Sound Level Stoplight

Grades 6-8

Lesson Overview

60 - 120 mins

During this lesson, students will design and code an experiment asking questions about data to learn about sound waves and the decibel scale. They will integrate Vernier sensors with Google Sheets and SAM Labs blocks.

Learn

Warm-Up
Mini-lesson

Identify how sound waves work.
Determine how various sounds rank on the decibel scale.

Do

Guided Lab Part 1
Debug Opportunity
Guided Lab Part 2
Extension Activities

Design, **code** and **extend** a program using a Sound Sensor that displays and collects data, extending to visualize the data using additional hardware; to explain the factors involved in the relative strength of an electromagnet.

Reflect

Wrap-Up

Reflect upon and **show evidence of understanding** of the decibel scale.

Standards Focus

NGSS DCI PS4.A, MS-PS4-1
CSTA Data and Analysis 2-DA-07, 2-DA-08, 2-DA-09

Equipment Required

SAM Labs RGB LED and Buzzer, Vernier Go Direct Sound

Link to lesson code on Workbench

https://edu.workbencheducation.com/cwists/preview/59739x

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Learn

Warm-Up

“How does sound work?”

Prior Knowledge Required

- Sound waves travel through the air and are created by moving objects such as an engine or vocal cords.
- Loud sound waves carry enough energy to hurt the human ear.

Key Information

- Sound is a mechanical wave; it is the periodic back-and-forth motion of air molecules.
- Without a medium like air, sound waves cannot travel.
- Sound waves have characteristics that affect how we perceive the sound:
    - Wave amplitude is related to how loud the sound is
    - Wave frequency is related to the pitch of the sound

Unplugged Activity

- Using Think Pair Share, students can discuss the questions on the slides, using the images as prompts.
    - What is the loudest sound you have ever heard?
    - What is the quietest sound you have ever heard?
    - When do people wear ear protection? What is it about those situations that make ear protection necessary?
- Students can complete a paired/independent KWL chart to record their prior knowledge, establish questions and set expectations for recording learning at the end of the lesson.

Link Forward

Students learn to use the decibel scale to measure loudness.

Sound Level Stoplight

Mini-lesson

How loud is that? Exploring the decibel scale.

Key Information

- The loudness of sound waves is measured in decibels (dB).
- The decibel scale is based on human hearing:
    - 0 dB is the “threshold of hearing”. Sounds quiet enough to be 0 dB are just at the limits of our ability to hear.
    - 130 dB is the “threshold of pain.” 130 dB sound waves are powerful enough to permanently damage human ears.

Unplugged Activity

- Students are grouped in pairs or threes.
- Student groups explore their environment, measuring sounds using the Go Direct Sound sensor.
    - Students use the Sound sensor with Graphical Analysis 4 software on a computer or smart device.
    - In the software, students should use the “Sound Level A-weighted” channel.
- Student groups create a sorted list of sounds, organized from quietest to loudest. Students should list the dB measurement and describe the situation that created that dB measurement. (Where? What was creating the sound? How far were you from it? How consistent was the measurement?)

Note regarding sound level monitoring: Sound level monitoring, such as students will be doing with the Go Direct Sound sensor, require some judgment. Sound levels will vary from moment to moment. Students will need to decide how they will take a measurement. Take the highest measurement? Collect data for 30 seconds and take an average? There is no incorrect way but students must be clear on what their method is and communicate that method when comparing with other groups.

Note regarding Go Direct Sound: The Go Direct Sound sensor can collect dB readings, in addition to capturing waveforms. Verify that students are on the “Sound Level A-weighted” channel before they begin their sound level exploration. More details about Go Direct Sound can be found here: https://www.vernier.com/manuals/gdx-snd/

Link Forward

Students code a program to measure sound loudness and decibels and turn on an LED if it is too loud.

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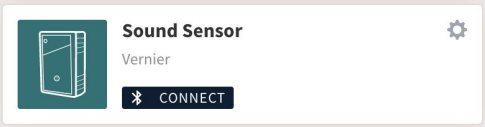
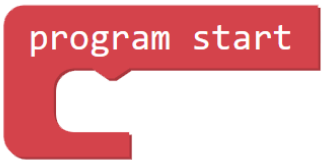
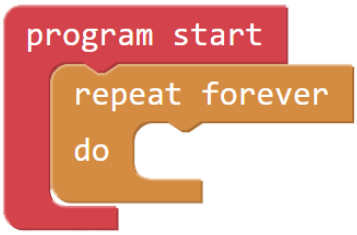
Do

Guided Lab - Part 1

Design and code a program that measures sound level.

Instructions	Workspace
Step 1 Click 'ADD DEVICE' and select: ● 'Sound Sensor' To connect the Sound Sensor, click 'CONNECT' and 'Pair'.	 **The sensor is paired when it appears under your 'Connected Devices' menu on the left hand side of the screen.** **The Go Direct Sound sensor power button is the yellow button in the middle of the sensor.** **Some tips for connecting to Vernier sensors:** ● **In the sensor list, sensors are identified by sensor order code and ID number, e.g. GDX-SND 0F100595 for Go Direct Sound sensor.** ● **Vernier Go Direct sensors connect wirelessly via Bluetooth technology, which is a 1-to-1 pairing process. Each sensor can only be connected to a single device (computer/Chromebook). Once one student has connected to a particular Vernier sensor, it will drop off from everyone else's sensor list.**
Step 2 From 'General', drag onto the workspace: ● 1 'program start' block.	
Step 3 From 'Loops', drag onto the workspace: ● 1 'repeat forever do' block. Snap into the 'program start' block.	

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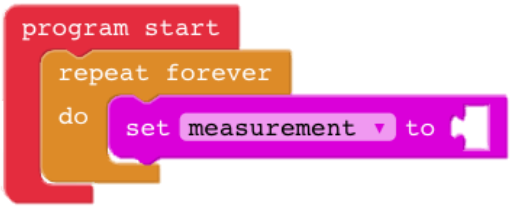
Step 4
From ‘Variables’, create variable ‘measurement’. Drag onto the workspace:

- 1 ‘set measurement to [ ]’ block.

Snap into the ‘repeat forever do’ block.

Ensure students understand that the ‘repeat forever do’ block will run all code within it until the program is stopped.

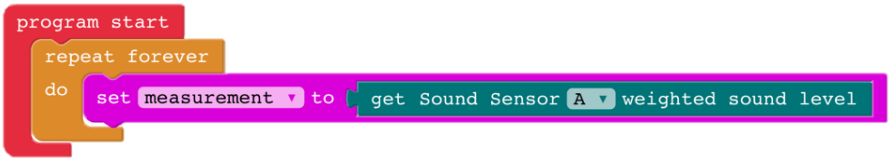


You can define and access variables from the ’Variables’ tab. Remind students that a variable is a temporary storage location and in each loop this value can be changed.

Step 5
From ‘Sound Sensor’ tab, drag onto workspace:

- 1 ‘get Sound Sensor A weighted sound level’ block.

Snap into the ‘set measurement to’ block.

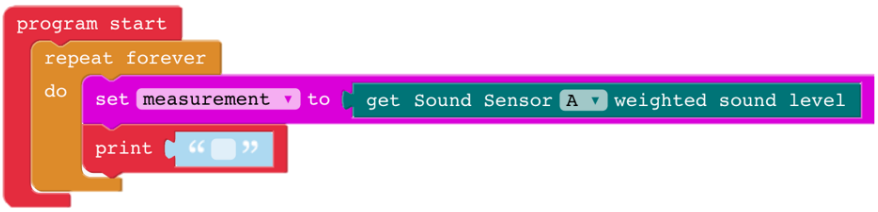


Teacher Note: The A-weighted sound level reading is a sound measurement based on the response characteristics of the human ear. For instance, the human ear is "tuned" to higher frequencies. Sound waves in the 1,000-10,000 Hz range sound louder to us than very low or very high frequency sound waves. A-weighted sound levels mirror that response. C-weighted, on the other hand, is essentially unweighted.

Step 6
From ‘General’, drag onto the workspace:

- 1 ‘print [“ “]’ block.

Snap into the ‘repeat forever do’ block below the ‘set measurement to [ ]’ block.



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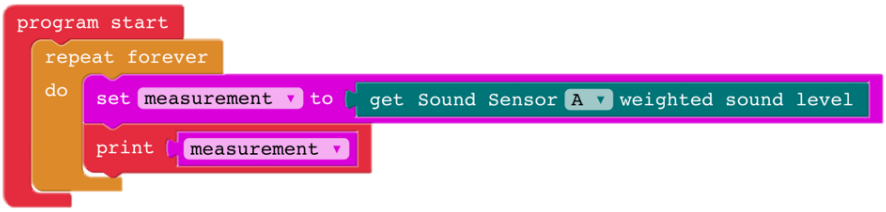
Step 7
From ‘Variables’, drag onto the workspace:
- ‘measurement’ block’

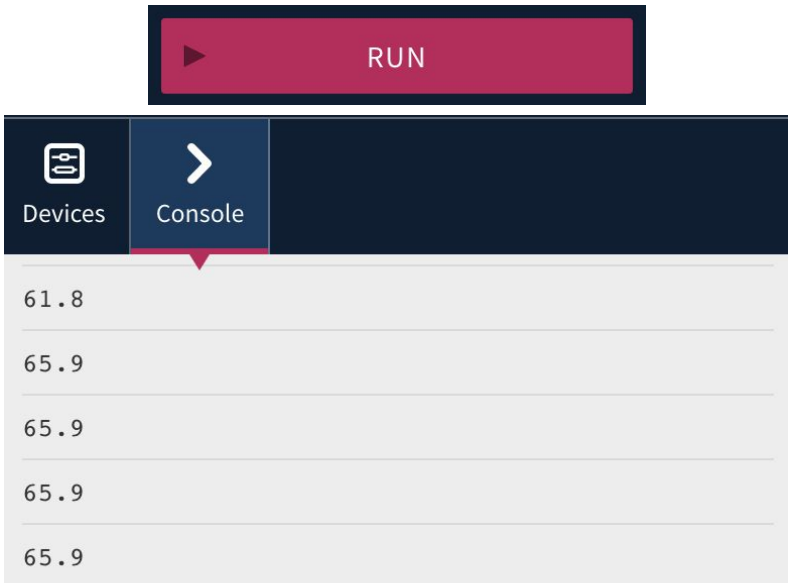
Snap into the ‘print [“ “]’ block.



The print function allows you to log and view data

Test your program by clicking on the "Run" button at the top of the Programming Canvas.

Step 8
Run your program.



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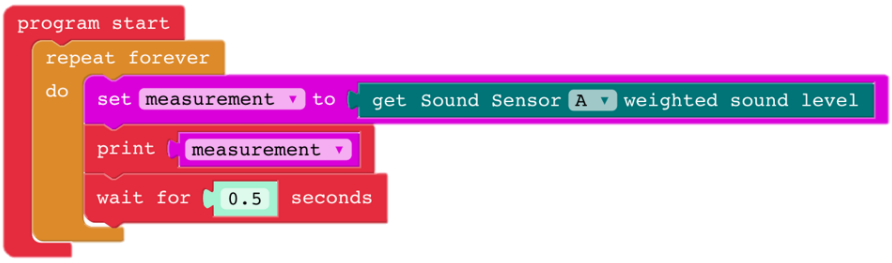
Debug Opportunity

The data is printed to the Console too quickly. How can I slow down the readings to better understand the data?

Instructions	Workspace
Step 1 From 'General' tab, drag onto the workspace: ● 'Wait for 2 seconds' block Snap under the 'print' block. Change the '2' second value to '0.5'.	 **Encourage students to compare recorded sound levels to those they collected in the mini-lesson.**

Link Forward
Students code a program that turns on an LED in response to the sound level measured by the sound sensor

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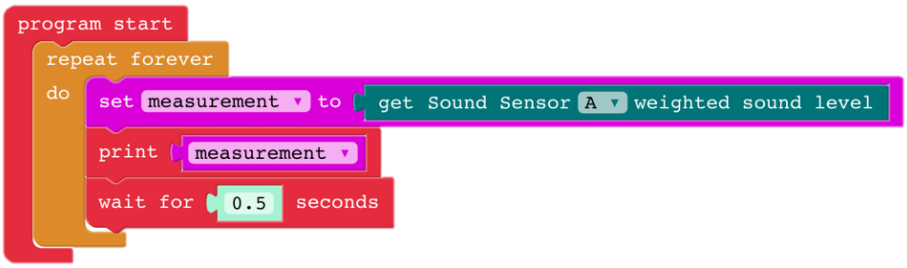
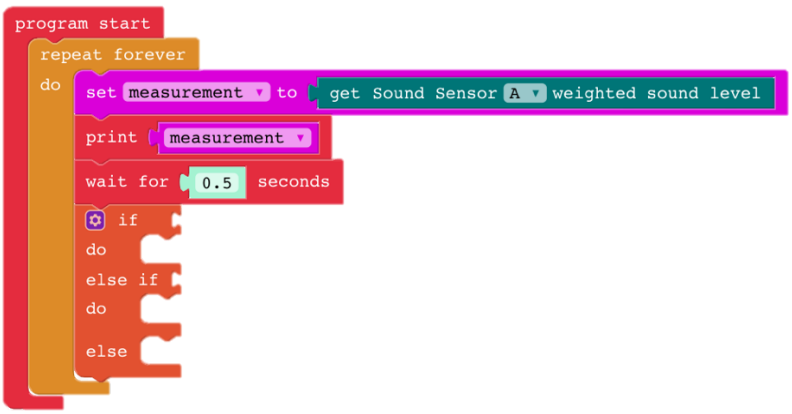
Guided Lab - Part 2

Design and code a program that gives students feedback to how loud their environment is.

Instructions	Workspace
Step 1 Check sound levels.	 **Use the program from Guided Lab - Part 1 to investigate sound levels. How loud is too loud? Encourage students to discuss what sound level is acceptable at each level and what color we would use to represent it.** **Teacher Note: Example ranges** • **Acceptable (green): less than 75 dB** • **Borderline (yellow): between 75 and 85 dB** • **Unacceptable (red): over 85 dB** **Note: In the instructions below, we'll use the values of 85 dB and 75 dB as the sound levels at which we want the LED to turn red and yellow, respectively. Use the sound levels you determined in the previous step.**
Step 2 From 'Logic' tab, drag onto workspace: • 'If do else if do else' block Snap under 'wait for .5 seconds' block	 

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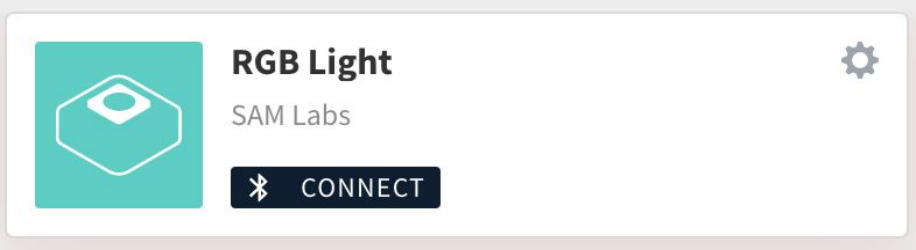
Step 3
Click ‘ADD DEVICE’ and select:
‘RGB Light’

To connect the RGB Light, click ‘CONNECT’ and ‘Pair’.



The sensor is paired when it appears under your ‘Connected Devices’ menu on the left hand side of the screen.

Teacher Note: When multiple SAM Labs RGB LEDs are powered on but not yet connected to a device, their indicator lights will show red. In the Connection list the LEDs will show as "SAM RGB LED (...)" with a series of numbers and letters in the parentheses. Student groups can pair one-by-one or gather all of the LEDs in one place and have students just select a random LED from the Connections list. Once they've connected to an LED, its indicator light will change color to match the color they've chosen in the programming canvas.

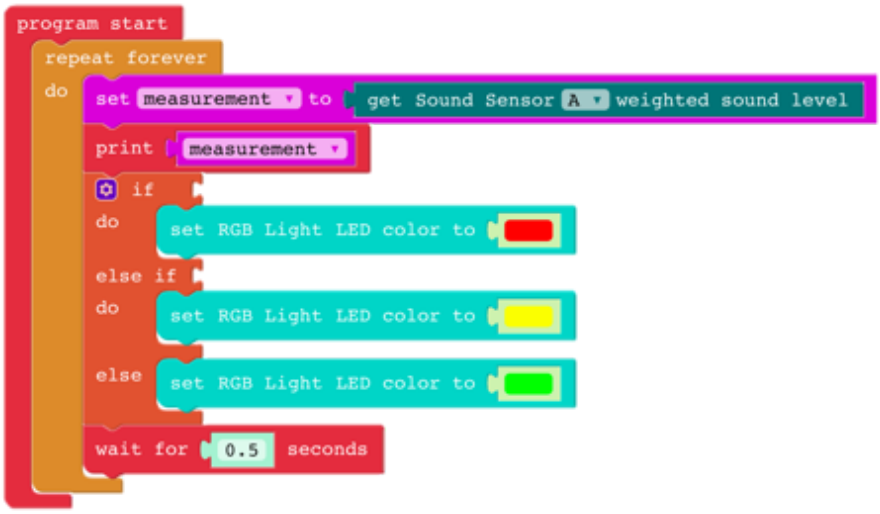
Step 4
From ‘RGB Light’ tab, drag onto workspace:

- ‘set RGB Light color to’ block

Snap Into first ‘do’ position.

Repeat two more times, once for each ‘do’ position.

Change colors so they are ordered red, yellow, green.



This "If-Do-Else" block has space for three actions. Our three actions are: turn Light red, turn Light yellow, and turn Light green.

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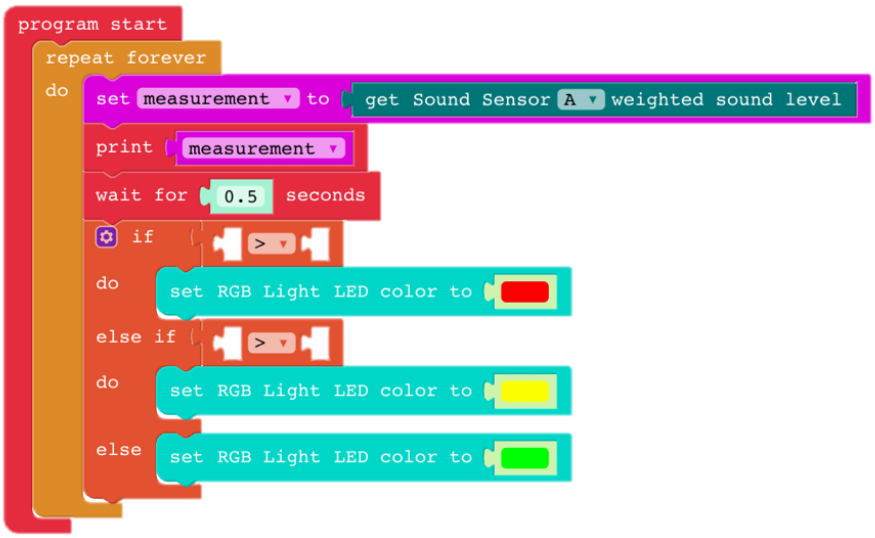
Step 5
From ‘Logic’ tab, drag onto workspace:

- 2 comparison blocks.

Snap inside the ‘if’ blocks.

Set both comparison blocks to ‘>’ using the drop down menu.



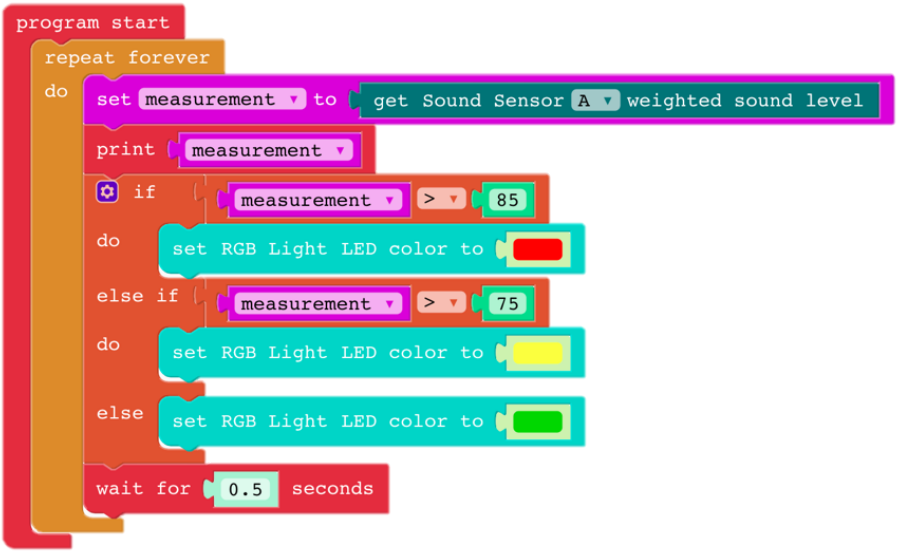
Encourage students to discuss what values the comparison blocks need to be set to for each sound level

Step 6
From ‘Math’ tab, drag onto workspace:

- 2 ‘0’ blocks.

Snap inside the ‘if’ blocks.

Set both comparison blocks to ‘>’ using the drop down menu.



Look at the completed "If-Do-Else" block. Encourage students to explain what will happen at different sound levels.

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Step 7
Run your program.

Run your sound level stoplight program.

Encourage students to discuss the following questions:

1. **Does the LED light change color when it is programmed to?**
2. **Are sound level ranges appropriate? Or do they need some tweaking?**
3. **Where should you place the Go Direct Sound sensor to give accurate readings of the sound level?**
4. **Are the sound level ranges appropriate with the sound sensor in this new location?**
5. **Can everyone see the RGB Light and tell what color it is? If not, where is the best placement?**

Teacher Note: Encourage students to refine their sound level stop light as if it were really going to be used. The process of iterative testing and refining is an essential part of the engineering process.

Some adjustments students may make:

- **Adjust the sound level thresholds at which the LED changes color. Once students decide on the best placement of the sound sensor and the LED, they may adjust the sound level thresholds to match the physical arrangement of the devices.**
- **LED may flicker as sound levels change quickly, making it hard to tell its color. Encourage students to experiment with the "wait for" block.**

Link Forward

Students extend their program to log data or trigger a buzzer as additional feedback to classroom sound level.

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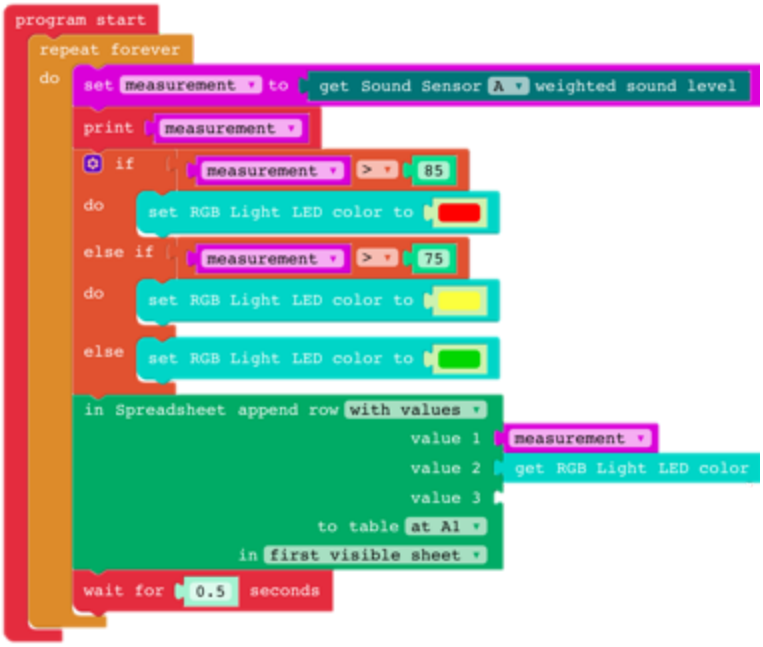
Extension Activities

Code a program that logs sensor data to Google Sheets or provides additional feedback with a buzzer.

Option 1 - Google Sheets Design Brief	Workspace
Record sound level data to a Google Sheet.	 **This shows example code that could be created to meet the design brief. This can be used to support students to develop their designs.** **Students can collect sound data throughout the day in different rooms and periods. Students can analyze how and why sound levels changed throughout the day.**

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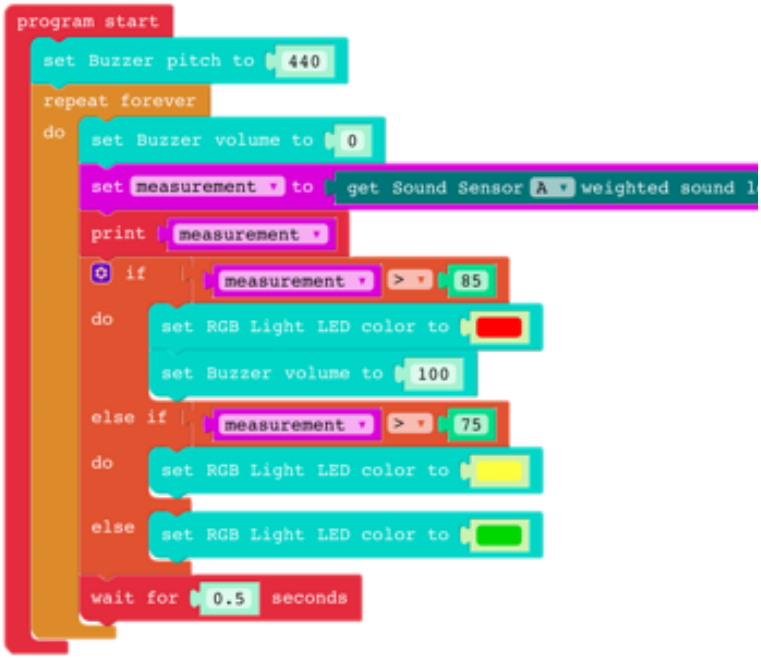
Option 2 - Buzzer
Design Brief

Trigger a buzzer as additional feedback when classroom sound level grows too large.

Workspace



This shows example code that could be created to meet the design brief. This can be used to support students to develop their designs.

Teacher Note: The wave amplitude can be manipulated with the Buzzer volume block and the wave frequency can be manipulated with the Buzzer pitch block. Encourage students to discuss a reasonable wave amplitude and frequency for the buzzer sound.

Option 3 - Prototype
Design Brief

Using classroom materials, 3-D printed materials, 3 RGB LEDs, and/ the Sound Sensor, design a Sound Level Stoplight prototype for daily use.

Workspace

Teacher Note: Students may want to use three SAM Labs RGB LEDs to more closely mimic the look of a stoplight for whole class use.

Opportunity for use of 3-D printed materials.

Sound Level Stoplight

Reflection Prompts

What factors affect how loud a sound will be measured by the sound sensor?

Do you think your sound level stoplight would really be effective? Why or why not?