Exploring Open Source Technology In The Classroom

Little Bits

Graphite Potentiometer

CNC Autosampler

RET 2 Curriculum Project by Jesse Kasehagen
March 15, 2013
RET I: Research

Research Topic: Biosensors

Objective: To build a point-of-care device for a doctor’s visit
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Research Topic: Biosensors

The new sensor platform is sensitive, selective, reusable, and rapid. Both the signal-on and signal-off streptavidin sensors respond sensitively to their target, exhibiting detection limits below 1 nM (Figure 3). Neither architecture responds significantly to nontargeted proteins, such as a mixture of IgG antibodies (Figure S2), and both architectures support the detection of their targets directly in complex sample matrices, such as 50% blood serum, 5% (w/v) soil in buffer, and foodstuffs (Figure 3, bottom and Figure S3). The sensors are also readily regenerable: a short rinse with deionized water to disrupt hybridization and remove the recognition strand before the addition of fresh recognition strand allows reuse for more than five cycles (Figure S4). Finally, both sensors equilibrate.
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Electricity is something students are commonly interested in...
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Curiosity

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RET II:
Curriculum Basis
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The Arduino
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Runs any program whether on a computer, as an integrated sensor or...
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A CNC
Built to run as a milling machine, explorative microscopy and autosampling
Why Open Source?
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Lesson Plans

- Introduction to circuitry using a variety of sources (e.g. Little Bits and Manylabs software) to learn about them (Lessons #1).
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Lesson Plans (Cont’d)
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- Exploring Graphite Potentiometers (Lesson #3).
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Lesson Plans (Cont’d)

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![Graphite Sensor Data Collection](image-url)
Lesson Plans (Cont’d)

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- Using a CNC machine as a platform for an autosampler (Lesson #4).
Lesson Plans (Cont’d)

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Lesson #1: Basic Circuitry

Overview:
To understand how various input/output modes can affect an outcome in a circuit by:

Using Little Bits parts to investigate circuits and develop input/output statements

Manipulatives are good for Kinesthetic Learners (Middle School)

Logic statements are good for forming complex circuits in codes and programming (High School)
Another Example of ManyLabs Software...
And....

A tabulation step

<table>
<thead>
<tr>
<th>Circuit #</th>
<th>Button</th>
<th>Knob</th>
<th>Light</th>
<th>Tilt</th>
<th>And</th>
<th>Or</th>
<th>Not</th>
<th>+</th>
<th>&lt;30</th>
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</tbody>
</table>

Place a “Y” for each part “used” to complete the circuit in the table below after completing the task on the computer for each exercise:

After tabulation, you can create coding sentence structure for programming languages.
If you know: Button = a switch; then “Copy & Paste Code”

/* switch

* Each time the input pin goes from LOW to HIGH (e.g. because of a push-button
* press), the output pin is toggled from LOW to HIGH or HIGH to LOW. There’s
* a minimum delay between toggles to debounce the circuit (i.e. to ignore
* noise).
* 
* David A. Mellis
* 21 November 2006
*/

int inPin = 2;         // the number of the input pin
int outPin = 13;       // the number of the output pin
int state = HIGH;      // the current state of the output pin
int reading;           // the current reading from the input pin
int previous = LOW;    // the previous reading from the input pin

// the follow variables are long's because the time, measured in milliseconds,
// will quickly become a bigger number than can be stored in an int.
long time = 0;         // the last time the output pin was toggled
long debounce = 200;   // the debounce time, increase if the output flickers

void setup()
{
  pinMode(inPin, INPUT);
  pinMode(outPin, OUTPUT);
}

void loop()
{
  reading = digitalRead(inPin);

  // if the input just went from LOW and HIGH and we've waited long enough
  // to ignore any noise on the circuit, toggle the output pin and remember
  // the time
  if (reading == HIGH && previous == LOW && millis() - time > debounce) {
    if (state == HIGH)
      state = LOW;
    else
      state = HIGH;
    time = millis();
  }

digitalWrite(outPin, state);

  previous = reading;
}
Lesson #2: Graphite Potentiometers

Goal: To understand what a potentiometer is and what it does

Measure Variable Voltage

Or...

Measure Variable Resistance
Lesson #2
Building A Graphite Circuit

Students get to create a circuit with graphite and then test its voltage or resistance using a voltmeter or LED.

Leads of Voltmeter are closest to source:
Reading=6.15V from a 9V battery.

Leads of Voltmeter are farthest from source:
Reading - 167.9mV from a 9V battery.

Hook an LED to resistive layer (graphite) and see what happens...
Lesson #3: Exploring Graphite Potentiometers using ManyLabs Software

Goal: To learn how to interpret data and determine a relationship between two variables (i.e., light and voltage)

Set Up:

- Dilution
- Bare Conductive Paint
- Light Box
- Arduino Set Up
<table>
<thead>
<tr>
<th>Preparation:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Four Dilutions, two beakers per dilution by yourself = 20 minutes</strong></td>
</tr>
<tr>
<td><strong>Light Box Setup:</strong> I used a box 6”x10”x2.25” with ~ 1”x2” slot cut out at top and bottom, with a “tail” to set light sensor</td>
</tr>
<tr>
<td><strong>Arduino Uno/Mega with Grove shield, and screw terminal to attach three alligator clips for your voltage sensor + connection for light sensor</strong></td>
</tr>
</tbody>
</table>

**And...**

Using an online software interface like ManyLabs
www.manylabs.org
Example: Clearly marked “potentiometer” and sample ManyLabs reading

Results after five readings:

Note: Have a backup set of “control” painted strips so students can trouble shoot what went wrong if it didn’t work

Possible Problem with results: Make sure students clearly label dilutions!
Lesson #4: Using a CNC as an Autosampler

Goal: To learn how to set up a complex experiment, collect data, and interpret that data.

Equipment:

- Open Source Desktop CNC Machine: ShapeOko
  Designed by Edward Ford

- Atlas Scientific Dissolved Oxygen Sensor

- Water samples
Lesson #4: Using a CNC as an Autosampler

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Equipment:

Open Source Desktop CNC Machine: ShapeOko
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Atlas Scientific Dissolved Oxygen Sensor

Trouble Shooting:
1. Mount for D.O. Sensor
2. Plotting x, y, z for all samples
3. Eccentricity of Z axis rod causes problems with programming gcode for smooth run
4. Getting D.O. Sensor to read
5. Calibrating D.O. Probe
6. Collecting Data

Water samples
Atlas Scientific Dissolved Oxygen Sensor with Arduino Mega wiring

Laptop to run CNC & D.O. Probe
Thank you

Dr. Kevin Plaxco, et al
Adriana Patterson, PhD, Mentor
Dr. Frank Kinnaman, MRL
Peter Sand, ManyLabs Founder
Edward Ford, ShapeOko
MRL
NSF