LITTLEBITS LESSON

INVENT A THROWING ARM

LESSON OVERVIEW

Students will use the littleBits Invention Cycle, and an understanding of the basics of circuitry, motion and simple machines, to construct a launcher that flings projectiles towards a target. Students will modify their launcher using Bits and other materials to try to make it more powerful or accurate. Results from these trials will be used to create a unique game using their modified launcher. Conclude the activity by hosting a game tournament, where students can explain and share their game, and test out others' inventions.

LESSON TAGS

GRADE LEVEL	SUBJECTS	DIFFICULTY	DURATION
elementary, middle	engineering art/design	beginner	90 minutes (minimum)

PREREQUISITE KNOWLEDGE

Introducing littleBits
Introducing the Invention Cycle

SUPPLIES

BITS	ACCESSORIES	OTHER MATERIALS	TOOLS USED
battery and cable	servo mount	paper cups	Phillips-head screwdriver
P1 power	mechanical arm (3)	recycled materials	scissors
button	screws (3)	markers	masking tape
servo	mounting board	paper	rubber bands
servo hub			tape measure

DESCRIPTION

LESSON OBJECTIVES

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

- Create and test a circuit containing a power source, inputs and outputs
- Construct a prototype of an autonomous art machine using littleBits and other materials
- Test their prototypes and make improvements
- Self-assess their work based on the outlined 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
- Devise a game that uses the resulting invention
- Communicate their process and share their invention by participating in a games tournament

ASSESSMENT STRATEGIES

The Invention Log checklist (Invention Log pg. 18) 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.

STANDARDS

NGSS

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 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.

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 meet 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. 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.

VOCABULARY

power
input
output
magnetism
parallel
circuits
torque
Angle
constraints
criteria for success

RESOURCES

ATTACHMENTS

[littleBits Invention Log](#)
[STEAM Student Set (SSS) Teacher' Guide](#)
[Build Instructions (video)](#)

Remix prompts (video)

TIPS & TRICKS

Look out below! This activity involves throwing objects through the air. We highly recommend establishing, or co-creating with your students, some classroom rules/codes of conduct on using their launchers (e.g. launchers should never be aimed at fellow classmates). Designating a test zone for the launch is also recommended.

Phillips-head screwdrivers (not included) and small screws (provided) will be required for mounting the mechanical arm to the servo. You may want to review how to properly use a screwdriver depending on the ability of your students. Guided projects can pair with the Invention Log for the Play and Remix phases of the Invention Cycle. The Create phase has already been outlined for students in their Invention Guides.

*For tips on how to break up your lesson over multiple class periods, see SSS Teacher's Guide pg. 117

INSTRUCTIONAL STEPS

STEP 1: SETUP - Prior to Class

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.

Set up a central location in the classroom for assorted materials and tools. You'll also want to clear or designate an area for your projectile testing zone.

During the Create phase, students will construct their first prototypes according to instructions in the Invention Guide. You may want to construct your own example prototype before the lesson begins. Seeing a working model of what they are building can help the students understand the goal of their Create phase and will allow you to quickly demonstrate working in the Play phase.

STEP 2: INTRODUCE

Duration: 10-15 minutes

Begin the activity by leading a short review of key vocabulary (see above) and the littleBits basics (e.g. magnetism, order matters, color-coding).

If this is the first time your students will be engaging in a challenge using the Invention Cycle framework and the Invention Log, take 5–10 minutes to review each stage (pg. 11).

Introduce the lesson objectives and define criteria for success and constraints that are appropriate for your students. For example, your criteria for success could be that the circuit must contain power, input and output. While the first prototype will be guided, your students will be able to customize their throwing arms in the Remix phase of the Invention Cycle.

STEP 3: CREATE

Duration: 20-30 minutes

A. CREATE IDEAS

Engage your students in a discussion around how objects move through the air (projectiles).

If you were to move an object towards a target that is across the length of the classroom, how would you do it? Students may suggest throwing, kicking, or using a physical object like a bat or racket.

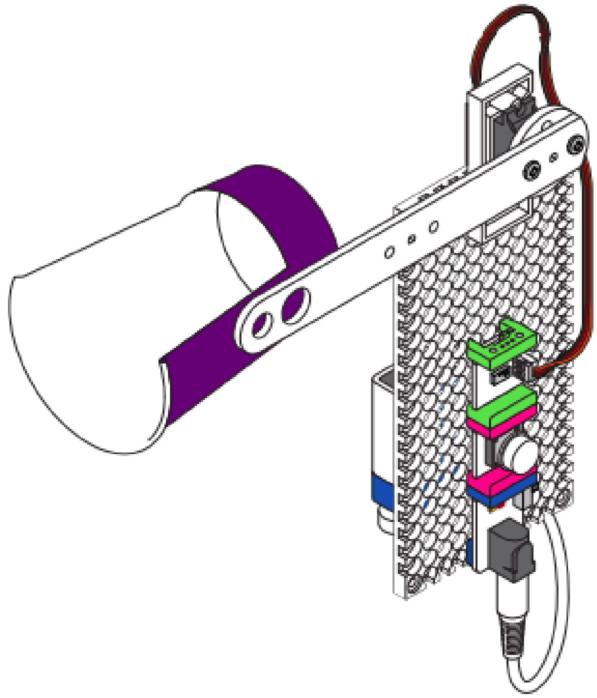
When throwing/projecting this object towards a target, what are some of the physical factors that you would need to consider? Answers may include speed, direction, gravity, force (air resistance/wind), weight of the object, size of the target, presence of obstacles in the path of the object. Write a list of their responses on the board. Ask your students to make predictions about some of these factors that may affect the trajectory of the throw (e.g. would a heavy ball go farther than a lighter ball?).

Students will be able to test out some of these ideas in the Remix phase of the Invention Cycle.

B. CREATE PROTOTYPE

Students will follow the instructions in their Invention Guide to build prototypes of The Launcher.

Encourage students to reference the Bit Index (pg. 7–27 in their Invention Guides) if they get stuck or want to learn more about a particular Bit or accessory. For younger students, you may want to pause the class after each step to troubleshoot any common problems, as well as share successful build strategies amongst the groups.



STEP 4: PLAY

Duration: 10-15 minutes

As you move through the play prompts, be sure to have students record their process and reflections in the Invention Log (starting with "How did your testing go?")

How did your testing go?

Once the models have been constructed, students should test their prototypes to make sure it works and to explore the circuit functionality. Have students create a target to practice their launchers; we suggest a tower of paper cups as shown on pg. 50 of the Invention Guide. Students could also use a cup or circle of paper to create a small basketball hoop.

1. TEST THE CIRCUIT (STUDENT PROMPTS):

To move objects forward, hold the mounting board and make sure the mechanical arm starts out pointing back towards your body. Press the button. The mechanical arm/basket should swing upwards and end parallel to the mounting board. If it doesn't work:

- Check the trigger
  - Make sure the button is pressed all the way down.
- Check your power
  - Make sure your power Bit is switched on and the cable connections are secure. Check for low batteries.
- Motors are in the correct mode
  - Check the setting on the servo, it should be set to TURN.
  - Tip on servos: servos are sensitive to weight; you may need to lighten the load if it starts shaking.

2. HOW IT WORKS

p1 power sends a signal to the button.

When pressed, the i3 BUTTON lets the signal through to the servo.

When th e o11 SERVO gets the signal, it turns, rotating the arm and throwing the projectile.

Either as a class or in groups, ask students to discuss/explain how the circuit works. A clear understanding of how it works will help them explore and experiment during the Remix phase. Make sure students understand how each component in the circuit functions, including the mechanical arm. Note: your students will have access to the answers above in their Invention Guide. Demonstrating how the circuit works and asking probing questions will help assess their understanding of the material.

For example, you could ask: What happens when...

• Your servo receives a full 5 volt signal? (the arm swings to the right)

• Your servo receives 0 volts? (the arm will move to the left)

Be sure to have students record their notes and processes in the Invention Log.

STEP 5: REMIX

Duration: 20-30 minutes

To meet the outlined NGSS standards, instruct students to fill out a new REMIX section in their Invention Logs (pg. 11–12) 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...)

Now it's time to flex your students' Engineering Design skills to enhance their car of the future. For this lesson, you'll be moving your students towards Remix C "Invent a Game" (found on pg. 52 in the Invention Guide), but tackling Remix A and B first will help your students think through possible invention adaptations and physical forces that they will have to take into consideration. You may choose to extend the lesson to meet additional curricular requirements (be sure to check out the Extension section for more ideas). You can find more advice on how to conduct the Remix Phase in the Invention Advisor section (SSS Teacher's Guide, pg. 13). As students make changes to their inventions, make sure they are documenting how their prototypes are changing and the results (good and bad) in their Invention Logs. Taping a tape measure to the floor will help students quantify the distance; record these measurements and use them to make decisions on how to improve the launcher. For speed and accuracy, encourage students to think through ways to quantify and record these results.

REMIX PROMPTS:

- Experiment with mechanics: Which parts of the launcher can be changed to influence distance,

accuracy and speed? Alter one variable at a time to best assess the impact of the design change on the performance of the launcher.
  - How does changing the length of the mechanical arm impact the throwing distance?
  - Use different objects for balls, of varying mass and shapes. What object gets thrown the farthest? What observations can be made about how the size and shape of the object affects the speed and distance traveled?
  - What happens when you change the bucket size or shape? How does it affect the throw? Do any changes make the throw more reliable? More accurate?

- Make it engaging: What other games can be played with the launcher?
  - Ideas include basketball, mini golf, or bowling; new games are also encouraged!
  - Consider how many players, what the objectives and rules are and how players will keep score.
  - Added challenge: Try using the number Bit + an input on the target for recording score. Collect and record data from multiple trials from one individual, or single trials between multiple users. What can this information tell the game designer about difficulty or individual player performance?

REMIX TIPS

- As you walk around the room, ask students to explain their remix choices and the resulting change in functionality and outcomes.
- NGSS-3-5ETS1-3 and MS-ETS1-3 Connection: Allow students to "borrow" the best aspects from one another's designs, setting all but one variable as fixed, and changing the amount of just one parameter to see how to maximize the agreed-upon criterion for success.

STEP 6: SHARE

Duration: 25-30 minutes

Host a game tournament! Have students explain the objectives, rules and scoring system that they have devised, then try out each other's games.

STEP 7: CLOSE

Duration: 5 minutes

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 8: EXTENSIONS

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

3-PS2-2 Motion and Stability: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion

To fulfill this standard, take time lapse pictures of the ball from the side and note similarities of motion,even under different conditions.

4-PS3-1 Energy: Use evidence to construct an explanation relating the speed of an object to the energy of that object.

To fulfill this standard, systematically categorize the energy of the ball given it being seen traveling at various speeds (as per time lapse pictures). Balls of different mass could be used.

4-PS3-1 Energy: Use evidence to construct an explanation relating the speed of an object to the energy of that object.

To fulfill this standard, systematically categorize the energy of the ball given it being seen traveling at various speeds (as per time lapse pictures). Balls of different mass could be used.

5-PS2-1 Motion and Stability: Support an argument that the gravitational force exerted by Earth on objects is directed down.

Create a game where students use the launcher to knock a cup off a table. Fill the cup with increasing amounts of weight and see how much weight is required to stabilize the cup so the launcher is no longer able to tip the cup.

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.

Systematically document the trajectories of students' ball throws, and ask them to explain their characteristic parabolic shape. This investigation could begin by looking at a video of trajectories in microgravity environments (space walks, etc).

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.

Allow students to come up with an agreed-upon criterion for success of their launcher (everyone should have the same goal) and constraints on them, e.g. "cost" of materials or "weight" in terms of number of pieces. An imagined, but motivating, scenario could be provided.

MS-PS2-2 Motion and Stability: 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.

Allow students to come up with different solutions to a problem and explicitly compare them on the basis of their ability to meet the goal within the constraints. For challenges with wheels, ideally additional wheel sizes and treads are available. This lesson would typically be taught (at least in part) by analyzing the trajectories of projectile motion.

MS-PS3-1 Energy: 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.

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.

MS-ETS1-2 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.

Allow students to come up with different solutions to the problem and explicitly compare them on the basis of their ability to meet the goal within the constraints.