit and students will need to choose Bits that satisfy the budget constraints. Being able to define and build within constraints is an important part of NGSS Engineering Design.

ADDITIONAL WAYS TO BRAINSTORM

- POST-IT® NOTES. Post-it Notes are a great tool for brainstorming. They are easy to distribute, quick for collecting ideas, and easy to reposition. A good practice for working with Post-it Notes is to only write one idea per note. Start by setting a timer (2–3 min) and have students write down ideas (one per Post-it). Then have each student post and explain their ideas to their group. Most likely, patterns will emerge on the Post-its. Next, have students reposition and cluster the ideas that are similar. These clusters can be great drivers of inspiration for invention.

- PLAY THE "YES, AND" GAME. Have one student start by saying a sentence related to the challenge. The other students say "yes, and". Then the next student in the group adds to the sentence. Have them go through five rounds. For example, in the Hack Your Classroom Challenge, one student could start by saying,

  "I walked into the classroom."
  yes, and
  (next student) "I opened my locker"
  yes, and
  (next student) "books fell on my head"...

  This could be inspiration to design a locker hack that notifies you if something is pressing up against the door of the locker.

- MINE STUDENTS' INTERESTS FOR INSPIRATION. Ideas are not always automatic when you start brainstorming. It's helpful to guide students' thinking towards things that interest them. For example, in the Hack Your Classroom challenge, you could lead brainstorming by looking at other places the kids feel excited and engaged. Their favorite parts of a video game, book, or game show could serve as inspiration for a new classroom invention.

- IMAGINE THE SCENARIO/EXPERIENCE MAP: As a way to help get the ideas flowing, you can ask your students to envision the scenario they are designing for.

  For example, in the Invent for Good challenge, you could ask them to spend one or two minutes with their eyes closed, imagining themselves going through the day of a friend or family member. When they are done, they can take a moment to write down what they did during their imaginary day and what problems or opportunities may have occurred to them (this is an experience map - it's like a mind map that documents a particular experience).

- EMPATHY: Empathy is important for challenges that are focused on designing for other people. In order for students to understand who they are designing for and what their needs are, you can have them act out what it would be like to be in that person's shoes.

  For example, if the prompt is to design a device to help an elderly person remember to take medication, the students can take turns acting out and imagining how the elderly person would act in different situations. The other students could call out scenarios like "on a vacation," "going out dinner," or "gardening." This way, students start thinking about many aspects of the person's life that they can help improve.

  If the students are designing for other students, another option is to have students interview each other. For example, in the Invent for Good challenge, students can ask one another questions like "When was the last time you felt angry?" and "When was the last time you were excited?"

TIPS FOR CHOOSING AN IDEA TO PROTOTYPE:

Once the ideas from the brainstorm are listed, students should choose an idea to prototype. They should also be able to articulate why they chose that particular idea. If the students seem stuck, ask a single guiding question to help them move forward.

Possible selection criteria could be:
- Which will be the most fun to use?
- Which am I most excited about?
- Which idea will help in the most scenarios (ex: Invent for Good challenge)

TIPS FOR CREATING THE FIRST PROTOTYPE:

- FEAR OF FAILURE: Students may worry about whether their prototypes will work. Remind them that this is just their first prototype. It's a test run so they can learn more about their idea and their circuit. If it doesn't work the way they planned the first time, there will be plenty of time to keep working on it - that's a normal part of the Invention Cycle that every inventor goes through.

- CONCEPT PROTOTYPES:

  "But I can't build a real ____ with littleBits..."

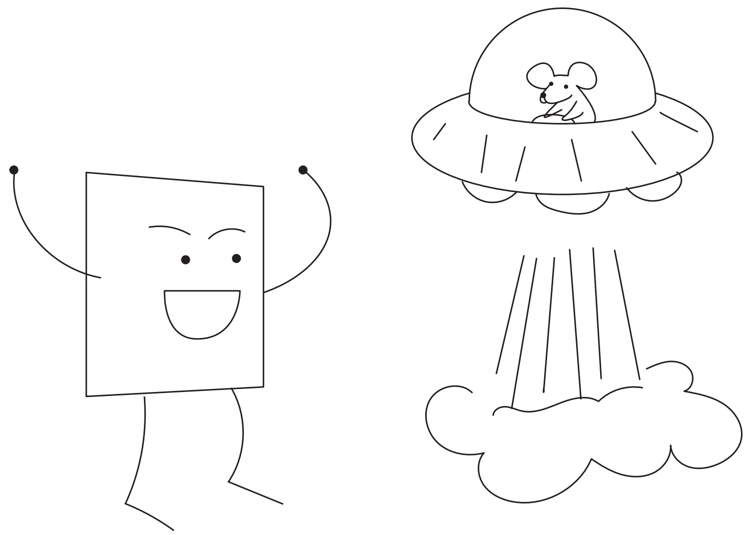
  Sometimes, students will have an idea that can't realistically be built with littleBits. This is ok! Students can still create a model that represents how the invention could work in the real world. In this case, testing and remixing becomes less about making it work, and more about exploring new features and making sure it tells the story. For example, in the Invent for Good challenge, if a student wants to design a smart time-based device that reminds grandma to to take her medication throughout the day, they can use Bits to model some of the key functionalities of the invention (i.e. button, pulse, RGB LED, and buzzer = blinking lights and buzzing sounds when it's time to take medication).

- REAL WORLD EXAMPLES: All the Bits have parallels to things that exist in the real world. These real-life scenarios can be found in the Bit Index. Make sure that students refer to the Bit Index if they are stumped by a Bit.

- EVERYDAY MATERIALS: Get inspired by the things around you! Can a cardboard box become a control station or a paper cup become the nose for a rocketship? Is there an existing object that can be improved? For example, in the Hack Your Classroom challenge, students could pick physical objects or spaces in the classroom to make "smarter." It is important to note that students will be using materials to build prototypes, not final-looking sculptures. Find more materials ideas on pg. 141.

- HELP WITH BUILDING & MECHANICS: Your STEAM Student Set includes useful accessories for attaching Bits, including hook & loop shoes, magnet shoes, and mounting boards. Refer to the Bit Index for more information about accessories.

INVENTION GUIDE PG. 7



PLAY

The goal of the Play phase is for students to test the prototype they made in the previous Create phase and reflect on how it can be improved.

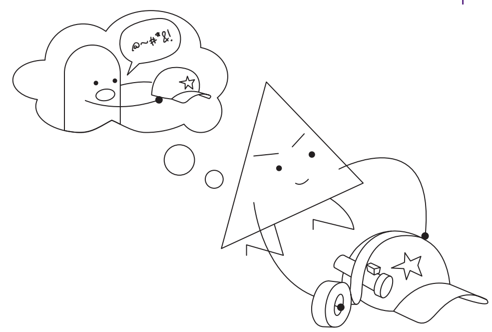
TIPS FOR TESTING YOUR LITTLEBITS PROTOTYPE:

- OUTLINE THE CRITERIA FOR SUCCESS: Students should determine what they want to test about their prototype before they start Playing. For example, if the invention they are testing is the Circuit Cruiser, students could write down three tests that the Circuit Cruiser should pass in order for it to be a success for them (i.e. it needs to be able to surprise someone, it has to be able to drive both forwards and backwards, it needs to be able to pass a note).

- TIME CONSTRAINTS: Play is an exciting phase because students actually get to use their inventions and test them out. It can be easy for students to get distracted at this point, so in order to help them focus, try using strict time constraints for testing and recording information.

- RECORD IN THE INVENTION LOG: The Invention Log is a great way to capture the students' process throughout the Invention Cycle. Make sure you build time into your lesson to take small breaks for students to reflect at each phase. These breaks should happen regularly so students capture important findings and changes as they happen. This way, at the end of the lesson, students will have a physical record of their invention, and the thought process that brought their original idea to fruition.

- WRITING FOCUS AREAS/QUESTIONS ON THE BOARD: Providing Invention Log topics ahead of reflection: in addition to students filling out the Invention Log as they go, it is a good idea to write some key questions up on the board so students can keep them in mind while they work.



REMIX

In the Remix phase, students will improve and adapt their inventions to fit criteria they've decided upon. There are three prompts per challenge in the Invention Guide. However, if a student is stuck, use this list to guide them.

Remixing is a phase in the Invention Cycle that you can repeat until you have an invention that you feel successfully accomplishes the challenge. You may remix your initial prototype once, or 50 times!

TIPS FOR REMIXING A PROTOTYPE:

- MASH-UPS: Every kid gets a secret ingredient bag. They have to integrate the ingredients in the bag into their invention.
- SIMPLIFY: More isn't always better. Try taking some things out of your invention. Does it work better or is it easier to use without them?
- PICK-A-BIT: Pick one Bit you aren't using in your project. What are all the ways you could add this to your invention? Do any of them make it better? Try closing your eyes when you pick the Bit. Sometimes unexpected things are the most helpful.
- DURABILITY: The world can be a tough place for a new invention. How could you make it stronger? Pro Tip: Think about how your invention will be used. You might need to reinforce the parts that get the most use.
- THE RIGHT LOOKS: Experiment with different styles for your invention. Think about how the looks would be pleasing to the intended user. For example, could the Circuit Cruiser be camouflaged to blend in with its surroundings? Could that make passing notes easier?
- BACK TO THE DRAWING BOARD: Instead of simply modifying your circuit, find a totally different way to achieve the same result, then compare. Which worked better?
- BORROW: Learn from others' successes and failures. Bring in ideas from other places.
- MASTERING MECHANICS: Bits aren't the only thing you can remix. If there are any moving parts in your invention, try different ways of connecting the parts or creating the motion. For example, if your servo hub is connected to the end of the mechanical arm, try repositioning the arm to the center. You could also try adding another material to the mechanical arm. What would happen if you added a pen to give it some weight?
- BRING IT TO LIFE WITH BITS: Look at the other objects in the room. What would happen if you combined any of them with your invention? Rolling trash cans, buzzing chairs, blinking backpacks...Bits can give everyday items a new life! For example, In the Hack Your Habits challenge, you could hack the recycling bin so that it flips up a smiley face sign when you recycle.
- ADAPT OR REPURPOSE: What are other ways/contexts the invention could be used? You've made a circuit, and it's probably good at lots of different things. This is also a great way to assess your students' understanding of the different features and capabilities of the Bits.
- "USER" TESTING: See how others use the invention, and incorporate your findings into the invention. Pair up, swap inventions, give feedback.

SHARE

The goal of the Share phase is for students to explain their invention and collect feedback about it.

WHAT SHOULD STUDENTS SHARE ABOUT AN INVENTION?

Possible questions to answer about an invention:

- What did you invent?
- How does your invention work?
- How did you come up with the idea?
- What were your biggest challenges when creating this invention?
- What were your biggest wins or most fun moments?
- What did you learn from creating this invention?
- What would you do differently if you were to invent this again?
- What would you do next if you had time to keep improving your invention?

HELPING STUDENTS TELL THE STORY OF THEIR INVENTION

- CREATE A STORYBOARD: A storyboard is a series of images that tell a story, similar to a comic. An invention storyboard could show different stages of how someone uses an invention or it could depict what life is like before and after the invention is introduced to the world. Another option is to have students storyboard their process from first prototype to final invention. This way you can follow along to see what they changed and how the invention improved.
- CREATE A COMMERCIAL: Have students act out (or film) a commercial to "sell" their invention. The commercial should highlight the key features of the invention and how it will solve a problem or improve the quality of life for someone else. For example, in the Invent a Chain Reaction Contraption challenge, a commercial is a great way for students to physically demonstrate how their invention works and the intricacies they thought about that may not be outwardly apparent by looking at it.
- ACT OUT A SKIT: Acting out scenarios helps to bring an invention to life. In small groups, have students play out "a day in the life" with the invention. Students can act out different scenarios in which the invention will be used throughout the day. For example, in the Invent for Good challenge, the students can act as the user and show how the invention helps them throughout the day.
- PRETEND IT'S A PRODUCT PITCH: Try to frame the presentation as if the students are Steve Jobs showing a new product to the world for the first time.

TIPS FOR FACILITATING A SHARE SESSION:

- PLAN ENOUGH TIME: Single student presentations to the class can be time-consuming. If you are planning to do presentations, you may want to budget an entire class period to make sure that everyone has a turn to present.
- CREATE A STUDENT-DRIVEN CODE: Feedback is extremely important to the invention process, but it can also sometimes hurt feelings. To avoid this, have students set up a code for giving and receiving feedback. The code should include 3–5 ground rules that are decided upon by the students. For example, never interrupt someone while they are talking, or feedback must be constructive.
- INVITE GUEST CRITICS: It can be fun to mix it up and bring in guests to give feedback on inventions. You could enlist a neighboring class to test out the inventions as brand-new users, or ask someone from the community to be a "guest judge." Outside guests can make the challenge feel important and exciting. You will want to make sure that guests know to only provide constructive feedback to keep up a positive atmosphere.

- SHARE INVENTIONS ON THE LITTLEBITS WEBSITE: littleBits has an online platform where students can upload their inventions and share them with the world. Online, students can write a description of their invention, select the Bits they used, add photos and videos of the invention in action, and write instructions for others on how to make it. The invention page is also an inspiring place to see what what others have made, as well as give and receive feedback from the community. Go to littleBits.cc/invention to get started. Often, classrooms or schools will create a singular account to showcase student work.

SHARING AND REFLECTING

Part of becoming a better inventor is thinking about how you work and how you could remix and improve your own process. The following questions are from the Share phase of the Introducing the Invention Cycle lesson. They can be a good framework for a reflective discussion with your students at the end of any design challenge.

CREATE PHASE:

- How did you come up with ideas for what to build?
- How did you decide what to do first?
- Were everyone's designs the same?
- Was your invention complete after putting it together the first time? Why not?

PLAY PHASE:

- When was the first time you used what you were working on? Did you ever give it a test? How did it go?
- Why is it important to test what you are working on?
- What did you learn from playing with it?
- Did anyone's project not work the way they hoped when they played with it?
- Was your invention complete after using it the first time? Why not?

REMIX PHASE:

- Did anyone make changes or improvements to their inventions after they played with them?
- Did anyone try more than one approach/method?
- What was the weirdest idea you tried? What did you learn from it?
- How many different ideas do you think you tried?
- How did you decide which method was the best?
- Why might you want to try more than one way of doing something?

SHARE PHASE.

- After seeing what others have done, do you think you could do it even better now?
- Were there ideas others had you would like to try?
- Did anyone have something to say to you about your project, maybe some praise or a suggestion?
- Why might you want to share the work you've done with others?
- Why might you want to listen to others share what they've done?

THE INVENTION LOG

The Invention Log is a workbook that students can use to document their invention process. It contains questions that help them reflect as they work and record their experiences. Encourage students to explore different methods of expressing themselves. A combination of drawings, words, and simple graphs not only bring the log to life, but also let your students explore different ways of communicating information.

THE INVENTION LOG AS A VALUABLE ASSESSMENT TOOL

For formative assessment, teachers can review Invention Log entries throughout the project, review students' understanding of the process, and help clarify areas of confusion. For summative assessment, teachers can collect logs at the end of the project to make sure students have completed all the necessary steps and met all constraints and criteria for success. See the Invention Log assessment checklist later in this section for tips on using the log as an assessment tool.

The final page of the Invention Log can be used to assess your students' understanding of the Invention Cycle, their use of the Invention Log, and their ability to attain the objectives of the lesson.

For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track (respective page numbers in the guide are provided below). The checklist can also be used as a self-assessment tool by students as they move from phase to phase.

For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

THE INVENTION LOG AFTER A CHALLENGE

As students move on to further challenges, they can review their previous Invention Logs. This will help them reflect on their process, build on previous work, and grow as thinkers and inventors.

The Invention Log also creates a lasting memory of each invention. Students are proud of their inventions, and it can be hard to for them to disassemble their work and return the Bits when the challenge is complete. The Invention Log is something students can keep and share when the challenge is done. It's not only a record of their hard work, but it also helps them to show off their work (and the ingenuity of their invention) to others.

TIPS AND TRICKS

It's a good idea to make structured time for working in the Invention Log. Students tend to get excited about experimenting with their inventions and forget to come back to the log to record their observations.

- To help with this pacing and to provide easy reference for teachers, section headers and prompts from the Invention Log have been embedded into the companion lesson for each open challenge.
- The blank Invention Log available for download has enough sheets for one Remix. We suggest you print out extra copies so students can add Remix sheets to their log as they work. Print out extra copies of pages 11 and 12 (Prototype # _______ and How Did Your Testing Go?)

Blank logs are available online for downloading and printing. The blank Invention Log file can be found at littleBits.cc/student-set

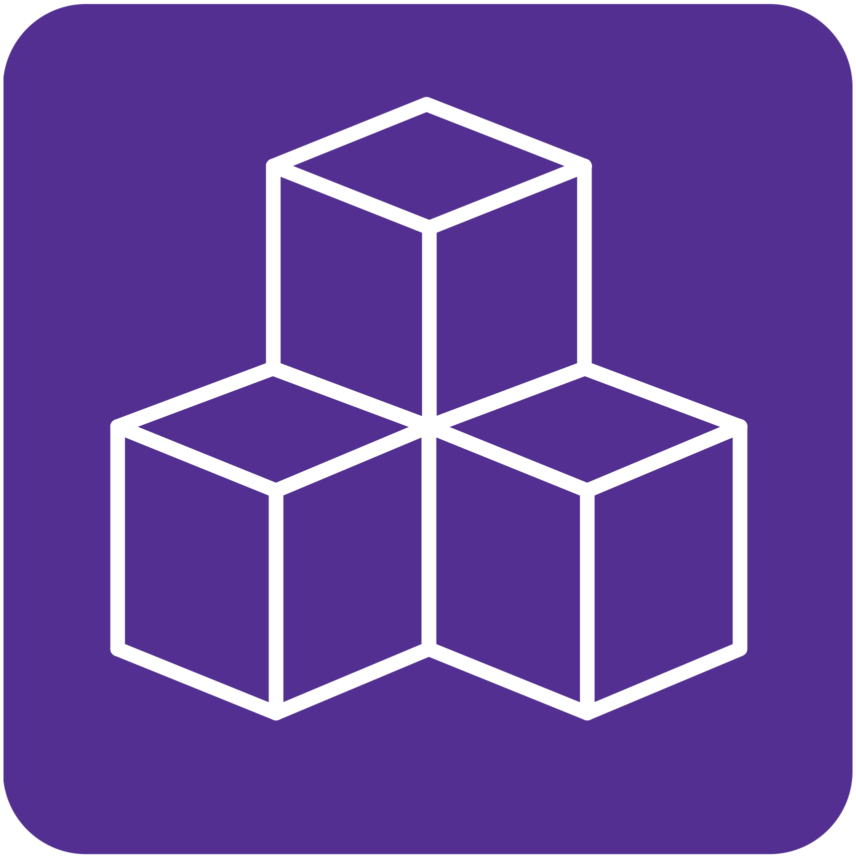
*Students will also receive copies of the Invention Log in their Student Workbooks.

INVENTION LOG

Name:

What challenge are you working on?

In a sentence or two, describe the challenge you will be working on.



1. CREATE

Explore new ideas and bring them to life. You can start by brainstorming, tinkering with Bits, and building from your imagination, or you can jump-start your challenge by building something from instructions.

PRO TIP

CREATE MULTIPLE PROTOTYPES! A PROTOTYPE IS JUST A TEST RUN TO HELP YOU LEARN MORE ABOUT YOUR IDEA. BE AMBITIOUS. BE BRAVE. TRY THINGS EVEN IF YOU'RE NOT SURE THEY'LL WORK.

What ideas do you have for solving the challenge?

Write down or draw as many ideas as you can think of. It doesn't matter how "good" the ideas are. The goal is to explore as many possibilities as you can. Feel free to use more sheets of paper to record your ideas.

Which idea seems best?

Look through your brainstorming list and choose which of your ideas you'd like to work on. Maybe it's the one you think will be the most fun to make, or it could be the one that will make the biggest difference in someone's life.

I will invent a...

What will it be?

that...

What will it do?

because...

Why did you choose that idea?

Storyboard: What's the "before" story?

Think of your invention journey as a "before and after" story. In the boxes below, draw or describe what life is like without your invention. (For example: I wake up late every morning, which causes me to run downstairs in a rush, which causes me to forget to grab my lunch out of the fridge, which causes me to be hungry the rest of the day.) Sharing this story helps people understand why you're creating your invention. This storyboard may also give you ideas for how your invention could work.

STEP ONE

CAUSES

STEP TWO

CAUSES

STEP THREE

Characters

Who are the people involved?

Setting

Where does it happen?

What are your constraints?

Constraints are your limits and requirements. For example, you might have limits on the amount of time you can spend on this challenge, the types of materials you can use, or how much your final invention can weigh. In the space below, create a list of any constraints you might need to keep in mind as you work.

What are your goals?

What do you want your invention to accomplish? Achieving these goals will help you know your invention was a success.

What are the important qualities for your invention to have?

These should all be things that will help it do its job better. For example, is it important that your invention is lightweight or durable?

How could your Bits help you achieve success?

Look through your Bits, accessories, and any materials you have to work with. How could they be used? For example, how could you use the movement of a motor? In the space below, write out or sketch how you might use some of the available Bits or materials

PRO TIP

IF YOU'RE NOT SURE WHAT A BIT DOES OR HOW IT COULD HELP, SNAP IT INTO A CIRCUIT AND START TO PLAY WITH IT. IF YOU'RE STILL STUMPED, READ THROUGH THE "BIT INDEX" SECTION OF YOUR INVENTION GUIDE.

POWER

INPUTS

OUTPUT

WIRE

ACCESSORIES

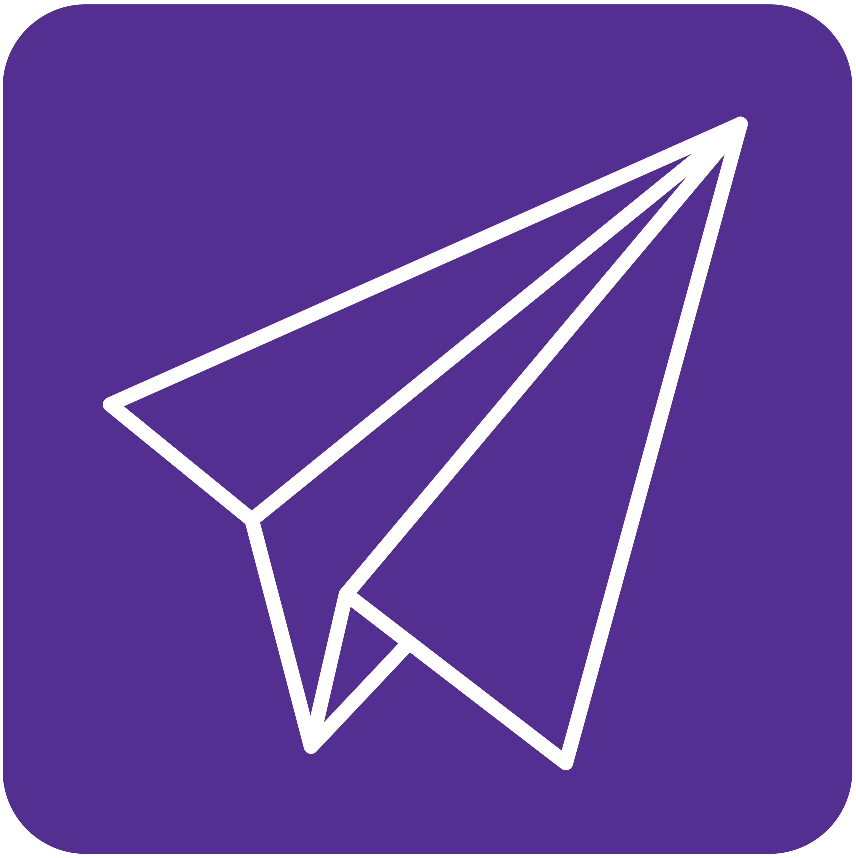
MATERIALS

PROTOTYPE #1

What does your first prototype look like?

Create a drawing of your prototype. Be sure to label which Bits you are using.

How do you think the prototype will work?



2. PLAY

Use it! Playing with what you've created is fun, but also an important part of inventing. Playing is like a test run. It's a chance to see how well your invention works, and look for ways you can make it better.

PRO TIP

KEEP YOUR EYES AND EARS OPEN. PAY SPECIAL ATTENTION TO HOW EACH PART OF THE PROTOTYPE IS WORKING.

How did your testing go?

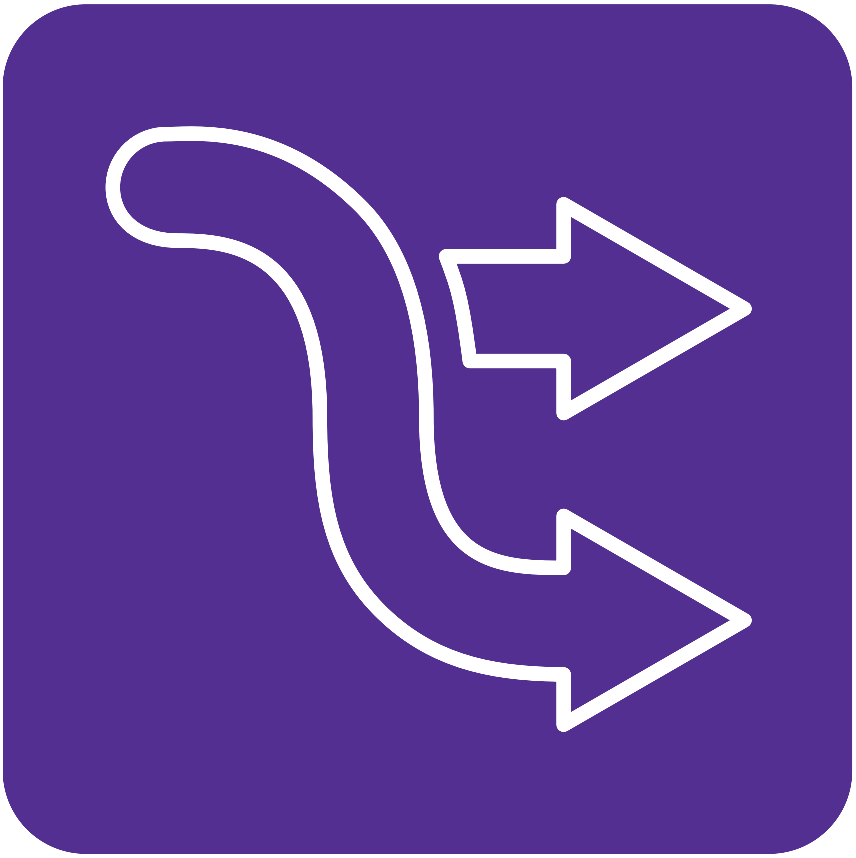
Describe how your test run went. What happened when you used your prototype?

Successes

What parts worked well? Did you meet any of your goals?

Still needs work

What parts didn't work well or go as planned? Are there any goals you still need to work on?



3. REMIX

Improve your invention. Keep experimenting! Add new Bits, swap parts with other inventions, or take all the pieces apart and put them together in a different way.

PRO TIP

BE PERSISTENT. REMIX YOUR INVENTION AS MANY TIMES AS YOU CAN. YOU'LL LEARN MORE EACH TIME, AND YOUR INVENTION WILL GET BETTER.

PROTOTYPE #______

What does your prototype look like?

Create a drawing of your prototype. Be sure to label which Bits you are using.

What's new?

Are you adding anything new or trying a different approach? Are you fixing or improving the things that didn't go well in your last test?

How do you think your changes will affect the way your prototype works?

How did your testing go?

Describe how your test run went. What happened when you used your prototype?

Successes

What parts worked well? Did you meet any of your goals?

Still needs work

What parts didn't work well or go as planned? Are there any goals you still need to work on?

4. SHARE

Tell your story. Inspire others. Show the world what you have created.

PRO TIP

BE OPEN TO FEEDBACK. LISTEN TO ANY IDEAS OTHERS HAVE ABOUT YOUR INVENTION. THERE IS ALWAYS ROOM FOR MORE PLAYING AND REMIXING.

SHARE

Invention Name

Create a drawing of your invention. Be sure to label which Bits you are using.

How does your invention work?

Storyboard: What's the "after" story?

It's time to tell the final part of your "before and after" story. Draw or describe what life is like with your new invention. (For example: I usually wake up late and rush out of the house without my lunch. But now, opening the front door triggers my lunch reminder alarm, which causes me to go back to the kitchen to grab my lunch bag, which causes me to not be hungry.) Storyboards like these can help other people understand why your invention is exciting.

STEP ONE

CAUSES

STEP TWO

CAUSES

STEP THREE

Characters

Who are the people involved?

Setting

Where does it happen?

What have you learned about being an inventor?

Part of becoming an inventor is thinking about how you work and how you could remix and improve your own process.

Did you learn anything about how your Bits work?

What was the most exciting part of inventing?

What is one new thing you learned during this challenge?

What did you learn from watching others go through the Invention Cycle?

What was the most challenging part of inventing? What is one thing you could do to try to get better at this?

What is something different you would like to try next time you work on an invention?

Invention Log Checklist:

Use this checklist to make sure you have completed all of the steps of the Invention Log.

	STUDENT	TEACHER
CREATE		
While brainstorming, I came up with at least 3 ideas related to the challenge.	☐	☐
I listed my constraints and criteria for success so when I remix, I can look back and make sure my remixes are on the right track.	☐	☐
I looked at all of my available Bits and materials and wrote down different ways some of them could help me complete the challenge.	☐	☐
I made a detailed drawing of my first prototype and explained exactly how I thought it would work during the Play phase of the Invention Cycle.	☐	☐
PLAY		
I paid careful attention to my prototype while I was playing so I could learn about how it worked.	☐	☐
I recorded my observations in my Invention Log, including both things that I liked about the prototype and things that weren't right yet and needed work.	☐	☐
REMIX		
For each one of my remix prototypes, I identified what new thing I was trying.	☐	☐
Every time I created a new prototype, I made a new prototype profile in my Invention Log so I could look back at all the different things I tried later.	☐	☐
After playing with and testing a prototype, I recorded what happened, what was successful, and what still needed work so I could continue to improve my invention.	☐	☐
SHARE		
I created an "after" storyboard to go with my "before" storyboard. Together they show how my invention has solved a problem or filled a need.	☐	☐
I shared my invention and the story of how or why it was made with someone else.	☐	☐
I thought about everything I did during the challenge, and wrote down future improvements & new things I want to try when I create my next invention.	☐	☐

INTRODUCTION TO LITTLEBITS

GOALS

- Get to know each other! Assign students to invention teams (3 students per group)
- Explore the Bits and the littleBits Invention Cycle
- Apply your students' skills in their first guided challenge

LESSONS AND PACING

Students will need their STEAM Student Set Invention Guides (found in the Kit boxes) for these activities.

INTRO TO LITTLEBITS

- Learn littleBits basics through a guided or exploratory introduction.

MINI-CHALLENGES

- Continue the Intro to littleBits lesson by going through the Mini Challenges provided on each Bit Index page in the STEAM Student Set Invention Guide.

INTRODUCING THE INVENTION CYCLE

- Explore the Create, Play, Remix and Share phases of the Invention Cycle through a competitive paper ball challenge

INTRODUCTION TO GUIDED CHALLENGES

- Choose any of the guided challenges from the STEAM Student Set Invention Guide (Circuit Cruiser, Art Bot, Throwing Arm, Backpack Alarm) to practice the Invention Cycle. Use the STEAM Student Set Invention Guide as your pacing tool (no formal lesson provided).

INTRODUCING LITTLEBITS

DESCRIPTION

This lesson provides a structured way to introduce littleBits to your students for the first time. They will start by exploring Bit Basics (e.g. color-coding, everything connects with magnets, order is important). Once they've built their understanding of these core ideas they will engage in short rounds of mini-challenges to explore all their Bits, gain confidence, and spark their imagination.

OBJECTIVES

By the end of the lesson, students will be able to:

- Identify and understand the functional grouping of the the four color-coded Bits: powers, inputs, outputs, wires
- Use logic to create basic circuits
- Demonstrate knowledge of how the Bits connect via magnets
- Make connections between Bits and real-world applications

SUPPLIES

BITS
power, button, RGB LED, servo, wire
mini challenge: littleBits STEAM Student Set

ACCESSORIES
battery, power cable, purple screwdriver

TOOLS USED
timer

OTHER MATERIALS
see list of commonly used materials on pg. 141

ASSESSMENT STRATEGIES

There are questions embedded throughout the Exploratory and Guided portions of this lesson that can be used to assess students' understanding as they explore the basic principles of littleBits.

Additionally, you can review the circuits students make during the mini-challenges to assess their understanding of building littleBits circuits.

TYPE

GRADE LEVEL
elementary
middle

SUBJECT AREAS
engineering
design

DIFFICULTY LEVEL
beginner

PRE-REQUISITES
none

DURATION*
45 minutes (minimum)

KEY VOCABULARY

signal
circuit
power
input
output
wire
magnetism

*For tips on how to break up your lesson over multiple class periods, see pg. 139

STANDARDS

For curricular connections, refer to the "Extension" section at the end of this lesson.

ADDITIONAL LINKS & TIPS

INSPIRATIONAL LINKS

TED Talk: Building Blocks that Blink and Teach - Ayah Bdeir

http://ted.com/talks/ayah_%20bdeir_building_blocks_that_blink_beep_and_teach

HELPFUL LINKS

Bit Basics PDF

https://d3ii2lldyojfer.cloudfront.net/pdf/STEAM+Student+Set/STEAM-Student-Set-Bit-Basics.pdf

This can also be found on pg. 4–5 of the Invention Guide.

TIPS AND TRICKS

Before starting the lesson, establish your classroom set up and clean up protocol. Establishing good habits will help ensure Bits are taken care of in the classroom. See pg. 140 for additional classroom management tips.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and an Invention Guide.

STEP TWO: INTRODUCE (5 MIN)

Begin by asking students to brainstorm ways in which we use and rely on electronics in our everyday lives. In small groups or as a class, ask students to rank the top five electronic devices they couldn't live without, providing rationale for the ways in which our lives would be significantly different without electronics.

Ask the class if anyone knows how these electronics work. If you have already completed a unit on circuits and electricity, use this opportunity to provide a brief review of relevant vocabulary (e.g. circuit, signal, power, input, output, wire).

After this introduction, explain to students that they are going to begin experimenting and investigating with circuits to better understand how these electronics work. The tool that they'll be using is called littleBits. You may want to show Ayah Bdeir's TED Talk to provide context and get students excited.

CREATE

STEP THREE: CREATE (20 MIN)

Distribute a single input Bit (button) and an output Bit (RBG LED) to each student and encourage them to explore how the Bits connect. After a few minutes, ask students to share what they have observed and learned about the Bits (for example, they are color-coded, they snap together, there are magnets on the ends). Write responses on the board. Discuss how the magnets will indicate if you have correctly connected the pieces (could you feel the pieces repel if they were aligned the wrong way?).
Helpful tip: Point out the arrows on the top of the Bit; they will always point to the right when currently aligned.

Now it's time to make a functioning circuit. Choose exploratory or guided instructions below, depending on the age and ability of your students. If you or your students need additional support, refer to the littleBits Basics in the Invention Guide. Introducing this "cheat sheet" at the end is also a good way to review and visualize what the students have just learned.

INVENTION GUIDE PG. 4

EXPLORATORY:

Distribute additional parts to each student or group: power Bit, battery, cable, purple screwdriver, servo and wire Bit. Again, provide a few minutes for students to explore their Bits independently. Through experimentation and trial and error, students will naturally learn how to assemble Bits. It is important to provide students with this opportunity and get them comfortable with the Bits. After a few minutes of exploration, ask students to share what they have observed and learned about assembling the Bits. Use guiding questions to promote deeper understanding and engage students in active inquiry.

EXAMPLE GUIDING QUESTIONS:

- How do you know that you are connecting Bits the right way?
- How can you tell the top of the Bit from the bottom?
- Does the order of assembly matter?
- What do the colors mean?
- What happens when a pink Bit comes after a green Bit?
- What role does the blue Bit play in the circuit (and how can you tell that it's powered on)?
- Did you notice that some Bits are adjustable? Who can demonstrate how to use the switch on some Bits, or use the screwdriver to make changes to the functionality of one Bit.

Within this discussion, use and define the following terms in relation to the Bits: circuit, power, input, output, wire, switch.

GUIDED:

Some students or classes may need a bit more support and focus through this first circuit-building exercise. An alternative pathway is detailed below (note the order in which the Bits and other tools are distributed). Each step in this introduction has accompanying questions you can use to asses students' understanding of the material:

Identify Bit anatomy as a class. Pick up the button or RGB LED from the table. Take time to make sure each student can recognize the top, bottom, and feet of the Bit.

Q: How can I tell the top of the Bit from the bottom of the Bit?

A: The top has the name of the Bit written on the white circuit board. The bottom of the Bit has four feet or legs (like a table).

Hand out the blue power Bit, battery and cable. Have students connect the cable and battery to the power Bit. Use the little black switch to turn the power Bit on (it will shine red).

Q: How can I tell if the power Bit is on?

A: A red light on the Bit will shine.

Instruct students to connect the power Bit to the RGB LED. Identify green Bits as outputs: these are the "doers" of the circuit.

Q: What happens when you connect power to an output?

A: The power Bit gives power to the LED, so it turns on.

Pick up the pink button and add it in between the blue and the green Bits. Identify pink Bits as inputs: these are the controllers of the circuit.

Q: What happens when the button is pushed?

A: The light turns on.

Point out that the order your Bits are in affects how they function.

Q: What happens when you move the pink button to a position after the green LED Bit?

A: The button can no longer control the LED - inputs only control Bits that come after them.

Hand out the servo motor and attach it to the end of this circuit (power > RBG > button > servo). Let students explore how the motor functions. Ask the class about any observations they've made. For example, they may notice that the motor turns back and forth.

Point out the switch on the servo Bit. Have students flip the switch to SWING mode and press the button. Then have them flip the switch to TURN and press the button. They should notice that in SWING mode, the servo continually moves by itself when the button is pressed; but in TURN mode, the servo moves 90° when the button is pressed, and moves back to its original position when the button is released.

Q: What does adjusting the switch do to the Bit?
A: It changes how the servo motor moves.

Finally, to practice adjusting the Bits, have the students change the RGB settings with the small purple screwdriver (hand this out).

Q: What happens when you adjust the dials on the Bit?
A: The light changes color.

Point out that there are other Bits in the STEAM Student Set with switches and dials for making adjustments. They can explore how those switches work when they try those Bits later.

Hand out an orange wire Bit and see how that affects the circuit.

Q: What does the wire do?
A: It connects Bits together and lets you place Bits farther apart or turn corners.

PLAY

STEP FOUR: PLAY (10 MIN)

INVENTION GUIDE PG. 6

Hand out a piece of paper, pencil/pen and the rest of the STEAM Student Set materials to each student or group, and instruct students to open their Invention Guides to the Bit Index. The Bit Index lists each Bit, describes what it does, how it works, and provides some real world analogies. Each page also contains a mini-challenge to help familiarize students with the Bit, and spark their imagination for building with the Bits. These pages will be an important resource as your students learn and grow with littleBits.

Assign one Bit/mini-challenge to each student or group. Give students no more than 5 minutes: 1–2 minutes to read through the instructions/try out a basic circuit and 2–3 minutes to tackle the challenge. Set a timer. At the end of the time, have each student draw or describe their circuit for an additional 2–3 minutes. What did they learn about their Bit? How did they meet the challenge?

Assign another round of Bits and continue the exercise. Walk around the room and troubleshoot any common problems being encountered, and share successful building strategies discovered by groups.

REMIX

STEP FIVE: REMIX (10 MIN)

If time allows, continue the exercise, allowing students to choose which Bits they want to tackle. You can ask students to make more than one solution to each prompt, or ask them to think of some real-world analogies for what they're making. Be sure to set separate timers for play and recording to keep students moving through the challenges.

SHARE

STEP SIX: SHARE (10–15 MIN)

Wrap up the lesson by reviewing what students have learned about how Bits work; have students refer to their notes from the mini-challenge activity. Read off the names of different Bits and have groups raise their hands if they used the Bits in their circuit. Ask students what they learned about the focal Bit and discuss struggles and successes encountered while addressing the challenges. How do the circuits students made compare to circuits they've seen in the real world?

STEP SEVEN: CLOSE (5 MIN)

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide, clean up their materials and hand in their papers.

STEP EIGHT: EXTENSIONS

Incorporate one (or more) of the following extensions in the Remix section of this challenge to bolster your lesson's NGSS applications:

3-PS2-4 MOTION AND STABILITY: Define a simple design problem that can be solved by applying scientific ideas about magnets.

MS-PS2-5 MOTION AND STABILITY: Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

To fulfill the above standards, design a careful experiment with the magnets that couple the Bits together.

4-PS3-2 ENERGY: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.

To fulfill this standard, explore how the Bits connect and tell a story about how energy moves from place to place in the circuit; what form it might be in at different times. E.g. LEDs and motors convert electricity to light and motion, respectively. Sensors convert light, motion, or heat to an electrical signal.

INTRODUCING THE LITTLEBITS INVENTION CYCLE

DESCRIPTION

This lesson will introduce students to the littleBits Invention Cycle, a process that can help guide students through the invention and engineering design process. Students will start the lesson with a 15-minute challenge using littleBits. The class will then reflect on their process and learn how their experience connects to the littleBits Invention Cycle.

SUPPLIES

BITS
STEAM Student Set

ACCESSORIES
STEAM Student Set

OTHER MATERIALS
notebook or copier paper for making paper balls (or a collection of similar small objects)
see list of commonly used materials on pg. 141

TOOLS USED
timer
masking tape

TYPE

GRADE LEVEL
elementary
middle

SUBJECT AREAS
engineering
art/design

DIFFICULTY LEVEL
beginner

PRE-REQUISITES
Introducing littleBits

DURATION*
50 minutes

KEY VOCABULARY

invention
prototype
engineer
designer
remix
power
input
output
wire
circuits
magnetism

OBJECTIVES

By the end of the lesson, students will be able to:
- Create a circuit containing a power source, inputs, outputs and wires
- Identify and explain the value of each phase of the Invention Cycle

ASSESSMENT STRATEGIES

During the final one minute of the challenge, students will be able to demonstrate their ability to create a functional circuit using littleBits.

There are questions embedded throughout the Share and Close steps of this lesson that can be used to assess students' understanding of the core concepts of the Invention Cycle.

*For tips on how to break up your lesson over multiple class periods, see pg. 139

ADDITIONAL LINKS & TIPS

TIPS AND TRICKS

We suggest removing the buzzers and environmental sensors (light, temperature sensors) from the STEAM Student Sets for this activity; they aren't essential tools to run the challenge and may be distracting.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and Inventiont. We suggest handing out the Bits in the Create phase to keep students focused on initial instructions and review activities. For more experienced users, you may want to provide access to additional Bits in the Play and Remix phases to provide a greater diversity of circuit combinations.

Set up a central location in the classroom for assorted materials and tools that students will use to build their inventions.

For each group, use masking or painter's tape to create two 1 ft. by 1 ft. squares on the floor. The squares should be about 3 ft. apart (with no obstructions between). You will also need to create a collection of roughly equal-sized crumpled paper balls. Students will be using their Bits and the construction materials to invent ways of moving the paper balls from their starting square to their goal square.

STEP TWO: INTRODUCE (10 MIN)

Introduce the lesson objectives and the concept behind the challenge:

You can begin the lesson with some of the following questions to frame the activity:
- What do engineers and designers do?
- How do they figure out what to make?
- How do they make sure their projects work?
- What happens if the project doesn't work?
- How do they get better at the work they do?

Explain to the students that they are going to use Bits to complete a short engineering design challenge so they can experience how engineers and designers work.

Introduce the challenge to the students:

> Using Bits and the provided craft materials, groups will need to move as many paper balls from one square (starting square) to the other (goal square). Each team will be given 15 minutes of work time to create and test their inventions. The final test will happen after this period. Each group will have one minute to move as many balls as they can from their starting square into their goal square.

Teams must agree on the following rules:
- They can only use their Bits and the construction materials provided.
- Balls can only be sent to the goal square if a littleBits circuit is causing them to move. Students cannot touch the balls on their way to the goal (e.g. students can use the Bits to push, throw, or carry balls to the goal, but can't throw or carry the balls themselves)
- At any point, students can add more balls to their starting circle.
- Balls must be in the goal square at the end of the one minute in order to be counted.

STEP THREE: CREATE (15 MIN)

CREATE

Now the students will begin the challenge. Once each group is familiar with the rules, pass out the Bits and materials, start a timer with 15 minutes on the clock, and announce that teams may begin building. Either place the timer in a prominent place, or announce the time every five minutes so teams can try to pace themselves appropriately.

Walk around the room and observe how the groups work. These observations will be helpful during the the next step when the class discusses their process. Here are some things to keep your eyes open for:
- How do the groups start working? Some may begin by planning, while others will dive in and and start with hands-on experimentation.
- Do the groups try to execute one single plan or do they experiment with several different approaches to determine what works best?
- How do groups decide what to build or what changes to make?
- How often are their experiments unsuccessful? Do they get discouraged?
- How often are their experiments successful and kept as part of the project?

When the timer goes off, have each group collect the paper balls and prepare for their one-minute challenge.

STEP FOUR: PLAY (5 MIN)

PLAY

Run the one-minute challenges. You can use half of the students as timers and counters, while the other half try to move balls to the goal squares, and then flip the groups. Alternatively, you can have each group go one at time so all students get to watch each invention perform.

REMIX

OPTIONAL STEP FIVE: REMIX (15 MIN)

If time, ask students if they had extra time, do they think they could make their invention even better? Now give students 10 additional minutes to remix or improve their inventions. Then run the Play trial again and compare their "growth score" which is how many additional balls they were able to move in the second trial.

SHARE

STEP FIVE: SHARE (10 MIN)

Once all the one-minute challenges are complete, gather the students together. The goal of this discussion is to have the students reflect on each group's design and engineering process so you can draw connections between their methods of working and the littleBits Invention Cycle.

Create four empty columns on a whiteboard (or use four large sheets of paper). Each column will help explain a step of the Invention Cycle, but don't label the columns yet.

In the first column, you will put responses relating to the Create phase. To get students thinking about how they got started, you could ask:

- How did you come up with ideas for what to build?
- How did you decide what to do first?
- Were everyone's designs the same?
- Was your project complete after putting it together the first time? Why not?

In the second column, you will put responses relating to the Play phase. To get students to think about how they used and tested their prototypes, you could ask:

- When was the first time you used what you were working on? Did you ever give it a test? How did it go?
- Why is it important to test what you are working on?
- What could you do with what you learn from testing?
- What did you learn from playing with it?
- Did anyone's invention not work the way they hoped when they played with it?
- Was your invention complete after using it the first time? Why not?

In the third column, you will put responses relating to the Remix phase. To get students thinking about how they experimented with and improved their inventions, you could ask:

- Did anyone make changes or improvements to their inventions after they played with them?
- Did anyone try more than one approach/method?
- What was the weirdest idea you tried? What did you learn from it?
- How many different ideas do you think you tried?
- How did you decide which method was the best?
- Why might you want to try more than one way of doing something?

In the fourth column, you will put responses relating to the Share phase. To get students thinking about how to share and why it is important, you could ask:

- After seeing what others have done, do you think you could do it even better now?
- Were there ideas others had you would like to try?
- Did anyone have something to say to you about your invention, maybe some praise or a suggestion?
- Why might you want to share the work you've done with others?
- Why might you want to listen to others share what they've done?

STEP SIX: CLOSE (10 MIN)

Now you will summarize and connect the lesson to the Invention Cycle. Once all the columns are filled, verbally summarize the main ideas in each and draw attention to what they went through as a process. For example:

In the first phase they created a bunch of ideas, picked one of them, explored the Bits to see how they could help, and created a prototype of their idea. After summarizing, write Create at the top of the first column to highlight these ideas.

Next, they tested their idea by playing with it. They learned which parts of their ideas were on the right track and which parts still needed work. Some of the inventions might not have worked at all, but these "failures" weren't actually bad. They helped the students understand their inventions in a better way. After summarizing, write Play at the top of the second column to highlight these ideas.

After playing with and learning about their invention, they made changes and tested those out. Sometimes these changes were small improvements. Others might have pushed aside their old model and tried a totally different approach to the problem. Each time they tried new combinations of Bits and materials, the groups got smarter about the invention, and the inventions got a little better. After summarizing, write REMIX at the top of the third column to highlight this.
The term "Remix" is common in the popular music industry, but kids may not be familiar with it. To clarify, you could explain that "-mix" means to put things together (like mixing ingredients in a cake batter) and "re-" means again (like renewing a library book). So remix means to put things together again.

When the challenge time is up, give students a chance to walk around and see what others have done. They could see the strategies others used, ask questions, and offer comments or suggestions. Sharing helps students feel proud of their work and os a source of fresh new ideas and inspiration. Some may even want to take these new ideas and keep working. After summarizing, write Share at the top of the fourth column to highlight this.

Explain to students that they just went through the littleBits Invention Cycle. They created a first prototype, played with it to see how it worked, then remixed it with adjustments, improvements, and perhaps tried a few totally different approaches. After a lot of experimentation and comparison, they got to share their results with others, collecting feedback and inspiration.

Lots of designers and engineers have a process they go through when inventing. This is the process the team at littleBits uses when they create new Bits and Kits. The students will also be using it when they complete their littleBits challenges.

To check students' understanding of the Invention Cycle, you could ask them if there are other times in their life when they have done all or part of this process. For example, have they ever made a recipe, but decided to change some of the ingredients? Or perhaps they were building with LEGOs and continued to build and experiment even after following the printed instructions.

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide and clean up their materials.

GUIDED CHALLENGES

GOALS

- Practice the littleBits Invention Cycle through Guided Challenges
- Develop comfort and skill in combining Bits and other materials

LESSONS AND PACING

Guided challenges can be completed in 2–3 hours. Additional remixes or extensions can be chosen to extend the activity.

If breaking up an activity over 2 sessions, the following flow is suggested:
- Session 1: Create, Play, Remix*
- Session 2: Remix, Share, plus Optional Extensions

*Be sure to store inventions in a safe place

Students will refer to the relevant guided challenge instructions and guided Invention Logs in their Student Workbooks.

For students and teachers that have prior experience with littleBits, use the design challenge prompt to turn the lesson into a more open-ended experience. See lessons for more detail.

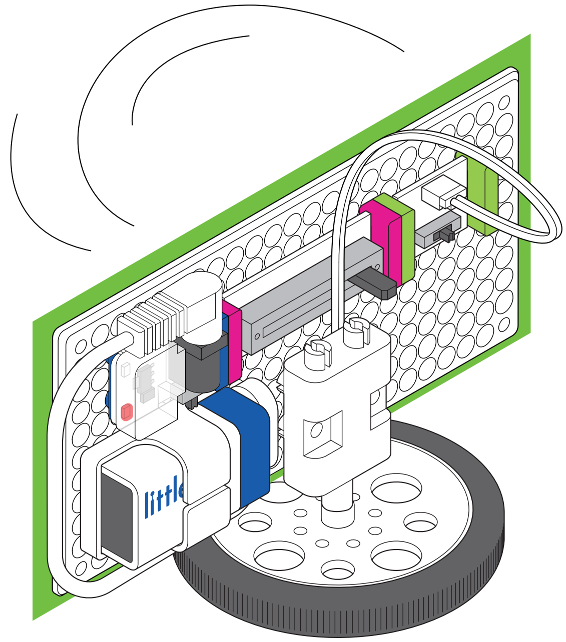
SMART SIGN
- Create an eye catching spin that helps playground visitors enjoy the space.

CONSTELLATION VIEWER
- Create a hand-held constellation viewer that can display stars, or a design of your choice.

FORTUNE TELLER
- Create a toy/game that "predicts" the future.

HAND RAISER
- Create a hand raising invention for an injured classmate.

SMART SIGN



DESIGN CHALLENGE

Design an activation system that displays a "good idea" sign to playground visitors.

OVERVIEW

LESSON OBJECTIVES

Students will:

- Engineer a "good idea" sign that captures people's attention when triggered in the playground.

SUGGESTED ACTIVITY TIME (90 MIN)

- Explore (15 min)
- Build (50 min)
- Reflect (25 min)

Optional: Extensions at the end of the lesson provide 30+ more minutes of activity time.

GETTING READY

MATERIALS NEEDED PER GROUP

BITS	ACCESSORIES
p4 power (1)	a1 battery and cable (1)
i5 slide dimmer (1)	a24 wheel (1)
o25 DC motor (1)	a30 mounting board (1)

For the open pathway, students will have access to all of the Bits and accessories in their kit.

OTHER MATERIALS

- Student Workbook
  Construction/colored/cardstock paper
- Markers/drawing materials
- Tape/glue
- Scissors
- Optional: Decorating materials (stickers, glitter, pipe cleaners etc.)

PRIOR TO THE CHALLENGE

- No additional preparation necessary.

OPEN CHALLENGE

- If students are comfortable using littleBits, you may choose to have students brainstorm their own ideas in the Invention Log and then construct their sign without instructions.

EXPLORING THE CHALLENGE (15 MIN)

Elicit student responses to gauge understanding and warm-up for the activity.

1. Make a list of behaviors people should do in nature parks to be respectful to nature. Add to the list what behaviors people should do in nature parks to stay safe. For example, you could suggest to students that we should always throw away our trash, or that we should take turns on the swing set.
2. Have each group share out their list. At the end, ask students if they have any additional ideas after hearing all of them. Call attention to any instances where people should be "cautioned" to do something: not to step on plants, not to throw trash on the ground, not to be too loud at night, etc.
3. Discussion: Ask students, "How could we notify people about these good ideas?" Suggest that we engineer an attention-grabbing sign to remind people of the best way to use the playground.

   Questions to engage student thinking might include: What should our signs say? How can we explain what people should do in just a few words? Should we include pictures? Or movement?
4. Students may use their Invention Logs to write down some ideas and initial sketches for their sign.

BUILDING THE CHALLENGE (50 MIN)

Facilitate the following instructions with student groups as they build.

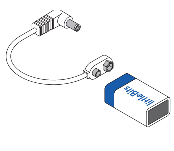
OPTIONAL–OPEN

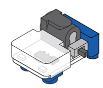
- Provide groups access to all the Bits and accessories in their kit, as well as assorted craft materials, and allow them time to engineer a sign. Circulate the room as students build their creations. If a group needs assistance, consider making suggestions from the guided instructions below, such as, "What if we used the wheel as a base?"
- After about 20 minutes, check in with each group. They should be solidifying their structure and crafting their sign.
- Once you see each group's initial prototype, direct them to the "Play" section in the Invention Log for them to sketch their first draft.

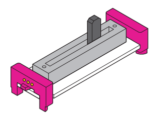
CREATE

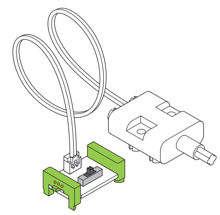
DESIGN CHALLENGE
Design an activation system that displays a “good idea” sign to playground visitors.

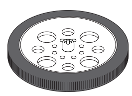
1. Gather your invention tools.

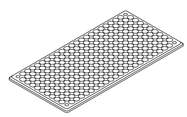

a1 battery & cable

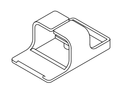

p4 power


i5 slide dimmer


o25 DC motor


a25 wheel

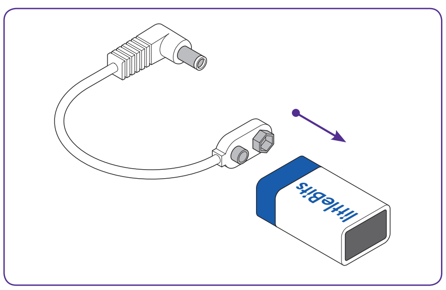

a30 mounting board

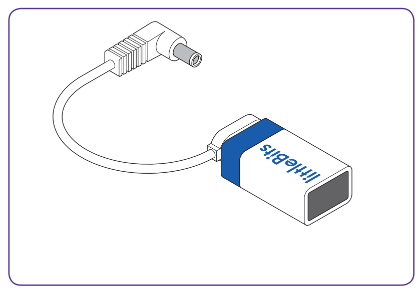

a31 battery clip

Other materials:

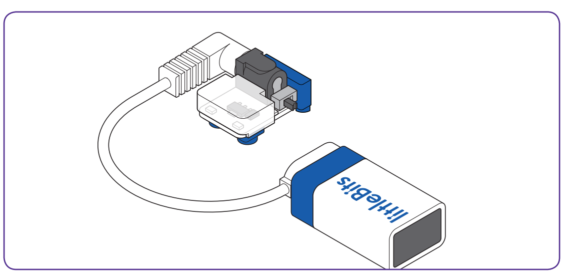
- Construction/colored/cardstock paper
- Markers/drawing materials
- Tape/glue
- Scissors
- Optional: Decorating materials (stickers, glitter, etc.)

2. Attach the battery cable to the battery.

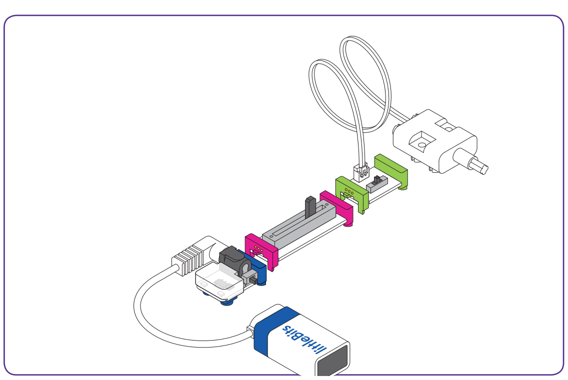




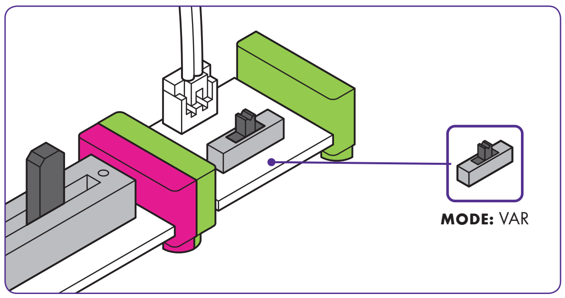
3. Attach the p4 power Bit to the battery cable assembly.



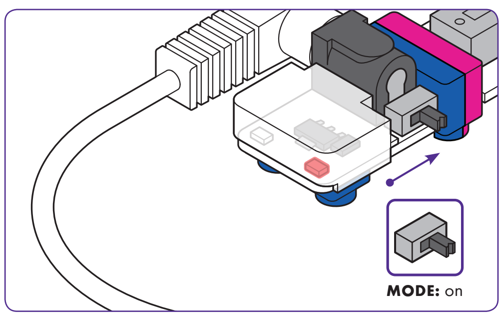
4. Snap this circuit together.



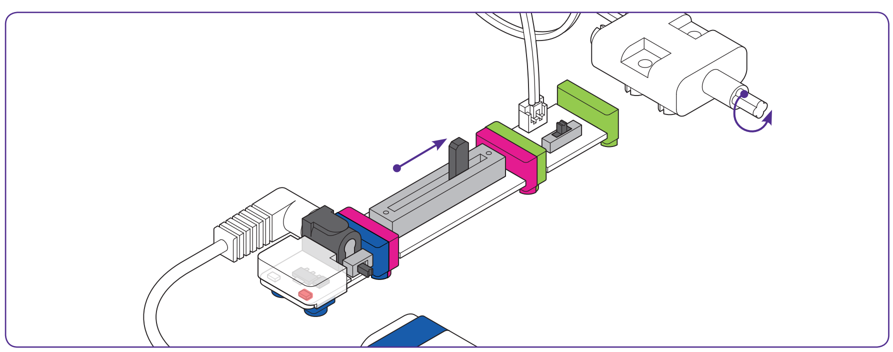
5. Set the DC motor to "var" (variable mode).



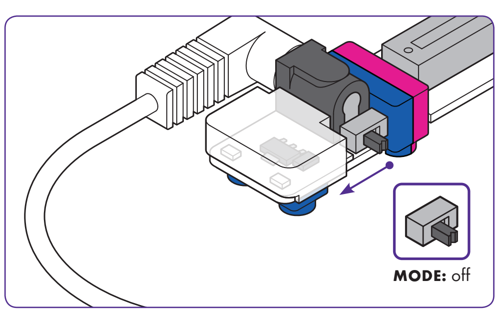
6. Let's test that your circuit works! Power on your circuit.



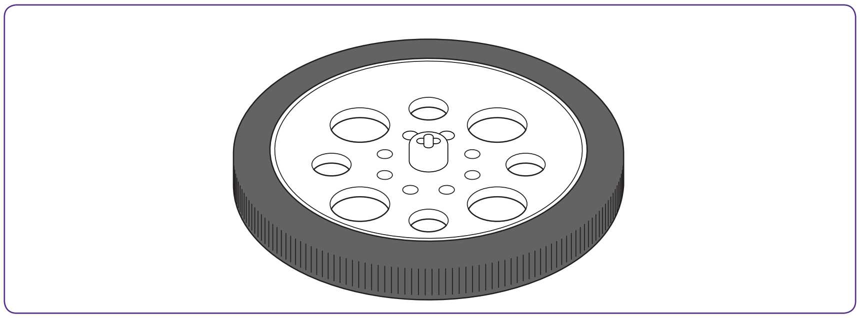
7. Slide the dimmer to the right. The DC motor shaft should spin.



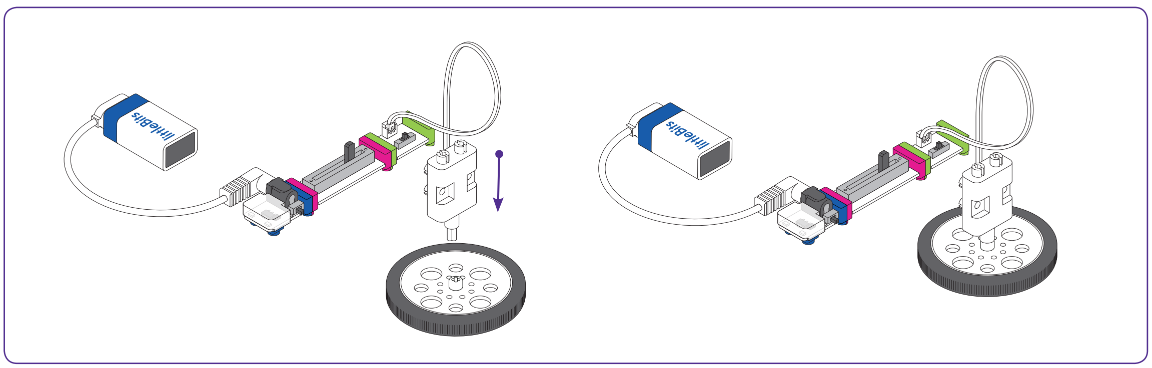
8. Power off your circuit.



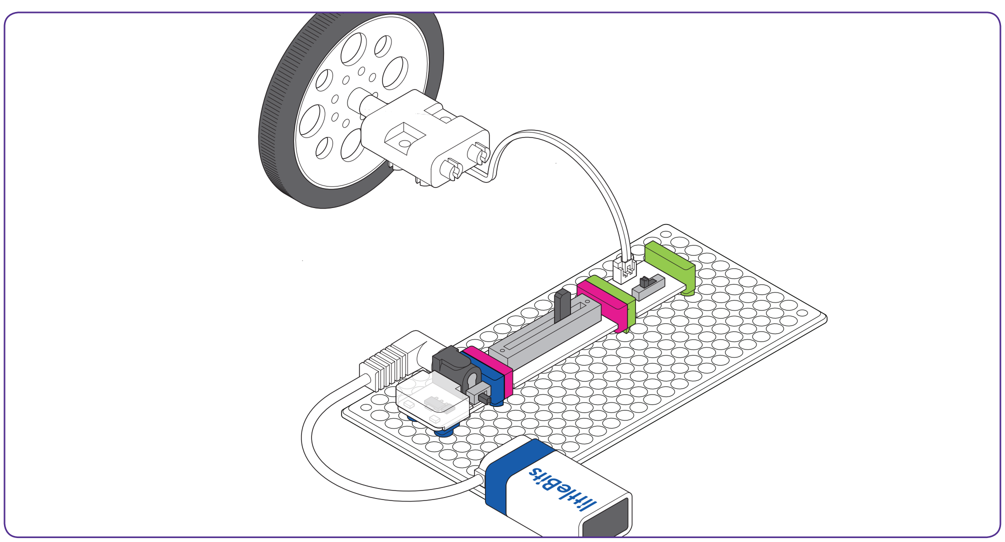
9. Now pick up a wheel and lay it on the table with the longer axle side facing up.



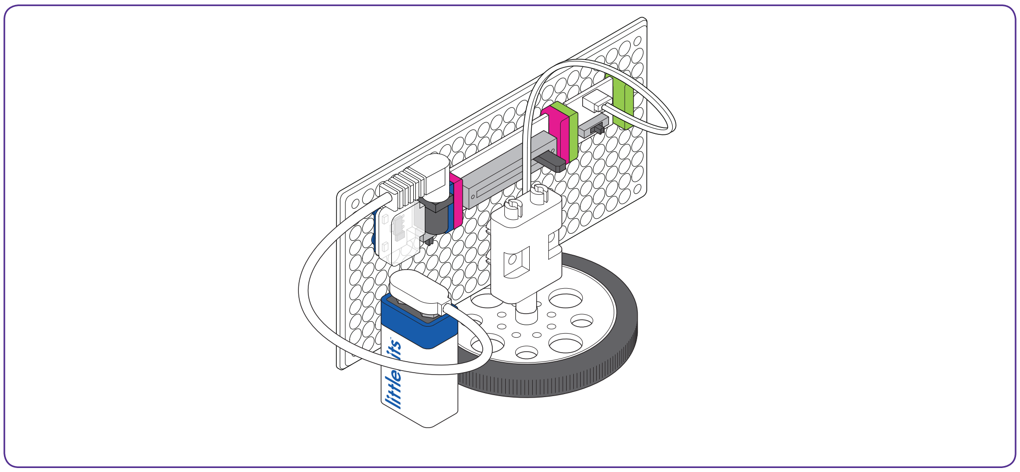
10. Line up the DC motor axle with the cross shape of the wheel and gently press.



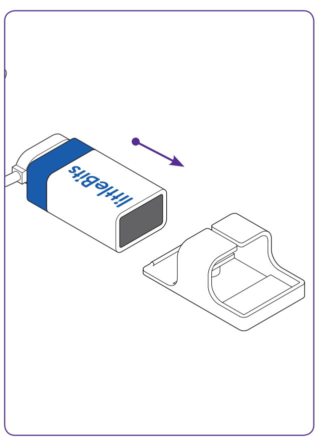
11. Press your circuit onto the mounting board.

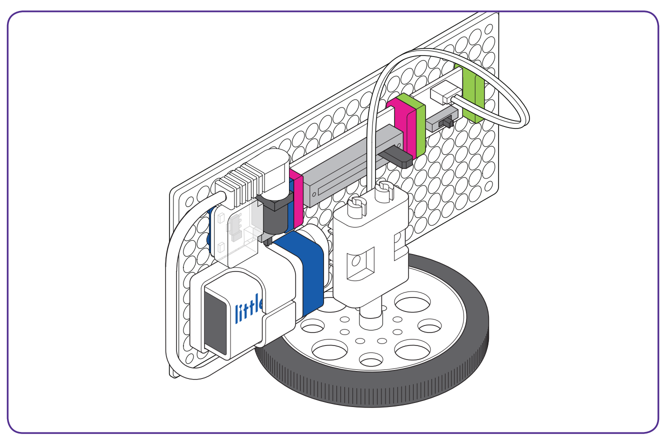


12. Press your DC motor onto the edge of the mounting board.

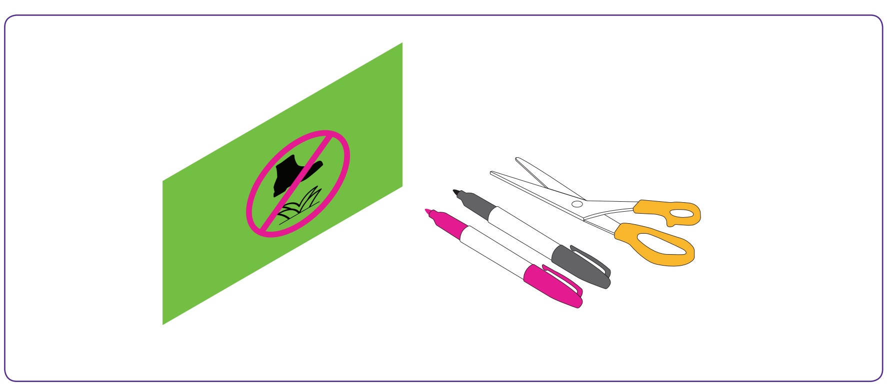


13. Slide your 9-volt battery into the battery clip. Press your battery into the mounting board.

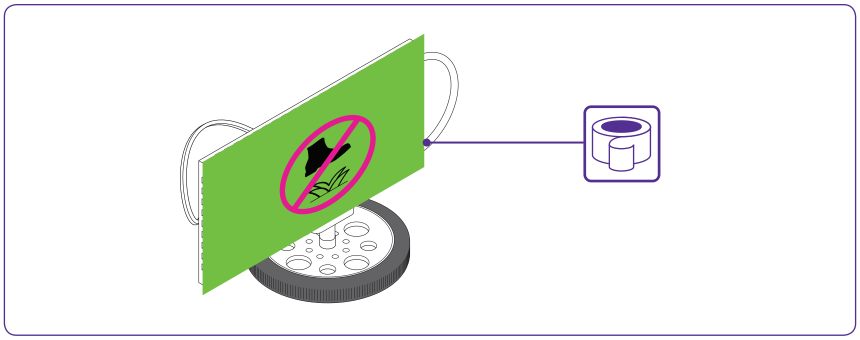




14. Now it's time to create your sign! Customize your message using classroom materials, like construction paper, tape, scissors, pipe cleaners, balsa wood etc.

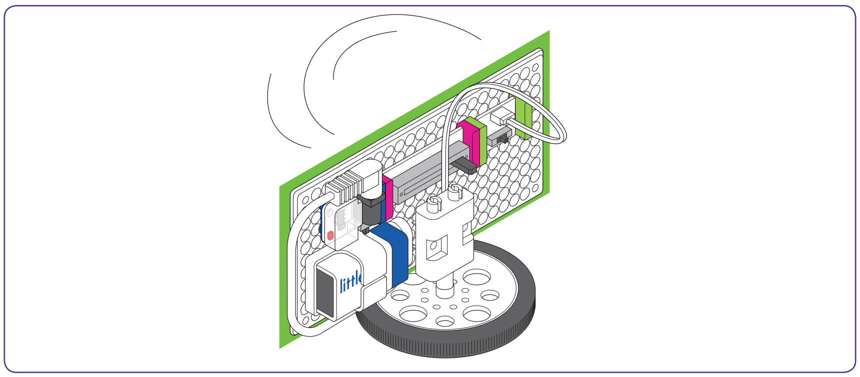


15. When your sign is designed, tape it to the empty side of the mounting board.



PLAY

16. When your sign is ready, place your sign on the table (with the wheel flat on the table), turn on the power Bit and move the slide dimmer to set the direction and speed.



REMIX

17. Take it further! Ask students:

a. "How could we engineer our sign to spin more slowly, making it easier to read?" Students should point out that they can use the slide dimmer Bit to control the speed of the DC motor. Moving the slide dimmer to the left will slow down the sign.

b. "What about making the sign stand out even more?" Students may suggest adding lights or a buzzer to their circuit or incorporating different craft materials.

c. "How about if we wanted to make it only turn on during the day?" Students would use the light sensor in their circuit, after the power Bit and before the DC motor.

18. Allow students time to remix and improve their invention, then record notes in the Remix section of their Invention Log.

SHARE

REFLECTING ON THE CHALLENGE (25 MIN)

Prompt students to extend, record, and explore their creations.

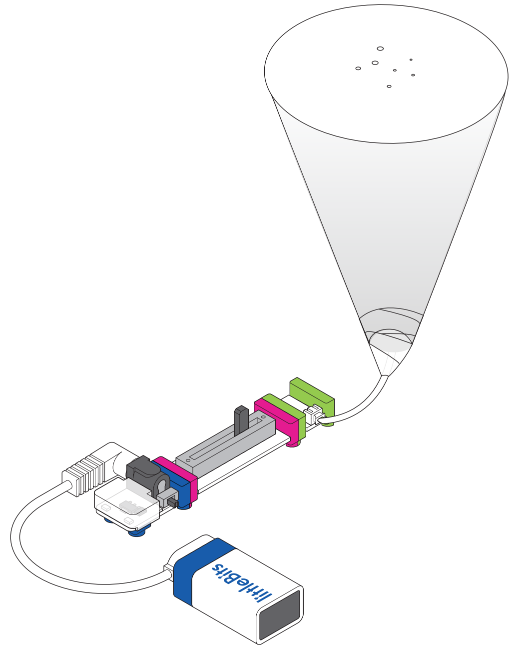
1. Ask students to write a few sentences in the Share section of their Invention Log explaining where their sign would be located in a playground, and what their sign communicates.
2. If time allows, have each group present their creation and its purpose.
3. **Until next time, littleBits!** Place the Bits gently back in the box according to the diagram on the back of the Bit Index; return classroom materials to their proper place; check the area around your workstation.

REMIX

EXTENSIONS

- Should any of these signs be implemented around our school or community? Which ones and why?
- How could we weatherproof a sign?
- Could we design a littleBits system where two signs are signaled at once?

CONSTELLATION VIEWER



DESIGN CHALLENGE

Design a hand-held constellation viewer that allows us to see the stars up close.

OVERVIEW

LESSON OBJECTIVES

Students will:

- Engineer a constellation viewer out of littleBits and invention materials in order to explore stars in relation to Earth.

SUGGESTED ACTIVITY TIME (90 MIN)

- Explore (10 min)
- Build (40 min)
- Reflect (40 min)

Optional: Extensions at the end of the lesson provide 30+ more minutes of activity time.

GETTING READY

MATERIALS NEEDED PER GROUP

BITS

p4 power (1)
i5 slide dimmer (1)
o2 long LED (1)

ACCESSORIES

a1 battery and cable (1)

For the open pathway, students will have access to all of the Bits and accessories in their kit.

OTHER MATERIALS

- Student Workbook
- Constellation viewer template*
- Constellation stencil*
- Tape
- Glue stick
- Sharp objects in various sizes: thumbtacks, pencils, pens
- Scissors
- 1 piece of corrugated cardboard, cut into a 5″ square

**available in the Student Workbook*

PRIOR TO THE CHALLENGE

- Cut out 5″ cardboard squares, 1 for each group

OPEN CHALLENGE

- If students are comfortable using littleBits, you may choose to build the constellation viewer together, then challenge them to create their own light circuit to power their invention.

EXPLORING THE CHALLENGE (10 MIN)

Elicit student responses to gauge understanding and warm-up for the activity.

1. Explain that students will be making a constellation viewer in order to illustrate the different sizes of stars and explore how stars appear to our eyes.

2. Assign a constellation found on the constellation stencils to each group. Clearly denoted constellations work best, such as Ursa Major, Leo, Ursa Minor, Orion, and Canis Major. If time permits, allow students to familiarize themselves with the legend of their constellation.

BUILDING THE CHALLENGE (40 MIN)

Facilitate the following instructions with student groups as they build.

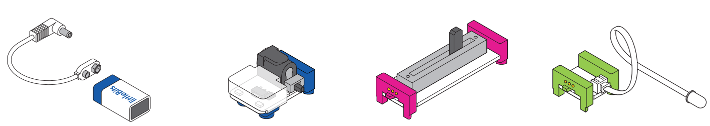
OPTIONAL–OPEN

- Skip the guided circuit construction (steps #1–7) and have students create the constellation viewer first (steps #8–19).
- Then provide 5 minutes for students to create their light circuit, without instructions, and figure out how to place their circuit within the viewer. Refer to steps #20–21 for support as needed.
- Once constructed, have students test out their viewer (step #22–23) and make any necessary changes to improve the experience.

CREATE

DESIGN CHALLENGE
Design a hand-held constellation viewer that allows us to see the stars up close.

1. Gather your invention tools.

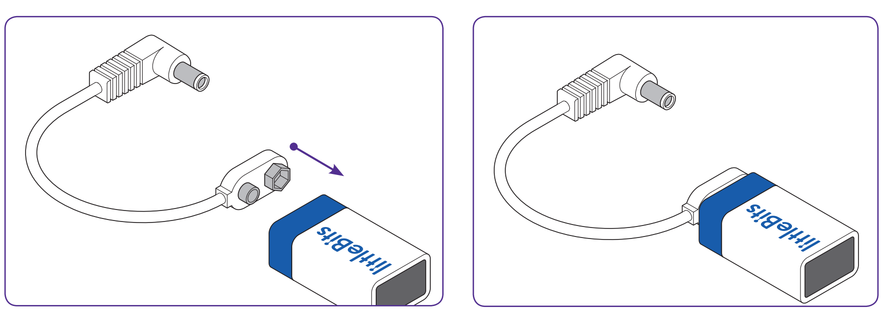


a1 battery & cable   p4 power   i5 slide dimmer   o2 long LED

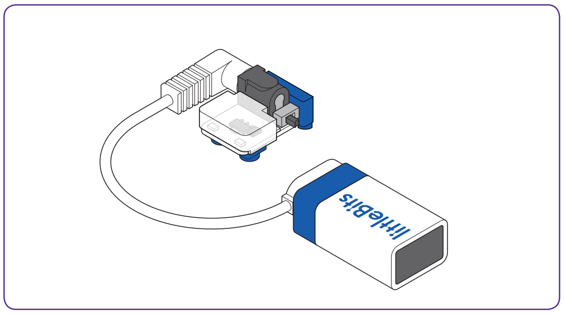
Other materials:

- Constellation viewer template
- Constellation stencil
- Tape
- Glue stick
- Sharp objects in various sizes: thumbtacks, pencils, pens
- Scissors
- 1 piece of corrugated cardboard, cut into a 5" square

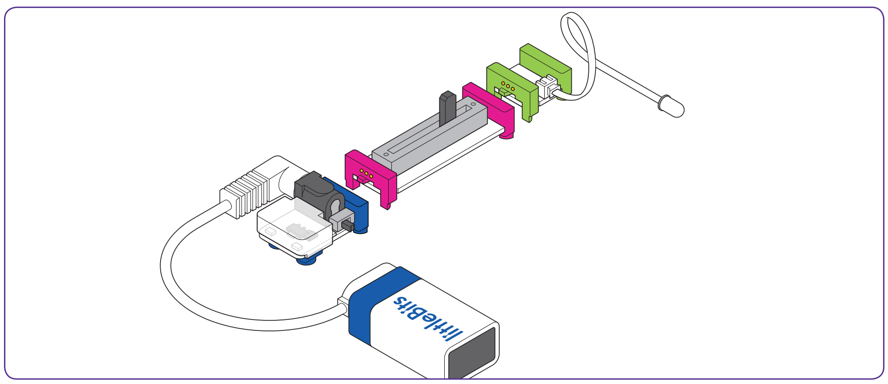
2. Attach the battery cable to the battery.



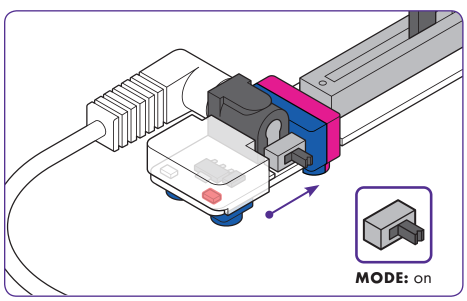
3. Attach the power Bit to the battery cable assembly.



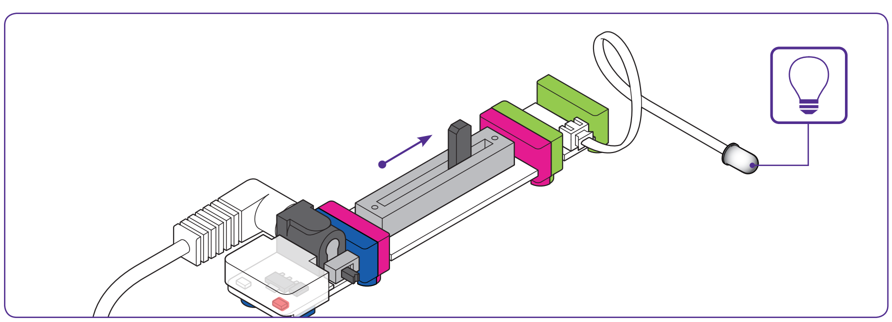
4. Snap this circuit together.



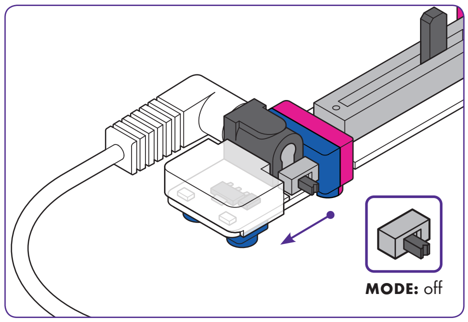
5. Let's test that your circuit works! Power on your circuit.



6. Slide the dimmer to the right. The long LED should light up.

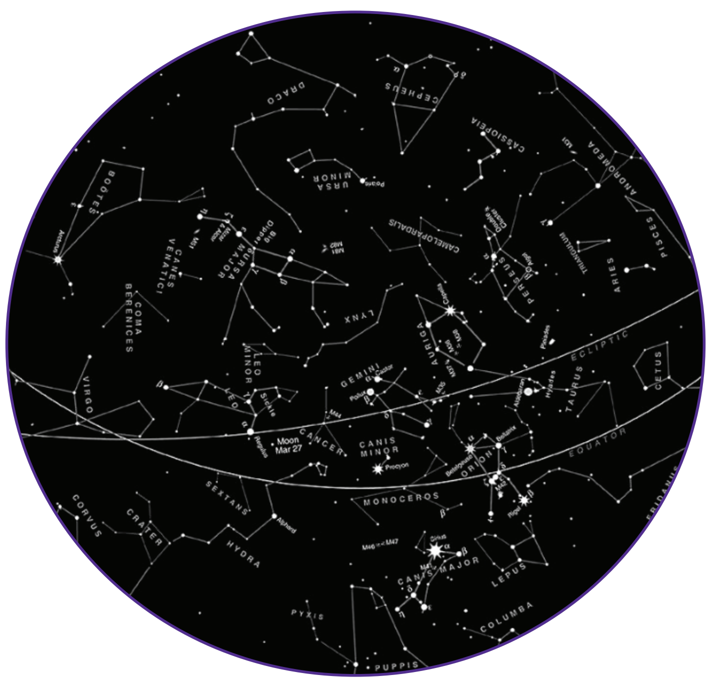


7. Power off your circuit.

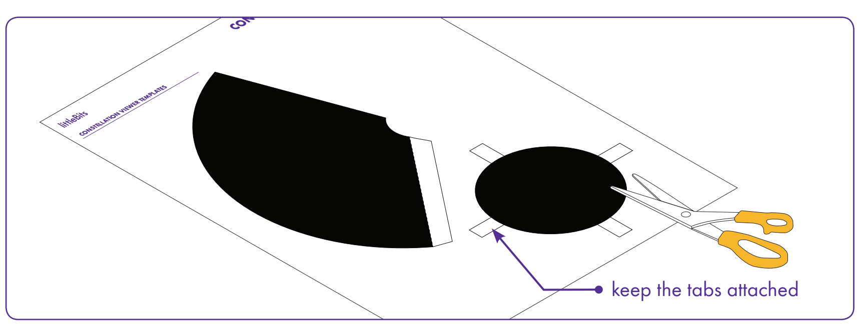


Let's create the constellation stencil

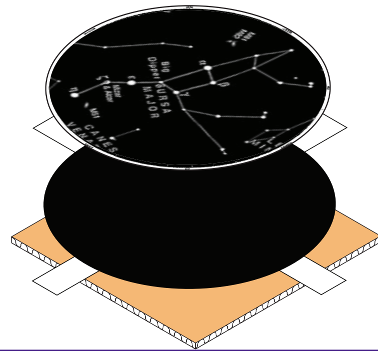
8. Cut out your assigned constellation from the stencil sheet.



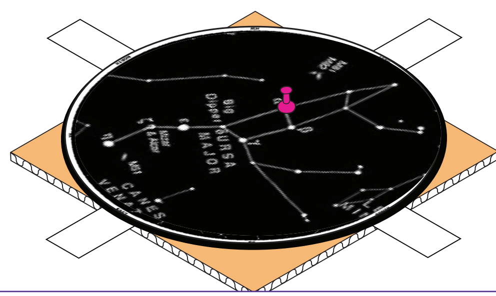
9. Cut out the circle shape from the constellation viewer template, making sure to include the tabs.



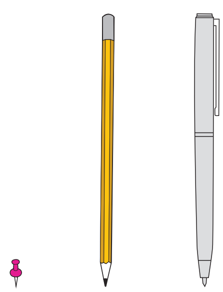
10. Lay your circle template on top of a piece of corrugated cardboard. Then put your constellation stencil on top.



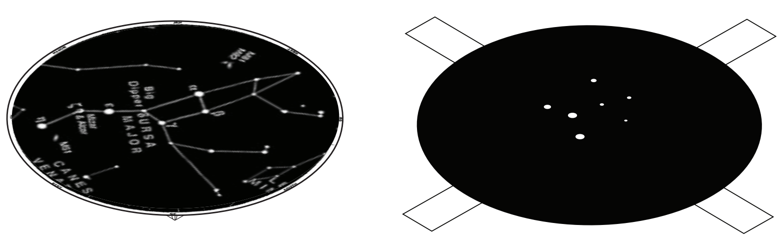
11. Insert a thumbtack into one of the stars of your constellation. Leave this pin in place to secure the stencil. If you don't have a thumbtack, press firmly to hold the stencil in place.



12. Use thumbtacks, pencils, or pens to poke holes of different sizes that correspond to the sizes of stars in the stencil.

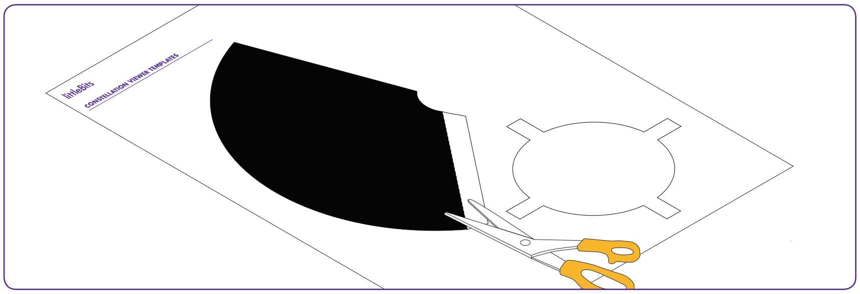


13. When you are finished, remove the thumbtack and put your circle template aside for the next section.

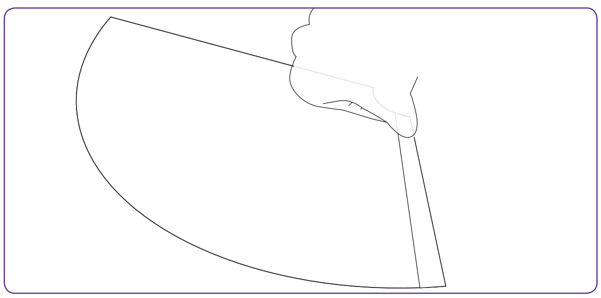


Let's create the constellation viewer

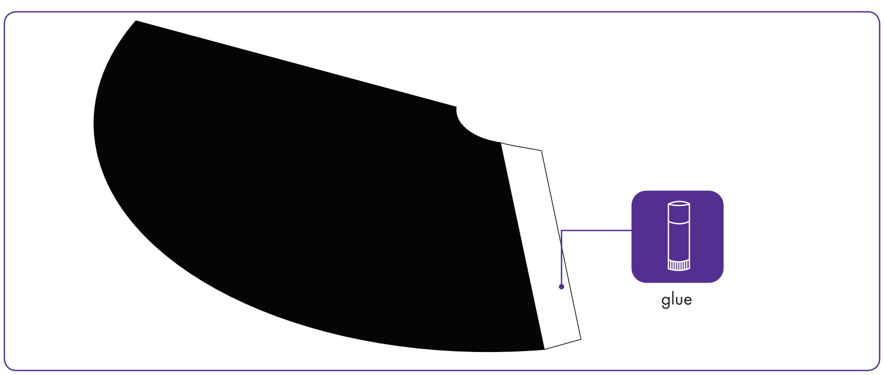
14. Cut out the half circle shape from the constellation viewer template. Be sure to keep the white tab intact with your cutout.



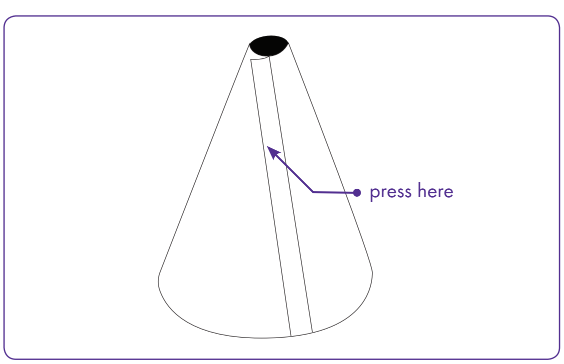
15. With the black side of the template facing down, fold the flap over along the fold line.



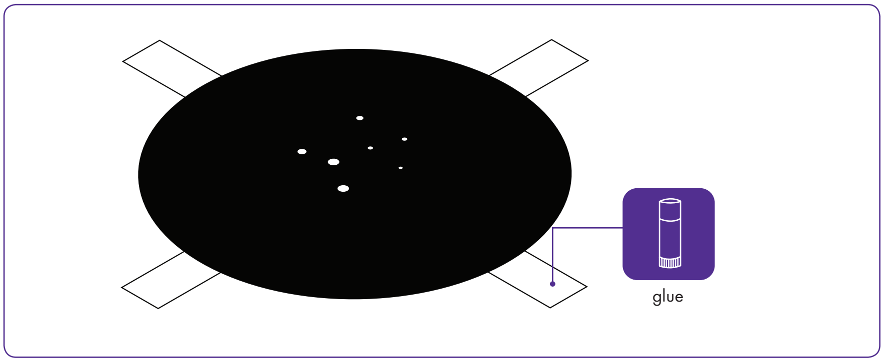
16. Flip your template over and add glue to the white strip.



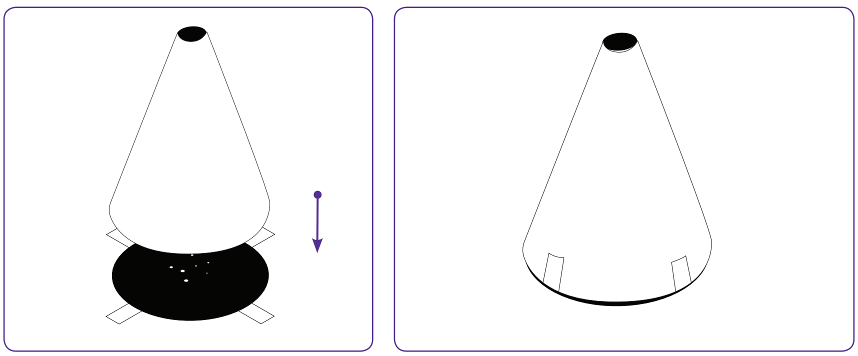
17. Take the larger template and roll the paper into a cone, with the white side facing out towards you. Press the glued flap to the other side of the paper.



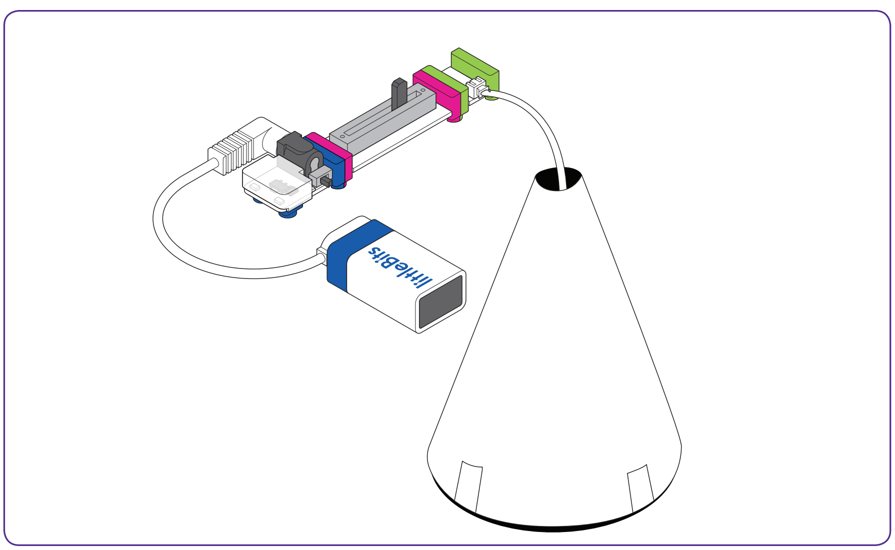
18. Pick up your circle template so that the black side is facing up. Add glue to each white tab.



19. Place the cone on top of the circle template. Press the four tabs to the sides of the cone to glue them together.

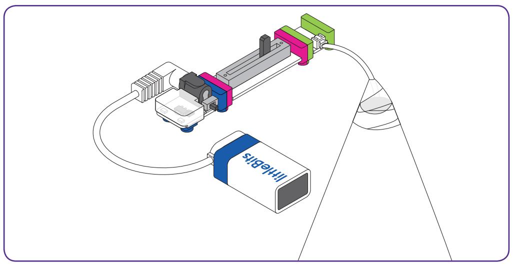


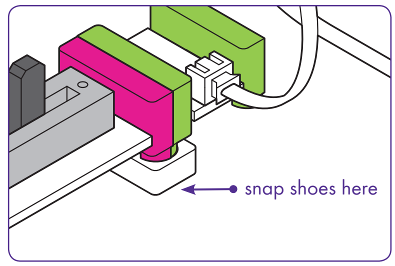
20. Now stick the end of the long LED into the hole in at the top of the cone.



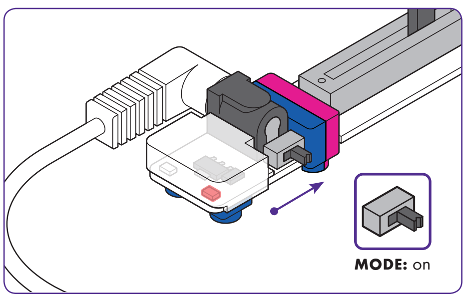
21. Tape the wire of the long LED to the cone to block out any extra light. Voila! Now you have a constellation viewer!

TIP! If you find that the Bits in your circuit are unsnapping as you lift it, try adding shoes to the feet of the slide dimmer to provide extra support.



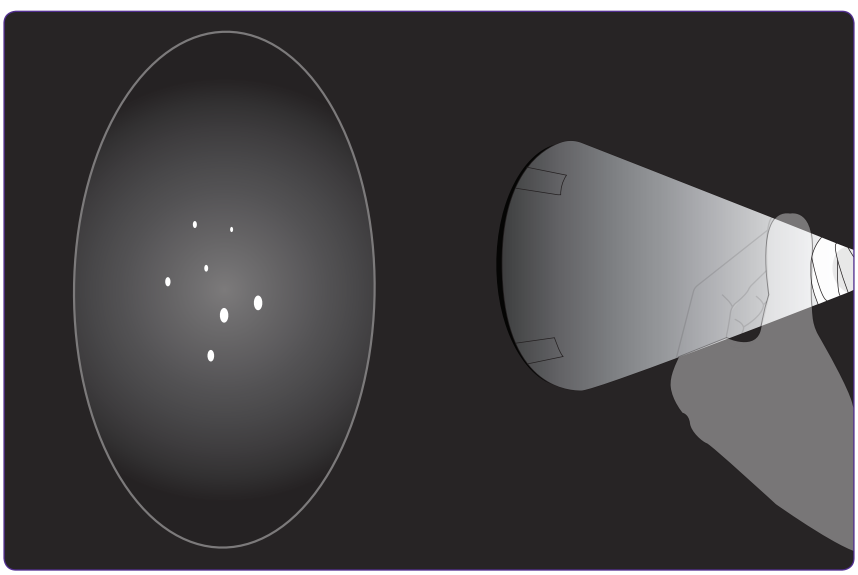


22. Let's try it out! Turn your power Bit "on."



PLAY

23. Turn off the lights and point the wide end of your viewer towards a wall or flat surface to admire the night sky view.



24. Ask students to test out their invention and record notes in the Play section of their Invention Log.

REFLECTING ON THE CHALLENGE (40 MIN)

Prompt students to extend, record, and explore their creations.

1. Ask students to look through their viewer and draw their group's constellation. What do they think our ancestors thought this outline was? An animal? An object? Draw your guesses!

REMIX

2. Ask students to sketch in their Invention Logs how their constellation viewer might be improved. Give students 15 minutes to try out their Remix ideas.

   Answers include: having a brighter light; going into an even darker room; having more holes for more stars; making the star chart bigger.

SHARE

3. Ask each group to share how they changed their viewer and what the results were. If time allows, students can record their reflections in the Share section of their Invention Logs.
4. **Until next time, littleBits!** Place the Bits gently back in the box according to the diagram on the back of the Bit Index; return classroom materials to their proper place; check the area around your workstation.

SUPPORTING MATERIALS

1. Constellations Where I Live: https://theskylive.com/
2. Extension Lesson: What is a Constellation
   http://astroedu.iau.org/en/activities/1607/what-is-a-constellation/

REMIX

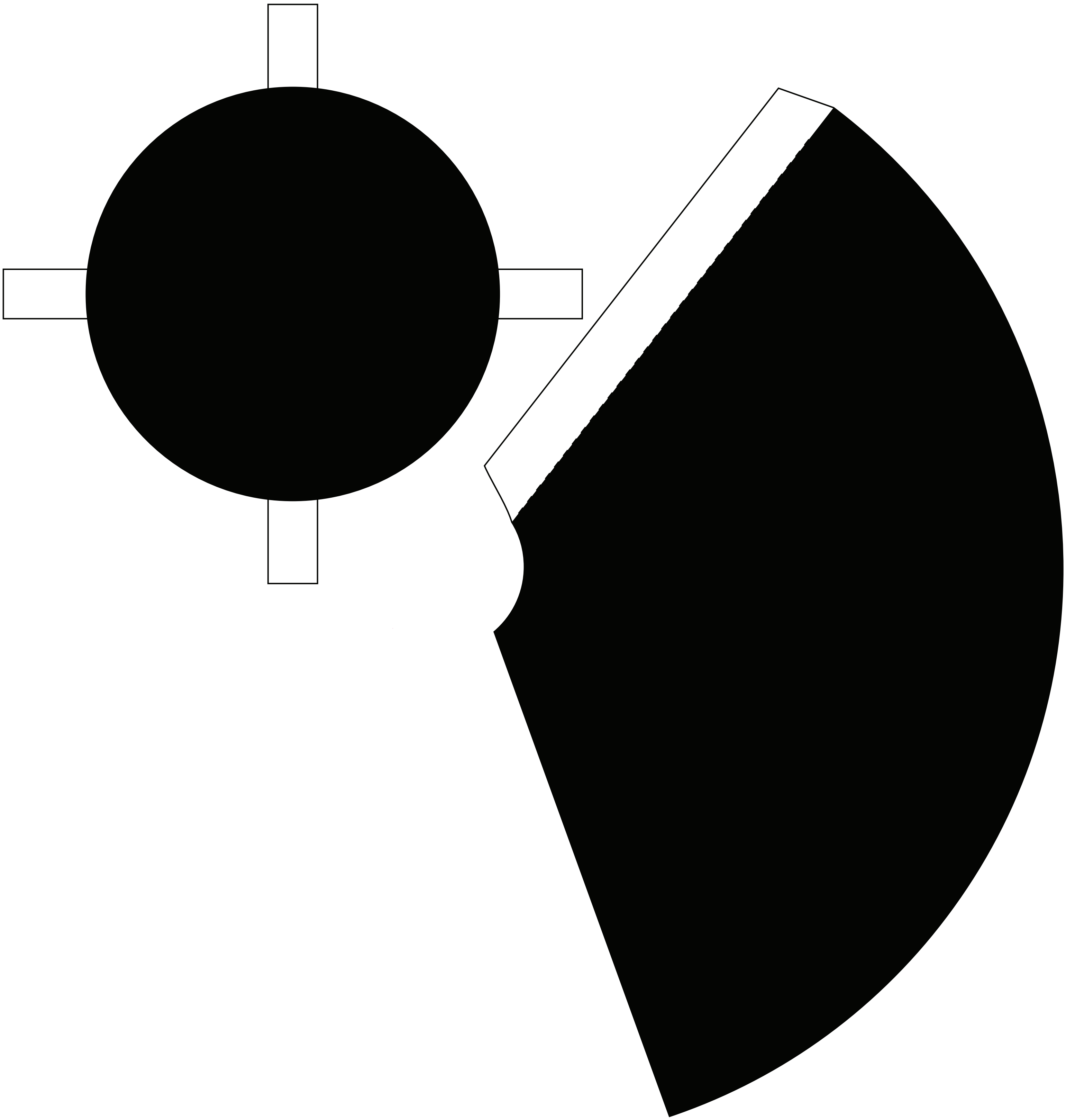
EXTENSIONS

- Rather than using the slide dimmer to trigger the long LED, ask students how we could engineer a solution where the light turned on only when it was dark (Answer: the light sensor Bit; set to dark mode).
- Trade constellation viewers with another group, and draw their constellation. What do you think our ancestors thought this constellation represented? Draw your guesses!
- Ask students to research their constellation and include their findings during their share out.

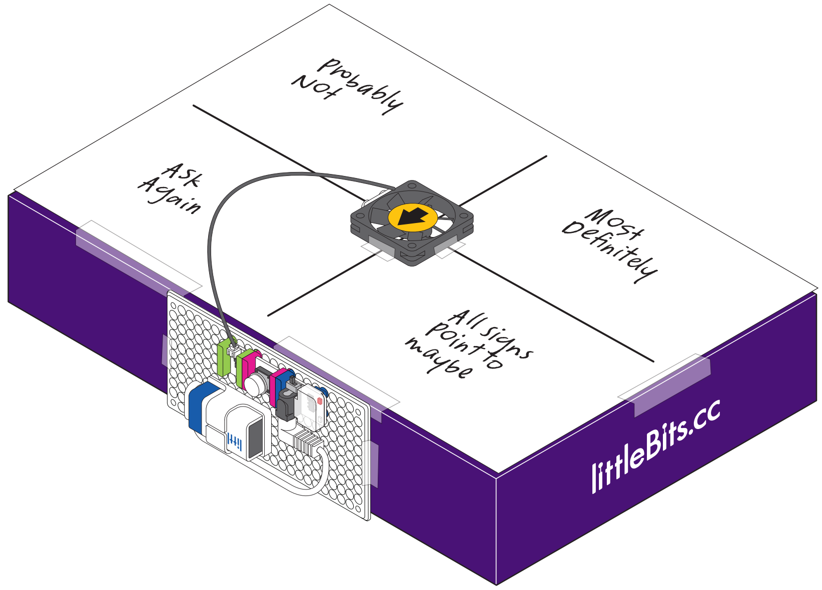
- Have students remove the star stencil from their viewer and create their own stencils on black construction paper. Ideas include students' names, pictures of animals, or a constellation that they design themselves.
- To connect this activity to your science unit, ask students to consider how the brightness of the stars relates to the distance that the stars are away from Earth. Explore how we see stars because of their energy as light.

CONSTELLATION VIEWER STENCIL

CONSTELLATION VIEWER TEMPLATES



FORTUNE TELLER



DESIGN CHALLENGE

Design a toy that predicts the future.

OVERVIEW

LESSON OBJECTIVES

Students will:

- Use littleBits and other materials to create a fortune telling toy.

SUGGESTED ACTIVITY TIME (90 MIN)

- Explore (10 min)
- Build (40 min)
- Reflect (40 min)

Optional: Extensions at the end of the lesson provide 30+ more minutes of activity time.

GETTING READY

MATERIALS NEEDED PER GROUP

BITS

p4 power (1)
i3 button (1)
o13 fan (1)

ACCESSORIES

a1 battery & cable (1)
a30 mounting board (1)
a31 battery clip (1)

For the open pathway, students will have access to all of the Bits and accessories in their kit.

OTHER MATERIALS

- Student Workbook
- 2 Sheets of paper
- Markers
- Scissors
- Tape
- littleBits Kit box (or similar sized box)

OPEN CHALLENGE

- If students are comfortable using littleBits, you may choose to have students brainstorm their own ideas for creating a fortune teller in the Invention Log and then construct their toy without instructions. Alternatively, you could ask students to create a futuristic toy that moves.

EXPLORING THE CHALLENGE (10 MIN)

Elicit student responses to gauge understanding and warm-up for the activity.

1. Ask students if they've ever played a game or played with a toy that predicts the future. Answers may include a magic 8 ball, fortune telling booth, or a paper fortune teller.

2. Our challenge today is to build a toy that moves—and predicts the future! You can remind students that fortune telling isn't real, but it's a lot of fun, especially when you make one yourselves!

BUILDING THE CHALLENGE (40 MIN)

Facilitate the following instructions with student groups as they build.

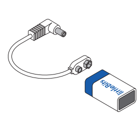
OPTIONAL–OPEN

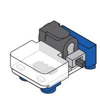
- For the open challenge, skip the guided steps and challenge students to design their own fortune telling or futuristic toy that moves. You may have students use anything from their Kit [harder], or just the Bits and accessories from step #1 below [easier].
- Other design constraints could include:
  - The toy must be powered by littleBits. (Additional constraint could be that the circuit must have one output Bit and at least one input Bit.)
  - The toy must demonstrate at least two forms of energy: lights, motion, sound etc.
  - The toy must incorporate some additional materials, in addition to the Bits and accessories.
- Before they begin, ask students to brainstorm ideas in the "Create" section of the Invention Log. This should include a list or sketch of the different forms of energy they wish to include.
- Then, after some building time, students complete the "Play" and "Remix" sections where they reflect on their design and how to improve it.

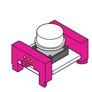
CREATE

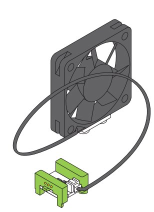
DESIGN CHALLENGE
Let's design a moving fortune telling toy.

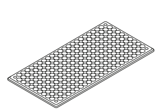
1. Gather your invention tools.

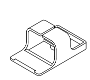

a1 battery & cable


p4 power


i3 button

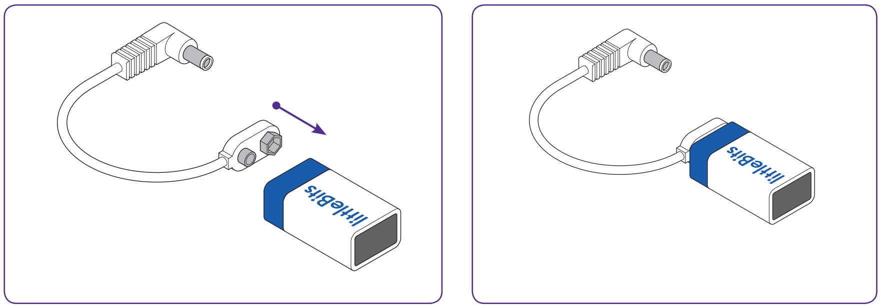

o13 fan


a30 mounting board

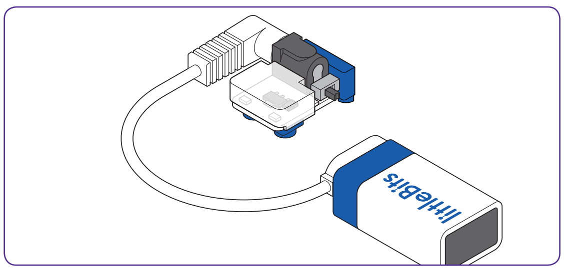

a31 battery clip

Other materials:
- 2 Sheets of paper
- Markers
- Scissors
- Tape
- littleBits Kit box (or similar sized box)

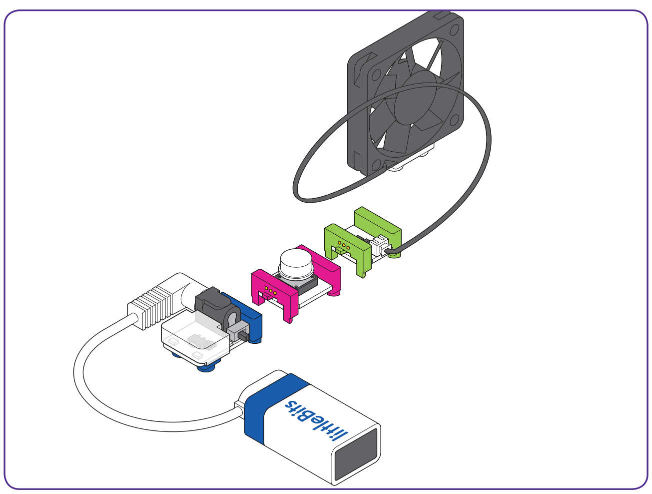
2. Attach the battery cable to the battery.



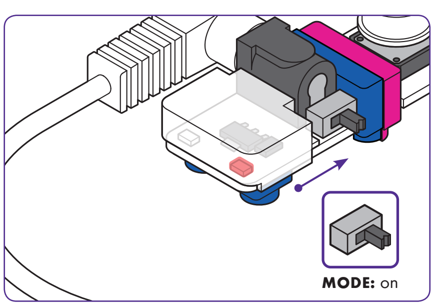
3. Attach the p4 power Bit to the battery cable assembly.



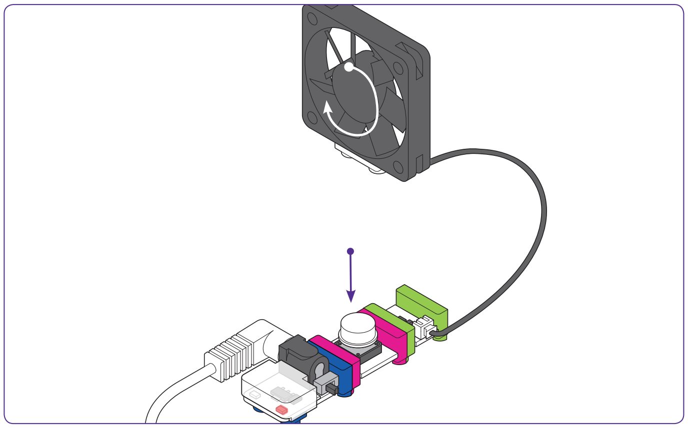
4. Snap this circuit together.



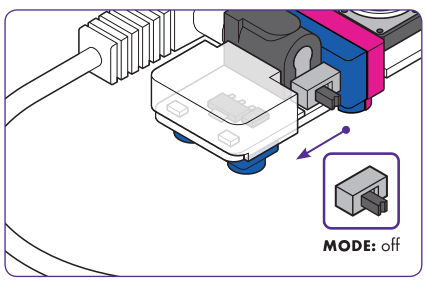
5. Let's test that your circuit works! Power on your circuit.



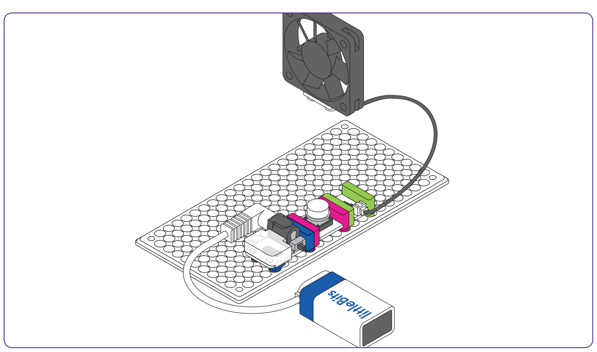
6. Push the button. The fan should spin while the button is pressed. When you let go of the button, the fan should stop.



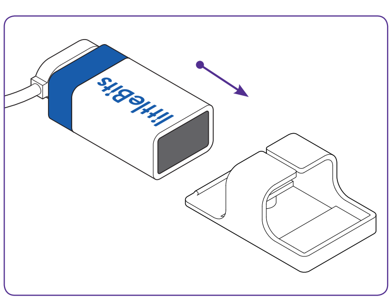
7. Power off your circuit.

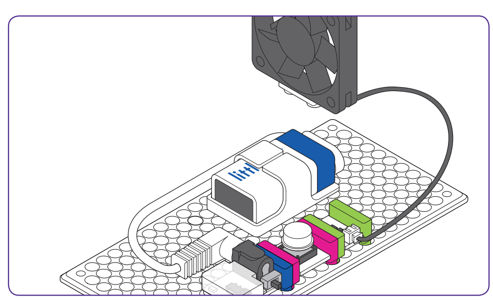


8. Press your circuit into the mounting board.



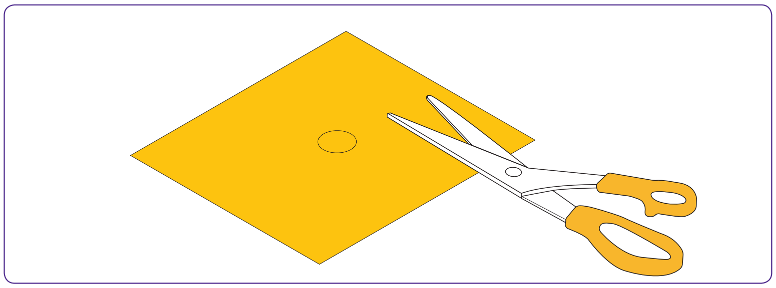
9. Slide the 9-volt battery into the battery clip and press it onto the mounting board.



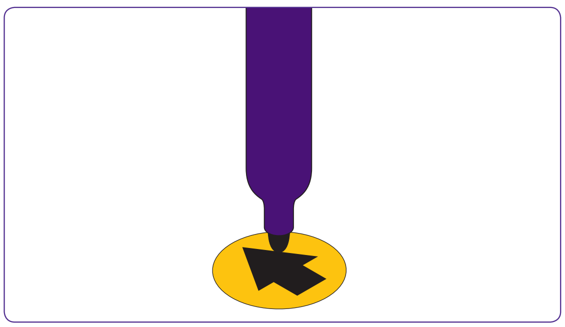


Let's design the toy

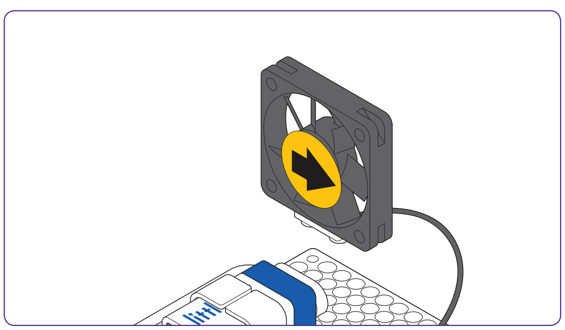
10. Use a marker or pen to draw a small circle about the size of a quarter on paper. Then cut it out.



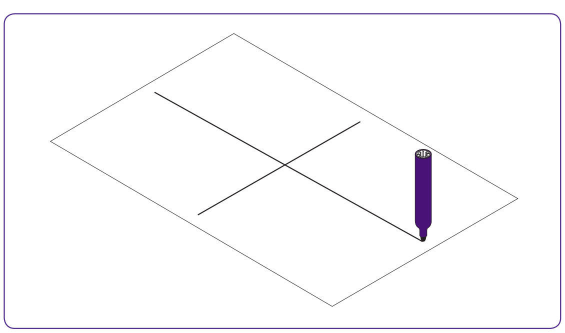
11. Draw an arrow on the circle.



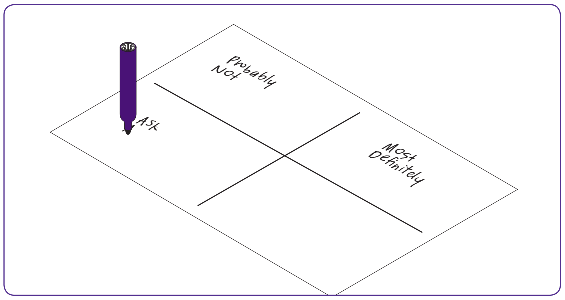
12. Tape the arrow onto the center of the fan on the side that spins.



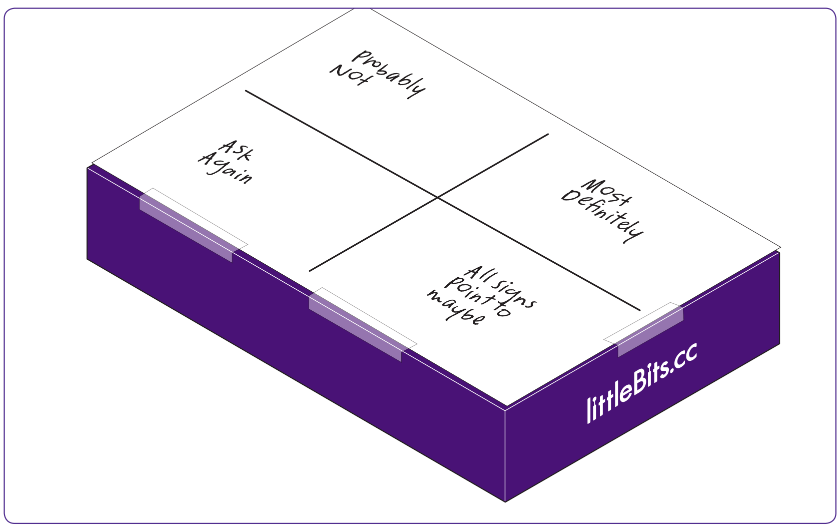
13. Take a full-sheet of paper and draw two lines, one straight down and one across, to divide the paper into four equal sections.



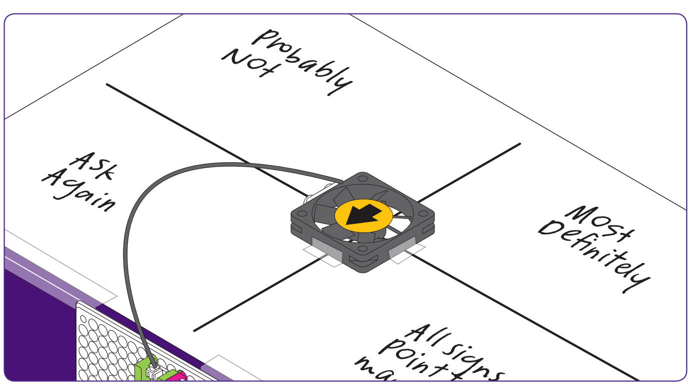
14. Label each section with a different "fortune" that answers a yes/no question. Each member of the group should choose a fortune and write it in one of the quadrants. Remind students to include a variety of potential answers, both positive (like "Most definitely!") and negative (like "Probably Not"). Other ideas include: " It is certain; Without a doubt; Most likely; Signs point to yes; Ask again later; Better not tell you now; Don't count on it; Outlook not so good; Very doubtful."



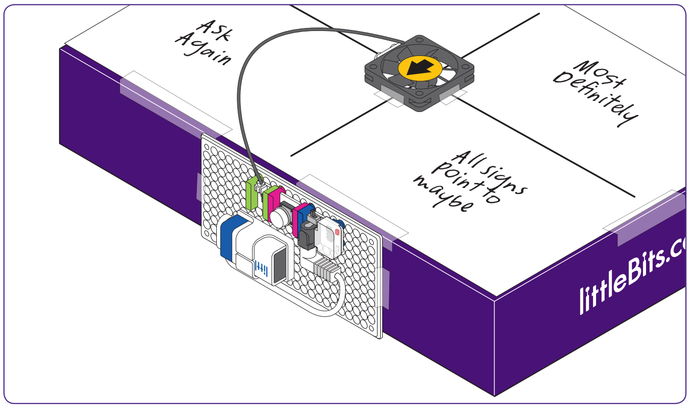
15. Tape your paper to the top of the littleBits kit box.



16. Use a rolled piece of tape to attach the bottom of the fan to the middle of the paper where the lines intersect. Make sure that the tape doesn't prevent the fan blades from spinning.



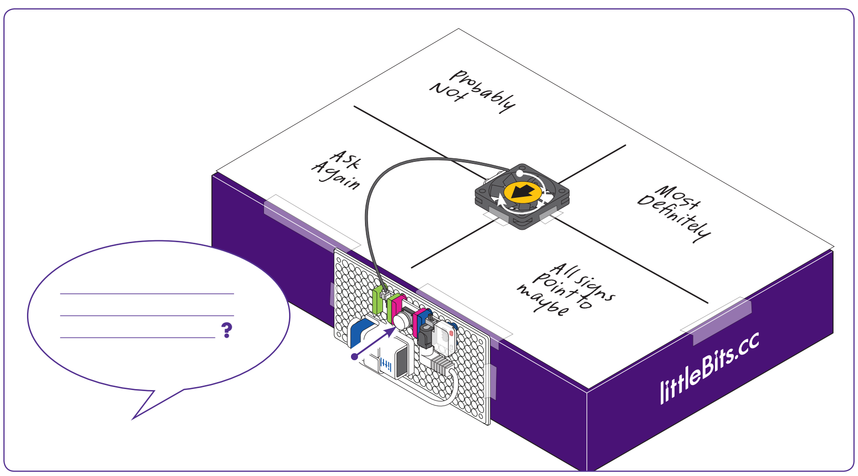
17. Place the mounting board on the side of the box. Tape the mounting board to the box if you need extra support.

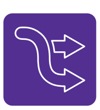


PLAY

18. Test out your toy! What does your future hold? Will you be rich and famous? Will you get an A on your next science test? Let's find out!

Turn your circuit on. Ask a yes/no question, press the button, and let the toy decide your fate! Have students take turns playing with the toy.





REMIX

19. Give students another 15 minutes to remix their fortune tellers by changing the appearance of the toy or adding new Bits (to add new features like lights or sound, different inputs to change how the toy is activated or changing the way the toy moves/provides the prediction).

REFLECTING ON THE CHALLENGE (40 MIN)

Prompt students to extend, record, and explore their creations.

1. Have groups pair up and test out each other's remixed toys. Be sure to include reflections in the Remix section of the Invention Log.
2. Give students 10 additional minutes to improve their toy based on feedback they received in the peer play testing.
3. Record the finished product in the Share section of the Invention Log. Allow students to present their remixed toys to the class. If time, create short commercials that pitch their toys to a toy manufacturer.

SHARE

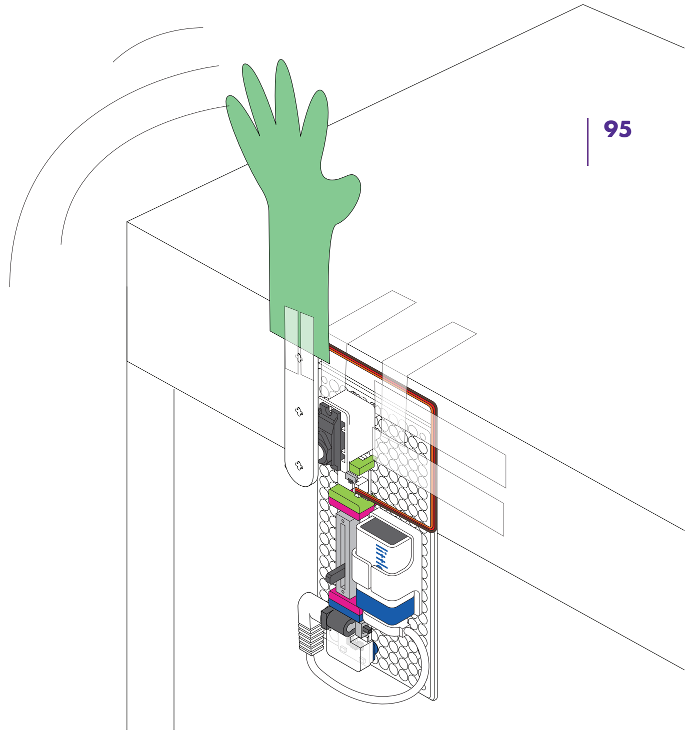
4. **Until next time, littleBits!** Place the Bits gently back in the box according to the diagram on the back of the Bit Index; return classroom materials to their proper place; check the area around your workstation.

EXTENSIONS

REMIX

- How could we add another form of energy to our circuit?
- What changes could we make to the design that would allow us to adjust the speed of the fan?
- For a science lesson, dive deeper into how energy is transferred in the fortune telling circuit. Where do we see potential and kinetic energy?
- Think of a toy that you have that moves. How could you create a replica of that toy using littleBits?

HAND RAISER



DESIGN CHALLENGE
Use littleBits to design a hand-raising device for an injured classmate!

OVERVIEW

LESSON OBJECTIVES

Students will:

- Engineer a "hand raiser" invention through group collaboration and design thinking.

SUGGESTED ACTIVITY TIME (90 MIN)

- Explore (15 min)
- Build (45 min)
- Reflect (30 min)

Optional: Extensions at the end of the lesson provide 30+ more minutes of activity time.

GETTING READY

MATERIALS NEEDED PER GROUP

BITS
p4 power (1)
i5 slide dimmer (1)
o11 servo (1)

ACCESSORIES
a1 battery & cable (1)
a23 mechanical arm (1)
a30 mounting board (1)
a31 battery clip (1)

For the open pathway, students will have access to all of the Bits and accessories in their kit.

OTHER MATERIALS

- Student Workbook
- Construction paper
- Scissors
- Tape
- For the open challenge: Rubber bands, binder clips, recycled paper, paper clips, and other common building tools.

OPEN CHALLENGE

- If students are comfortable using littleBits, you may choose to have students brainstorm their own ideas for creating a hand raising invention in the Invention Log and then construct their design without instructions.

EXPLORING THE CHALLENGE (15 MIN)

Elicit student responses to gauge understanding and warm-up for the activity.

1. Here's the scenario: Our friend James recently got in a bike accident and has to a cast on his right arm. He also isn't supposed to lift his left arm higher than his chest for six weeks. Let's design a hand-raising device for James so he can still participate in class. The invention we will be building should be able to meet the following criteria for success:
    - The hand raises with only minimal student effort.
    - The hand stays raised when a student isn't touching it.
    - A student can make the hand go back down with only minimal effort.
    - The hand is somehow attached to the table, desk or surface without ongoing student assistance.
2. In the Create section of the Invention Log, ask students to jot down some ideas they have for solving the challenge. Be sure that they record their design constraints. Consider what Bits and other materials you would use to construct your invention.

BUILDING THE CHALLENGE (45 MIN)

Facilitate the following instructions with student groups as they build.

OPTIONAL–OPEN

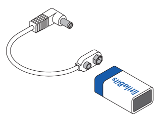
- For the open challenge, skip the guided steps and challenge students to design their own hand-raising device. You may either allow students to use anything in their Kit (more challenging pathway), or limit them to the Bits and accessories shown in step #1 (easier pathway).
- You may want to provide the following constraints on their:
    a. The hand raises with only minimal student effort.
    b. The hand stays up when a student isn't touching it.
    c. A student can make the hand go back down with only minimal effort.
    d. The hand is somehow attached to the table, desk, or other surface without ongoing student assistance.
- After some building time, instruct students to complete the "Play" section of the Invention Log.

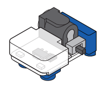
CREATE

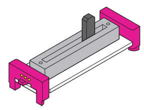
DESIGN CHALLENGE
Design a hand-raising device to help James participate in class.

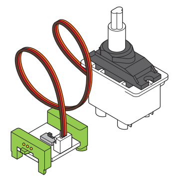
Let's create the circuit!

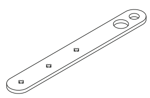
1. Gather your invention tools.

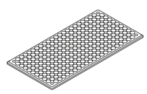

a1 battery & cable

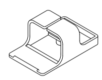

p4 power


i5 slide dimmer


o11 servo


a23 mechanical arm

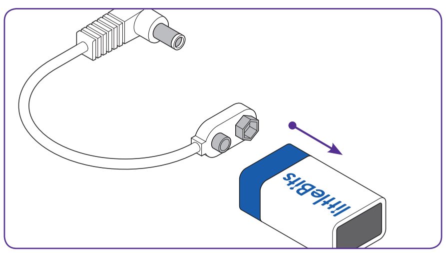

a30 mounting board

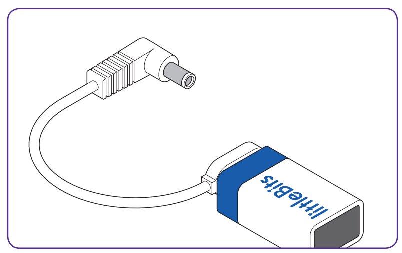

a31 battery clip

Other materials:

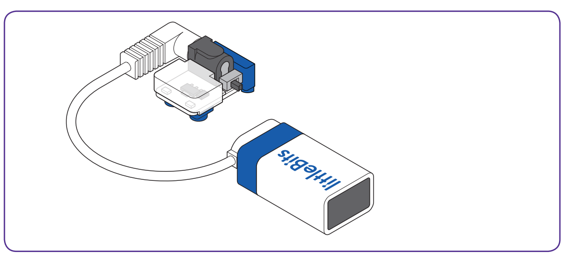
- Construction paper
- Tape
- Scissors
- Optional: Rubber bands, binder clips, recycled paper, paper clips, and other common building tools.

2. Attach the battery cable to the battery.

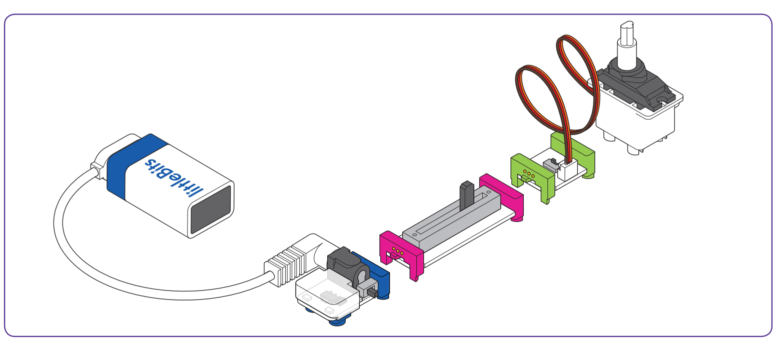




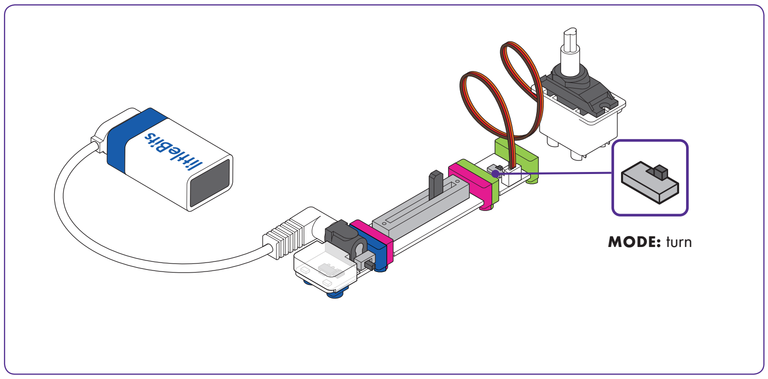
3. Attach the power Bit to the battery cable assembly.



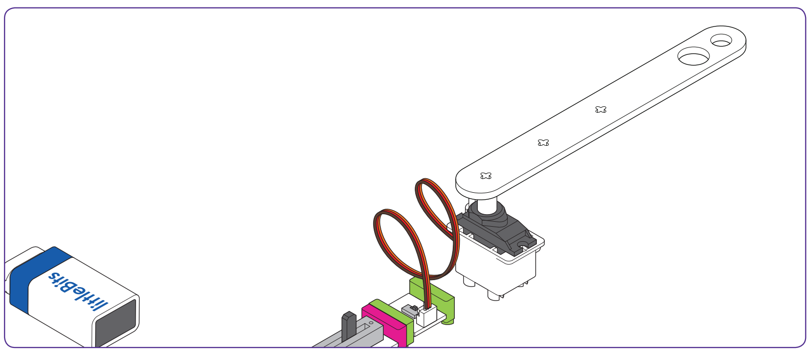
4. Snap the following circuit together.



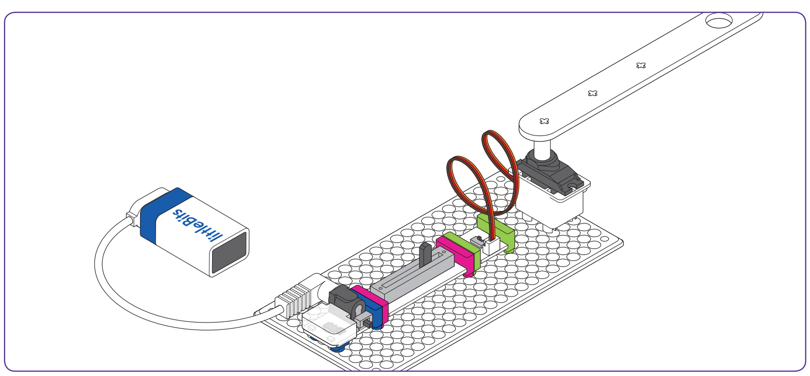
5. Switch the servo to "turn" mode.



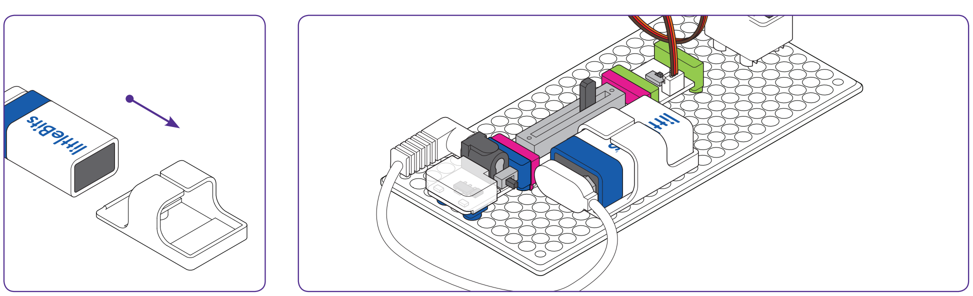
6. Attach the mechanical arm to your servo.



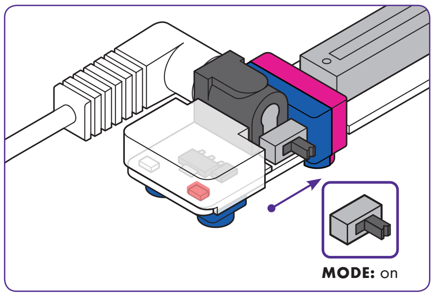
7. Press the circuit into the mounting board as shown.



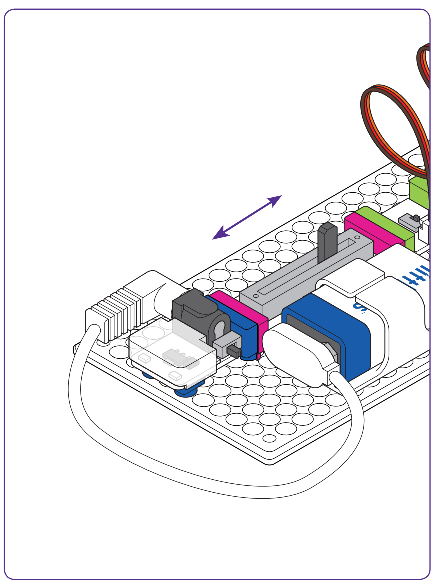
8. Slide the battery into the battery clip and press it into the mounting board.

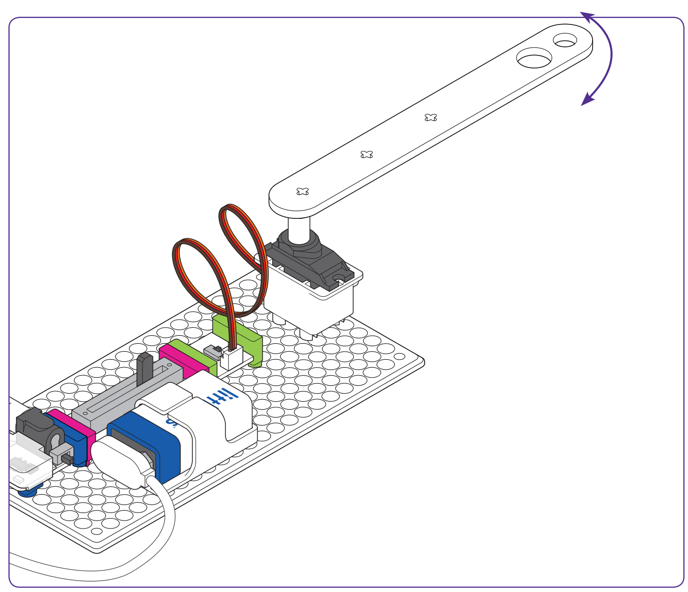


9. Let's test that your circuit works! Power on your circuit.

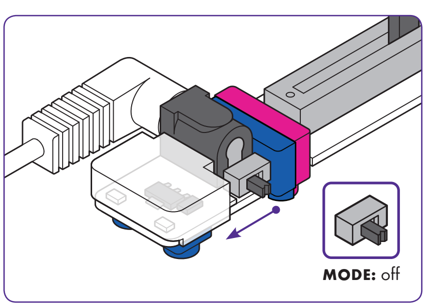


10. Try moving the slider left and right. What happens to the mechanical arm as you move the dimmer?

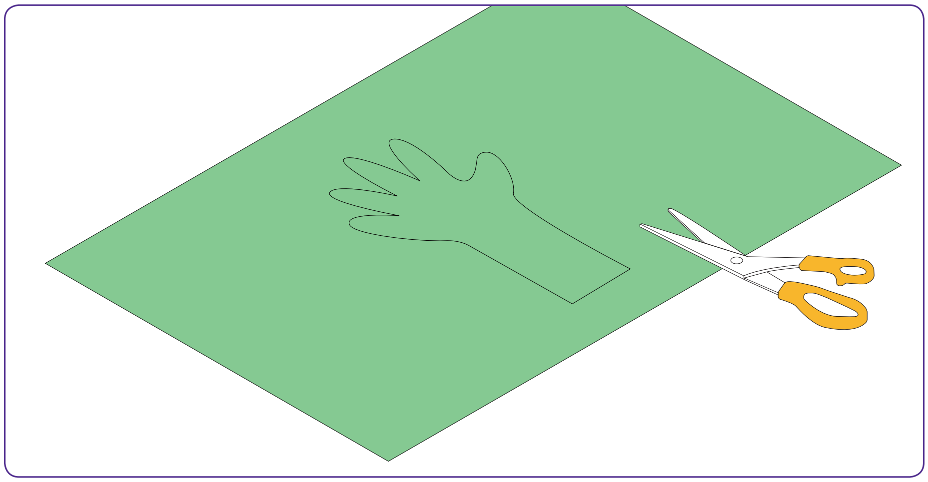




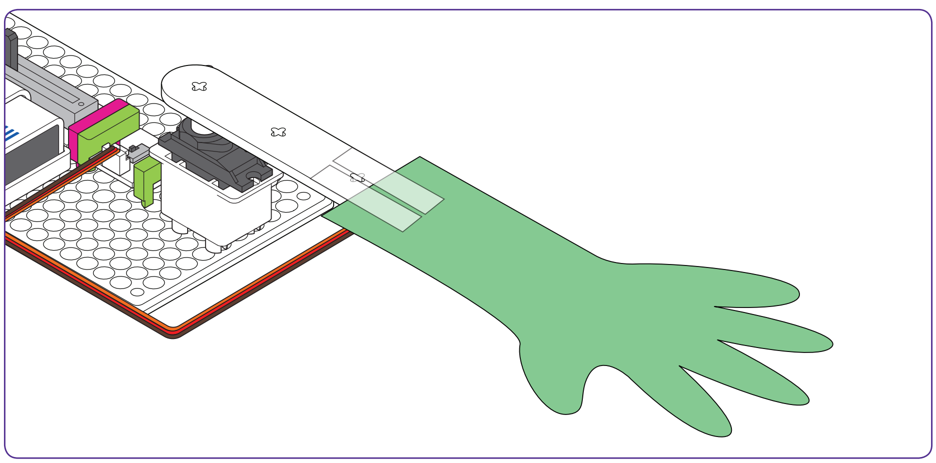
11. Turn off your power Bit.



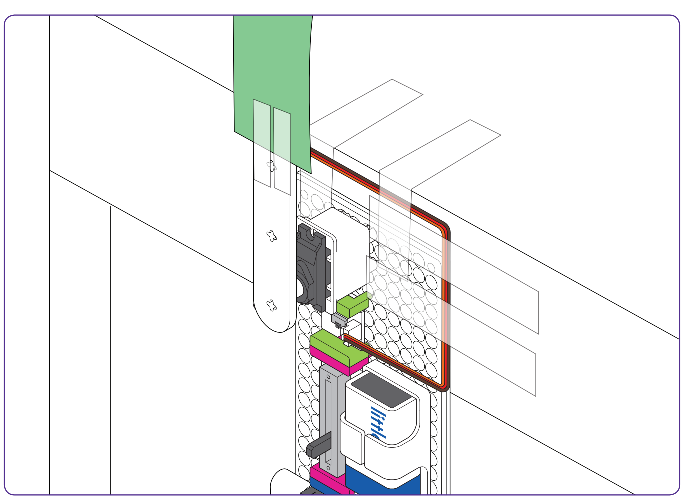
12. Trace a group member's hand on construction paper and use scissors to cut it out.



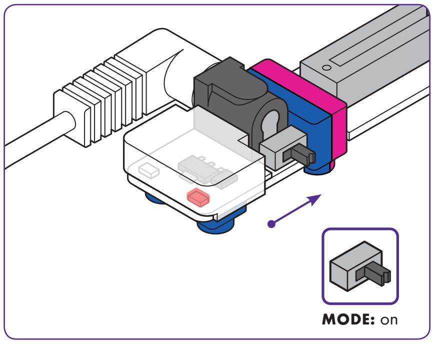
13. Tape the hand onto the mechanical arm.



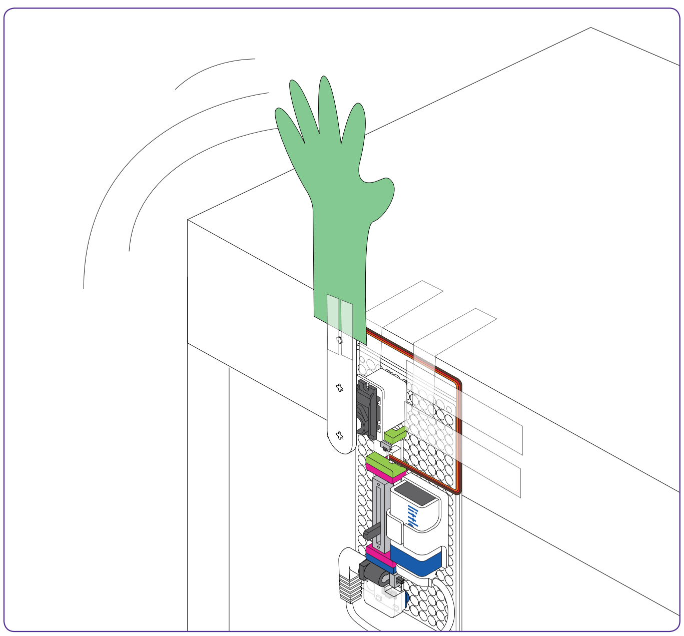
14. Tape your mounting board to the edge of the desk/table.



15. Turn on your power Bit.



16. Test out your helping hand using the slide dimmer!



Test your circuit to see if your invention satisfies the requirements:

- The hand raises with only minimal student effort.
- The hand stays up when a student isn't touching it.
- A student can make the hand go back down with only minimal effort.
- The hand is somehow attached to the table, desk, or surface without ongoing student assistance.

If your invention isn't working as intended, work with your group members to troubleshoot the problem.

REMIX

REFLECTING ON THE CHALLENGE (30 MIN)

Prompt students to extend, record, and explore their creations.

1. How would you change your invention to make it better? Draw an example of how you would change it.

   Give students an additional 15 minutes to experiment with their remix ideas. Record their observations in the Remix section of the Invention Log.

SHARE

2. Have groups record reflections in the Share section of their Invention Log. If time, ask students to create a storyboard showing how their invention improved James' experience in the classroom.

3. **Until next time, littleBits!** Place the Bits gently back in the box according to the diagram on the back of the Bit Index; return classroom materials to their proper place; check the area around your workstation.

REMIX

EXTENSIONS

- Invite students to modify their hand-raiser to throw a ball, or to raise with a different input Bit (like the light sensor Bit).

- Can students invent other littleBits designs for those with accessibility challenges? For inspiration, read: https://littlebits.cc/challenges/invent-for-good

- For a science connection, ask students to consider how raising a hand requires work and power. Explore the role that potential gravitational energy plays in the act of raising a hand.

OPEN CHALLENGES

GOALS

- Flex your invention skills by tackling open challenges, where students brainstorm and then bring their ideas to life using littleBits and other materials.

LESSONS AND PACING

Open challenges can be completed in 4–8 hours. Additional remixes or extensions within the lesson can be chosen to extend the activity.

Depending on how deeply you want to engage in the material, you may choose to break up your lesson into 2–4 sessions, with each session being 2 hours:

TWO SESSIONS (4 hours = Ideal for Illumination or Make it Move Challenge)
- SESSION 1: Create (Ideas and Prototypes), Play, Remix*
- SESSION 2: Continue Remixing (fine tune prototypes), Share

FOUR SESSIONS (8 hours = Ideal for Carnival Games or Inventing to Improve NYC)
- SESSION 1: Create (Ideas and Prototypes)*
- SESSION 2: Play and Remix*
- SESSION 3: Fine tune prototypes and plan out presentations*
- SESSION 4: Finalize presentations and host a showcase

*Be sure to store inventions in a safe place between session

Students will refer to the Open Invention Logs in their Student Workbooks.

ILLUMINATION
- Create an invention that glows.

MAKE IT MOVE
- Create an invention that moves.

CARNIVAL GAMES
- Create a game that others can play.

INVENTING TO IMPROVE NYC
- Create an invention that has a positive impact on your neighborhood or city.

ILLUMINATION

GOAL

Use skills developed throughout the course to create an invention that uses light in an functional, expressive, and/or aesthetic way.

DESCRIPTION

Light plays a critical role in our lives. It allows us to stay up late, play video games, make haunted houses spookier, or tell stories through shadows. In this lesson, students will use the Invention Cycle to design a lamp or light sculpture that solves a functional, aesthetic, or expressive problem. First they will brainstorm ideas for their glowing object and explore how light interacts with different types of materials. Then they will build and test multiple prototypes of their favorite idea, making improvements and measuring each against their criteria for success. At the close of the lesson, they will create a short film of their inventions in action.

LESSONS AND PACING

TWO DAYS: OPEN CHALLENGE: ILLUMINATING INVENTION

Suggested division of challenge:

DAY 1:CREATE (IDEAS AND PROTOTYPES), PLAY, REMIX

- Store and label each group's project in a safe place overnight.

DAY 2: CONTINUE REMIXING (FINE-TUNE PROTOTYPES), SHARE

SUPPLIES

BITS
any Bits

ACCESSORIES
any accessories

OTHER MATERIALS
see list of commonly used materials on pg. 141

TOOLS USED
see list of commonly used tools on pg. 141

TYPE

GRADE LEVEL
elementary
middle

SUBJECT AREAS
engineering
art / design

DIFFICULTY
beginner

PRE-REQUISITES
Introducing littleBits

DURATION*
120 minutes

KEY VOCABULARY

power
output
magnetism
constraints
input
circuits
criteria for success

OBJECTIVES

- Brainstorm ideas for meeting the designated challenge
- Create and test a circuit containing a power source, inputs, outputs, and wires
- Construct a prototype of an invention using Bits and other materials
- Test prototypes and make improvements
- Self-assess work based on the identified success criteria and constraints
- Demonstrate the ability to CREATE, PLAY, REMIX and SHARE an invention through the littleBits Invention Cycle by recording processes in the Invention Log
- Summarize the process and share the results by creating videos of the glowing creations in action

ASSESSMENT STRATEGIES

The Invention Log checklist can be used to assess your students' understanding of the Invention Cycle, use of the Invention Log and ability to attain the objectives of the lesson. For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track. The checklist can also be used as a self-assessment tool by students as they move from phase to phase. For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

*For tips on how to break up your lesson over multiple class periods, see pg. 139

STANDARDS*

3-5-ETS1-1 Engineering Design: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

To fulfill this standard, students are explicit about the need or want being designed for, and call it such, as well as criteria for success and constraints of materials, time, cost, etc. that they're willing to work within.

3-5-ETS1-2 Engineering Design: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

To fulfill this standard, students explicitly compare multiple solutions on the basis of the success and criteria constraints.

3-5-ETS1-3 Engineering Design: Engineering Design: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

To fulfill this standard, students test their prototypes and make improvements. Set all but one variable as fixed, and change just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

MS-ETS1-1 Engineering Design: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

To fulfill this standard, students set various criteria for success, as well as constraints for the successful completion of the design problem.

MS-ETS1-2 Engineering Design: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

To fulfill this standard, students create different solutions to the problem and explicitly compare them on the basis of their ability to meet the goal within the constraints.

MS-ETS1-3 Engineering Design: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into new solutions to better meet the criteria for success.

Students test their prototypes and make improvements. Set all but one variable as fixed, and change the amount of just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to “borrow” the best aspects from one another’s designs during this process.

To meet these standards, students will need to fill out information in the REMIX section of the Invention Log (pg. 11 and 12) every time a variable is changed and tested. Be sure to print additional copies of these pages before the lesson begins.

*For other curricular connections, see the “Extension” section at the end of this lesson.

ADDITIONAL LINKS & TIPS

HELPFUL LINKS

- littleBits Invention Log
  http://littleBits.cc/student-set

INSPIRATIONAL LINKS

- Challenge page
  http://littleBits.cc/challenges/create-an-illuminating-invention?sort=recent&page=1&per_page=12
- Trailer
  https://drive.google.com/open?id=0B-XXgpRozw0nSHM4YThkcDRZLWM
- Inspiration with videos + links to inventions
  http://littleBits.cc/feb-challenge-is-full-of-glowing-goodness
- Workshop Guide
  http://littleBits.cc/lessons/illuminating-invention-workshop-guide
- Quick Start Slide Deck (The Invention Cycle step-by-step)
  https://docs.google.com/presentation/d/14PsVFrApWEuOIWVBDK3iBk-liJo5GnNAM7drmIp0Iy0/edit#slide=id.p
- littleBits Invention Inspiration Cards
  https://docs.google.com/presentation/d/1ETbDMzb-2s_ZdnvFx2Goum2TfaiONKKuKMVeg11EfLU/edit#slide=id.p
- Mini-Challenge Cards
  https://docs.google.com/presentation/d/1ncE-ZodmOQvsYXpD-8CaMJOw2wBQnoqGasHfr7xe-PA/edit#slide=id.g1afd977ed4_0_11

TIPS AND TRICKS

For Open Challenges, we recommend that the teacher create an example invention, which may or may not be shown to students at the beginning of the lesson. Taking the challenge through the Invention Cycle will better equip teachers to successfully conduct the lesson and be more knowledgeable about where the class, or specific students, may need a bit more time or support.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and Invention Guide, plus one Invention Log and Assessment Checklist per student. We suggest handing out the Bits in the Create phase to keep students focused on initial instructions and review activities. For more experienced users, you may want to provide access to additional Bits in the Play and Remix phases to provide a greater diversity of circuit combinations. Place a variety of construction materials and tools in a central location in the room.

STEP TWO: INTRODUCE

INTRODUCE THE LESSON OBJECTIVES AND THE CONCEPT BEHIND THE CHALLENGE:

- What would life be like if we didn't have electric light? What if Thomas Edison, Nikolai Tesla, and other inventors had never tried to understand how to control electricity and convert it to a usable form? Ask students to brainstorm three ways their life would be different without the electric light bulb. What activities could they still do? Which ones would be impossible? They can draw, write, or discuss ideas with a partner, then share out as a large group. (Turn out the classroom lights for effect.)
- Explain that they will work in small teams to create an illuminating invention using littleBits and other materials. They can create an invention that has a practical use (like a flashlight for night reading), artistic use (a lightbox diorama that illustrates a story), or expresses an idea (a glowing lantern for Chinese New Year). Share the challenge trailer and a few of the community inventions in the Inspiration Links above to get their creativity flowing.

Before jumping into the challenge, provide a quick review of the Invention Cycle framework and the format of the Invention Log (pg. 19). Ask students to share lessons learned about Bits, the invention process and things they enjoyed or struggled with from previous challenges.

CREATE

STEP THREE: CREATE (45–55 MIN)

A. CREATE IDEAS

For each of the prompt sections below, students will record their process and reflections in their respective Invention Logs.

What ideas do you have?

- Prompt students to create a list (either as a class, or in groups) of illuminated objects they would like to create. Refer to pg. 21 for brainstorming tips.

Which idea seems best?

- After making a list of 5–10 ideas, have students choose the everyday activity that they want to accomplish. It could be the idea that sounds the most fun to solve or is the most accessible in the classroom.
- Students should frame their thinking in the following framework: I will invent a________that_______because______.

What's the "before" story?

- What is life like now, before the proposed invention exists? Ask students to draw or describe the series of events before, during and after to show cause-and-effect scenarios. Be sure to consider the characters involved and the setting that the "story" takes place in.

What are the constraints?

- Constraints are the limits and requirements that need to be considered in the invention process. Examples include time, materials, weight. Have students detail any constraints that they may need to keep in mind as they work. For younger students, you may choose to run this exercise as a class and have students record shared ideas.

What are the criteria for success?

- How will students know if their invention works? Describe the number-one goal for the invention. What qualities are important for the invention to have?

B. CREATE PROTOTYPE

- For each of the prompts below, students will record their process and reflections in their respective Invention Logs.

How could Bits help you solve your problem?

- Instruct students to look through their available Bits and materials to see how they could (or couldn't) be combined to help solve your problem. For example, how could a servo trigger a slide dimmer? How could a DC motor trigger a light sensor? Could the inverter play a role? How could other materials (e.g. books, cardboard, cups) serve as triggers?
- If students get stuck, try snapping a Bit into a circuit or read through the Bit Index (pg. 7–27 in their Invention Guide).

What does your first prototype look like?

- Students create a drawing(s) of their first prototype, labeling Bits and any important features. A description of how the prototype is supposed to work should also be included. This is a time for students to dig into the Bits and materials, and start to bring their ideas to life.

PLAY

STEP FOUR: PLAY (10–15 MIN)

How did your testing go?

Once the prototypes have been constructed, students should test their invention to see if it works. Put student groups in pairs: Group 1 will have 3 minutes to share their invention and Group 2 will have 2 minutes to give feedback, then switch. When it's their turn, each group should state their goal, demo the invention, then allow the other group to try it. Try using the Glow, Grow, Question, Suggestion feedback protocol.

- Glow: One thing you liked
- Grow: One area for improvement
- Question: A question about the invention
- Suggestion: An idea for the group to use

Students should take note of successes and things that still need to be improved in their Invention Logs.

REMIX

STEP FIVE: REMIX (15–25 MIN)

To meet the outlined NGSS standards, instruct students to fill out a new Remix section in their Invention Logs (pg. 11 and 12) every time a variable is changed and tested. If you do not plan to adhere to the NGSS standards, allow students more flexibility and exploratory pathways during this phase of the design process.

Prototype # 2 (and more...)

- This is the opportunity to experiment with fixes and improvements. As students make changes to their inventions, make sure they are documenting in their Invention Logs how their prototypes are changing and the results (good and bad).
- If students need some inspiration, set the invention aside and look through the remaining Bits and available materials. Is it possible to complete a step with them? Try a few options and see how they compare to what has already been created.
- Continue the Remix phase (and remind students to play with their updated inventions) until the prototype is able to meet the criteria for success, or until the allotted time runs out. If you need more advice on how to conduct and provide prompts in the Remix phase, read through the Invention Adviser section (p. 25).

SHARE

STEP SIX: SHARE (30–35 MIN)

Wrap up the challenge by reflecting and tying together the story of the invention. Have students take a video of their invention in action and post it to their favorite social media channel or the Illuminating Invention Challenge page on the littleBits website.

STEP SEVEN: CLOSE (5 MIN)

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide, clean up their materials and hand in their Invention Logs.

STEP EIGHT: EXTENSION

Incorporate the following extension in the Remix section of this challenge to bolster your lesson's NGSS applications:

> MS-ETS1-4 Engineering Design: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

To fulfill this standard, students define and iteratively collect data to explore the explicit connection between the invention and a physical or environmental interaction that may impact the design. For example, modeling the impact of friction on the ability of a wheeled invention to climb a slope, or the impact of an invention on human behavior. The storyboard in the Invention Log should be used and updated throughout the lesson for each iteration tested.

MAKE IT MOVE

GOAL

Use skills developed throughout the course to make motion using Bits!

DESCRIPTION

Movement is all around us, from the earth orbiting the sun, to your eyes moving across the screen right now to read about this challenge! We see movement in nature, and we invent movement everyday to get around, help us do work, and sometimes just to let loose and dance! In this lesson, students will use Bits to invent the vehicle of their dreams. First they will brainstorm ideas for their moving vehicle and explore how motors can be used with different materials. Then they will build and test multiple prototypes of their favorite idea, making improvements and measuring each against their criteria for success. At the close of the lesson, they will create a short film of their inventions in action.

LESSONS AND PACING

Grade 2-3: FOUR DAYS of OPEN CHALLENGE
- DAY 1: Create (Ideas and Prototypes)
- DAY 2: Play and Remix
- DAY 3: Fine tune prototypes and plan out presentations
- DAY 4: Finalize presentations and show to classmates

Grade 4-5: TWO DAYS of OPEN CHALLENGE
- DAY 1: Create (Ideas and Prototypes), Play, Remix
- DAY 2: Continue Remixing (fine tune prototypes), Share

Be sure to store and label each group's invention in a safe place overnight.

SUPPLIES

BITS
any Bits

ACCESSORIES
any accessories

OTHER MATERIALS
see list of commonly used materials on pg. 141

TOOLS USED
see list of commonly used tools on pg. 141

TYPE

GRADE LEVEL
elementary

PRE-REQUISITES
Introducing littleBits

DIFFICULTY*
beginner

DURATION
120 minutes

KEY VOCABULARY

power
output
magnetism
criteria for success
input
circuits
constraints

OBJECTIVES

Participants will use the Invention Cycle to design and build the vehicle of their dreams.

Learners will...
- Use actual vehicles as inspiration for the vehicles they'd like to see now or in the future.
- Create a functioning circuit that moves.
- Design a vehicle that can transport people or goods from one place to another.
- Give and receive constructive verbal feedback while testing their inventions.
- Write an instruction set for creating their vehicle.
- Film a short movie using digital media tools to document their process and/or final product.

ASSESSMENT STRATEGIES

The Invention Log checklist can be used to assess your students' understanding of the Invention Cycle, use of the Invention Log and ability to attain the objectives of the lesson. For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track. The checklist can also be used as a self-assessment tool by students as they move from phase to phase. For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

*For tips on how to break up your lesson over multiple class periods, see pg. 139

STANDARDS*

ISTE STANDARDS (FORMERLY NETS)
1.a - Apply existing knowledge to generate new ideas, products, or processes.
1.c - Use models and simulation to explore complex systems and issues.
2.d - Contribute to project teams to solve problems.
4.b - Plan and manage activities to develop a solution or complete a project.
4.d - Use multiple processes and diverse perspectives to explore alternative solutions.

NGSS SCIENCE AND ENGINEERING PRACTICES
3-5-ETS1-2 Engineering Design: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

To meet this standard, students will need to fill out information in the REMIX section of the Invention Log (pg. 11 and 12) every time a variable is changed and tested. Be sure to print additional copies of these pages before the lesson begins.

CCSS COMMON CORE STATE STANDARDS
CCSS.ELA-LITERACY.W.6.2.
Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

*For other curricular connections, see the "Extension" section at the end of this lesson.

ADDITIONAL LINKS & TIPS

HELPFUL LINKS

- littleBits Invention Log
  http://littleBits.cc/student-set

INSPIRATIONAL LINKS

- Challenge page
  http://littleBits.cc/challenges/create-an-illuminating-invention?sort=recent&page=1&per_page=12
- Trailer
  https://drive.google.com/open?id=0B-XXgpRozw0nSHM4YThkcDRZLWM
- Inspiration with videos + links to inventions
  https://littlebits.cc/challenges/make-it-move?sort=recent&page=1&per_page=12
- Workshop Guide
  https://docs.google.com/document/d/1EO2IZt14HBJVMJv6sHIK8kUvbyFgcWugzN_

vt20KCy8/edit

- Quick Start Slide Deck (The Invention Cycle step-by-step)
  https://docs.google.com/presentation/d/1MBHu8FYwj_yIrr4KuLSLMjYD_d5cyoCktJq-dwJB0HM/edit#slide=id.g1ba45e56da_0_164
- littleBits Invention Inspiration Cards
  https://docs.google.com/presentation/d/1MCE9ZaMtkhLmse3pYoY2vzsJKfSd8E1y61B7Seq8Kmg/edit#slide=id.g1afd977ed4_0_11
- Mini-Challenge Cards
  https://docs.google.com/presentation/d/1uBk-xg5XF5USUf4fqdNlKcEt6PVJI2MqpHMgpnGg92c/edit

TIPS AND TRICKS

For Open Challenges, we recommend that the teacher create an example invention, which may or may not be shown to students at the beginning of the lesson. Taking the challenge through the Invention Cycle will better equip teachers to successfully conduct the lesson and be more knowledgeable about where the class, or specific students, may need a bit more time or support.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and Invention Guide, plus one Invention Log and Assessment Checklist per student. We suggest handing out the Bits in the Create phase to keep students focused on initial instructions and review activities. For more experienced users, you may want to provide access to additional Bits in the Play and Remix phases to provide a greater diversity of circuit combinations. Place a variety of construction materials and tools in a central location in the room

STEP TWO: INTRODUCE (10 MIN)

INTRODUCE THE LESSON OBJECTIVES AND THE CONCEPT BEHIND THE CHALLENGE:

- Today you will use littleBits to invent the vehicle of your dreams - but it must be able to physically move on its own, powered by Bits!
- There are many types of vehicles both real and imagined - you don't have to invent a car! Your vehicle can move in any way, whether it's currently physically possible or not, and can move over or through anything, for any purpose! As long as you can use Bits to make a model that shows how it would work, you're ready to invent.
- Ask: What are the three coolest vehicles you have ever seen, heard of, or read about? Teacher's choice: They can draw, write, or talk with a partner to respond

to the question.
- Ask: Who would like to share and describe one vehicle you drew/wrote about/ talked about? (Let a few learners share ideas.)
- Show the trailer (see Helpful Links) to introduce the challenge and explain that they will be working in small teams to create a moving vehicle with littleBits.

Before jumping into the challenge, provide a quick review of the Invention Cycle framework and the format of the Invention Log (pg. 19). Ask students to share lessons learned about Bits, the invention process and things they enjoyed or struggled with from previous challenges.

STEP THREE: CREATE (45–55 MIN)

CREATE

A. CREATE IDEAS

For each of the prompt sections below, students will record their process and reflections in their respective Invention Logs.

What ideas do you have?

- Prompt students to create a list (either as a class, or in groups) of vehicles they would like to create. Refer to pg. 21 for brainstorming tips.
- Encourage students to think outside the box! They can invent...
    - An undercover submarine
    - A Waiter Droid that circulates at parties to serve you and your friends
    - The car of 2050
    - A bicycle that can...?
    - A superspeed jet or airplane
    - A train that runs on renewable energy
    - A vehicle that digs and tunnels and travels underground
    - A hoverboard/hovercraft/jetpack
    - A flying carpet
    - A pilotable robot
    - A tricked out hamster wheel
    - A snow drifter/vehicle that skis/travels through snow
    - A motorized surfboard
    - A crawling vehicle for exploring the rainforest or desert

Which idea seems best?

- After making a list of 5–10 ideas, have students choose the everyday activity that they want to accomplish. It could be the idea that sounds the most fun to solve or is the most accessible in the classroom.
- Students should frame their thinking in the following framework: I will invent a________that_______because______.

  For example, "I will invent a submarine that uses wheels attached to DC motors and LED Bits to light the way because people want to travel to and examine deep sea life.

What's the "before" story?

- What is life like now, before the proposed invention exists? Ask students to draw or describe the series of events before, during and after to show cause-and-effect scenarios. Be sure to consider the characters involved and the setting that the "story" takes place in.

What are the constraints?

- Constraints are the limits and requirements that need to be considered in the invention process. Examples include time, materials, weight. Have students detail any constraints that they may need to keep in mind as they work. For younger students, you may choose to run this exercise as a class and have students record shared ideas.

What are the criteria for success?

- How will students know if their invention works? Describe the number-one goal for the invention. What qualities are important for the invention to have?

B. CREATE PROTOTYPE

- For each of the prompts below, students will record their process and reflections in their respective Invention Logs.

How could Bits help you solve your problem?

- Instruct students to look through their available Bits and materials to see how they could (or couldn't) be combined to help bring your vehicle to life. For example, how could a servo trigger a slide dimmer? How could a DC motor trigger a light sensor? Could the inverter play a role? How could other materials (e.g. books, cardboard, cups) serve as triggers?
- If students get stuck, try snapping a Bit into a circuit or read through the Bit Index (pg. 7–27 in their Invention Guide). Students can also reference the "Circuit Cruiser" guided challenge build steps for additional support.

What does your first prototype look like?

- Students create a drawing(s) of their first prototype, labeling Bits and any important features. A description of how the prototype is supposed to work should also be included.
- This is a time for students to dig into the Bits and materials and start to bring their ideas to life.

PLAY

STEP FOUR: PLAY (10–15 MIN)

How did your testing go?

Once the prototypes have been constructed, students should test their invention to see if it works. Put student groups in pairs: Group 1 will have 3 minutes to share their invention and Group 2 will have 2 minutes to give feedback, then switch. When it's their turn, each group should state their goal, demo the invention, then allow the other group to try it. Try using the Glow, Grow, Question, Suggestion feedback protocol.

- Glow: One thing you liked
- Grow: One area for improvement
- Question: A question about the invention
- Suggestion: An idea for the group to use

Students should take note of successes and things that still need to be improved in their Invention Logs.

REMIX

STEP FIVE: REMIX (15–25 MIN)

To meet the outlined NGSS standards, instruct students to fill out a new Remix section in their Invention Logs (pg. 11 and 12) every time a variable is changed and tested. If you do not plan to adhere to the NGSS standards, allow students more flexibility and exploratory pathways during this phase of the design process.

Prototype # 2 (and more...)

- This is the opportunity to experiment with fixes and improvements. As students make changes to their inventions, make sure they are documenting in their Invention Logs how their prototypes are changing and the results (good and bad).
- If students need some inspiration, set the invention aside and look through the remaining Bits and available materials. Is it possible to complete a step with them? Try a few options and see how they compare to what has already been created.
- Continue the Remix phase (and remind students to play with their updated inventions) until the prototype is able to meet the criteria for success, or until the allotted time runs out. If you need more advice on how to conduct and provide prompts in the Remix phase, read through the Invention Adviser section (pg. 25).

STEP SIX: SHARE (30–35 MIN)

SHARE

Wrap up the challenge by reflecting and tying together the story of the invention. Have students take a video of their invention in action and post it to their favorite social media channel or the Make It Move Challenge page on the littleBits website.

STEP SEVEN: CLOSE (5 MIN)

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide, clean up their materials and hand in their Invention Logs.

If there's additional time, give students time to reflect on the activity by asking questions like:

- What did they enjoy the most?
- What was the most challenging?
- If you could give one piece of advice to another team who hasn't done this, what would it be?
- Define the word "failure" and give at least one example from this workshop. How did failure lead to success?

STEP EIGHT: EXTENSION

Incorporate the following extension in the Remix section of this challenge to bolster your lesson's NGSS applications:
To fulfill this standard, students set various criteria for success, as well as constraints

> MS-ETS1-1 Engineering Design: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

for the successful completion of the design problem.

CARNIVAL GAMES

GOAL

Use skills developed throughout the course to make a carnival game that others can play!

DESCRIPTION

The best carnival games often use electronics to make things louder, brighter, and more exciting. In this lesson, students will use Bits and other materials to remake their favorite carnival game, or imagine a brand new game. First they will brainstorm ideas for their game and explore how Bits can be used with different materials. Then they will build and test multiple prototypes of their favorite idea, making improvements and measuring each against their criteria for success. At the close of the lesson, they will invite other students to play their games and explain the rules and experience what it takes to win.

LESSONS AND PACING

Grade 2–3: FOUR DAYS of OPEN CHALLENGE
- DAY 1: Create (Ideas and Prototypes)
- DAY 2: Play and Remix
- DAY 3: Fine tune prototypes and plan out presentations
- DAY 4: Finalize presentations and host a carnival!

Grade 4–5: TWO DAYS of OPEN CHALLENGE
- DAY 1: Create (Ideas and Prototypes), Play, Remix
- DAY 2: Continue Remixing (fine tune prototypes), Share

Be sure to store and label each group's invention in a safe place overnight.

SUPPLIES

BITS
any Bits

ACCESSORIES
any accessories

OTHER MATERIALS
see list of commonly used materials on pg. 141

TOOLS USED
see list of commonly used tools on pg. 141

Cardboard, new and recycled, is very useful in this challenge!

TYPE

GRADE LEVEL
elementary
middle school

PRE-REQUISITES
Introducing littleBits

DIFFICULTY*
intermediate

DURATION
120 minutes

KEY VOCABULARY

power
output
magnetism
criteria for success
input
circuits
constraints

OBJECTIVES

Participants will use the Invention Cycle to to design a carnival game.

Learners will...
- Use actual carnival games as inspiration for the games that they'd like to reinvent.
- Create a functioning circuit(s) that brings their game to life (can be motion, lights, sound or a combination of).
- Design a carnival game, that is real or imagined.
- Give and receive constructive verbal feedback while testing their inventions.
- Write an instruction set for creating their game and how players can win.
- Share their game with other students and explain the rules of the game.

ASSESSMENT STRATEGIES

The Invention Log checklist can be used to assess your students' understanding of the Invention Cycle, use of the Invention Log and ability to attain the objectives of the lesson. For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track. The checklist can also be used as a self-assessment tool by students as they move from phase to phase. For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

*For tips on how to break up your lesson over multiple class periods, see pg. 139

STANDARDS*

ISTE STANDARDS (FORMERLY NETS)
1.a - Apply existing knowledge to generate new ideas, products, or processes.
1.c - Use models and simulation to explore complex systems and issues.
2.d - Contribute to project teams to solve problems.
4.b - Plan and manage activities to develop a solution or complete a project.
4.d - Use multiple processes and diverse perspectives to explore alternative solutions.

NGSS SCIENCE AND ENGINEERING PRACTICES
3-5-ETS1-2. EGenerate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

To fulfill this standard, students explicitly compare multiple solutions on the basis of the success and criteria constraints.

To meet this standard, students will need to fill out information in the REMIX section of the Invention Log (pg. 11 and 12) every time a variable is changed and tested. Be sure to print additional copies of these pages before the lesson begins.
*For other curricular connections, see the "Extension" section at the end of this lesson.

CCSS COMMON CORE STATE STANDARDS
CCSS.ELA-LITERACY.W.6.2.
Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
CCSS.ELA-LITERACY.RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

ADDITIONAL LINKS & TIPS

HELPFUL LINKS
- littleBits Invention Log
  http://littleBits.cc/student-set

INSPIRATIONAL LINKS
- Challenge page
  http://littleBits.cc/challenges/create-an-illuminating-invention?sort=recent&page=1&per_page=12
- Inspiration with videos + links to inventions
  https://littlebits.cc/challenges/carnival-games?sort=recent&page=1&per_page=12
- Cardboard Games Workshops
  http://littlebits.cc/lessons/cardboard-games-workshop

TIPS AND TRICKS

For Open Challenges, we recommend that the teacher create an example invention, which may or may not be shown to students at the beginning of the lesson. Taking the challenge through the Invention Cycle will better equip teachers to successfully conduct the lesson and be more knowledgeable about where the class, or specific students, may need a bit more time or support.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and Invention Guide, plus one Invention Log and Assessment Checklist per student. We suggest handing out the Bits in the Create phase to keep students focused on initial instructions and review activities. For more experienced users, you may want to provide access to additional Bits in the Play and Remix phases to provide a greater diversity of circuit combinations. Place a variety of construction materials and tools in a central location in the room.

STEP TWO: INTRODUCE (10 MIN)

INTRODUCE THE LESSON OBJECTIVES AND THE CONCEPT BEHIND THE CHALLENGE:

- Today you will use littleBits to recreate or design your own carnival game!
- Ask: What are some of your favorite carnival games that incorporate electronics? Teacher's choice: They can draw, write, or talk with a partner to respond to the question.
- Ask: Who would like to share and describe one game that you drew/wrote about/talked about? (Let a few learners share ideas.)

Before jumping into the challenge, provide a quick review of the Invention Cycle framework and the format of the Invention Log (pg. 19). Ask students to share lessons learned about Bits, the invention process and things they enjoyed or struggled with from previous challenges.

STEP THREE: CREATE (45–55 MIN)

CREATE

A. CREATE IDEAS

For each of the prompt sections below, students will record their process and reflections in their respective Invention Logs.

What ideas do you have?

- Prompt students to create a list (either as a class, or in groups) of carnival games they would like to create. Refer to pg. 21 for brainstorming tips.
- If students are feeling creative, they can dream up their own game.

Which idea seems best?

- After making a list of 5–10 ideas, have students choose the everyday activity that they want to accomplish. It could be the idea that sounds the most fun to solve or is the most accessible in the classroom.
- Students should frame their thinking in the following framework: I will invent a_______that______because_____.

  For example, "I will invent a **skee ball** game that **uses the number Bit and button** because **that will help us keep track of points.**

What's the "before" story? (Optional)

- What is life like now, before the proposed invention exists? Ask students to draw or describe the series of events before, during and after to show cause-and-effect scenarios. Be sure to consider the characters involved and the setting that the "story" takes place in.

What are the constraints?

- Constraints are the limits and requirements that need to be considered in the invention process. Examples include time, materials, weight. Have students detail any constraints that they may need to keep in mind as they work. For younger students, you may choose to run this exercise as a class and have students record shared ideas.

What are the criteria for success?

- How will students know if their invention works? Describe the number-one goal for the invention. What qualities are important for the invention to have?
- How will students know when they win or lose the game? What are the rules players should follow?
- For students who are designing a new game, have them consider the following elements:
    - COMPONENTS: Whether it's the players that make the game, little wooden pawns, or extraterrestrial obstacles, your game needs items.
    - PLAYERS: Is it an individual or multi-player game?
    - SPACE: Well, it all needs to happens somewhere, right?
    - MECHANICS: The actions that you take in the game. Think of verbs like jumping, pushing, swinging!
    - GOALS: Make your game have multiple goals that allow your players to make interesting choices.
    - STRATEGY: Even if you are making a very simple game, make sure that it allows for some strategy so that, if played again, the game will not give the same outcomes. Bottom line: If the same person is winning over and over, something is wrong.
    - SURPRISES: You might not be the surprise type, but a game is no fun without some unexpected moments.

B. CREATE PROTOTYPE

- For each of the prompts below, students will record their process and reflections in their respective Invention Logs.

How could Bits help you solve your problem?

- Instruct students to look through their available Bits and materials to see how they could (or couldn't) be combined to help bring your vehicle to life. For example, how could a servo trigger a slide dimmer? How could a DC motor trigger a light sensor? Could the inverter play a role? How could other materials (e.g. books, cardboard, cups) serve as triggers?
- If students get stuck, try snapping a Bit into a circuit or read through the Bit Index (pg. 7–27 in their Invention Guide).

What does your first prototype look like?

- Students create a drawing(s) of their first prototype, labeling Bits and any important features. A description of how the prototype is supposed to work should also be included.
- This is a time for students to dig into the Bits and materials and start to bring their ideas to life.

PLAY

STEP FOUR: PLAY (10–15 MIN)

How did your testing go?

Once the prototypes have been constructed, students should test their invention to see if it works. Put student groups in pairs: Group 1 will have 3 minutes to share their invention and Group 2 will have 2 minutes to give feedback, then switch. When it's their turn, each group should state their goal, demo the invention, then allow the other group to try it. Try using the Glow, Grow, Question, Suggestion feedback protocol.

- Glow: One thing you liked
- Grow: One area for improvement
- Question: A question about the invention
- Suggestion: An idea for the group to use

Students should take note of successes and things that still need to be improved in their Invention Logs.

REMIX

STEP FIVE: REMIX (15–25 MIN)

To meet the outlined NGSS standards, instruct students to fill out a new Remix section in their Invention Logs (pg. 11 and 12) every time a variable is changed and tested. If you do not plan to adhere to the NGSS standards, allow students more flexibility and exploratory pathways during this phase of the design process.

Prototype # 2 (and more...)

- This is the opportunity to experiment with fixes and improvements. As students make changes to their games, make sure they are documenting in their Invention Logs how their prototypes are changing and the results (good and bad).
- If students need some inspiration, set the invention aside and look through the remaining Bits and available materials. Is it possible to complete a step with them? Try a few options and see how they compare to what has already been created.

- Continue the Remix phase (and remind students to play with their updated inventions) until the prototype is able to meet the criteria for success, or until the allotted time runs out. If you need more advice on how to conduct and provide prompts in the Remix phase, read through the Invention Adviser section (pg. 25).

STEP SIX: SHARE (30–35 MIN)

SHARE

Host a classroom carnival! Have each group create an informational card/poster with the name of the game, what Bits they used, the goal of the game, and any rules the player should know about. Then set out the cards next to each group's invention and take turns playing. This share session is even more fun if multiple classes are combined. Considering giving students game tickets to play a set number of games, or hand out scorecards for players to provide additional feedback to inventors.

STEP SEVEN: CLOSE (5 MIN)

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide, clean up their materials and hand in their Invention Logs.

If there's additional time, give students time to reflect on the activity by asking questions like:

- What did they enjoy the most?
- What was the most challenging?
- If you could give one piece of advice to another team who hasn't done this, what would it be?

A BETTER DAY IN THE LIFE: INVENTING TO IMPROVE NYC

GOAL

In this challenge, students will apply everything that they have learned to create an invention that solves a problem for people living in the city.

LESSONS AND PACING

- Day 1: Identifying the problem + brainstorming
- Day 2: Prototyping
- Day 3: Testing inventions and developing presentations
- Day 4: Finalizing inventions and presenting to groups

Be sure to store and label each group's invention in a safe place overnight.

SUPPLIES

BITS
STEAM Student Set

ACCESSORIES
any accessories

OTHER MATERIALS
Craft Packs

TOOLS USED
see list of commonly used tools on pg. 141

TYPE

GRADE LEVEL
elementary

SUBJECT AREAS
engineering
art/design
urban planning

DIFFICULTY
beginner

PRE-REQUISITES
Introducing littleBits
Introducing the Invention Cycle, Invent a Self-Driving Vehicle, Invent for Good

DURATION*
four 120 minutes sessions

KEY VOCABULARY

power
output
magnetism
constraints
feedback
input
circuits
user personas
criteria for success

OBJECTIVES

- Identify and define a problem that affects a group of people living in their city.
- Formulate a problem statement.
- Construct a user persona to understand the problem better and evaluate the success of the invention.
- Brainstorm ideas for meeting the designated challenge
- Create and test a circuit containing a power source, inputs and outputs
- Construct a prototype of an invention using Bits and other materials
- Test their prototypes and make improvements
- Recognize and deliver constructive feedback to individuals and teams
- Self-assess their work based on the identified success criteria and constraints
- Write a persuasive elevator pitch and present to an outside audience (ideally)
- Demonstrate their ability to CREATE, PLAY, REMIX and SHARE an invention through the littleBits INVENTION CYCLE by recording their processes in the Invention Log

ASSESSMENT STRATEGIES

The Invention Log checklist can be used to assess your students' understanding of the Invention Cycle, use of the Invention Log and ability to attain the objectives of the lesson. For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track. The checklist can also be used as a self-assessment tool by students as they move from phase to phase. For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

*For tips on how to break up your lesson over multiple class periods, see pg. 139

ADDITIONAL LINKS

INSPIRATIONAL LINKS

- Real-Time Weather Dashboard
  http://littlebits.cc/projects/real-time-weather-dashboard
- NYC Taxi Cab
  http://littlebits.cc/projects/nyc-taxi-cab
- Bike Helmet Light
  http://littlebits.cc/projects/bike-helmet-light
- BitBike
  http://littlebits.cc/projects/invent-for-good-bitbike-ca5fd139-739f-41b3-aff9-319841d9c6a5

DAY 1: IDENTIFYING THE PROBLEM + BRAINSTORMING

STEP ONE: SET UP

Put students into groups of three. Have each team choose a name, then assign roles to each student:

- PROJECT MANAGER: You make sure everyone is working together well and knows what to do. You make sure everyone's voice gets heard.
- SPOKESPERSON: You report back to the class and help your teammates prepare for the final presentation.
- LEAD TESTER: You run testing during the Play phase and help your team get good feedback.

STEP TWO: WARM UP

"YES, AND..." (10 MIN)

- Have the whole class stand in a circle. Explain that you are going to play a game called "Yes, and..." The goal is to tell a story together. As we go around the circle, each of you will add a sentence to it. Your sentence must start with "Yes, and..." Let's try it.
- Have a student beside you give a starter sentence, then model the "Yes, and..." structure. Do this until they understand the exercise. Highlight that it can get kooky and exaggerated. Once they feel good about it, restart the game with the sentence, "I walked out of my house to come to (name of the program)." Have students go around in a circle at least once and add a sentence.

STEP THREE: INTRODUCTION

DESIGN CHALLENGE (10 MIN)

- The mayor's Office of Intelligent Urban Innovation has approached this program to submit youth-created proposals that identify a problem in the city, and then invent something to solve that problem or make it better. This week we will be using everything we've learned over the past four weeks to create an invention that will improve life in NYC.
- Show inspirational links. Ask students for any examples they've seen.
- Review the week's agenda:
    - Day 1 (Create): Identifying the problem + Brainstorming
    - Day 2 (Create): Prototyping
    - Day 3 (Play + Remix): Testing inventions and developing presentations
    - Day 4 (Share): Finalizing inventions and presenting to groups

CREATE

STEP FOUR: CREATE

BRAINSTORMING: COLLECT AND CLUSTER (20 MIN)

- Brainstorming: Collect and cluster

IDENTIFY THE PROBLEM (10 MIN)

- Have each team choose one problem and record it in the Invention Log on pg. 3.
- One student should copy the problem statement on a large piece of paper and secure it to a wall nearby, if possible.
    - Have these documents visible throughout the process for students to watch their progress.

USER PERSONAS (30 MIN)

- Explain that each team is going to create a character that they can use to figure out if their invention is solving the problem. These are called user personas. The groups will go back to these characters throughout the process as a way to determine if their invention is successful.
- Have students flip to the back of their Student Workbooks for blank scratch paper. On the paper they will draw one character who lives in NYC that sees this problem in their daily lives. (If a team is moving fast, they can draw more than one.)
- On another piece of paper, have each team write the following about each character:
    - Name
    - Neighborhood
    - Occupation
    - Family members
    - You should encourage them to add other dimensions as well to keep it fun and playful such as:

    - Favorite music
    - Best subway distraction
    - Favorite game
    - Favorite sport
- After coming up with the character(s), each team will fill out the storyboard in the Invention Log and describe how this character sees or deals with the problem in their lives.
    - Next, each team will complete the following sentence:
    - ________ needs a way to ___________ so she/he can ________________________

SKETCHING (15 MIN)

- At this point, each team should know the problem they are tackling and the people it impacts.
- Now the fun begins: Teams will start sketching ideas for possible inventions to solve the problem. Start with pg. 6 in the Invention Log.

SHARE

STEP FIVE: SHARE (25 MIN)

- When the groups are finished, explain that they will pair up to present and receive feedback. The Spokesperson will describe the problem they are trying to solve, introduce the character to the other group, and present initial sketches. The other group will give feedback using the following Glow, Grow, Question, Idea protocol described below.
- First they will watch one group present in a fishbowl for 5 minutes. The goal is to model the behavior students should use during this exercise.
    - A fishbowl is a teaching strategy that promotes active listening. A smaller group of students participates in an discussion or activity while the rest observe and take notes (silently or written).
- Each group should present for 4 minutes and have 4 minutes for feedback. During this process, don't interrupt, but do encourage them if they get stuck or need help.
- Things to note:
    - You don't have to take feedback. Take what you think is important and leave out the rest.
    - Pay attention to what they are saying and how they are acting. Sometimes the most helpful information comes from quiet observation.
    - Be constructive!
- Glow, Grow, Question, Idea Protocol: Explain that it's important to structure feedback sessions in order to keep it constructive and focused. This is a quick and simple way to have participants get feedback on their project or ideas. Being able to give and receive feedback is key to developing collaboration skills, so we want to focus on having participants practice it regularly. Students will find a copy of the Feedback Matrix on the last page of each Invention Log in their Student Workbooks (see pg. 135 in your Teacher Workbook).

Glow - What do you like about it? What works? What makes it exciting and cool?

- Grow - What could be changed to make it better? What are some of the problem areas?
- Question - Are there any clarifying or probing questions?
- Idea - Do you have ideas of ways to make it better?

STEP SIX: REFLECTION (5 MIN)

- Have students work individually to determine what will make their invention successful and record it in their Invention Log on pg. 5.

DAY 2: PROTOTYPING!

STEP ONE: SET UP

- Put all craft materials out at the front of the room. The goal is to create a space of possibility for the students.
- Have students get back into their teams.
- Write the agenda in a place that everyone can see.

STEP TWO: WARM UP (7 MIN)

- Spectogram Exercise
    - Have the class gather in the middle of the room.
    - Explain that in this exercise, we are going to use our bodies and words to show how we feel about a topic. Choose one end of the room to be "Totally Agree" and the other end to be "Totally Disagree." Tell them there is an invisible line connecting the two.
    - Explain that you will say a statement and when you say "go" they should put themselves on that line based on how they would answer.
    - Start with an easy statement: I like chocolate. Give them a minute to organize, then pick a few students on the line to explain why they chose that place on the line.
    - Move onto statements more related to the challenge:
        - Prototyping is hard.
        - I like living in NYC.
        - NYC is too noisy.
        - The subway is my favorite form of transportation.
        - (Ask students to volunteer a statement or two)

STEP THREE: INTRODUCTION (7 MIN)

- Before sending teams off, go over the agenda (include times if you think it's helpful):
    - Prototyping
    - Share out
    - Iteration
    - Cleanup
    - Reflection
- Teams should start by having a discussion about their invention goals and come up with a final list.
- Record the goals on pg. 5 of the Invention Log.

STEP FOUR: PROTOTYPING (30 MIN)

- Get to it! Each team should have at least two ideas to share with another team.

SHARE

STEP FIVE: SHARE (20 MIN)

- Pair teams up with a group they have not presented to yet.
- The first team shares out for 5 minutes and has 5 minutes for feedback. Remind them to use the Glow, Grow, Question, Idea Protocol.
- Give them a 2 minute warning before switching.
- Switch teams and have the second team present using the same structure.

STEP SIX: ITERATING (40 MIN)

- Based on the feedback they received, each team should choose to move forward with one idea and start constructing their final prototype.
- Teams should write their final idea in the "Which idea seems best" section on pg. 3 in the Invention Log.
- You as the facilitator should circle around to each group and have them pitch their idea. They should be able to answer questions like:
    - What is the problem you are trying to solve?
    - Who is it for?
    - What were your initial ideas?
    - What feedback did you receive?
    - How are you incorporating it into this next stage?
    - How do you think this helps [insert their user persona's name]?
- Remember: Don't tell them what to do or which direction to go in. Your role is to ask questions to help them move forward.

STEP SEVEN: CLEANUP (10 MIN)

- Have the entire group stop what they are working on to tidy the space. Each team member is responsible for:
    - Project manager - Storing the project safely
    - Spokesperson - Putting all craft materials and supplies back
    - Lead tester - Putting extra bits back in storage
    - Everyone - Cleaning up paper scraps and trash in the surrounding area

STEP EIGHT: REFLECTION (5–7 MIN)

- On a blank piece of paper in the back of their workbooks, students should write a response to the following questions:
    - What was the most helpful piece of feedback? Why?
    - What was the least helpful?

DAY 3: TESTING + DEVELOPING YOUR PRESENTATION

STEP ONE: SET UP

STEP TWO: WARM UP (10 MIN)

TELEPHONE BONANZA

- Have everyone stand in a circle. Explain that you are going to play "Telephone." I am going to whisper a phrase to the first person who will pass it along the circle until the end. The last person will say it out loud to see how close we got.
- Do a round with only one sentence. Try to make it moderately difficult.
- For the next round, start another sentence after the first reaches the 3rd person so there are two sentences going at the same time. Keep adding sentences until there are 5 going - see how many they get right!

STEP THREE: INTRODUCTION (7 MIN)

- Before sending teams off, go over the agenda (include times if you think it's helpful):
    - Prototyping
    - Testing
    - Iterating + finalizing
    - Cleanup
    - Reflection

- Remind them that the goal for today is to have a final prototype to share out tomorrow with a larger group.

STEP FOUR: CONTINUE PROTOTYPING (30 MIN)

- Each team should develop their prototype enough to test it on another group.
- The Lead Tester is responsible for coming up with 3–5 questions the team wants to focus on to achieve the goals they developed on day 2.

STEP FIVE: TESTING (25 MIN)

- Before getting started, remind teams to have their questions ready. Also point out that they should pay attention to the body language, expressions, and other nonverbal cues as feedback. Sometimes a frown when you expected a smile is the best kind of feedback.
- Each team should test their invention with another group: 5 minutes of testing, 5 minutes of feedback, then switch.

STEP SIX: ITERATING + FINALIZING (35 MIN)

- Teams should discuss their feedback and integrate into their prototype.
- By the end of this session, they should have a finished prototype.
- You should walk around to each group to provide 1:1 feedback for teams.

STEP SEVEN: CLEANUP (10 MIN)

- Have the entire group stop what they are working on to tidy the space. Each team member is responsible for:
    - Project manager - Storing the project safely
    - Spokesperson - Putting all craft materials and supplies back
    - Lead tester - Putting extra bits back in storage
    - Everyone - Cleaning up paper scraps and trash in the surrounding area

DAY 4: FINALIZING + SHARING YOUR INVENTION

STEP ONE: SET UP

STEP TWO: WARM UP (5 MIN)

- Rock paper scissors tournament!
    - Each of you will play a round of RPS, best out of three. The student who lost sits down and the winner plays another winner. Continue until only one winner left.

STEP THREE: INTRODUCTION (5 MIN)

- Before sending teams off, go over the agenda (include times if you think it's helpful):
    - Presentation pitch + prep
    - Share
    - Reflection + Celebration
- Remind them that the goal for today is to have FUN! They've worked hard :)

STEP FOUR: PRESENTATION PITCH (40 MIN)

- Tell the teams that they will have 30 minutes to prepare a pitch for the a representative from the Mayor's office. Before getting started, give them a quick introduction to pitching:
    - Explain that a pitch is a short presentation that persuades someone to do something.
    - Ask a student to pitch you a few reasons why you should buy a chocolate bar from them. Don't forget to make them work for it a little bit.
    - Afterwards, ask the class what statements worked well and additional ideas for what could have been included in the pitch. Have students consider these learnings for their own project pitch.
- Now explain that each team should be ready to share the following:
    - Problem statement: What are they trying to solve? What does success look like?
    - User persona: Who are they solving this problem for?
    - Prototyping process:
        - What did their first prototypes look like?
        - What was the most helpful feedback they received?
    - Final prototype: What does it do? How does it solve the problem? Was it successful?
- Give them the option of making a poster, speaking directly with notes, creating a slide deck, or something else.

SHARE

STEP FIVE: SHARE (50 MIN)

- Each team has 7 minutes to present and 3 minutes for feedback.
- Students who are watching should fill out the Glow, Grow, Question, Idea matrix.
- End with a HUGE thank you to all the teams for their hard work!

STEP SIX: REFLECTION + CELEBRATION (30 MIN)

littleBits education

FEEDBACK CHART

Name:

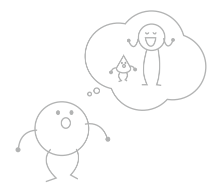
Invention:

GLOW

What did you really like about the invention?

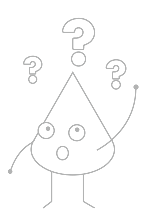
GROW

What do you think could be improved?



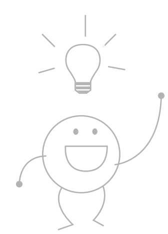
QUESTION

What questions do you have?



IDEA

What suggestions do you have to make it better?



FREE-PLAY RESOURCES

This section contains a variety of helpful resources for implementing littleBits. The free-play resources will help you organize informal learning activities. The classroom management tips offer advice for facilitating a classroom filled with Bits and inventors. The Troubleshooting section provides additional support for getting the most out of your Bits.

FREE-PLAY RESOURCES

- INVENTIONS ONLINE: The littleBits website (ittlebits.com/projects) contains over a thousand invention examples to inspire and expand student (and educator) creativity.
- ONLINE CHALLENGES: Each month, littleBits presents a challenge to the community and invites them to exercise their imagination to use Bits in a whole new way. Every challenge has a new theme and multiple categories for invention submissions. Multiple entries are encouraged! The judges for each challenge are experts in that field. Prizes range from trips, to Bits, to cash rewards! Submissions are made through the Invention page on the littleBits website with a unique hashtag.
- THE LITTLEBITS APP: Your personal guide to unleashing creativity. You can discover thousands of step-by-step instructions, get inspiration for new inventions and lessons, connect with the global littleBits community, and access step-by-step invention tutorials. It even has lessons specifically for educators. Available for iOS and Android devices.

TIPS FOR CLASSROOM MANAGEMENT

A. TIME MANAGEMENT

- Depending on the structure and length of your class period, you may need to split a Guided Challenge between 1 – 2 sessions and 2+ for Open Challenges.
- If you need to break up a lesson, we recommend stopping after the following sections have been completed:
    - Create phase
    - Play and Remix phases
    - Share phase
- The Invention Log will be an essential tool for keeping track of notes and processes during these breaks. Before starting the next class, review lesson objectives and steps that were accomplished in the previous class. You may want to take 1 – 2 minutes for students to flip through their Invention Logs and add any ideas or reflections that have come to mind during the break.

B. SETUP & CLEANUP

- Establish your cleanup and storage expectations. Show students how you would like them to handle the Bits, and how Bits should be organized for storing between lessons.

TIPS FOR CLASSROOM MANAGEMENT

- For challenges in progress, develop a classroom protocol for labeling and storing prototypes (and Bits), so your students can easily put away and access their inventions again with limited interruption.
- The back of the Invention Guide has a map showing where the Bits fit into the packaging.
- Clean up ALL the Bits before getting out any craft material.

C. WORKING IN TEAMS

- Keep groups small
    - Students can work with their STEAM Student Set in pairs or small groups (up to three students). Keep in mind that larger groups may cause students to become frustrated if there aren't enough Bits to go around, particularly power Bits, batteries, and cables as these are limiting factors within a circuit. While some students may prefer to work alone, grouping students encourages collaboration and may lead to increased learning gains through peer communication.
- Create Groups Based on Interests
    - Groups can be determined by interest or project, for example, grouping students who are interested in designing a home improvement device. In this option, it is recommended that you divide the STEAM Student Sets to best match the Bits to the challenge. Other options include mixed grouping by ability level, gender, or special needs.
- Create Student Roles
    - When breaking off into groups, it can be helpful to give students specific roles to keep them engaged and participating. For example, each student can be responsible for one key skill per class period. Keep in mind that each student will be accountable for all of the learning laid out in the lesson, no matter what their role is. Try these or make up your own:
        - The Troubleshooter: this person is responsible for making sure the circuit works. They should check that the Bits are in the correct color-coded order. If the circuit is not working as expected, this person unsnaps and resnaps the Bits together, wipes the bitSnaps, checks the battery, etc.
        - The Scribe: this person reminds the group to record their processes and leads the charge with the Invention Log, being sure to record experiments and results.
        - The Ideas Person: this person is in charge of adding wacky ideas to the mix at every phase. These wacky ideas can make the challenges fun, and force students to think about how to best answer the challenge.
        - The Questioner: this person questions everything in every phase of the Invention Cycle. They constantly ask why (e.g. why the group is choosing the Bits they are using, why they are making changes, why they are presenting information in a certain way). This person helps the group think critically about the decisions they make.

D. HELPFUL TOOLS AND MATERIALS

- Favorite Materials
    - Tape: Whatever you're making, you're probably going to have to find a way to stick stuff together and tape is great for that. There are tons of different kinds of tape out there, and they each have their specialty. Duct tape is perfect for big jobs, masking tape is easy to stick on and take off when you need to keep something together temporarily, and transparent tape (like Scotch) is the go-to tape when you don't want your tape to show.
    - Glue Dots®: These double-sided sticky dots are easy to apply, don't need to dry, and have some serious sticking power. They come in handy all the time in the littleBits design shop.
    - Cardboard: Even the fanciest littleBits inventions usually start out as cardboard models. It's easy to cut, bend, and fold and, best of all, easy to find. We dig through the recycling bins all the time to collect cardboard for our inventions. Shipping boxes are a good source of rigid corrugated cardboard. Cereal boxes are the perfect source for thinner, more flexible stuff.
    - Empty Containers (paper cups, milk jugs, water bottles): Yup... we go through our recycling bins for this stuff too. Pro tip: you'll probably want to wash these things out before you use them. These containers can come in pretty cool shapes as well, so they're a great way to give an invention a unique style.
    - Construction Toys: It's probably no surprise that we're a big fan of construction toys like LEGO®, K'nex® , and Erector® sets. They are a great way to build quick structures for littleBits inventions.
    - String: We know that string is good for tying things together, but it's also really helpful for making things move. When you tie one end to the servo arm, it becomes easy to pull them with the servo or wind them up and down with the DC motor.
    - Colored Paper: Paper is another quick and easy building material we use pretty often in the studio. Colored construction paper is also a great way to give inventions style or personality.

- Useful Tools
    - Scissors: Materials rarely come in the exact shape you want them to be, which is why scissors are first on our list of favorite tools. (Pro Tip: don't run with them... we tried and it didn't end well).
    - Ruler: Sometimes you need to know exactly how long something is and sometimes you need to draw or cut a nice straight line. Rulers do an awesome job at both. The soft, flexible tape measures that come in sewing kits are also pretty handy if you need to measure something that isn't flat (like a round bottle).
    - Pens, Pencils, Markers: From your first brainstorm sketches to your final

decorative details, these mark-making tools will be your best friends. If you're not sure about a particular idea or detail, sketch it out with pencil first and if you like it, go over it in marker or pen to make it stand out.

- Sketchbook: Some people like to write down ideas and draw up some plans before they start making. Everyone at littleBits headquarters has a sketchbook or notebook where they collect thoughts, take notes, and sketch ideas (and doodle when a meeting goes on a little too long). Sketchbooks are great because they keep all these things in one place, so it's easy to go back and find them later.
- Smartphone/Camera: There are Bitsters all around the world who would love to see the cool stuff that your students make (and your colleagues probably want to see it, too). Pictures are a great way to share what your class has made, plus taking photos of inventions as they come together will help students better remember and later share their process.

E. CARE AND MAINTENANCE OF YOUR BITS

- Cleaning Bits
    - Occasionally, you may need to clean your Bits. If you find that you're getting a poor connection between Bits, cleaning is a good first step to troubleshoot the problem.
    - The best way to clean Bits is to wipe them with a dry cloth (a clean T-shirt works perfectly). If any of the electrical connectors are oxidized (you may see dark deposits on them), put a small amount of isopropyl alcohol on a soft, clean cloth and gently wipe the deposits. Do not use any other cleaning products on your Bits.
    - Note: Some electrical connector cleaners have chemicals that can damage the plastic part of the Bit, and therefore are not recommended.
- Power Source
    - Every circuit that students build will require a power source, so maintaining power will prove to be an important part of managing littleBits in the classroom. Signs of low batteries may include:
        - Low or flickering lights (especially when you try to run one of the motors in the circuit)
        - Erratic behavior with the servo motor
        - Motors that won't run
    - When you see that batteries are running low, it's time to recharge or replace them. USB power can also be used instead of 9V batteries.
    - Do you have access to extra batteries or a device that can check battery strength? Locate these items now.
    - How will you manage batteries in your classroom? Who will be responsible for checking and replacing low batteries?

TROUBLESHOOTING

STUDENT TROUBLESHOOTING

- The first step is to define a protocol you wish students to follow if they encounter an issue. Some educators evoke an "ask three before me" rule, in which students are required to ask three peers for help before asking the teacher. Show students how to reference the Bit cards, or use other available resources, for independent problem solving.
- Another option is to co-create a troubleshooting checklist with students. This checklist might include helpful tips. For example, check all connections, check switches and screws, check the battery, and so forth.
- You may find it helpful to post "tips and tricks" posters around the classroom to help students independently solve common problems and Share creative solution ideas. Students can post any solutions, tips, or tricks they have discovered to create a collective peer-generated resource for using littleBits.

MY CIRCUIT ISN'T WORKING

- Is your power Bit switched on? The switches are small, and sometimes students miss them. When turned on, there should be an LED light on the power Bit that shines red.
- If you're using a battery, does it need to be charged or replaced? You may want to keep a battery tester in your classroom.
- Do you need to wipe your connectors? If there is dust on the connectors or the magnets, wipe them off with a clean, dry cloth.
- Do you need to clean your connectors? If any of the three electrical connectors are oxidized (they'll have dark deposits on them) you can use some isopropyl alcohol on your soft, clean cloth.

CONTACT CUSTOMER SERVICE

- Our team of specialists is ready and waiting to help you out Monday through Friday from 9am - 6pm EST. Give them a call at 917-464-4577 or email support@littleBits.com.

FINAL NOTE: GROWING LITTLEBITS IN YOUR CLASSROOM (AND BEYOND!)

Congrats! You've made your way to the very end of the Teacher's Guide (trumpets sound!). By now you've likely tried out some of the challenges in your classroom (and hopefully created your own!) and experienced first-hand the joy that littleBits brings to the learning experience. The STEAM Student Set is just the beginning; students and educators of all ages, backgrounds and abilities are inventing, learning and growing with littleBits every day, all around the world. We're thrilled to have you on this journey with us; we can't wait to see what your students dream up!

Join our community to check it out for yourself and be sure to download the littleBits Invent App for challenge and lesson inspiration.

GLOSSARY

Brainstorm	Brainstorming is an activity that helps generate a large number of ideas. There are many variations on how to brainstorm. The important thing is to let your imagination run wild. The best solutions often come from unexpected places.
Circuit	Circuits are paths that electric currents follow.
Clockwise	Turning in the same direction as the hands of a clock.
Counterclockwise	Turning in the opposite direction as the hands of a clock.
Create	This is the first phase of the Invention Cycle where you explore new ideas and bring them to life with your first prototype.
Hack	A quick (and sometimes scrappy) way to change or improve something.
Input	Inputs let you put information or energy into a system. For example, a keyboard is an input that lets you send commands to a computer.
Invention	Something created or designed through your own/your group's ingenuity, experimentation, and/or imagination.
littleBits	littleBits is a platform of easy-to-use electronic building blocks for creating inventions large and small.
Magnetism	Magnetism is a force that can attract (pull closer) or repel (push away) objects that have a magnetic material like iron inside them.
Output	Outputs are where information or energy leave a system. For example, speakers are the outputs of a radio.
Play	This is the second phase of the Invention Cycle where you test your prototype for the first time.
Power	The energy used to do work.

Prototype	A model designed to test an idea.
Remix	This is the thrid phase of the Invention Cycle where you experiement with making changes to your prototype to see how you can improve it.
Sensor	A sensor is a device that detects or measures something from it's surrounding environment and converts it into an electrical signal.
Share	This is the fourth phase of the Invention Cycle where you show your invention to others to get feedback and inspire other inventors.
Signal	A signal is an electronic message sent from one Bit to another. Input Bits change the message this signal sends. Output Bits translate this signal into an action (like light, motion, or sound.
Volt	Just like water needs pressure to force it through a hose, electrical current needs some force to make it flow. A volt is the measure of electric pressure. Voltage is usually supplied by a battery or a generator.
Wire	Wires are made of conductive materials (usually metal) and used to connect different parts of an electrical circuit.

ADDITIONAL OPEN CHALLENGES: INVENT FOR GOOD

DESCRIPTION

How can students use their invention skills to make a difference in someone else's life? In this lesson, students will combine the littleBits Invention Cycle with an exercise in empathy. First, they will brainstorm ways they could solve common frustrations or improve everyday interactions for someone important to them. Then they will build and test multiple prototypes of their favorite idea, making improvements and measuring each against their criteria for success. At the close of the lesson, students will create advertisements that communicate their invention's power to make a difference.

SUPPLIES

BITS
any Bits

ACCESSORIES
any accessories

OTHER MATERIALS
see list of commonly used materials on pg. 141

TOOLS USED
see list of commonly used tools on pg. 141

TYPE

GRADE LEVEL
elementary
middle

SUBJECT AREAS
engineering
art/design

DIFFICULTY
Intermediate

PRE-REQUISITES
Introducing littleBits
Introducing the Invention Cycle

DURATION*
120 minutes (minimum)

KEY VOCABULARY

power
output
magnetism
criteria for success
input
circuits
constraints

OBJECTIVES

By the end of the lesson, students will be able to:
- Brainstorm ideas for meeting the designated challenge
- Create and test a circuit containing a power source, inputs and outputs
- Construct a prototype of an invention using Bits and other materials
- Test their prototypes and make improvements
- Self-assess their work based on the identified success criteria and constraints
- Demonstrate their ability to Create, Play, Remix and Share an invention through the littleBits Invention Cycle by recording their processes in the Invention Log
- Summarize their process and share the results by creating a skit, or a print or video advertisement to explain what they've invented and how it can help make life better for the customer

ASSESSMENT STRATEGIES

The Invention Log checklist can be used to assess your students' understanding of the Invention Cycle, use of the Invention Log and ability to attain the objectives of the lesson. For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track. The checklist can also be used as a self assessment tool by students as they move from phase to phase. For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

*For tips on how to break up your lesson over multiple class periods, see pg. 139

STANDARDS*

3-5-ETS1-1 Engineering Design: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

To fulfill this standard, students are explicit about the need or want being designed for, and call it such, as well as criteria for success and constraints of materials, time, cost etc. that they're willing to work within.

3-5-ETS1-2 Engineering Design: Generate and compare multiple possible solutions to problem based on how well each is likely to meet the criteria and constraints of the problem.

To fulfill this standard, students explicitly compare multiple solutions on the basis of the success and criteria constraints.

3-5-ETS1-3 Engineering Design: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

To fulfill this standard, students test their prototypes and make improvements. Set all but one variable as fixed, and change just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

MS-ETS1-1 Engineering Design: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

To fulfill this standard, students set various criteria for success, as well as constraints for the successful completion of the design problem.

MS-ETS1-2 Engineering Design: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

To fulfill this standard, students create different solutions to the problem and explicitly compare them on the basis of their ability to meet the goal within the constraints.

MS-ETS1-3 Engineering Design: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into new solutions to better meet the criteria for success.

To fulfill this standard, students test their prototypes and make improvements. Set all but one variable as fixed, and change the amount of just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

To meet these standards, students will need to fill out information in the Remix section of the Invention Log (pg. 11 and 12) every time a variable is changed and tested. Be sure to print additional copies of these pages before the lesson begins.

*For other curricular connections, see the "Extension" section at the end of this lesson.

ADDITIONAL LINKS & TIPS

HELPFUL LINKS

- littleBits Invention Log
  http://littlebits.cc/student-set

HELPFUL LINKS

- What is empathy?
  https://www.youtube.com/watch?v=icIlUdTEQnU&feature=youtu.be
- Think it up - Start empathy
  https://startempathy.org/thinkitup/

TIPS AND TRICKS

For Open Challenges, we recommend that the teacher create an example invention, which may or may not be shown to students at the beginning of the lesson. Taking the challenge through the Invention Cycle will better equip teachers to successfully conduct the lesson and be more knowledgeable about where the class, or specific students, may need a bit more time or support.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and Invention Guide, plus one Invention Log and Assessment Checklist per student. We suggest handing out the Bits in the Create phase to keep students focused on initial instructions and review activities.

For more experienced users, you may want to provide access to additional Bits in the Play and Remix phases to provide a greater diversity of circuit combinations. Place a variety of construction materials and tools in a central location in the room.

STEP TWO: INTRODUCE (15–20 MIN)

Introduce the lesson objectives and the concept behind the challenge:

What are some inventions that you use every day that you couldn't live without? What problems do they solve? Make a list on the board to capture student responses.

"Before these products came to life, they were just ideas. People saw problems in the world around them and they created potential solutions first through brainstorming and prototyping their ideas, and then by testing and improving upon their creation to make sure it worked. This is the job of a product designer and you've already been applying this process to make littleBits creations through the Invention Cycle. In this challenge, you're going to take what you've learned so far and think like a product designer to invent something that helps someone else."

Before jumping into the challenge, provide a quick review of the Invention Cycle framework and the format of the Invention Log (pg. 19). Ask students to share lessons learned about Bits, the invention process and things they enjoyed or struggled with from previous challenges.

STEP THREE: CREATE (45–55 MIN)

CREATE

A. CREATE IDEAS

For each of the prompt sections below, students will record their process and reflections in their respective Invention Logs.

What ideas do you have?

Prompt students to create a list (either as a class, or in groups) of ideas for a product. Start by thinking of an intended user (parent, neighbor, teacher, friend) and reflect on what their frustrations or difficulties are. For example, a neighbor that is hard of hearing might need a way to know if someone is knocking at their door. For additional brainstorming ideas, refer to pg. 22 in the Invention Adviser section (particularly the sections on Empathy and Experience Mapping).

Which idea seems best?

After making a list of 3–5 ideas, have students choose the issue that they want to work on. It could be the idea that sounds the most fun to solve, or makes the biggest difference in someone else's life.

Students should frame their thinking in the following framework: I will invent a_______that______because_____.

What's the "before" story?

What is life like now, before the proposed invention exists? Ask students to draw or describe the series of events before, during and after to show cause-and-effect scenarios. Be sure to consider the characters involved and the setting that the "story" takes place in.

What are the constraints?

Constraints are the limits and requirements that need to be considered in the invention process. Examples include time, materials, weight. Have students detail any constraints that they may need to keep in mind as they work. For younger students, you may choose to run this exercise as a class and have students record shared ideas.

What are the criteria for success?

How will students know if their invention works? Describe the number-one goal for the invention. What qualities are important for the invention to have?

B. CREATE PROTOTYPE

For each of the prompts below, students will record their process and reflections in their respective Invention Logs.

How could Bits help you solve your problem?

Instruct students to look through their available Bits and materials to see how they could (or couldn't) help solve their problem. If students get stuck, try snapping a Bit into a circuit or read through the Bit Index (pg. 7–27 in their Invention Guide). If students' initial ideas don't directly translate to the function of the available Bits, check out helpful suggestions in the prototypes section on pg. 23.

What does your first prototype look like?

Students create a drawing(s) of their first prototype, labeling Bits and any important features. A description of how the prototype is supposed to work should also be included. This is a time for students to dig into the Bits and materials and start to bring their ideas to life.

PLAY

STEP FOUR: PLAY (10–15 MIN)

How did your testing go?

Once the prototypes have been constructed, students should test the inventions themselves to make sure they work. Have students pretend that they are the customer who just purchased the invention. How well did the invention do its job?

Keep in mind that the inventions might not work the first time; failure is part of the process. Students should take note of successes and things that still need to be improved in their Invention Logs.

REMIX

STEP FIVE: REMIX (25–30 MIN)

To meet the outlined NGSS standards, instruct students to fill out a new Remix section in their Invention Logs (pg. 11 and 12) every time a variable is changed and tested. If you do not plan to adhere to the NGSS standards, allow students more flexibility and exploratory pathways during this phase of the design process.

PROTOTYPE # 2 (AND MORE...)

This is the opportunity to experiment with fixes and improvements. As students make changes to their inventions, make sure they are documenting in their Invention Logs how their prototypes are changing and the results (good and bad).

Getting feedback during the iteration process will help students make even better versions of their prototype. Pair up students so they each have someone else to test their prototype on (or ideally have the intended user try it out, if possible). Test the invention after a few improvements have been made. Have students ask the person what their favorite features are and what suggestions they have to make it better.

Continue the Remix phase (and remind students to play with their updated inventions) until the prototype is able to meet the criteria for success, or until the allotted time runs out. If you need more advice on how to conduct and provide prompts in the Remix phase, read through the Invention Adviser section (pg. 25).

SHARE

STEP SIX: SHARE (30–35 MIN)

Wrap up the challenge by reflecting and tying together the story of the invention. Create a skit, or a print or video advertisement to explain what they've invented and how it can help make life better for the customer. Share it with the classroom (or with the world!).

You may also encourage students to take their inventions further and recruit a product design team. Have students show their invention to friends or peers. How could a group of students, with different ideas and perspectives, work together to create an even better product?

STEP SEVEN: CLOSE (5 MIN)

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide, clean up their materials and hand in their Invention Logs

STEP EIGHT: EXTENSION

Incorporate one (or more!) of the following extensions in the Remix section of this challenge to bolster your lesson's NGSS applications:

MS-ETS1-4 Engineering Design: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Students define and iteratively collect data to explore the explicit connection between the invention and a physical or environmental interaction that may impact the design. For example, modeling the impact of friction on the ability of a wheeled invention to climb a slope, or the impact of an invention on human behavior. The storyboard in the Invention Log should be used and updated throughout the lesson for each iteration tested.

ADDITIONAL OPEN CHALLENGES: BITOLYMPICS

GOAL

Use skills developed throughout the course to create an Olympics-inspired invention.

KEY VOCABULARY

power
output
magnetism
constraints
input
circuits
criteria for success

DESCRIPTION

The Olympic Games are a worldwide competition that celebrates skill, sportsmanship, and global community. This lesson turns invention into a sport by having students create their own games and artifacts inspired by the Olympics. Students will use the Invention Cycle to brainstorm ideas, then build and test multiple prototypes of their favorite idea. Along the way they will make improvements and measure each prototype against their criteria for success. At the close of the lesson, they will showcase their inventions in a BitOlympic Games Day.

OBJECTIVES

- Brainstorm ideas for meeting the designated challenge
- Create and test a circuit containing a power source, inputs, outputs, and wires
- Construct a prototype of an invention using Bits and other materials
- Test prototypes and make improvements
- Self-assess work based on the identified success criteria and constraints
- Demonstrate the ability to CREATE, PLAY, REMIX and SHARE an invention through the littleBits Invention Cycle by recording processes in the Invention Log
- Summarize the process and share the results in the BitOlympic Games Day

LESSONS AND PACING

TWO DAYS: OPEN CHALLENGE: BITOLYMPICS
Suggested division of challenge:

DAY 1:CREATE (IDEAS AND PROTOTYPES), PLAY, REMIX

- Store and label each group's project in a safe place overnight.

DAY 2: CONTINUE REMIXING (FINE-TUNE PROTOTYPES), SHARE

ASSESSMENT STRATEGIES

The Invention Log checklist can be used to assess your students' understanding of the Invention Cycle, use of the Invention Log and ability to attain the objectives of the lesson. For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track. The checklist can also be used as a self-assessment tool by students as they move from phase to phase. For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

SUPPLIES

BITS
any Bits

ACCESSORIES
any accessories

OTHER MATERIALS
see list of commonly used materials on pg. 141

TOOLS USED
see list of commonly used tools on pg. 141

TYPE

GRADE LEVEL
elementary
middle

SUBJECT AREAS
engineering
art / design

DIFFICULTY
beginner

PRE-REQUISITES
Introducing littleBits

DURATION*
120 minutes

*For tips on how to break up your lesson over multiple class periods, see pg. 139

STANDARDS*

3-5-ETS1-1 Engineering Design: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

To fulfill this standard, students are explicit about the need or want being designed for, and call it such, as well as criteria for success and constraints of materials, time, cost, etc. that they're willing to work within.

3-5-ETS1-2 Engineering Design: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

To fulfill this standard, students explicitly compare multiple solutions on the basis of the success and criteria constraints.

3-5-ETS1-3 Engineering Design: Engineering Design: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

To fulfill this standard, students test their prototypes and make improvements. Set all but one variable as fixed, and change just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

MS-ETS1-1 Engineering Design: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

To fulfill this standard, students set various criteria for success, as well as constraints for the successful completion of the design problem.

MS-ETS1-2 Engineering Design: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

To fulfill this standard, students create different solutions to the problem and explicitly compare them on the basis of their ability to meet the goal within the constraints.

MS-ETS1-3 Engineering Design: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into new solutions to better meet the criteria for success.

Students test their prototypes and make improvements. Set all but one variable as fixed, and change the amount of just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

To meet these standards, students will need to fill out information in the REMIX section of the Invention Log (pg. 11 and 12) every time a variable is changed and tested. Be sure to print additional copies of these pages before the lesson begins.

*For other curricular connections, see the "Extension" section at the end of this lesson.

ADDITIONAL LINKS & TIPS

HELPFUL LINKS

- littleBits Invention Log
  http://littleBits.cc/student-set

INSPIRATIONAL LINKS

- Challenge page
  http://littleBits.cc/challenges/bitolympics-2016

Trailer
  http://bit.ly/2nPjriB

- Inspiration with videos + links to inventions
  http://littleBits.cc/news-bitosphere-august-2016
  http://littleBits.cc/bitolympics-end-surprise-twist
- Workshop Guide
  http://littleBits.cc/lessons/bitolympics-2016-workshop-guide

TIPS AND TRICKS

For Open Challenges, we recommend that the teacher create an example invention, which may or may not be shown to students at the beginning of the lesson. Taking the challenge through the Invention Cycle will better equip teachers to successfully conduct the lesson and be more knowledgeable about where the class, or speci c students, may need a bit more time or support.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and Invention Guide, plus one Invention Log and Assessment Checklist per student. We suggest handing out the Bits in the Create phase to keep students focused on initial instructions and review activities. For more experienced users, you may want to provide access to additional Bits in the Play and Remix phases to provide a greater diversity of circuit combinations. Place a variety of construction materials and tools in a central location in the room.

STEP TWO: INTRODUCE

INTRODUCE THE LESSON OBJECTIVES AND THE CONCEPT BEHIND THE CHALLENGE:

- Explain that they will work in small teams to create an invention inspired by their favorite Olympic game, artifact, experience, or athlete. Share the challenge trailer and a few of the community inventions to get their creativity flowing.

Before jumping into the challenge, provide a quick review of the Invention Cycle framework and the format of the Invention Log (pg. 19). Ask students to share lessons learned about Bits, the invention process and things they enjoyed or struggled with from previous challenges.

CREATE

STEP THREE: CREATE (45–55 MIN)

A. CREATE IDEAS

For each of the prompt sections below, students will record their process and reflections in their respective Invention Logs.

What ideas do you have?

- Make a chart with four columns and put the following words at the top of each: game, artifact, experience, and athlete. Prompt students to create a list (either as a class, or in groups) for each column. Once you have generated this inspiration board, have students sketch out or write down three ideas for their invention.

Which idea seems best?

- Have students choose one their ideas to execute in class. Ask them to translate their sketches to the following framework: I will invent a________that_______ because______. Be sure to give them a few examples to get started.

What's the "before" story?

- What is life like now, before the proposed invention exists? Ask students to draw or describe the series of events before, during, and after to show cause-and-effect scenarios. Be sure to consider the characters involved and the setting that the "story" takes place in.

What are the constraints?

- Constraints are the limits and requirements that need to be considered in the invention process. Examples include time, materials, weight. Have students detail any constraints that they may need to keep in mind as they work. For younger students, you may choose to run this exercise as a class and have students record shared ideas.

What are the criteria for success?

- How will students know if their invention works? Describe the number-one goal for the invention. What qualities are important for the invention to have?

B. CREATE PROTOTYPE

- For each of the prompts below, students will record their process and reflections in their respective Invention Logs.

How could Bits help you solve your problem?

- Instruct students to look through their available Bits and materials to see how they could (or couldn't) be combined to help solve your problem. For example, how could a servo trigger a slide dimmer? How could a DC motor trigger a light sensor? Could the inverter play a role? How could other materials (e.g. books, cardboard, cups) serve as triggers?
- If students get stuck, try snapping a Bit into a circuit or read through the Bit Index (pg. 7–27 in their Invention Guide).

What does your first prototype look like?

- Students create a drawing(s) of their first prototype, labeling Bits and any important features. A description of how the prototype is supposed to work should also be included. This is a time for students to dig into the Bits and materials, and start to bring their ideas to life.

PLAY

STEP FOUR: PLAY (10–15 MIN)

How did your testing go?

Once the prototypes have been constructed, students should test their invention to see if it works. Put student groups in pairs: Group 1 will have 3 minutes to share their invention and Group 2 will have 2 minutes to give feedback, then switch. When it's their turn, each group should state their goal, demo the invention, then allow the other group to try it. Try using the Glow, Grow, Question, Suggestion feedback protocol.

- Glow: One thing you liked
- Grow: One area for improvement
- Question: A question about the invention
- Suggestion: An idea for the group to use

Students should take note of successes and things that still need to be improved in their Invention Logs.

REMIX

STEP FIVE: REMIX (15–25 MIN)

To meet the outlined NGSS standards, instruct students to fill out a new Remix section in their Invention Logs (pg. 11 and 12) every time a variable is changed and tested. If you do not plan to adhere to the NGSS standards, allow students more flexibility and exploratory pathways during this phase of the design process.

Prototype # 2 (and more...)

- This is the opportunity to experiment with fixes and improvements. As students make changes to their inventions, make sure they are documenting in their Invention Logs how their prototypes are changing and the results (good and bad).

- If students need some inspiration, set the invention aside and look through the remaining Bits and available materials. Is it possible to complete a step with them? Try a few options and see how they compare to what has already been created.
- Continue the Remix phase (and remind students to play with their updated inventions) until the prototype is able to meet the criteria for success, or until the allotted time runs out. If you need more advice on how to conduct and provide prompts in the Remix phase, read through the Invention Adviser section (p. 25).

SHARE

STEP SIX: SHARE (30–35 MIN)

Wrap up the challenge with a group share and reflection. Declare the rest of the class BitOlympic Game Day! You can give each group 5 minutes to share their invention or create a gallery walk of inventions. If there's time, have students take a video of their invention in action and post it to their favorite social media channel or the BitOlympic Challenge page on the littleBits website.

STEP SEVEN: CLOSE (5 MIN)

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide, clean up their materials and hand in their Invention Logs.

STEP EIGHT: EXTENSION

Incorporate the following extension in the Remix section of this challenge to bolster your lesson's NGSS applications:

> MS-ETS1-4 Engineering Design: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

To fulfill this standard, students define and iteratively collect data to explore the explicit connection between the invention and a physical or environmental interaction that may impact the design. For example, modeling the impact of friction on the ability of a wheeled invention to climb a slope, or the impact of an invention on human behavior. The storyboard in the Invention Log should be used and updated throughout the lesson for each iteration tested.

ADDITIONAL OPEN CHALLENGES: MAGIC OF INVENTION

GOAL

Use skills developed throughout the course to create an invention inspired by the Harry Potter book and movie series.

DESCRIPTION

Technology has been used for decades to make movie magic and to bring fantasy worlds to life. In this lesson, students will use the Invention Cycle to create an invention inspired by Harry Potter. First they will brainstorm ideas for their magical creation. Then they will build and test multiple prototypes of their favorite idea, making improvements and measuring each against their criteria for success. At the close of the lesson, they will create a short film of their inventions in action.

LESSONS AND PACING

TWO DAYS: OPEN CHALLENGE: MAGIC OF INVENTION
Suggested division of challenge:

DAY 1:CREATE (IDEAS AND PROTOTYPES), PLAY, REMIX

- Store and label each group's project in a safe place overnight.

DAY 2: CONTINUE REMIXING (FINE-TUNE PROTOTYPES), SHARE

SUPPLIES

BITS
any Bits

ACCESSORIES
any accessories

OTHER MATERIALS
see list of commonly used materials on pg. 141

TOOLS USED
see list of commonly used tools on pg. 141

TYPE

GRADE LEVEL
elementary
middle

SUBJECT AREAS
engineering
art / design

DIFFICULTY
beginner

PRE-REQUISITES
Introducing littleBits

DURATION*
120 minutes

KEY VOCABULARY

power
output
magnetism
constraints
input
circuits
criteria for success

OBJECTIVES

- Brainstorm ideas for meeting the designated challenge
- Create and test a circuit containing a power source, inputs, outputs, and wires
- Construct a prototype of an invention using Bits and other materials
- Test prototypes and make improvements
- Self-assess work based on the identified success criteria and constraints
- Demonstrate the ability to CREATE, PLAY, REMIX and SHARE an invention through the littleBits Invention Cycle by recording processes in the Invention Log
- Summarize the process and share the results by creating videos of each Harry Potter-inspired invention.

ASSESSMENT STRATEGIES

The Invention Log checklist can be used to assess your students' understanding of the Invention Cycle, use of the Invention Log and ability to attain the objectives of the lesson. For formative assessment while students work, you can use this checklist to ask questions about their current task and ensure that they are on the right track. The checklist can also be used as a self-assessment tool by students as they move from phase to phase. For summative assessment, you can use this checklist to review students' entries into their Invention Log and assess their understanding of the challenge and the invention process as a whole.

*For tips on how to break up your lesson over multiple class periods, see pg. 139

STANDARDS*

3-5-ETS1-1 Engineering Design: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

To fulfill this standard, students are explicit about the need or want being designed for, and call it such, as well as criteria for success and constraints of materials, time, cost, etc. that they're willing to work within.

3-5-ETS1-2 Engineering Design: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

To fulfill this standard, students explicitly compare multiple solutions on the basis of the success and criteria constraints.

3-5-ETS1-3 Engineering Design: Engineering Design: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

To fulfill this standard, students test their prototypes and make improvements. Set all but one variable as fixed, and change just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

MS-ETS1-1 Engineering Design: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

To fulfill this standard, students set various criteria for success, as well as constraints for the successful completion of the design problem.

MS-ETS1-2 Engineering Design: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

To fulfill this standard, students create different solutions to the problem and explicitly compare them on the basis of their ability to meet the goal within the constraints.

MS-ETS1-3 Engineering Design: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into new solutions to better meet the criteria for success.

Students test their prototypes and make improvements. Set all but one variable as fixed, and change the amount of just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

To meet these standards, students will need to fill out information in the REMIX section of the Invention Log (pg. 11 and 12) every time a variable is changed and tested. Be sure to print additional copies of these pages before the lesson begins.

*For other curricular connections, see the "Extension" section at the end of this lesson.

ADDITIONAL LINKS & TIPS

HELPFUL LINKS

- littleBits Invention Log
  http://littleBits.cc/student-set

INSPIRATIONAL LINKS

- Challenge page
  http://littlebits.cc/challenges/the-magic-of-invention?sort=recent&page=1&per_page=12
- Trailer
  https://drive.google.com/file/d/0B4-gDlbAY9uKZUQ1RGpKcFlSSHc/view
- Inspiration with videos + links to inventions
  http://littleBits.cc/magical-holiday-challenge
  http://littleBits.cc/magic-of-invention-challenge-winners
- Workshop Guide
  http://littleBits.cc/lessons/magic-of-invention-workshop-guide
- Magical Hour of Code Inspiration + Lessons
  http://littlebits.cc/hour-of-code-with-littlebits

TIPS AND TRICKS

For Open Challenges, we recommend that the teacher create an example invention, which may or may not be shown to students at the beginning of the lesson. Taking the challenge through the Invention Cycle will better equip teachers to successfully conduct the lesson and be more knowledgeable about where the class, or specific students, may need a bit more time or support.

INSTRUCTIONAL STEPS

STEP ONE: SET UP

This lesson can be done individually or in small groups (2–3 students). Each group will need at least one STEAM Student Set and Invention Guide, plus one Invention Log and Assessment Checklist per student. We suggest handing out the Bits in the Create phase to keep students focused on initial instructions and review activities. For more experienced users, you may want to provide access to additional Bits in the Play and Remix phases to provide a greater diversity of circuit combinations. Place a variety of construction materials and tools in a central location in the room.

STEP TWO: INTRODUCE

INTRODUCE THE LESSON OBJECTIVES AND THE CONCEPT BEHIND THE CHALLENGE:

- Explain that they will work in small teams to create a magical invention using littleBits and other materials. They can create an invention that casts wireless spells, recreate their favorite scene, build a magical animatronic creature, forge an enchanted tool, and more. Share the challenge trailer and a few of the community inventions to get their creativity flowing.

Before jumping into the challenge, provide a quick review of the Invention Cycle framework and the format of the Invention Log (pg. 19). Ask students to share lessons learned about Bits, the invention process and things they enjoyed or struggled with from previous challenges.

CREATE

STEP THREE: CREATE (45–55 MIN)

A. CREATE IDEAS

For each of the prompt sections below, students will record their process and reflections in their respective Invention Logs.

What ideas do you have?

- Prompt students to create a list (either as a class, or in groups) of their favorite scenes from the book or movie. Refer to pg. 21 for brainstorming tips.

Which idea seems best?

- After making a list of 5–10 ideas, have students choose the everyday activity that they want to accomplish. It could be the idea that sounds the most fun to solve or is the most accessible in the classroom.
- Students should frame their thinking in the following framework: I will invent a________that_______because______.

What's the "before" story?

- What is life like now, before the proposed invention exists? Ask students to draw or describe the series of events before, during and after to show cause-and-effect scenarios. Be sure to consider the characters involved and the setting that the "story" takes place in.

What are the constraints?

- Constraints are the limits and requirements that need to be considered in the invention process. Examples include time, materials, weight. Have students detail any constraints that they may need to keep in mind as they work. For younger students, you may choose to run this exercise as a class and have students record shared ideas.

What are the criteria for success?

- How will students know if their invention works? Describe the number-one goal for the invention. What qualities are important for the invention to have?

B. CREATE PROTOTYPE

For each of the prompts below, students will record their process and reflections in their respective Invention Logs.

How could Bits help you solve your problem?

- Instruct students to look through their available Bits and materials to see how they could (or couldn't) be combined to help solve your problem. For example, how could a servo trigger a slide dimmer? How could a DC motor trigger a light sensor? Could the inverter play a role? How could other materials (e.g. books, cardboard, cups) serve as triggers?
- If students get stuck, try snapping a Bit into a circuit or read through the Bit Index (pg. 7–27 in their Invention Guide).

What does your first prototype look like?

- Students create a drawing(s) of their first prototype, labeling Bits and any important features. A description of how the prototype is supposed to work should also be included. This is a time for students to dig into the Bits and materials and start to bring their ideas to life.

PLAY

STEP FOUR: PLAY (10–15 MIN)

How did your testing go?

Once the prototypes have been constructed, students should test their invention to see if it works. Put student groups in pairs: Group 1 will have 3 minutes to share their invention and Group 2 will have 2 minutes to give feedback, then switch. When it's their turn, each group should state their goal, demo the invention, then allow the other group to try it. Try using the Glow, Grow, Question, Suggestion feedback protocol.

- Glow: One thing you liked
- Grow: One area for improvement
- Question: A question about the invention
- Suggestion: An idea for the group to use

Students should take note of successes and things that still need to be improved in their Invention Logs.

REMIX

STEP FIVE: REMIX (15–25 MIN)

To meet the outlined NGSS standards, instruct students to fill out a new Remix section in their Invention Logs (pg. 11 and 12) every time a variable is changed and tested. If you do not plan to adhere to the NGSS standards, allow students more flexibility and exploratory pathways during this phase of the design process.

Prototype # 2 (and more...)

- This is the opportunity to experiment with fixes and improvements. As students make changes to their inventions, make sure they are documenting in their Invention Logs how their prototypes are changing and the results (good and bad).
- If students need some inspiration, set the invention aside and look through the remaining Bits and available materials. Is it possible to complete a step with them? Try a few options and see how they compare to what has already been created.
- Continue the Remix phase (and remind students to play with their updated inventions) until the prototype is able to meet the criteria for success, or until the allotted time runs out. If you need more advice on how to conduct and provide prompts in the Remix phase, read through the Invention Adviser section (p. 25).

SHARE

STEP SIX: SHARE (30–35 MIN)

Wrap up the challenge by reflecting and tying together the story of the invention. Have students take a video of their invention in action and post it to their favorite social media channel or the Magic of Invention Challenge page on the littleBits website.

STEP SEVEN: CLOSE (5 MIN)

At the end of the lesson, students should put away the Bits according to the diagram on the back of the Invention Guide, clean up their materials and hand in their Invention Logs.

STEP EIGHT: EXTENSION

Incorporate the following extension in the Remix section of this challenge to bolster your lesson's NGSS applications:

MS-ETS1-4 Engineering Design: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

To fulfill this standard, students define and iteratively collect data to explore the explicit connection between the invention and a physical or environmental interaction that may impact the design. For example, modeling the impact of friction on the ability of a wheeled invention to climb a slope, or the impact of an invention on human behavior. The storyboard in the Invention Log should be used and updated throughout the lesson for each iteration tested.

THE LITTLEBITS INVENTION CYCLE: NGSS PRACTICE STANDARDS

The implementation models for littleBits are flexible and adaptable. Lessons or units that incorporate littleBits align well to contemporary standards, such as the Next Generation Science Standards (NGSS) and Common Core State Standards (CCSS). Information on how the STEAM Student Set can be used to meet these standards is introduced below, and detailed in the Connecting Lessons to NGSS Standards section (pg. 172). By using littleBits and the Invention Cycle framework, educators can introduce principles of art, design and technology into their lessons to bring robust STEAM learning to life.

NEXT GENERATION SCIENCE STANDARDS (NGSS)

The NGSS are a set of standards for science and engineering co-authored by 26 states and their partners. These standards set the bar for what scientific literacy and competance are for a modern generation of students.

The STEAM Student Set was developed to closely align with the NGSS Science and Engineering Practices and Engineering Design Standards.

LITTLEBITS CONNECTIONS

As you apply the Invention Cycle in the journey from Guided to Open Challenges, students will be able to understand and demonstrate the eight key practices of science and engineering outlined in the NGSS publication A Framework for K-12 Science Education.

In each phase of the Invention Cycle, specific practices can be reinforced with your students.

NGSS PRACTICE STANDARDS

1. Asking questions (science) and defining problems (engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (science) and designing solutions (engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

LITTLEBITS INVENTION CYCLE

CREATE

Asking questions to define a problem or question. Creating models and prototypes.

(1) (2) (3) (5) (6)

PLAY

Analyze the data you collected. Form more questions based on the data. Revise model. Do more experiments.

(1) (2) (3) (4) (6)

REMIX

Test your invention under a variety of conditions (different contexts, environments, people). Collect data about how well it works.

(1) (2) (3) (5) (7)

SHARE

Reflect on your process. Create and Share your story. Receive feedback. Reflect on feedback and consider what possible next steps are.

(4) (6) (7) (8)

THE LITTLEBITS INVENTION CYCLE: NGSS ENGINEERING DESIGN STANDARDS

NGSS ENGINEERING DESIGN STANDARDS

littleBits is an ideal tool for learning about Engineering Design, one of the NGSS Disciplinary Core Ideas. Engineering Design is composed of three main phases:

- DEFINING AND DELIMITING ENGINEERING PROBLEMS. This involves stating the problem to be solved as clearly as possible in terms of criteria for success, and constraints or limits.
- DESIGNING SOLUTIONS TO ENGINEERING PROBLEMS. This begins with generating a number of different possible solutions, then evaluating potential solutions to see which ones best meet the criteria and constraints of the problem.
- OPTIMIZING THE DESIGN SOLUTION. This involves a process in which solutions are systematically tested and refined and the final design is improved by trading off less important features for those that are more important.

These phases are wrapped into the littleBits Invention Cycle and are practiced throughout the STEAM Student Set challenges. The Engineering Design Standards that your students will address are separated by age level below:

The STEAM Student Set companion lessons also provide guidance for extended NGSS connections, primarily based in Disciplinary Core Idea: Physical Science, which includes performance expectations in "Forces and Interactions" and "Energy." More information can be found on pg. 172.

ELEMENTARY SCHOOL STUDENTS (GRADES 3–5)

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

MIDDLE SCHOOL STUDENTS (GRADES 6–8)

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

THE LITTLEBITS INVENTION CYCLE: COMMON CORE

COMMON CORE STANDARDS (CCSS)

FOR WRITING: While working on a littleBits challenge, your students will be writing in their Invention Logs to document, explain, and express their ideas, processes, and findings. Examples shown below are for 6th grade, additional grade-specific standards are found on the pages that follow.

CCSS.ELA-LITERACY.W.6.1 Write arguments to support claims with clear reasons and relevant evidence.

CCSS.ELA-LITERACY.W.6.2 Write informative and explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

CCSS.ELA-LITERACY.W.6.7 Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

CCSS.ELA-LITERACY.W.6.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

FOR COMMUNICATION: The collaborative nature of littleBits challenges, combined with the support of prompts in the Remix and Share phases of the Invention Cycle, encourages students to communicate for comprehension and express their ideas, addressing CCSS standards for speaking and listening.

CCSS.ELA-LITERACY.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

CCSS.ELA-LITERACY.SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

CCSS.ELA-LITERACY.SL.6.5 Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.

FOR MATHEMATICS

As students apply the littleBits Invention Cycle to meet Engineering Design challenges, relevant Common Core Standards for Mathematics include:

MP.5 Use appropriate tools strategically. (3-5-ETS1-1; 1-2)

MP.2 Reason abstractly and quantitatively. (3-5-ETS1-1; MS-ETS1-2; MS-ETS1-3; MS-PS3-1)

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-2; MS-ETS1-3)

CONNECTING LESSONS TO NGSS STANDARDS

This chart provides an overview of the NGSS standards that can be met by, or extended to meet, specific STEAM Student Set challenges found in the Student Invention Guide. Information on how to fulfill these performance expectations, as well as suggestions for integrating Common Core standards in ELA/Literacy and Mathematics, are included in the pages that follow. Assessments and objectives that tie to these standards are incorporated into the companion lessons (download the STEAM Student Set Teacher's Guide at: https://d3ii2lldyojfer.cloudfront.net/pdf/STEAM+Student+Set/STEAM-Student-Set-Teacher%27s-Guide-1-1.pdf).

NGSS STANDARD	LESSON(S) THAT FULFILL THIS STANDARD*	TYPE*	PG#
ELEMENTARY SCHOOL			
3-5-ETS1-1	All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits	◊	173
3-5-ETS1-2	All Open Challenges: Hack Your Class, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits	◊	174
3-5-ETS1-3	All Guided Challenges: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device, and all Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits	◊	175
3-PS2-2	Invent an Art Machine; Invent a Throwing Arm	Δ	176
4-PS3-1	Invent a Self-Driving Car; Invent an Art Machine; Invent a Throwing Arm	Δ	177
4-PS3-3	Invent a Throwing Arm	Δ	178
5-PS2-1	Invent a Throwing Arm	Δ	179
3-5-ETS1-1	All Guided Challenges: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device	Δ	173
3-5-ETS1-2	All Guided Challenges: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device	Δ	174
3-PS2-4	Introducing littleBits	Δ	180
4-PS3-2	Introducing littleBits	Δ	181
MIDDLE SCHOOL			
MS-ETS1-1	All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits	◊	182
MS-ETS1-2	All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits	◊	163
MS-ETS1-3	All Guided Challenges: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device, and all Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits	◊	184
MS-ETS1-4	Hack Your Habits	◊	185
MS-PS3-1	Invent a Self-Driving Car; Invent a Throwing Arm	Δ	186
MS-PS2-2	Invent a Throwing Arm	Δ	187
MS-PS4-2	Invent a Security Device	Δ	188
MS-ESS3-3	Hack Your Habits	Δ	189
MS-ETS1-2	All Guided Challenges: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device	Δ	183
MS-ETS1-4	Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption	Δ	185
MS-PS2-5	Introducing littleBits	Δ	190

* ◊ = A lesson in this document directly addresses this standard
Δ = A lesson in this document must be extended to meet this standard

3-5-ETS1-1

NGSS STANDARD CONNECTION

ENGINEERING DESIGN

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

TO MEET THIS STANDARD...

Students are explicit about the need or want being designed for, and call it such, as well as criteria for success and constraints of materials, time, cost, etc. that they're willing to work within.

LITTLEBITS LESSON(S)

All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits.

GRADE LEVEL

Grades 3–5

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

3-5.OA Operations and Algebraic Thinking

3-5-ETS1-2

NGSS STANDARD CONNECTION

ENGINEERING DESIGN

3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

TO MEET THIS STANDARD...

Students explicitly compare multiple solutions on the basis of the success and criteria constraints.

LITTLEBITS LESSON(S)

All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits.

GRADE LEVEL

Grades 3–5

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.1 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

3-5.OA Operations and Algebraic Thinking

3-5-ETS1-3

NGSS STANDARD CONNECTION

ENGINEERING DESIGN

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

TO MEET THIS STANDARD...

All challenges will allow students to test their prototypes and make improvements. Set all but one variable as fixed, and change the amount of just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

LITTLEBITS LESSON(S)

All Guided Challenges: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device.
All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits.

GRADE LEVEL

Grades 3–5

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.

W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.

W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

MP.4 Model with mathematics.

MP.5 Use appropriate tools strategically.

3-PS2-2

NGSS STANDARD CONNECTION

MOTION AND STABILITY

3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

TO MEET THIS STANDARD...

ART MACHINE Systematically categorize some quality of the motions (for this age, these could be drawings or pictures, or even a way to categorize the scribble itself) and how this quality changes e.g. when the pulse is changed systematically.

THROWING ARM Take time lapse pictures of the ball from the side and note similarities of motion, even under different conditions.

LITTLEBITS LESSON(S)

The following lessons can be extended to meet this standard: Invent an Art Machine, Invent a Throwing Arm.

GRADE LEVEL

Grade 3

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

W.3.7 Conduct short research projects that build knowledge about a topic.

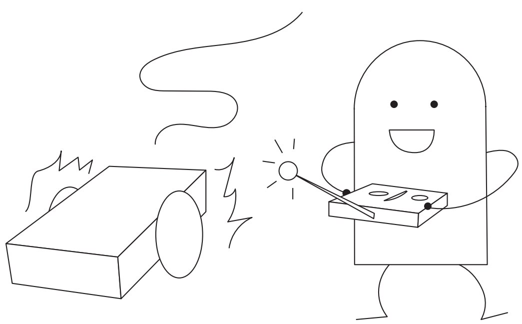
W.5.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.

4-PS3-1

NGSS STANDARD CONNECTION

ENERGY

4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.



TO MEET THIS STANDARD...

SELF-DRIVING CAR: Systematically categorize the energy of the car for different settings of the slide dimmer by adding a Number Bit in VALUE or VOLTS mode to the circuit. Students' intuitive ideas about how to define the car's energy are appropriate for this grade.

ART MACHINE: Systematically categorize the energy of various pulse settings on a basis they systematically categorize (for this age, these could be drawings or pictures, or even a way to cut out and categorize the scribbles themselves from less to more "energy"). Their intuitive ideas are appropriate for this grade.

THROWING ARM: Systematically categorize the energy of the ball given it being seen to be travelling at various speeds (as per time lapse pictures). Balls of varying mass could be used.

LITTLEBITS LESSON(S)

The following lessons can be extended to meet this standard: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm.

GRADE LEVEL

Grade 4

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RI.4.1 Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text.

W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

RI.4.9 Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.

W.4.9 Draw evidence from literary or informational texts to support analysis, reflection, and research.

4-PS3-3

NGSS STANDARD CONNECTION

ENERGY

4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.

TO MEET THIS STANDARD...

Decide on how much energy the moving arm of the lever and/or the ball has at different times in its motion. This “measure” of energy is entirely qualitative and relative one level to the next. Create a game where students use the launcher to knock a cup off a table. Fill the cup with materials increasing in weight and see how much is required to stabilize the cup so the launcher can no longer tip the cup over.

LITTLEBITS LESSON(S)

The "Invent a Throwing Arm" lesson can be extended to meet this standard.

GRADE LEVEL

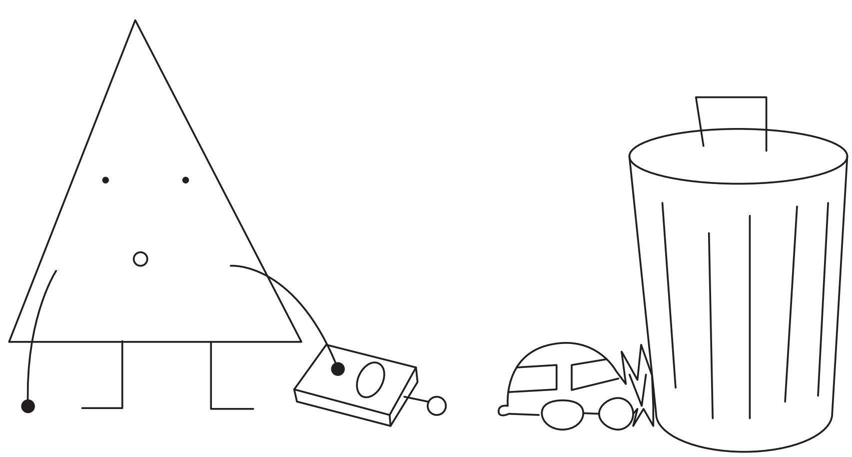
Grade 4

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.



5-PS2-1

NGSS STANDARD CONNECTION

MOTION AND STABILITY

5-PS2-1 Support an argument that the gravitational force exerted by Earth on objects is directed down.

TO MEET THIS STANDARD...

Systematically document the each ball's trajectory, and ask students to explain their characteristic parabolic shape. This investigation could begin by looking at a video of trajectories in microgravity environments (space walks, etc).

LITTLEBITS LESSON(S)

The "Invent a Throwing Arm" lesson can be extended to meet this standard.

GRADE LEVEL

Grade 5

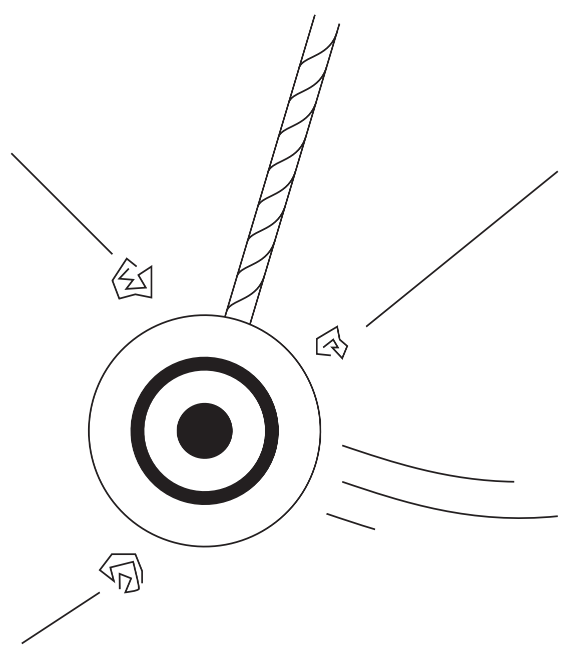
COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.

RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.

W.5.1 Write opinion pieces on topics or texts, supporting a point of view with reasons and information.



3-PS2-4

NGSS STANDARD CONNECTION

MOTION AND STABILITY

3-PS2-4 Define a simple design problem that can be solved by applying scientific ideas about magnets.

TO MEET THIS STANDARD...

Design a careful experiment with the magnets that couple the Bits together.

LITTLEBITS LESSON(S)

The "Introducing littleBits" lesson can be extended to meet this standard.

GRADE LEVEL

Grade 3

4-PS3-2

NGSS STANDARD CONNECTION

ENERGY

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.

TO MEET THIS STANDARD...

Explore how the Bits connect and tell a story about how energy moves from place to place in the circuit; what form it might be in at different times. E.g. LEDs and motors convert electricity to light and motion, respectively. Sensors convert light, motion, or heat to an electrical signal.

LITTLEBITS LESSON(S)

The "Introducing littleBits" lesson can be extended to meet this standard.

GRADE LEVEL

Grade 3

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic.

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

CONNECTING TO STANDARDS

MS-ETS1-1

NGSS STANDARD CONNECTION

ENERGINEERING DESIGN

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

TO MEET THIS STANDARD...

Students set various criteria for success, as well as constraints for the successful completion of the design problem.

LITTLEBITS LESSON(S)

All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

MS-ETS1-2

NGSS STANDARD CONNECTION

ENERGINEERING DESIGN

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

TO MEET THIS STANDARD...

Students create different solutions to the problem and explicitly compare them on the basis of their ability to meet the goal within the constraints.

LITTLEBITS LESSON(S)

All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits.
The Guided Challenges can be extended to meet this standard by adding a step to define the goals and constraints of the lesson: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

MS-ETS1-3

NGSS STANDARD CONNECTION

ENERGINEERING DESIGN

MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into new solutions to better meet the criteria for success.

TO MEET THIS STANDARD...

All challenges will allow students to test their prototypes and make improvements. Set all but one variable as fixed, and change the amount of just one parameter in attempts to maximize the agreed-upon criterion for success. Students may also be allowed to "borrow" the best aspects from one another's designs during this process.

LITTLEBITS LESSON(S)

All Guided Challenges: Invent a Self-Driving Car, Invent an Art Machine, Invent a Throwing Arm, Invent a Security Device.
All Open Challenges: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption, Hack Your Habits.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

MS-ETS1-4

NGSS STANDARD CONNECTION

ENERGINEERING DESIGN

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

LITTLEBITS LESSON(S)

The "Hack Your Habits" lesson meets this standard. The following lessons can be modified to meet this standard: Hack Your Classroom, Invent for Good, Invent a Chain Reaction Contraption.

TO MEET THIS STANDARD...

Students define and iteratively collect data to explore the explicit connection between the invention and a physical or environmental interaction that may impact the design. For example, modeling the impact of friction on the ability of a wheeled invention to climb a slope, or the impact of an invention on human behavior. The storyboard in the Invention Log should be used and updated throughout the lesson for each iteration tested.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

7.SP Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

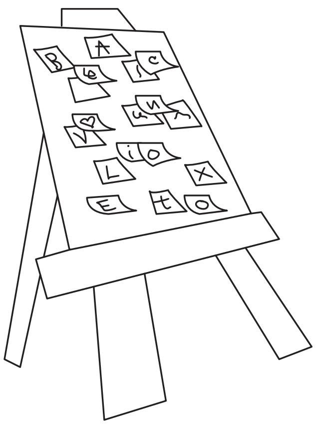
MATHEMATICS

MP.2 Reason abstractly and quantitatively.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

CONNECTING TO STANDARDS

MS-PS3-1



NGSS STANDARD CONNECTION

ENERGY

MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

TO MEET THIS STANDARD...

INVENT A SELF-DRIVING CAR Use burst image capture of the motion of the car to calculate some distance over time measure (speed) and plot its kinetic energy for different cars of different mass.

INVENT A THROWING ARM Use the trail of the projectile to calculate some distance over time measure (speed) of its trajectory and plotting its kinetic energy for balls of different mass. This is a tried and true physics lab.

LITTLEBITS LESSON(S)

The following lessons can be modified to meet this standard: Invent a Self-Driving Car, Invent a Throwing Arm.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

6.RP.A.2 Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship.

7.RP.A.2 Recognize and represent proportional relationships between quantities.

8.EE.A.1 Know and apply the properties of integer exponents to generate equivalent numerical expressions.

8.EE.A.2 Use square root and cube root symbols to represent solutions to equations of the form $x2 = p$ and $x3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that $\sqrt{2}$ is irrational.

8.F.A.3 Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear.

MS-PS2-2

NGSS STANDARD CONNECTION

MOTION AND STABILITY

MS-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

TO MEET THIS STANDARD...

This lesson would typically be taught (at least in part) by analyzing the trajectories of projectile motion.

LITTLEBITS LESSON(S)

The "Invent a Throwing Arm" lesson can be modified to meet this standard.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

MATHEMATICS

MP.2 Reason abstractly and quantitatively.

6.EE.A.2 Write, read, and evaluate expressions in which letters stand for numbers.

7.EE.B.3 Solve multi-step, real-life and mathematical problems posed with positive and negative rational numbers in any form, using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

CONNECTING TO STANDARDS

MS-PS4-2

NGSS STANDARD CONNECTION

WAVES AND THEIR APPLICATIONS

MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

TO MEET THIS STANDARD...

Use the buzzer to explore how sound waves work. Supplement with a sound level meter. Support students in developing a model for how sound works. Why is it so faint if the light is turned on inside the backpack, but loud if the light reaches the sensor by opening the backpack?

LITTLEBITS LESSON(S)

The "Invent a Security Device" lesson can be modified to meet this standard.

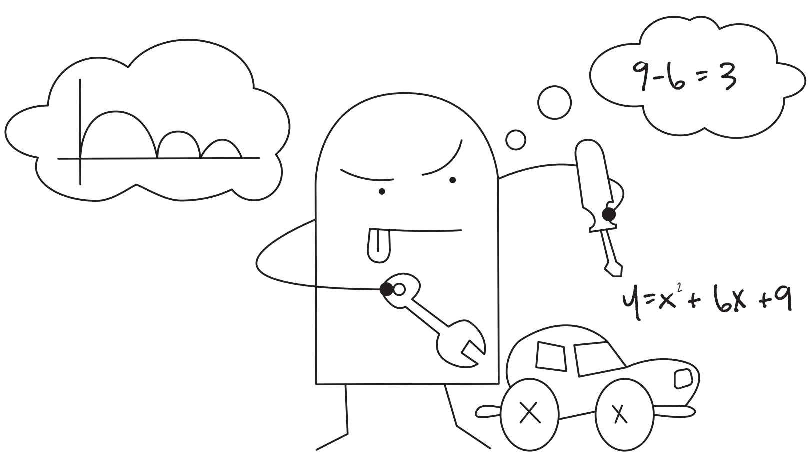
GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.



MS-ESS3-3

NGSS STANDARD CONNECTION

EARTH AND HUMAN ACTIVITY

MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

TO MEET THIS STANDARD...

Choose a personal and individual behavior that is known to have an impact on the environment (e.g. leaving the lights on when no one is home).

LITTLEBITS LESSON(S)

The “Invent a Throwing Arm” lesson can be modified to meet this standard.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

7.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

MATHEMATICS

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

7.RP.A.2 Recognize and represent proportional relationships between quantities.

MS-PS2-5

NGSS STANDARD CONNECTION

MOTION AND STABILITY

MS-PS2-5 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

TO MEET THIS STANDARD...

Design a careful experiment with the magnets that snap the Bits together.

LITTLEBITS LESSON(S)

The "Invent a Throwing Arm" lesson can be modified to meet this standard.

GRADE LEVEL

Middle School

COMMON CORE STANDARD CONNECTIONS

ELA/LITERACY

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.