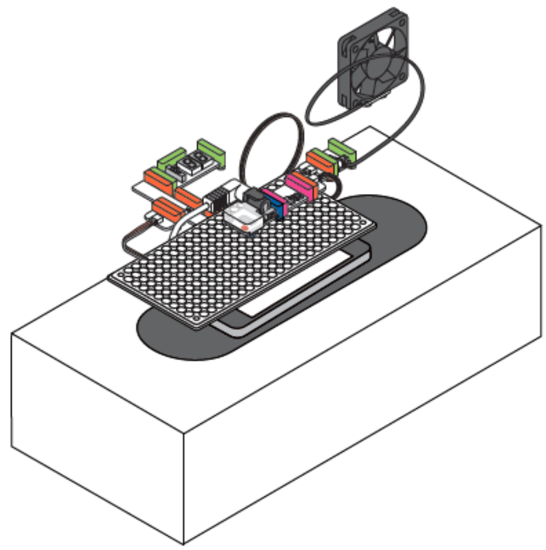
LESSON

Keep It Cool



Overview

In this lesson, students will:

- Model the relationship between data centers and processors.
- Understand and account for dependent and independent variables.
- Experiment to find the most efficient design for a cooling system.

THE CHALLENGE

Design a littleBits thermometer and cooling system to experiment with data-center cooling design.

Lesson Tags

GRADE LEVEL:

Elementary (grade 5)

SUBJECTS:

Science, technology, engineering

DIFFICULTY:

Intermediate

DURATION:

90 minutes

PREREQUISITE KNOWLEDGE:

- littleBits basics
- Basic understanding of the scientific process and experimental variables

Supplies

Bits:

- STEAM Student Set (power, fan, number, temperature sensor, fork, 2 wires, battery and cable, battery clip, and mounting board)

Tools Used:

- Pen/pencil
- Stopwatch or timer
- Scissors
- Tape

Other Materials:

- Empty rectangular box (tissue or similarly shaped)
- 2+ smartphones or tablets that can fit inside a box
- Insulation materials, such as foil, napkins, fabric
- Optional: If using ice, place the cubes in a sealed plastic bag to keep your littleBits dry

Description

LESSON OUTLINE:

INTRO: Introduce the lesson prompt and assess students' current knowledge.

CREATE: Groups of 2-3 students start to build their inventions.

PLAY: Students test their prototypes to make sure that it works and record temperature data.

REMIX: Plan for ways to decrease the recorded temperature, then try it out. Record data under these new conditions. [Optional: additional remix]

SHARE: Share designs and reflect on the variables in this experiment.

ASSESSMENT STRATEGIES:

FORMATIVE ASSESSMENT: Circulate the classroom as students work, assessing their use of the Bits, teamwork, and any other relevant skills you wish to focus on. Depending on students' level of experience, you might look for students putting Bits together backwards (e.g. trying to force them together and not aligning the right sides and getting a magnetic snap), students not adding a power source etc.

SUMMATIVE ASSESSMENT Students should complete the student handout. You may choose whether this is an individual or group submission.

Standards

NGSS

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.

CPALMS

SC.5.N.1.3 Recognize and explain the need for repeated experimental trials.

Vocabulary

Control	Independent Variable
Dependant Variable	Data center

Resources

ATTACHMENTS

Keep It Cool: Student Handout

SUPPORTING LINKS

How do you cool a data center? (video)

NPR: Google Moves In and Wants To Pump 1.5 Million Gallons Of Water Per Day

Popular Mechanics: Why Is My Phone So Hot?

Science Buddies: Science Fair Variables

TIPS & TRICKS

#1: Keep an eye on the clock, and where students are at. Some students will want to spend too much time in the Create stage, and some students will try to speed through it.

#2: We occasionally update our Bits and accessories, so some of the names and images included in the student handout may look different from those in your STEAM Student Set. Use your Invention Guide from within your Kit to support students with the parts that they have accessible to them. Use a rubber band or glue dots if you don't have a battery clip in your Kit. The invention will function the same!

#3: Water and littleBits don't mix so be careful if using ice to cool down the temperature! We recommend putting ice in a sealed plastic bag.

PACING (90 mins)

Prep + Setup

Intro (10 mins)

Create (20 mins)

Play (10 mins)

Remix (35 mins)

Share (10 mins)

Close (5 mins)

Instructional Steps

Step 1: SETUP

DURATION: 10 minutes (prior to class)

This lesson can be done individually or in small groups (2-3 students). Each group will need one STEAM Student Set and a lesson handout. Set up a central location in the classroom for assorted materials and tools. Cut holes into the top of the boxes if needed (large enough to fit the smartphones/tablets).

Each group will need a power Bit, fan, number, temperature sensor, fork, 2 wires, battery and cable, battery clip, and mounting board. If you don't have a battery clip in your kit, use tape, glue dots or elastic bands to secure the battery to the board. Younger students can start out with just these materials, so they aren't overwhelmed and don't try to add unnecessary Bits. Older/more confident students can have access to any Bits in their Kits.

NOTES

- You should use a classroom timer or [digital timer] to help keep students on track.

Step 2: INTRODUCE

DURATION: 10 minutes

Discussion

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

1. Ask students to power up their smartphones or tablets (pair up if needed). They can stream music or videos (on mute) or use a map app to give directions. These activities use a lot of power and have the potential to generate heat.
2. Discussion: Ask students these "True or False" statements:
   a. When your phone is running high-powered activities, like streaming music or video, it's better to have it plugged in and charging while you watch.
      i. Answer: False! Streaming music or video may run the risk of heating up the phone, and charging the battery also generates heat! Because overheating can decrease your phone's battery life (see the article from Gizmodo in Supporting Materials), it's better to charge your battery when your phone is doing nothing else! Feel free to review why a battery generates heat, from the electric current flowing between charged particles.
   b. When it comes to overheating, your phone case plays a big part.
      i. Answer: True! It's important that your phone has proper ventilation. Think about exercising in a winter coat: the heat can't escape, and the cold can get in. Of course, you want to balance the need to protect your phone and while still giving it a chance to "breathe"—perhaps we just take the case off when we're doing highly-powered activities!
3. Have you ever thought about how much heat is produced in a data center with thousands of electronics running at all times? Play the "How do you keep a data center cool video?" and ask students to reflect on what they've observed and if they have any questions.

Introduce the Challenge

Data center designers and technicians work hard to ensure that processors stay cool. Explain to students that today they will take on the role of designers and develop their very own cooling invention using littleBits and the littleBits Invention Cycle. The activity will be broken up into the following steps:

CREATE: Build your prototype following the directions given.

PLAY: Test your circuit to see how well it works and record temperature data.

REMIX: Plan for ways to decrease the recorded temperature, then try it out. Record data under these new conditions.

SHARE: Share your designs and reflect on the variables in this experiment.

Divide the class into groups of 2-3 and have them set up their workstations.

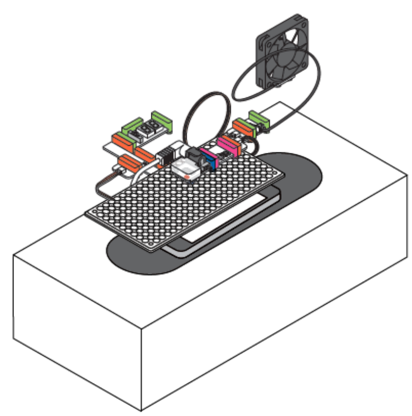
Step 3: CREATE

DURATION: 20 minutes

Students will follow the instructions and diagrams in the student handout to build their prototype of a data center.

NOTES

- If students need a little extra help getting started, reference the Bit Index in their STEAM Student Set Invention Guide or the littleBits website to learn how specific Bits work.
- The Create phase may take more or less time, depending on the group and students' familiarity with littleBits. You may want to give students guidance on what they should do after assembling their circuit (e.g. move on to the Play phase to test their circuit), so they can self-pace.



Step 4: PLAY

DURATION: 10 minutes

Test your invention!

Stream music/video or set up directions in a map app on your devices (make sure they are on mute!). Then, place the mounting board and devices into the box and keep the rest of the circuit outside of the box. Remind students that the temperature reading is coming from the temperature sensor Bit. They should keep their devices near the temperature sensor for the most accurate temperature measurement.

Power on the circuit and let the devices sit inside the box for three minutes, then
Writing Box #1: Record the temperature and conditions under "Reading #1. Sample entry:

	VALUE	CONDITIONS
READING #1	81°F	All devices in box; no fan or additional ventilation; box in indirect sunlight
READING #2		
READING #3		

Tip: If students are seeing a lower reading, make sure the temperature Bit is set to F and not C degrees.

Step 5: REMIX

DURATION: 35 minutes

Writing Box #2: Work with your group to come up with a list of ways that you can decrease the temperature inside the box. Be sure to take the following constraints into account:

- All devices must remain inside the box.
- The box must remain at least partially intact (just as a computer must have some sort of protective casing).
- You cannot put any exposed liquid inside the box (just as moisture can damage a computer).

Feel free to place any additional constraints on the brainstorm. Students might suggest cutting holes for ventilation; placing the fan in the top of the box; cutting a hole for the fan on the side of the box; turning the fan to face outward to "suck" warm air out rather than blow cool air in; placing a container of ice in front of the fan to blow cool air inside; using foil or other insulating material to intensify the cooling effects; moving the entire box to a cooler location.

After discussing your plan with your group, engineer a cooling solution using available materials.

When ready to test, set up your device and let your experimental condition run for 3 minutes. Record "Reading #2" in your chart.

Sample entry:

	VALUE	CONDITIONS
READING #1	81°F	All devices in box; no fan or additional ventilation; box in indirect sunlight
READING #2	78°F	All devices in box; fan at one side in a hole; opposite side ventilator hole
OPTIONAL: READING #3		

Optional extension: If time allows, give students an opportunity to remix their design to get an even lower reading. Repeat the testing setup and data collection and enter their value into the chart under "Optional: Reading #3."

Writing Box #3: Have students discuss and record in groups what the dependent, independent, and controlled variables of this experiment are.

Circulate the room and check for understanding. Sample entries:

CONTROLLED VARIABLE(S)	DEPENDENT VARIABLE(S)	INDEPENDENT VARIABLE(S)
Things that we need to remain constant throughout the whole experiment to ensure results are consistent. • The temperature in the room • The amount of devices inside the box • The amount of heat the devices generate in the box	Things that we change and adjust in order to observe the outcome(s). It's important to only change one dependent variable at a time. • The placement of the vents. • The orientation of the fan. • Bowl of ice in front of fan. • Materials/insulation inside box.	The outcome(s) we're trying to affect with our changes and adjustments. • The temperature inside the box.

Step 6: SHARE

DURATION: 10 minutes

Ask students to share out their cooling design with the class. What worked? What didn't work? What dependent variables were changed within the class?

If time permits, read the NPR article on Google's use of water to cool down a data center. Discussion questions include: What are the risks and rewards of using water to cool down a data center? How could Google make its request for water more friendly to the environment and the local community? What do we mean by “sustainability”?

Step 7: CLOSE

DURATION: 5 minutes

Students should take apart their inventions and put away the Bits according to the diagram on the back of the Invention Guide. Students should clean up their workspace and return any usable materials/tools.

Step 8: EXTENSIONS

Consider the following invention or discussion prompts:

- How could we prototype a temperature alert system that lets us know when our phone gets too hot?