Forefronts of Research Educational Modules

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Workshop Report

Prepared By

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Supported in part by

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Left to right: Daniel Schwab, Kara Parker, Babak Seradjeh. *Not pictured*: Adam Maltese, Jospeh Santonacita.
Venue: Science House of Indiana University College of Arts and Sciences Office of Science Outreach

June 1, 2016 (Day 1)

High school inquiry-based science teaching

The first day of the workshop was mostly focused on general aspects and best practices for (guided inquiry) high school science teaching.

Kara Parker started out the discussion by relating her experience. She uses mostly hands-on activities to begin each unit and finishes with a debriefing of the subject, which can include teacher-led discussions and paragraph-long essays by students. She uses Process Oriented Guided Inquiry Learning (POGIL) units, hand outs, and other resources to guide her students. While there are many POGIL resources available for chemistry/biology, physics has been catching up more recently.

Joe Santonacita's experience was influenced by his decision to go back to graduate school and concentrate on physics education through working with his advisor, Eugina Etkina at Rutgers University. His teaching has been ever since influenced by the Investigative Science Learning Environment (ISLE) methodology, developed by Etkina and others. His teaching is driven by concepts and his assessments are at least 50% conceptual. This is done through use of multiple representations and other to strategies that solicit student inquiry.

Daniel Schwab is a biology graduate student. His experience with high school students is mostly though his involvement with the Foundation of Science and Mathematics program, a twoweek summer program for high school students in the area, as well as his lab's outreach program that brings demos and hands-on modules to local schools. Though his interactions with students are shorter than a normal classroom teacher, he pointed out there is added value to having a scientist visit the class, though it might create logistic challenges in some situations.

Adam Maltese is a faculty in Indiana School of Education whose research program focuses on quantitative and qualitative data regarding students experiences and engagement in science education. He and other participants pointed out that the students reception of inquiry-based teaching and active learning methods is usually resistive at first, but they usually end up learning more and liking the method. Some of this resistance is due to built-in expectations from previous experiences of learning and a greater burden on students in the active learning methods.

Participants discussed the role of science standards in the curriculum and assessment. The science standards in Indiana have recently been updated in response to criticism of Common Core standards. The new standards, however, have a lot of overlap with common core and the more updated Next Generation Science Standards (NGSS). For the wider use of modules developed in project FOREM, it was recommended to follow NGSS.

Assessment and grading was also discussed. A lot of formative assessment happens in inquiry-based teaching, and both Kara and Joe use various ways of assessing work through lab reports, essays, and participation feedback. However, for grading purposes, they would use a combination of The more typical quizzes, midterm and final exams, with the added structure that some of these tests can be retaken to improve scores. Standardized tests do not play a big role in either teaching or assessment of students' learning.

High school inquiry-based science teaching

Adam Maltese presented his findings and research on student engagement. through this work, he has gathered a wealth of data on what sparks the initial interest in STEM for various people of diverse backgrounds. An interesting and relevant finding is that the closer to college this interest is sparked, the more likely the individual is (~ 2 times) to major in STEM.

Various phases of interest were also presented, and practical methods to increase student engagement were presented. The most important factor is relevance of the activities to the students' experience and interests. It is also important to let the students play first instead of starting with definitions and facts. This would set a common set of experiences and tangible physical interactions, on which the rest of the instruction can be based. Kara and Joe both confirmed this in their experience.

Daniel pointed out that science education has the advantage of dealing with concrete, hands-on subjects that can motivate active learning. He referred to resources in biology such as the Jim Holland Summer Science Research Program at Indiana University, a one-week research program for high school students to gain lab experience under a faculty mentor, as well as the Berkeley recourse library on evolution that includes modern example of evolutionary thinking and phenomena. These programs may be useful as templates for the modules developed in FOREM.

Module framework and structure

There was a brief discussion of the structure of modules. The length of each module would depend on the topic. It was argued that shorter modules are preferable to start with because they are more usable. Each module can be structured to be adaptable to a short 2-day discussion with suggestions for extended activities up to 1 or 2 weeks.

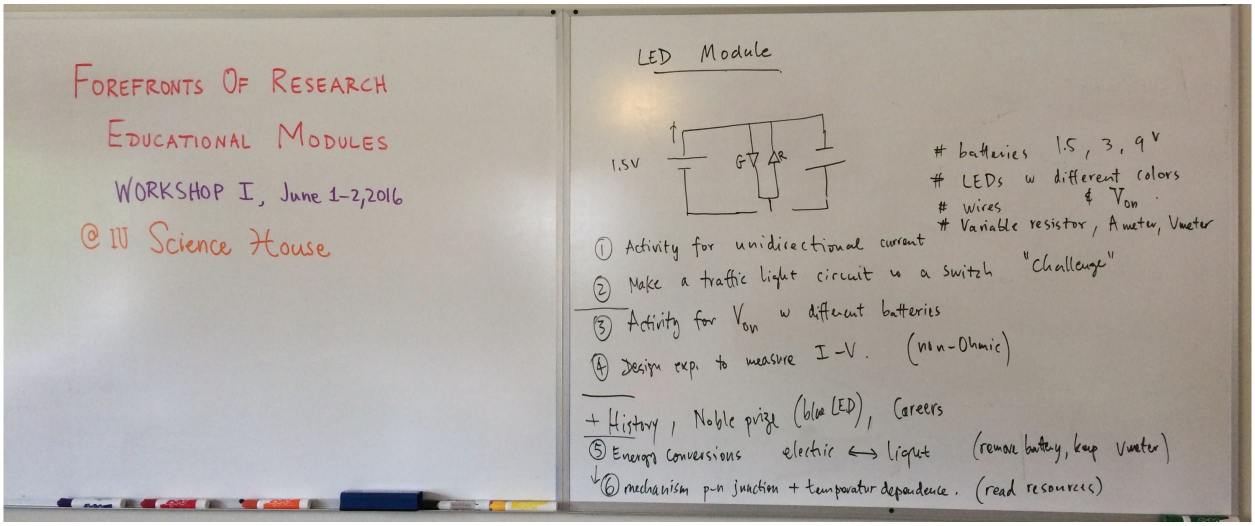
The topic of first modules

Several topics of potential use for the first two modules were discussed. Among these were: of first modules were roughly divided into two group of concrete and abstract topics. Some examples are:

More concrete topics	*More general/abstract*
LEDs	Symmetry
Wireless power transmission	Space travel
GPS	
Scales of motion	

Joe and Kara discussed what topics could be useful in their experience. Based on these discussions, a tentative list of possible topics was made to discuss for the first two modules.

June 2, 2016 (Day 2)



Module 1: Light Emitting Diodes

LEDs were suggested by Joe as a suitable device for several topics in electricity and modern physics, covered in regular and AP physics courses. A quick internet search brought up a series of resources on the use of LEDs for activities in high school physics courses. In particular, three papers published by Eugenia Etkina and **** in The Physics Teacher have listed various activities using LEDs for use in the ISLE cycle, such as one-directional circuit elements, non-Ohmic *I-V* curves, energy conversion from electrochemical to light and back, and more modern aspects of the internal mechanism of LEDs such as semiconductors, p-n junctions, and the quantum nature of electronic properties. The development of LEDs also provides an opportunity for discussing the history of discoveries, recent advancements and the 2014(?) Nobel prize for blue LEDs, STEM careers in research and industry.

Kara and Babak continued this discussion by drawing up a blueprint for the module. The structure can be divided into several layers with increasing levels of advancement. At a minimum, activities and challenges for a unit of 2 classes can be chosen. Extended activities and challenges can be chosen up to 1-2 weeks. These levels are:

1) LED as an element of a circuit
2) Non-Ohmic *I-V* characteristic; turn-on voltage
3) Energy conversion
4) Mechanism: temperature dependence of LED color, p-n junctions
5) History and STEM careers

Kara and Babak sketched activities and challenges for the first 2 levels (see below). Babak will develop more activities for the other labels. Additional content and structure will be developed and discussed with Kara, Joe, and the participants of workshop II later in June.

Module 1: LEDs (Blueprint)

Material and supplies:

+ LEDs of different colors (red, yellow, green, blue), 1 each per group of 3-4 students

+ 1.5V batteries, individual and in 3V series, 1 each per group

+ wires and circuit connectors

+ variable resistor

+ Ammeter

+Voltmeter

Lesson 1

This lesson assumes students are already familiar and understand how a simple battery-bulb circuit works. An understanding of series and parallel connections to a battery source will also be helpful, though it may not be strictly necessary. In this lesson, the students will learn about LED light bulbs as a circuit element that allow current only in one direction (diode).

The lesson starts by asking the students what they know about LEDs. It is expected that some students have heard about LEDs and may already know how they work. Places where students might have already encountered LEDs may be: some TV screens; home lighting bulbs; ***. Some may confuse them with LCDs, which they may know about from their TV, laptop, smartphone and tablet screens. They may already know they are a low-powered and energy-saving lighting and electronic element. The teacher can start by announcing the topic of the day is about LEDs and ask students about what they already know. The teacher can then collect the students responses (verbal/written) and reflect them back to the class. At this stage, it is not important for responses to be correct. This is just to set the stage and bring everybody more or less on the same page. It is also a chance for the teacher to gauge the students pre- and mis-conceptions about LEDs.

The lesson will then proceed to an activity/challenge to light the LED bulbs. The lesson will end with the challenge to make a "traffic light" circuit.

Activity 1: switch on the LED lamp

In the first activity, the students will experiment with the elements of the circuit, consisting of LEDs, 3V battery packs, and wires, with the challenge to light the LED lamps.

They will be asked to observe, record and communicate their observations in groups. It is anticipated that some groups will connect their LED bulbs the right way and some will connect them the wrong way; so some initial attempts will not be successful. Some of these students may proceed to flip the LED connections and get the lamp to light up. They may infer from this that the LEDs work as one-directional elements. Some may not make that inference.

The teacher will ask each group to report their results. It may be useful for the teacher to monitor the group activities and come up with an order in which he or she will call on the groups to report. For example, it may be better to call on a group that could not light their LED first; this can create an opportunity to pose a question for the rest of the class why their connection did or did not work.

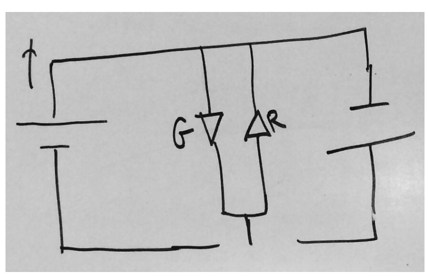
The teacher should not just state why a group's connection did or did not work. Instead, this should be discussed with the class as a question. Answers given to this question can be collected on the board for further discussion. The teacher will then ask the class to assess each answer and suggest a way to test it.

This activity is expected to be short due to its simplicity.

Activity 2

Each group will now be given a green and a red LED lamp, two 3V battery pack, wires, and a switch and will be challenged to make a circuit for a "traffic light" that can be operator by the switch. This challenge relies on the one-directional current flow in the LEDs and requires some circuit design creativity. However, the circuits are simple enough to be done within the same class.

A simple design is shown above. The two LEDs are connected in opposite directions. The



two battery packs are connected in a way that will direct the current in opposite directions depending on the position of the switch: when the switch is on the left, the left battery will direct the current clockwise through the left circuit, which will light up the green LED; when the switch in on the right, the right battery will direct the current clockwise through the the right circuit, which will light up the red LED.