Research and Collaboration: Integrating Engineering and Computer Science in the High School Chemistry Classroom

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Introduction

My participation in the Internet of Things (IoT) Research Experience for Teachers (RET) at the University of Central Florida (UCF) introduced me to fields in which I had very little understanding. Prior to my participation in this program, my interactions with computer science was very similar to that of most people: being the end-user. I use a computer and my cellphone practically on a daily basis. I also use other forms of technology, such as a television, kitchen appliances, and countless devices with electronic components. But, being an end-user is quite different from understanding the development of these electronic devices and technologies that power them from a computer science and engineering perspective. The IoT RET at UCF allowed me to get an introductory level of understanding of IoT. This was facilitated through six weeks of full immersion which included:

- Cutting-edge research activities on environmental sensors.
- Lectures on various topics (e.g. micro electromechanical systems (MEMS).
- Introduction to different programming languages, source codes, hardware, software and network development platforms such as field-programmable gate arrays (FPGAs), Raspberry Pi®, Java™ Development Kit (JDK) and Eclipse™ Integrated Development Environment (IDE).

Research Activities

1. Etched an image on a titanium plated silicon wafer using the photolithography process (**Figure 1**) and analyzed it under a microscope (a process normally used for making integrated circuits and microchips that can be nanometers in size).

2. Fabricated and used a chitosan biopolymer-coated screen-printed carbon electrode sensor (**Figure 2**) to determine the concentration of Zn^{2+} (or other heavy metals) present in drinking water using square wave anodic voltammetry.

3. Fabricated and used a glass needle-type oxygen micro-sensor (diameter tip = 10µm, which is less than the diameter of a human hair!) to analyze the oxidization of a simulated lead soldered copper pipe transporting inking water (**Figure 3**).

4. Learned logic and computer language and wrote my first code in C and Java programming language using Eclipse IDE (**Figure 4**).

Figure 1: Etching an image on a silicon wafer using photolithography.

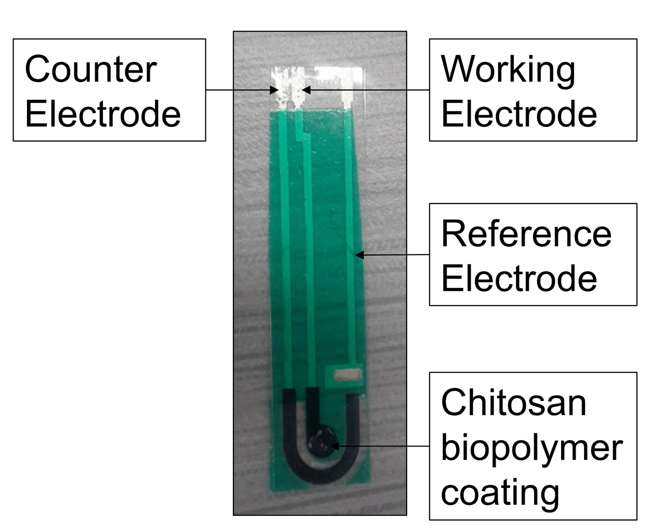


Figure 2: Chitosan biopolymer sensor.

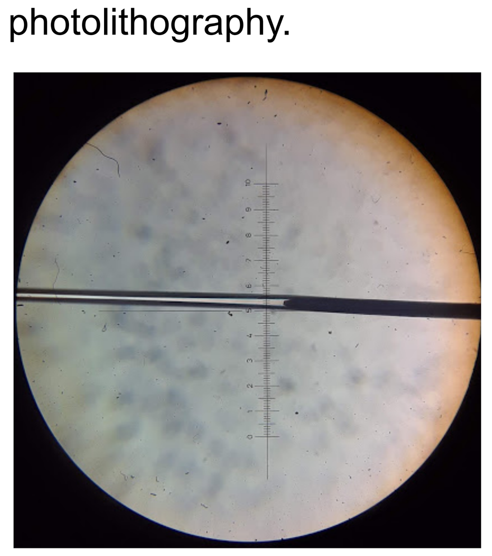


Figure 3: Needle-type micro-sensor tip (approx. 0.5 mm).

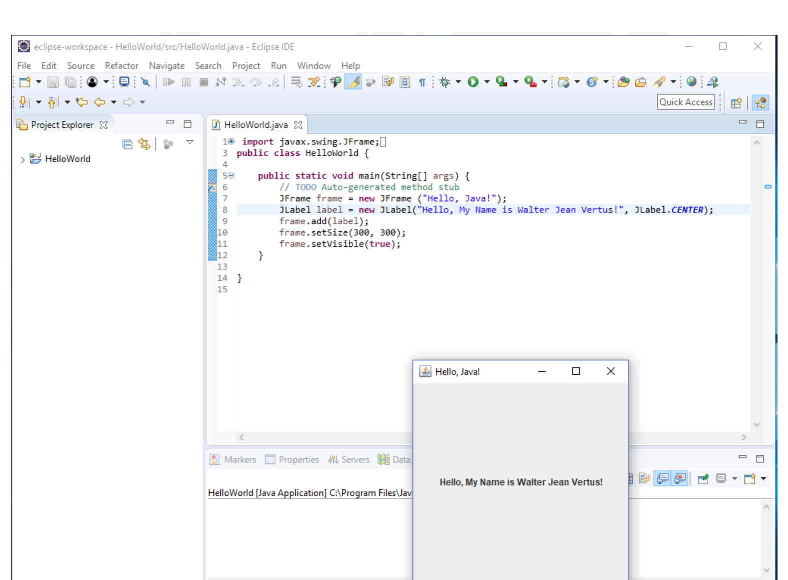


Figure 4. My first code in Java.

Lesson Plan

This lesson plan was inspired by Hossain et al. (2015) where the Color Grab™ application for Android™ was used as a colorimeter to determine the pH of water samples from lakes and oceans in a type of "*lab-in-a-phone*" experiment conducted in Australia. The Color Grab app allows a user to "grab" the RGB code for a color of an image on the camera (see Figure 6).

The increase in sensor development and interest was made possible by the rise in Mobile Communication Devices (MCD), namely cellphones. Cellphones themselves have many sensors built in, e.g., imaging camera, microphone, accelerometer, gyroscope, magnetometer, GPS and proximity, to name a few. As MCDs are getting smaller and smaller, there is a need to make the sensors smaller and smaller. The miniaturization of sensor (microsensors) is becoming an important subfield of study in sensor technology.

Students engineer a sample holder out of construction paper and other general classroom supplies (paper clips, glue, etc.) to fit the camera and flash layout of their phone.

Figure 5: Some standards for the calibration curve (100, 50, 25 and 12.5% Juice)

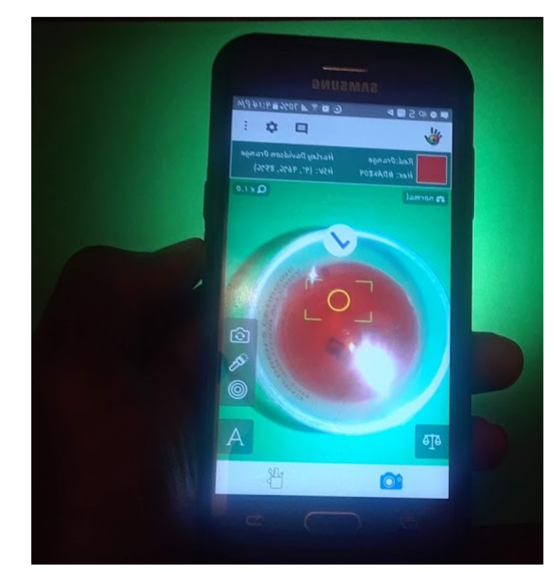
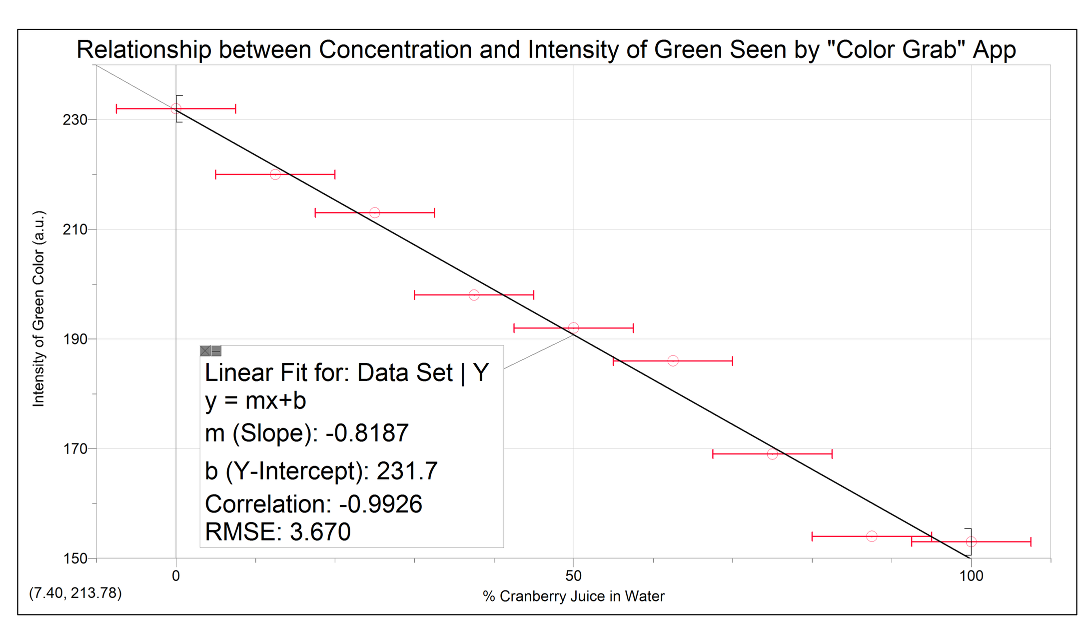


Figure 6: Using the Color Grab ™ app to quantitatively determine the concentration of an analyte.

Students develop procedures for collecting data and form a calibration curve, and ultimately use the Color Grab™ application to determine the concentration of an unknown colored solution such as $CuSO_4$ or $CoCl_2$. Colored juice products (e.g. apple juice, cranberry) can also be used (**Figure 5,6**). The students can take this further by analyzing its effectiveness compared to a market colorimeter or spectrophotometer. Also the sugar content can be predicted if using juice products as the analyte.



Graph: Correlation between intensity of green and relative concentration of the analyte (anthocyanin flavonoid which gives cranberry juice its red color.)

Almost every student has a cellphone, so learning about and using their cellphones for purposes other than texting, calling or checking their messages would broaden their knowledge of sensors in a cellphone.

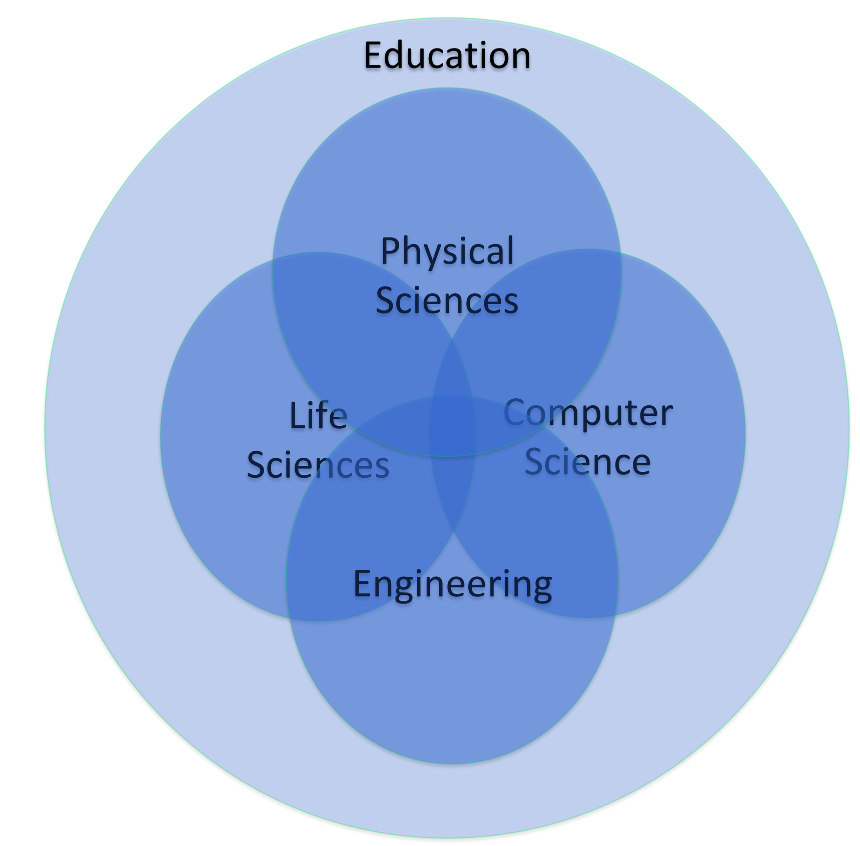
Motivating Students in the Classroom

Teaching strategies that can be incorporated into the classroom to increase motivation, conscientiousness and interest in engineering and computer science fields in specific and STEM fields in general (Bryan et al., 2011):

- Invite community leaders in the field to speak to students in the high school classrooms in person or via video phone/internet.
- Have student research career options in STEM fields.
- Incorporate game design and gaming in the classroom.
- Display photos and work of leaders in STEM fields in the classroom, particularly those representing women and minority groups.
- Assign projects deliberately designed to produce an interdisciplinary approach by students.
- Assign projects in the life and physical science classes that require the use of computer science/programming to complete.

Discussion

- Technologies that entertain us and make our lives more efficient and productive are complex - containing many layers, taking many years and involving countless man hours to develop.
- There is a wide gender gap and lack of ethnic diversity in fields of engineering and computer science.
- The fields of engineering and computer science relies on an interdisciplinary approach for success:



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