ACCESS, INNOVATION, AND EVALUATION

2020 Education Innovation and Research (EIR) Project Directors and Evaluators Technical Assistance Meeting

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Learning by Making: an integrated 9th grade CSTEM curriculum

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Mendocino County teachers and students engaged in *Learning by Making*

Learning by Making Curriculum

- Implements all three strands of the Next Generation Science Standards
- Focus on scientific and engineering design practices
- Students
  - **design, construct, analyze and explain** their own experiments
  - **measure** and **understand data** that are personally relevant and critical to the future of our economy and our planet!
- Career Technical Education connections through yearly field trip, career presentations

Next Generation Science Standards

1. Scientific and Engineering Practices

- Asking questions and defining problems
- Developing and using models
- Planning and carrying our investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in arguments from evidence
- Obtaining, evaluating and communicating information

2. Crosscutting Concepts

- Patterns
- Cause and effect
- Scale proportion and quantity
- Systems and system models
- Energy and matter
- Structure and Function
- Stability and change

3. Disciplinary Core Ideas

- Physical Science s
- Life Sciences
- Earth and Space Sciences
- Engineering, Technology , and the Applications of Science

Units

- Unit 0: My Computer
- Unit 1: Turtle Logo
- **Unit 2: Going with the Electron Flow**
- Unit 3: Doing Science with Sensors
- Three Experimental Units:
  - Water and Soil
  - Light and Energy
  - Microbial Fuel Cell
- Students use experimental units to engage in story line based on physical phenomena

NGSS Focus for Unit 2

- **PEs:**
  - **HS-PS2-6**: Communicate scientific and technical information about why the molecular-level structure is important in the function of design materials.
  - **HS-PS3-3:** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- **DCIs:**
  - **PS1.A: Structure and Properties of Matter:** The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
  - **PS3.A Definitions of Energy:** "Electrical energy" may mean energy stored In a battery or energy transmitted by electric currents. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.

Building up the performance expectation

- **HS-PS2-6**: Communicate scientific and technical information about why the molecular-level structure is important in the function of design materials.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical).	**PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Lessons in Unit 2

2.1 Introducing the BasicBoard

2.2 BasicBoard Anatomy

2.3 Powering the BasicBoard

2.4 Using Digital Pins to Control LEDs

2.5 Ohm's Law

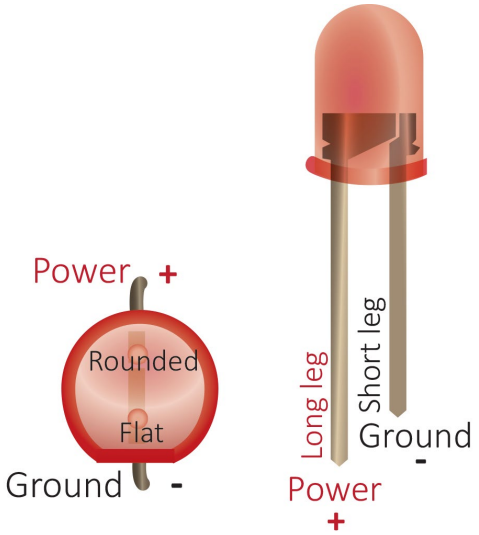
2.6 Let There Be Light!

2.7 Coding LED Lights

2.8 Blinking LEDs

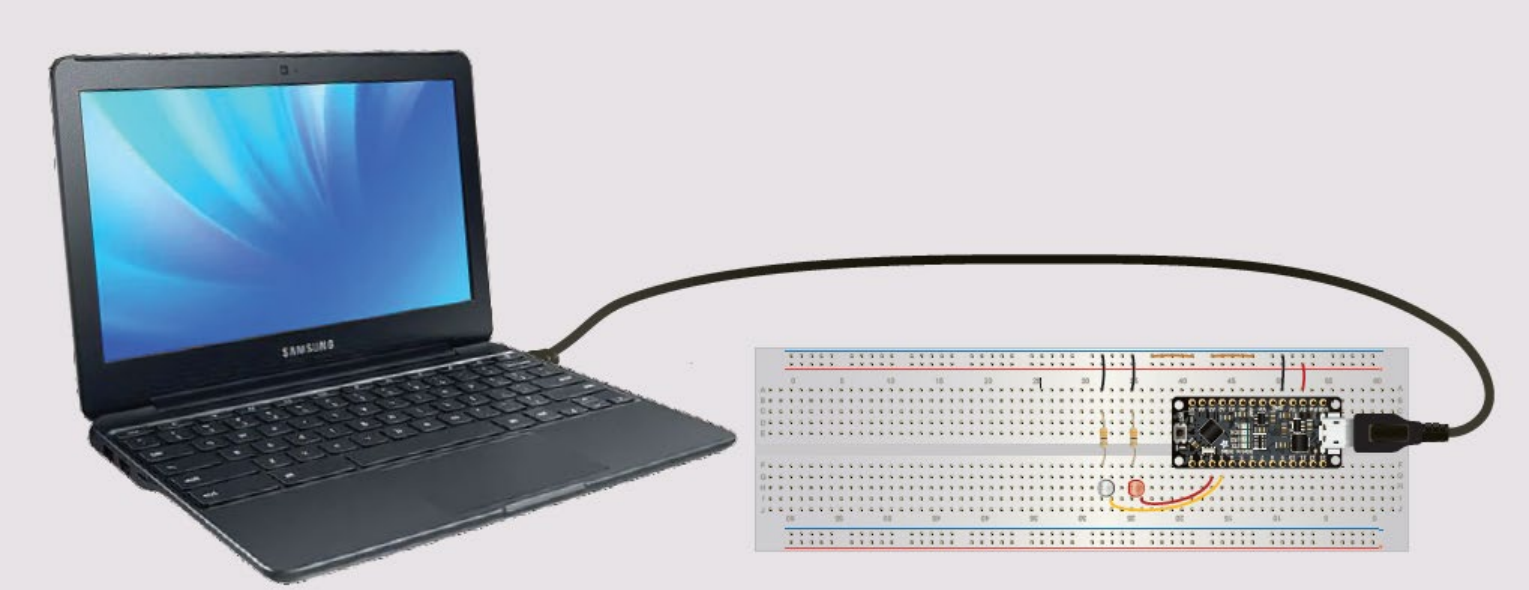
2.9 Coded Communications

The first six lessons build up and scaffold the performance expectations.



Basic Setup

- Plug computer into BasicBoard using USB cable
- Arduino microcontroller on breadboard controls hardware



Lesson 2.1 Learning Objectives and Example

- Students will investigate the structure and function of the Arduino, BasicBoard, and breadboard.
- Students will identify components of the BasicBoard system as conductors or insulators
- Example student activity:

The Arduino has 28 metal pins (legs) that are plugged into holes in the white plastic breadboard. Look in the holes (you might need a flashlight).

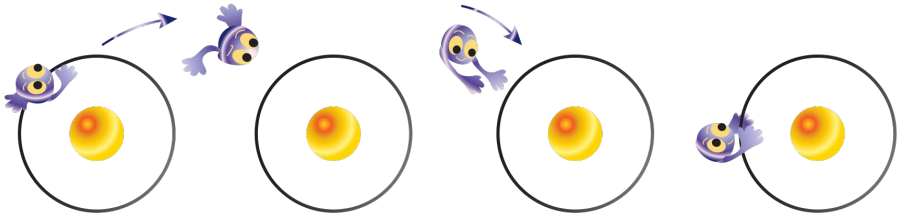
What type of material do you think is in the holes?

Metal or plastic?

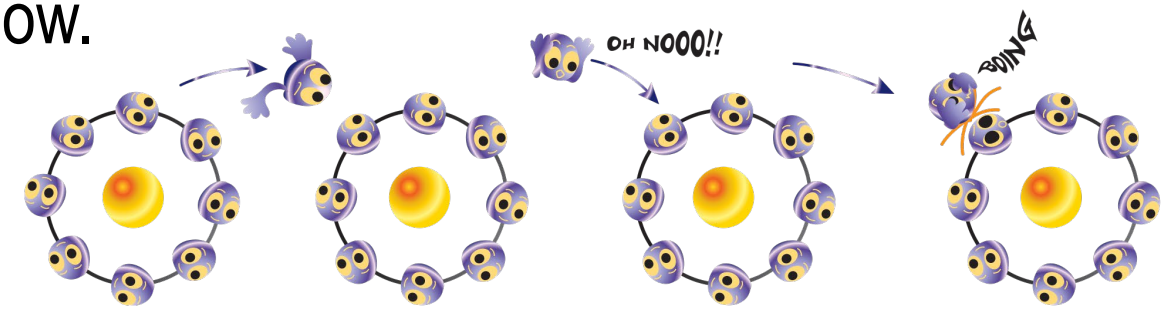
Explain your choice.

Conductors vs. Insulators

- A electric **conductor** is a material in which electrons can easily flow between atoms, creating **electric current**



- An electric **insulator** is a material in which electrons do not flow.



Next steps in working through the PE

- Identifying conductors and insulators based on physical properties (metals vs. non-metals)
- Gathering evidence to determine the underlying structure of the breadboard and the paths that current can flow
- Explaining electricity as the flow of electrons which carry electrical energy
- Explaining conductors and insulators in terms of shells of electrons
- Connecting open shells with ability for electrons to flow
- Explaining resistance to current flow in terms of molecular structure using the periodic table of the elements

How do you assess a performance expectation?

- Our method has been through worksheets that document the STEPs that the students go through, followed by Challenges.
- For speedier students, there are Double Dare Challenges.
- But these types of results don't lend themselves to randomized control studies
- They do, however, demonstrate that the performance expectations have been satisfied
- Needed: overall summative assessment of the PE

Other learning pathways in LbyM curriculum

- LbyM is an integrated CSTEM curriculum
- The primary science is NGSS-aligned Physical Science
- Other pathways are:
  - Mathematics – including some geometry, algebra, proportionality, graphing, line fitting and trends
  - Computational thinking
    - Concepts: sequence, loops, events, operators, conditionals, data
    - Practices: experimenting and iterating, testing and debugging, reusing and remixing, abstracting and modularizing, algorithmic thinking
  - Electronic circuits – voltage, resistance, current, use of digital multimeters, LEDs, and sensors