



## Little Sensors Collect Big Data

### Description

*This 90-minute lesson is designed to introduce students to micro sensors used in the creation of wearable devices.*

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### Introduction

Wearable devices are becoming more common each year. These devices come in many shapes, and carry out numerous functions. MobileHealthNews.com reported in 2014 that 1 in 5 Americans own a wearable device and 1 in 10 wear it on a daily basis. Statista.com reported in January of 2016 that global wearable market is expected to exceed \$19 billion dollars in 2018.

At the heart of these wearable devices are tiny sensors and energy harvesters. This lesson focuses on the capabilities of, and applications for, these tiny sensors.

## **Curriculum Alignment**

This lesson can be modified for just about any age or science class.

NGSS. 2-PS1-2. Analyze data obtained testing different materials to determine which materials have the properties that are the best suited for an intended purpose. [Clarification Statement: Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.]

NGSS. 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.

NGSS. 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.

NGSS Practice 3. Planning and Carrying Out Investigations

## **Objectives**

Students will (SW) be able to apply the scientific method to solve problems.

SW write and test a hypothesis.

SW graph data collected from the sensors.

## **Time & Location**

This lesson takes approximately 90 minutes and can be conducted in one room.

## **Teacher Materials**

1. Arduino Inventor's Kit (<https://www.sparkfun.com/products/12060>)
2. 3 additional breadboards (<https://www.sparkfun.com/products/12757>)
3. Computer (capable of running the Arduino software)
4. Pulse sensor, optional (<https://www.sparkfun.com/products/11574>)

Notes:

- The Arduino Inventor's Kit is recommended. The individual parts are sold separately but the inventor's kit comes complete with canned programs, a storage box for the many small parts and a guide book.
- The teacher will need three additional breadboards in order to run four sensors at the same time.
- The teacher may want to have a computer attached to each breadboard. Alternatively, teacher can run the sensors using a battery.

With the kit TTW be able to program a photocell to detect changes in ambient light levels, a flex sensor to detect movement, and a temperature sensor. The teacher may want to purchase a pulse sensor. The sensor is a non-obtrusive device for measuring heart rate and can be purchased here:

<https://www.sparkfun.com/products/11574>

## **Student Materials**

SW need a notebook for recording their observations and paper for the assessment portion of the lesson.

## **Safety**

TTW will want to check all connections prior to allowing students to explore the stations to minimize the risk of shock.

## **Student Prior Knowledge**

Students should be familiar with the five senses (touch, balance, smell/taste, hearing and vision). Students should have studied the scientific method prior to this lesson. This lesson provides a low-stakes way for the teacher to assess student understanding of the scientific method.

## **Teacher Preparations**

TTW want to become familiar with the breadboard and how to connect the various sensors to the board. With the Inventor's Kit no prior programming or wiring experience is necessary. However, TTW want to have all sensors calibrated and running before class begins. It is suggested that the teacher preps this portion a week in advance to ensure all sensors are working properly. Also worth noting here is preparing the computer to run the software may take an hour or two.

## Activities

Warm Up (15 minutes): SW respond to the following prompt: How do you observe your world?

TTW will place a clear plastic bottle filled with a clear liquid on a table or counter where all students can see the bottle. Ask students to write a description of what they observe. After giving students a few minutes, TTW ask students to volunteer their observations. Typically, most students will say they see a bottle of water. Ask students if they are able to confirm that the liquid is water with a visual observation.

TTW ask S to share their response to the warm up prompt: How do you observe your world?

TTW make a list on the board. TTW guide the discussion to include a list of sensory systems. Make sure to clarify the misunderstanding that olfaction and gustation are separate systems. Taste and smell use the same areas of the brain to process information.

Think/Write/Pair/Share (15 minutes)

TTW ask S if people ever use tools to extend their ability to observe the world. Depending on the age of students, the teacher may need to provide more guidance. Have students think and make a list of tools used to extend our ability to observe our universe. Typically, S will say telescope, microscope, and stethoscope. After 3 minutes have students share in pairs.

TTW make a class list of the tools identified by S. Compare the microscope and telescope. TTW ask S what is different about the two. Students will usually understand that one makes small objects appear larger and the other makes far away objects appear closer.

Consensus Census 1-3-6 (30-45 minutes)

TTW ask students if anyone wears a smartwatch or fitness wearable. TTW then asks students what the devices do. Each student will write an answer to the question on a note card. Students should write their name on the card and turn it into the teacher before beginning the next step. TTW review student responses using the cards. TTW will help students understand that the devices collect data.

TTW introduce students to the sensor stations. (Four stations are temperature sensor, flex sensor, light sensor, and pulse sensor. With a few small sensor

purchases teacher can create additional stations. Be aware that adding additional stations will require more time for this activity.)

S will move station-to-station in groups of three. Ask students to reach an agreement about what type of data the sensors collect.

After students have 20 minutes to explore stations have them share their findings in groups of six. The groups of six should create a list of what the sensors are and what type of data they collect. After groups reach a decision TTW lead a class discussion to create a class consensus about what data was being collected by each sensor.

<b>Sensor Type</b>	<b>Sensor Detects:</b>
Temperature	Energy expressed as heat
Flex	Flex or bend in an object
Light	Light energy
Pulse	Heart Rate

After building consensus teacher may want to review vocabulary terms and ask students questions about the scientific method. This will depend on the age and preparedness of the students.

### **Summative Assessment**

With the remaining time in class TTW introduce the summative assessment and distribute rubrics. In order to assess student understanding of sensors TTW have each student design an experiment that uses one of the sensors to collect data. The experiment should demonstrate student understanding of what data the sensor collects and how the sensor can be used to collect that data. TTW evaluate the student experiment using the attached rubric. Students should use the rubric as a checklist in preparing their experiment. Students should use the vocabulary terms in writing a description of their experiment. TTW encourage students to include graphs, drawings and other ways to convey information in addition to the write up.

The Summative Assessment continues in the next class period. Allow 60-90 minutes for the assessment. TTW collect the assessment and provide hot and

cold feedback. TTW will provide an additional 30 minutes for students to make corrections and submit for final assessment. This type of Summative Assessment serves as a learning opportunity and assessment. The use of document sharing software makes this process much easier.

### **Critical Vocabulary**

Observation – The action or process of observing something or someone carefully in order to gain information.

Observe – To notice or perceive something and register it as significant. Take note or detect something in course of scientific study.

Inference – A conclusion reached on the basis of evidence and reasoning.

Hypothesis – A proposed explanation made on the basis of limited evidence as a starting point for further investigation

Independent variable – an experimental variable manipulated by the experimenter

Dependent variable – an experimental variable whose value depends on another, it responds to the independent variable

Constant – variables in an experiment that are the same for all groups regardless of test condition

Control – an experimental group resembling the other experimental groups but not receiving the factor being studied

Sensor – an object that detects events or changes in its environment and then provides a corresponding output

## **Author Information**

I teach science classes at Vernon Malone College and Career Academy, a Wake County Public School System in Raleigh, North Carolina. Our unique school is housed in a building that once served as a Coca Cola bottling plant, a plant I visited on a fifth grade field trip! This fabulous facility provides students with a comfortable environment specifically designed to encourage student collaboration.

My career as a professional educator began at the University of Colorado where I taught Psychology and Statistic courses to undergraduates and graduate students. I took a break from teaching to help start two different breweries and a food service company. During that time I dearly missed teaching. Ten years ago I was at the right place at the right time and received an offer to return to the classroom. I taught 8<sup>th</sup> grade science for five years. Over the past five years I have taught high school students of all ages Algebra, Algebra 2, Geometry (before Common Core), Honors Earth Science, Honors Biology, AP Environmental Science and AP Biology.



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You can read my musings on teaching  
and my Kenan Fellowship here:

<https://kenanfellows.org/2017-ttomlinson>

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## Meet the Mentors

My Kenan Fellowship mentors are both faculty members at North Carolina State University who work at the Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) Center. They focus their energy on developing nano-enabled energy harvesting, energy storage, nanodevices and sensors to create battery-free, body-powered, and wearable health monitoring systems.

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