Activities Exploring Open Source Technology to Promote a Better Understanding of Investigation, Experimentation and Data Collection Methods in the Science Classroom

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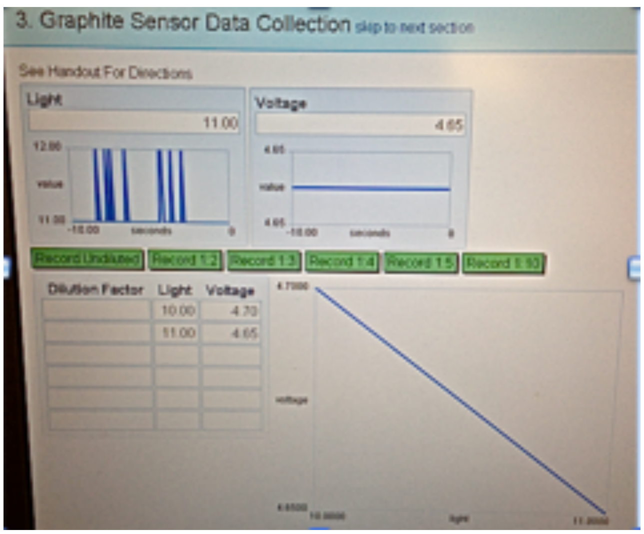

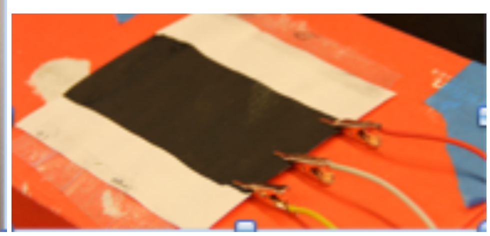

Materials Research Laboratory

U.C. Santa Barbara

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Abstract:

This project is an exploration of emerging hardware and software projects which share a common theme of being “open source” projects. Along with being generally innovative and engaging, open source projects are communal in their development and relatively low cost in their implementation. Developed and applied in this curriculum project is an interactive exercise using student-made graphite potentiometers, arduino sensors and the open-source educational software program “ManyLabs”. Two separate “Sensor Circuits” lessons were also investigated using ManyLabs and “LittleBits” hardware. Another direction briefly explored in this project is the low-cost open-source CNC hardware to conduct microscopy projects and as an autosampler in the classroom.

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Introduction to RET I Research Project:

My RET I research project focus was on developing eDNA biosensors for the purpose of developing a point-of-care device for rapid detection of viruses in human blood. The eDNA biosensor consists of an engineered single-stranded, stem loop of anchoring DNA to which a specially engineered strand of peptide nucleic acid (PNA), a recognition strand, hybridizes. The DNA strand contains a redox tag (methylene blue) which gives off an electrical signal detected by a potentiostat machine. The PNA strand contains an antibody binding site to which the target in blood will attach and cause, in our case, a decrease in signal detected from the potentiostat machine. This rapid response to detecting antibody in any medium makes this type of sensor easy to fabricate, washable and reusable.

To further demonstrate the viability of this type of sensor, tests were done using specific antibody-detecting PNA strands for 4B3 and FLAG antibodies. These two antibodies are engineered for testing purposes only and we demonstrate their potential for real world application in the manuscript titled: *A Reagentless, Electrochemical Approach for the Rapid, Quantitative, Multiplexed Detection of Specific Antibodies*.

During RET I, I was exposed to manufacturing and testing of eDNA biosensors, collaborated with both PhD candidates and PhD's in the field of biochemical engineering, and gained a deeper appreciation and understanding for how nature can exploit signaling mechanisms to detect a specific target such as HIV antibody.

Rationale for Teaching Open Source Curriculum:

There are no middle school California science standards that address electricity directly, although one small part of 8th grade physical science standards addresses conductivity. The few that are addressed in the high school standards cover predicting voltage or current to understanding magnetic fields. This unit was designed to introduce electricity in a more concrete form to middle school and high school students through three activities that directly address circuits and ultimately sensor integration. Each activity is "hands-on" and enable students to demonstrate their understanding of circuitry through practice and application.

Students will be engage in higher learning by incorporating these three basic activities into performing a real-world scientific experiment set to determine water quality of various local hydrological sources (e.g., well, ocean, creek, stagnant pond) by using a complex device like an autosampler to collect data over a period of time and analyze the factor of dissolved oxygen content in several water samples.

Learning Objectives:

After completion of this unit of activities, students will be able to explain how a simple direct circuit works, understand how a potentiometer behaves within a circuit, and be able to correlate two quantities (e.g. light and voltage) to determine a direct relationship between the two variables.

Overview of California State Standards Covered in Activities:

Eighth Grade Physical Science

7c: *Students know* substances can be classified by their properties, including their melting temperature, density, hardness, and thermal and electrical conductivity.

High School Electric and Magnetic Phenomena

5. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:

a. *Students know* how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.

b. *Students know* how to solve problems involving Ohm's law.

c. *Students know* any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = *IR* (potential difference) · *I* (current) = *I2R.*

d. *Students know* the properties of transistors and the role of transistors in electric circuits.

e. *Students know* charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.

f. *Students know* magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

g. *Students know* how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.

h. *Students know* changing magnetic fields produce electric fields, thereby inducing currents in nearby conductors.

i. *Students know* plasmas, the fourth state of matter, contain ions or free electrons or both and conduct electricity.

j.* *Students know* electric and magnetic fields contain energy and act as vector force fields.

k.* *Students know* the force on a charged particle in an electric field is *qE*, where ***E*** is the electric field at the position of the particle and *q* is the charge of the particle.

l.* *Students know* how to calculate the electric field resulting from a point charge.

m.* *Students know* static electric fields have as their source some arrangement of electric charges.

n.* *Students know* the magnitude of the force on a moving particle (with charge *q)* in a magnetic field is *qvB* sin(a), where *a* is the angle between ***v*** and ***B*** (v and *B* are the magnitudes of vectors ***v*** and ***B,*** respectively), and students use the right-hand rule to find the direction of this force.

o.* *Students know* how to apply the concepts of electrical and gravitational potential energy to solve problems involving conservation of energy.