

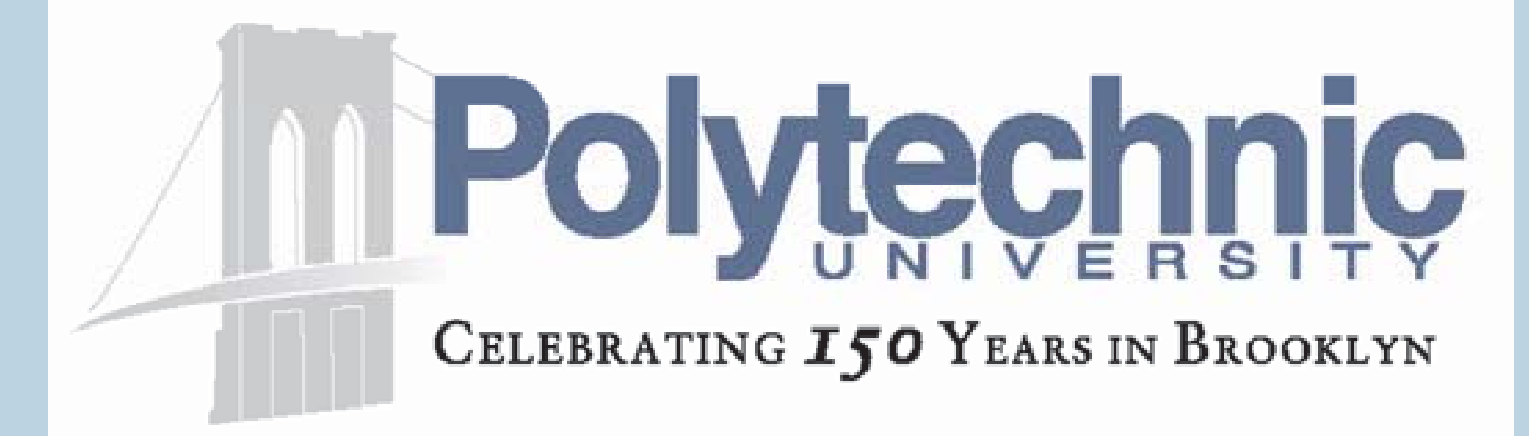


Using Real-Time Sensors in High School Living Environment Labs: A GK – 12 Project

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URL: <http://raise.poly.edu>

Today's High School Students

- Lack of interest in science & mathematics due to:
 - Uninspiring lab experiments
 - Lack of connection to real life applications



- Attracted to new gadgets
 - iPod
 - Video games
 - Cell phones



Revitalizing Achievement by using Instrumentation in Science Education (RAISE)

- Funded by an NSF GK—12 Grant

- Partnership between Polytechnic University and four New York City high schools

- Participating high schools:

- Year 1:
 - George Westinghouse, Marta Valle, Seward Park and Paul Robeson
- Year 2:
 - Seward Park is replaced by the High School of Telecommunications Arts and Technology



Project Goals

- Elevate academic achievement of students on standardized math and science tests

- Build the infrastructure for a sensor-based science curriculum

- Entice students to pursue STEM careers

- Provide technology literacy to teachers

- Improve communication, technical, and leadership skills of fellows



Fellows' Responsibilities

- Integrate modern sensing technology into current science curriculum

- Pair with a teacher and spend at least 10 hours per week at their assigned high school

- Tutor students

- Serve as an "engineers in residence"



Living Environment Sensors

| | | | | |
|---|---|---|--|--|
| Infrared radiation susceptible to CO ₂ is emitted into a region of space. Infrared detectors opposite to the source measure infrared energy lost to CO ₂ molecules. | Light is emitted into a liquid. Intensity of light exiting liquid is then measured. | A voltage is applied to two plates submerged into a solution. The resulting current is measured and conductivity is calculated. | Oxygen is chemically reduced in water, setting up a current proportional to the rate of diffusion. | Muscle activity results in polarization of muscle cells. When a portion of the heart is polarized and an adjacent section is depolarized, a measurable electrical current is set up. |
| | | | | |
| A membrane is deflected as pressure changes. | Pressure variations are measured. | Oxygen reacts with an electrochemical cell generating a measurable current. | A chemical reaction with a gel generates a measurable voltage. | Utilizes a gas pressure sensor to monitor respiratory patterns. |
| | | | | |

Living Environment Experiments

| Experiment | Description |
|---------------------------|--|
| 1. Acid Rain | A pH sensor is used to understand the relationship between pH and CO ₂ concentration of distilled water and how different pH level affects living organisms. |
| 2. Acid and Base | A pH sensor is used to measure the pH of different liquids that are acidic and basic and help understand the pH scale. |
| 3. Anaerobic Respiration | A CO ₂ gas sensor is used to measure the rate of respiration. Students compare different rates of respiration for different energy drinks which helps them to conclude which energy drink is the most effective. |
| 4. Aerobic Respiration | A gas pressure sensor is used to measure the rate of respiration. Students compare different rate of respiration for various energy drinks which help them conclude which energy drink is the most effective. |
| 5. Colors Content in Food | A temperature probe is used to determine the energy content of a small sample of food. Students learn how energy is given off by food as it burns. |
| 6. Conducting Solutions | A conductivity probe is used to measure the conductivity level of different solutions. Students have to understand how the number of ions of solutions relates to conductivity level. |
| 7. Diffusion | A conductivity probe is used to measure the change in ionic concentrations in a solution over a period of time. Different factors affecting the rate of diffusion are studied. |
| 8. Enzymes | A colorimeter sensor was used to study the functions of an enzyme present in various detergents. |
| 9. Greenhouse Effect | A temperature probe was used to measure the temperature changes within an environment to understand the greenhouse effect as a physical phenomenon. |
| 10. Heart Rate Monitoring | An EKG sensor was used to graph one's heart's electrical activity. Based on the EKG recording the heart rate can be calculated. |
| 11. Photosynthesis | A carbon dioxide and an oxygen sensor was used to calculate the rate of photosynthesis and compare the effects of light on the rate of photosynthesis. |
| 12. Population Dynamics | A colorimeter was used to monitor a closed population growth of yeast by measuring the turbidity or cloudiness. Plotting of light strike the yeast cell and reflect away from the photometer. The colorimeter monitors the light reflected by the photometer as absorbance which is proportional to the yeast present in the medium. |

Sensor-based Labs Example: Photosynthesis

| Traditional Lab | Sensor-based Lab |
|---|--|
| –Bicarbonate indicator | –Oxygen & carbon dioxide sensors |
| –Results in 1 day | –Results in 45 mins |
| –Detect approximate change in concentration of carbon dioxide | –Detect exact real time change in concentration of carbon dioxide and oxygen |
| –Student's attention is lost | –Student are able to change parameters and affect the experiment |

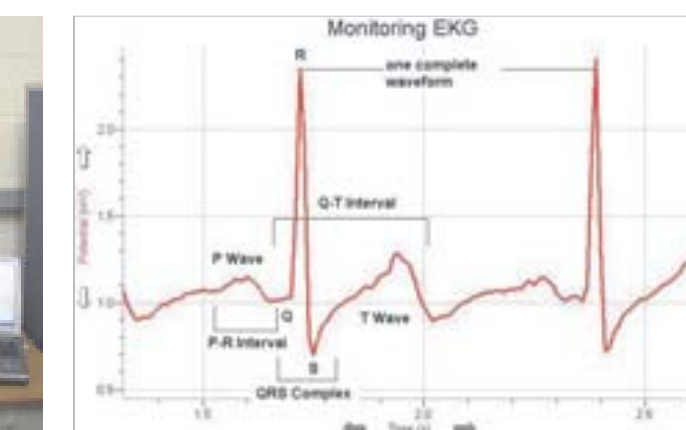


E.K.G.

- Description
 - An electrocardiogram (EKG) is a graphical representation of the electrical activity that occurs within our heart
 - Muscle activity results in a chemical process which polarizes muscle cells and thus sets up a potential difference between cells
 - EKG sensor is used to graph the student's heart activity and the heart rate is estimated from the resulting graph



George Westinghouse students performing the experiment

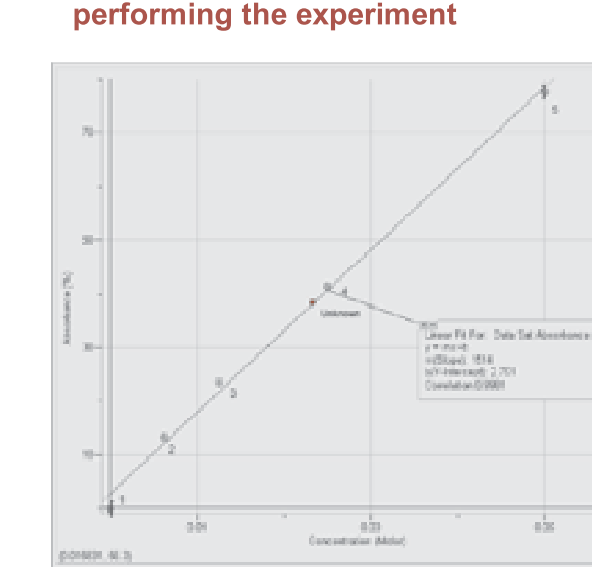
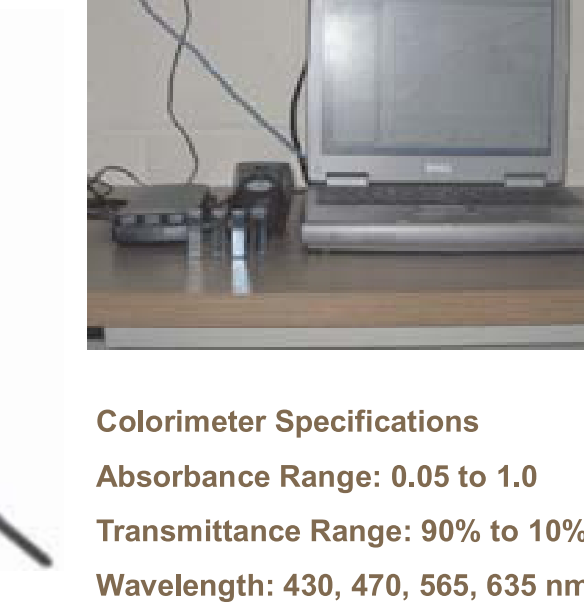


C.S.I.

- Description
 - Students take part in a lab to demonstrate how sensors can aid in solving a crime
 - Colorimeter is used to investigate if the suspicious anesthesia concentration enough to kill a person



George Westinghouse students performing the experiment

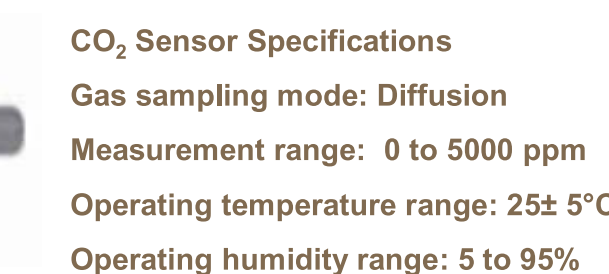


Anaerobic Respiration

- Description
 - A CO₂ Sensor is used to determine the rate of fermentation using yeast to breakdown different sugars
 - Anaerobic respiration, or fermentation, which is the process of breaking down sugar to produce energy in the absence of oxygen
 - The rate of fermentation is the slope of the line of the graph of CO₂ versus time
 - Students get to realize real time rates of fermentation in different sugars, using different drinks to simulate the sugars



High School of Telecommunications Arts and Technology students performing the experiment



Our Experience

- Year 1
 - Difficulties
 - Scheduling conflicts
 - Lack of appropriate equipment
 - Successes
 - Motivated students
 - Appreciation for sensors
- Year 2
 - Scheduling conflicts resolved by hiring more graduate students
 - All school equipped with computers



Assessment

- Impact on High School Students
 - Appreciate modern sensing technology
 - Favor sensor-based technology in labs
 - Better understanding of scientific concepts
- Impact on Fellows
 - Improved communication and technical skills
 - Polish leadership and management skills
 - Superior problem-solving abilities
 - Pursue a higher degree (M.S.)



Related Activities

- Career Day
- NYC GK-12 Grant Holders Meeting
 - Columbia University Engineering
 - Columbia University Science
 - City University of New York
 - Polytechnic University
- Annual GK-12 Meeting at NSF
- Third Annual Convergence on Inquiry @ the Natural Museum of History
- Research Experience for Teacher (RET) Program



Voice from Students

"I like labs with sensors because we get to experience real-time data [collection]"
-Student @ HSTAT

"Sensor labs captivate my attention because they show instantaneous results. Unlike traditional labs that are slow, boring and inactive."
-Student @ GWHS

"The use of sensors is beneficial as it helped me to learn to use computers to conduct a lab. Technology is the key to the future."
-Student @ HSTAT

"Sensor labs are more fun to complete because they make me feel like a real scientist. I enjoy the team work and the results that we get on the computer's screen. It's easier this way for me to understand the concept being studied."
-Student @ GWHS

High School of Telecommunications Arts and Technology students use sensors in their science project

