Revitalizing **A**chievement by using **I**nstrumentation in **S**cience **E**ducation (RAISE): A GK-12 Project

NSF Grant # DGE–0337668

Polytechnic University

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URL: http://raise.poly.edu and http://gk12.poly.edu

Description

- Partnerships
  - Polytechnic University
  - George Westinghouse HS
  - Marta Valle HS
  - Paul Robeson HS
  - Seward Park HS
- Industry Partnerships
  - American Museum of Natural History
  - Con Edison
  - FIRST
  - Honeybee Robotics
  - Symbol Technologies
- People
  - 2 professors of engineering and a faculty member with extensive experience in education
  - 12 RAISE fellows
  - 13 high school teachers
  - ≈400 high school students
- Courses affected
  - Living Environment
  - Active Physics
  - Regents Physics
  - Math A

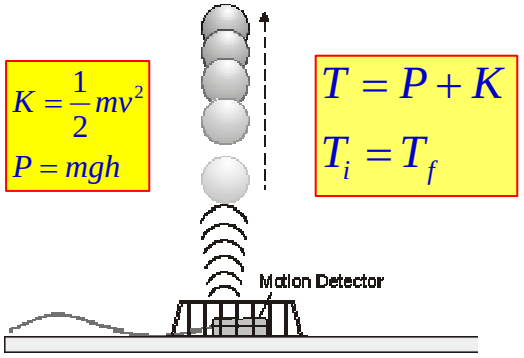
- Objectives
  - Elevate academic achievement of students in STEM disciplines
  - Prepare students to succeed on standardized exams
  - Entice and prepare an underserved student population for higher education and productive career opportunities in STEM disciplines
  - Provide technology literacy to students and teachers
  - Reinforce science and math skills of students
  - Provide professional development (PD) opportunities for NYC teachers
  - Build lab infrastructure for sensor-based STEM curriculum and instruction
  - Advance discovery and learning through technology-enhanced STEM curriculum and instruction

Approach

- 12 RAISE fellows deployed in 4 NYC high schools and paired with teachers
- Fellows develop sensor-based lab experiments and demos to illustrate scientific phenomena
- Lab modules are designed such that every member in a group has an active role in the experiment
  - Team members must constantly interact with one another to complete lab assignments
- Experiments demonstrate connections between real-life applications and high school science
  - In some cases, sensor-based experiments illustrate concepts that would be difficult to illustrate in the absence of sensors

- Integration of real-time sensors alleviates the drudgery of manual data collection and allows students to focus on concepts to be learned
- Each school is equipped with 4 computerized setups, accommodating 4 to 5 students per setup
- Senor-based labs and Vernier's LoggerPro software allow instructors to convey the material through a wide range of learning styles:
  - Graphical user interface displays sensor measurements through which visual learners easily pick up the concept
  - Team-based tasks require group effort which ultimately benefits auditory/verbal learners
  - Hands-on lab activities aid the tactile/kinesthetic learners

To illustrate the concept of conservation of energy, a ball is tossed directly above an ultrasonic sensor which detects with precision the position and velocity of the ball throughout its path. Using this information, the potential and kinetic energy of the tossed ball can be calculated at any two or more locations to verify that the total mechanical energy is conserved.



Preliminaries

- Technical training for RAISE fellows
  - In summer 2004, RAISE fellows were provided extensive hands on training in mechatronics using Parallax Inc.'s "STAMPS in Class" educator's program
  - RAISE fellows attended a 2 week series of introductory lectures on mechatronics conducted under an NSF funded Research Experience for Teachers (RET) Site project
  - RAISE fellows learnt to use sensing and data acquisition tools of Vernier Inc. and developed high school relevant sensor-based physics and living environment labs
- Education/pedagogy workshops for RAISE fellows
  - Ms. Karen Millard, an education expert from the UFT Teacher Center, conducted a 4-day long educational workshop
  - Topics discussed:
    - Lesson planning and effective questioning techniques (pedagogical skills)
    - Student behavior and cognition
    - Learning theory and styles
    - Classroom/group management skills
    - Effective communication/presentation skills
- Technical workshop for RAISE teachers from partner schools
  - PI's organized the workshop to expose teachers to Vernier sensors and data acquisition tools
  - RAISE fellows developed material for the workshop

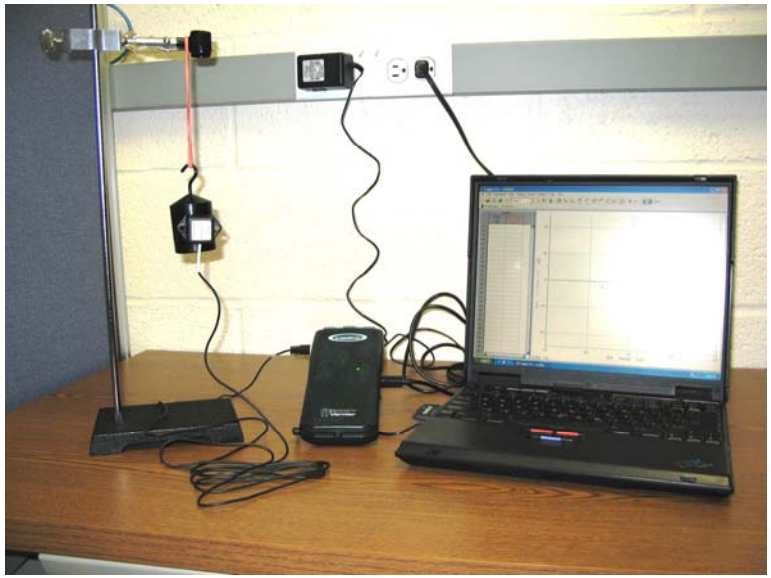
Physics Sensors

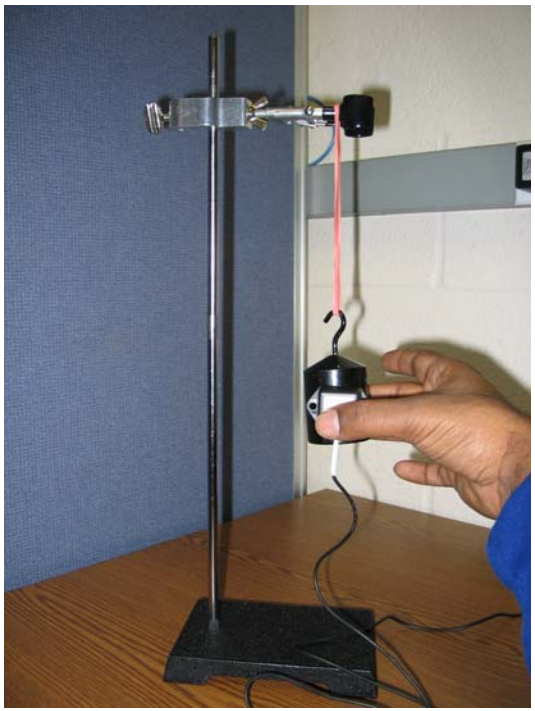
Piezoelectric material is used to generate a voltage proportional to pressure variations.  **Acoustic Sensor**	Current is determined by measuring voltage drop over a known resistance.  **Current Probe**	A conductor's resistance varies linearly under tension or compression.  **Dual Range Force Sensor**	Input voltage is compared with the output of a D/A converter.  **Differential Voltage Probe**	A photodiode is used to generate a voltage proportional to light intensity.  **Light Sensor**
Charge flowing through a conductor is deflected when a magnetic field is applied. A voltage is thus generated which is proportional to magnetic field intensity.  **Magnetic Field Sensor**	The path of an infrared light is broken by an object passing through the gate.  **Photogate**	Resistance of a conductor varies linearly with temperature.  **Temperature Sensor**	High frequency sound waves are emitted and reflected back to the sensor. Time of flight is recorded.  **Ultrasonic Sensor**	Acceleration is determined by measuring capacitance of parallel plate capacitors embedded in an IC.  **Accelerometer**

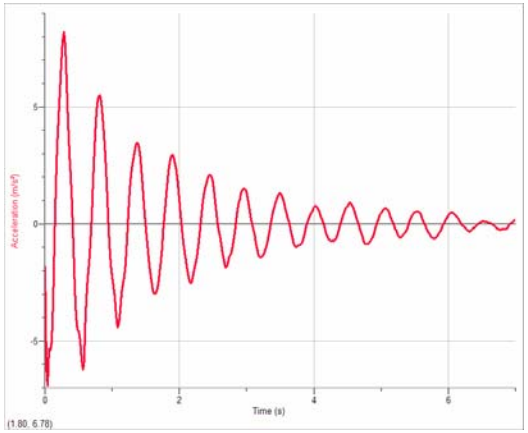
Damped Vibrations

- **Description**
  - Damped vibrations occur naturally in numerous natural and engineered systems
  - No material is ideal and thus all oscillating systems experience damping
- Accelerometer is used to observe the exponentially decreasing acceleration of a mass-spring system
- After recording the acceleration time history, system parameters (e.g. frequency and damping ratio) are obtained

Accelerometer Specifications
Range: ±50 m/s2 (±5 g)
Accuracy: ±0.5 m/s2 (±0.05 g)
Frequency Response: 0–100 Hz



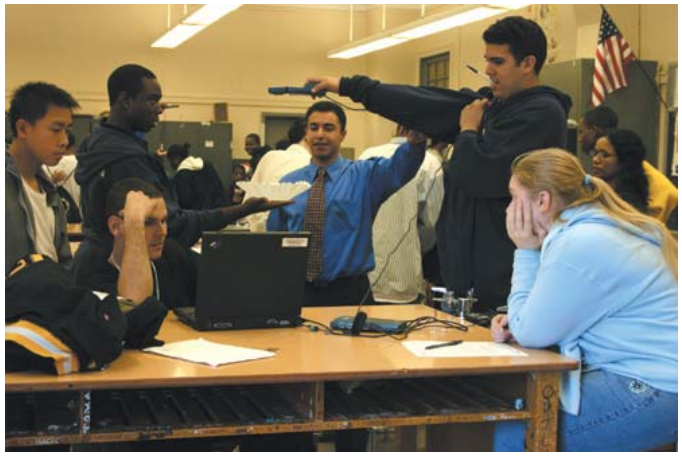




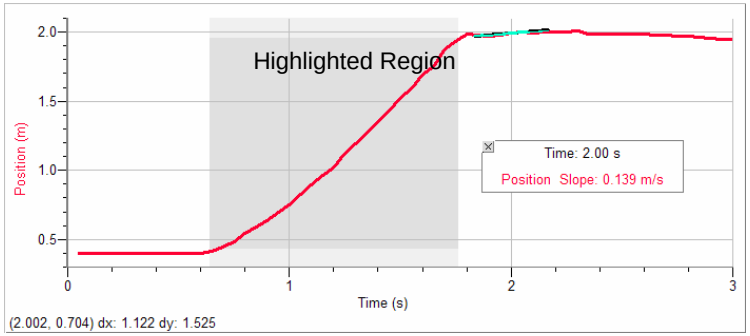
Air Resistance: Drag

- **Description**
  - **Object passing through a fluid experiences resistance acting against its velocity (drag)**
  - **At low speeds, drag is proportional to the object's velocity**
- **Ultrasonic sensor records the position time history of a free falling coffee filter**
- **Linear displacement in the highlighted region suggests constant velocity (terminal velocity)**
- **Increase number of coffee filters to find a correlation between mass of a free falling object and its terminal velocity**

Ultrasonic Sensor Specifications
Range: 0.15 to 6 m
Resolution: 1 mm

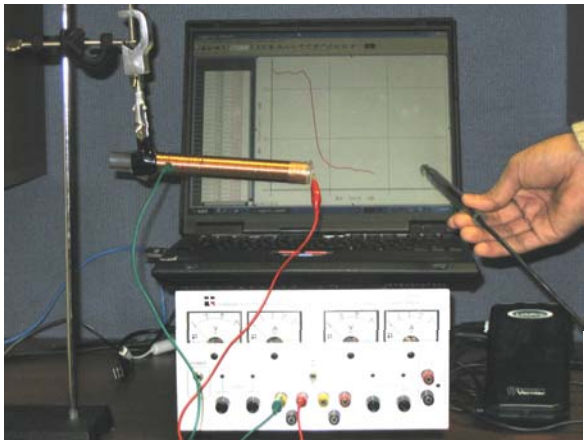


George Westinghouse students performing the experiment



Other Physics Experiments Developed

Experiment	Description
Buoyancy	A force sensor is used to measure the buoyant force of an object immersed in liquid. Knowing the submerged volume of the object the density of the liquid is obtained.
Conservation of Mechanical Energy	An ultrasonic sensor is used to determine the position and velocity of a tossed ball. Using the position and velocity at various locations, conservation of total energy is verified.
Electromagnetism	A magnetic field sensor is used to verify properties of a solenoid such as uniform field strength within the core, negligible field outside the core, direction of poles formed due to current direction, and attenuation of field as measured axially.
Freefall Acceleration	Using a photogate, the acceleration due to gravity of a free falling object is measured.
Heat Transfer	Using a temperature probe, the rate of cooling and heating of water is measured. Insulating properties of different materials are also investigated.
Projectile Motion	Two photogates are used to measure the horizontal component of the initial velocity of a ball being rolled off a table. Using this value, the range of the horizontal landings is calculated.
Simple Harmonic Motion	An ultrasonic sensor is used to measure the amplitude and frequency of a mass-spring oscillator. From this, maximum velocity and acceleration are calculated and the mathematical model of harmonic motion is verified.
Stability	A force sensor is used to pull a block until the block tips or slides. The critical forces are then computed theoretically and compared with the sensor measurements.
Static and Kinetic Friction	A force sensor is used to pull on a wooden block, sliding over a frictional surface, to determine the coefficient of static friction. Kinetic friction is determined using an ultrasonic sensor that measures the deceleration of a sliding block coming to rest.



Electromagnetism

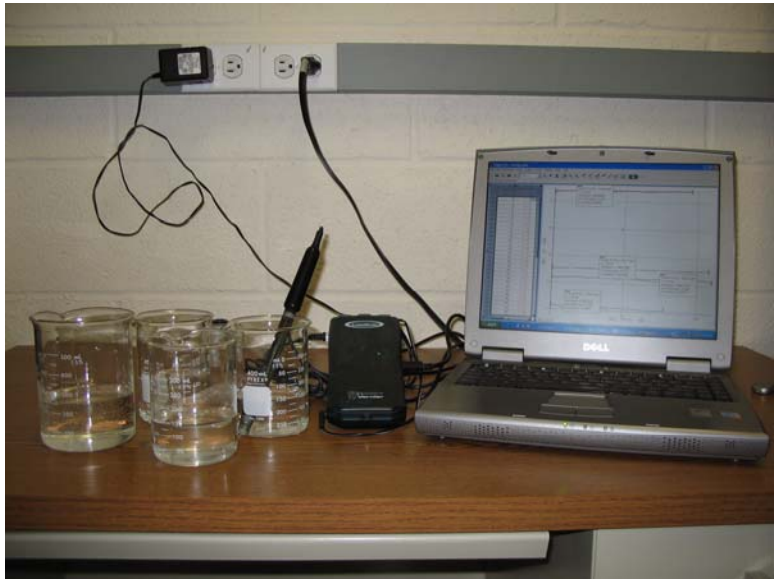
Stability

Biology Sensors

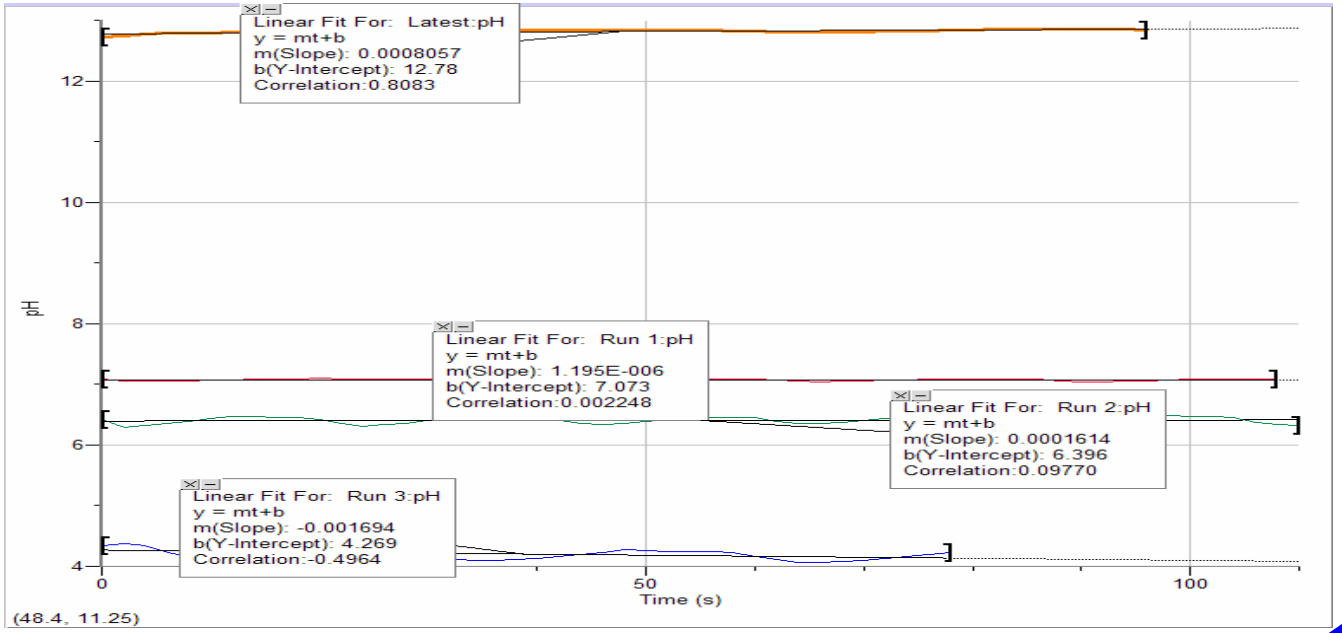
Infrared radiation susceptible to CO_2 is emitted into a region of space. Infrared detector opposite to the source measure infrared energy lost to CO_2 molecules.  **Carbon Dioxide Gas Sensor**	Light is emitted into a liquid. Intensity of light exiting liquid is then measured.  **Colorimeter**	A voltage is applied to two plates submerged into a solution. The resulting current is measured and conductivity is calculated.  **Conductivity Probe**	Oxygen is chemically reduced in water, setting up a current proportional to the rate of diffusion.  **Dissolved Oxygen Sensor**	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.  **EKG Sensor**
A membrane is deflected as pressure changes.  **Gas Pressure Sensor**	Pressure variations are measured.  **Heart Rate Monitor**	Oxygen reacts with an electrochemical cell generating a measurable current.  **Oxygen Sensor**	A chemical reaction with a gel generates a measurable voltage.  **pH Sensor**	Utilizes a gas pressure sensor to monitor respiratory patterns.  **Respiration Monitor Belt**

pH of Acids and Bases

- **Description**
  - **A liquid can be classified as either an acid or a base**
  - **Ratings are on a pH scale, which ranges from 0-14**
- **pH sensor is used to determine pH values of several acids and bases**
- **Solutions will be characterized in terms of their ability to resist pH change**



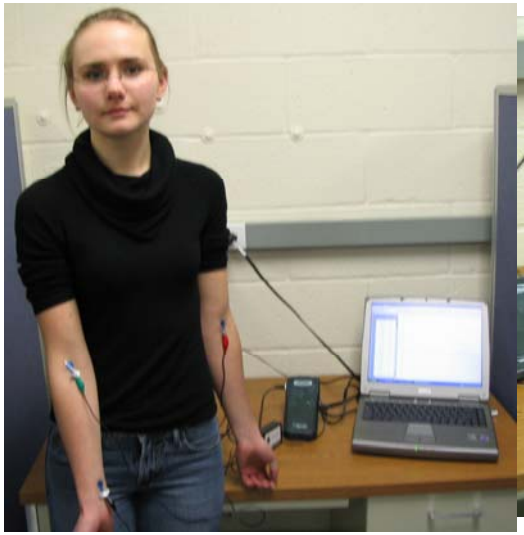
pH Sensor Specifications
Type: Sealed, gel-filled, epoxy body, Ag/AgCl
Response time: 90% of final reading in 1 second
Temperature range: 5 to 80°C
12 mm OD
Range: pH 0-14

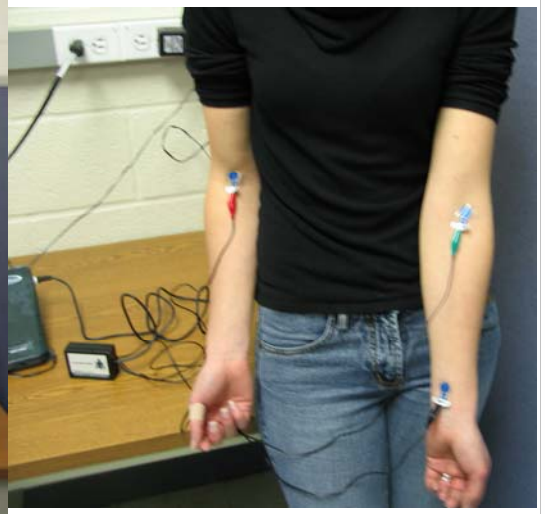


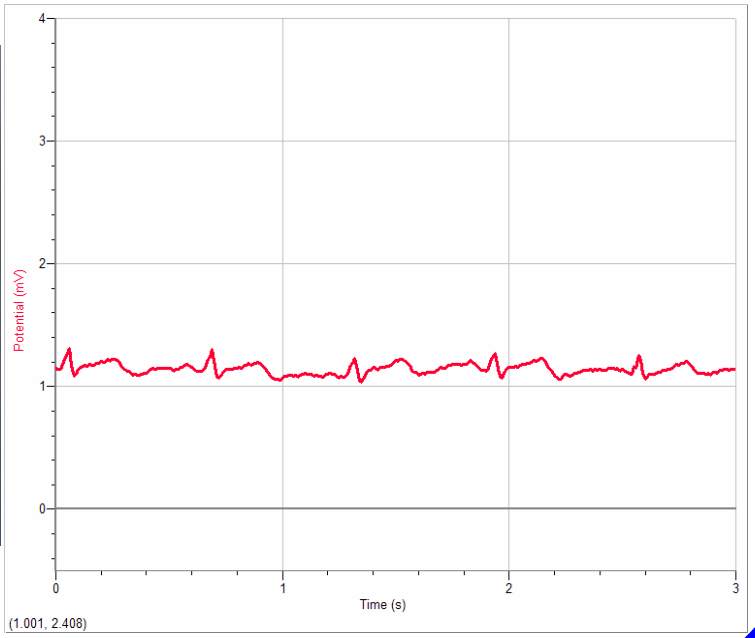
How to find our heart rate? EKG Lab

- **Description**
  - **An electrocardiogram (EKG) is a graphical representation of the electrical activity that occurs within our hearts**
- **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**

EKG Sensor Specifications
Offset: ~1.00 V (±0.3 V)
Gain: 1 mV body potential / 1 V sensor output

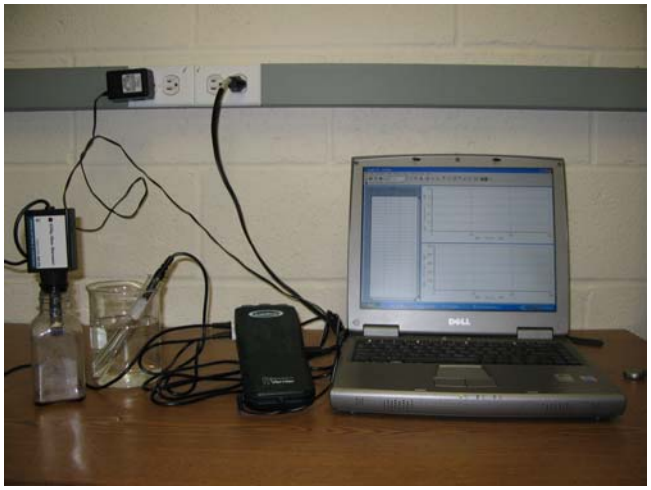




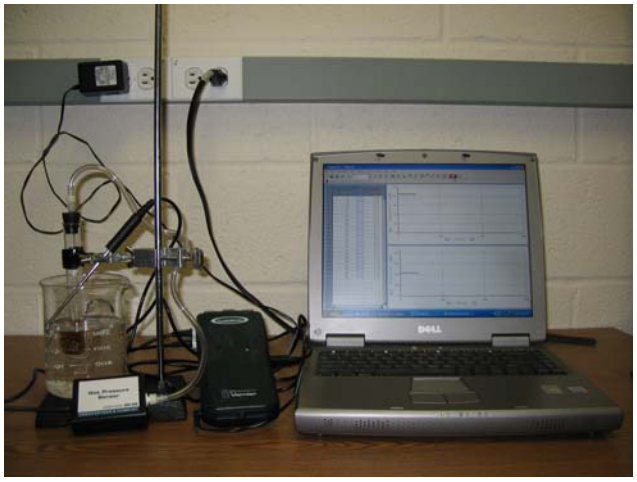


Other Biology Experiments Developed

Experiment	Description
Acid Rain	A ph sensor is used to measure the acidity of various concentrations of carbon dioxide in water.
Aerobic Respiration	A carbon dioxide gas sensor is used to determine the rate of respiration while using yeast to breakdown different sugars. The rate of respiration due to different types of sugar is also investigated.
Anaerobic Respiration	A gas pressure sensor is used to determine the rate of fermentation while using yeast to breakdown different sugars.
Cell Respiration	An O_2, CO_2, and temperature sensor is used to determine the effects of temperature fluctuations on cell respiration.
Conducting Solution	A conductivity probe is used to determine the conductivity level of different solutions. A relationship is developed between the concentration of a solution and its conductivity level.
pH Level of Shampoo	A pH sensor is used to determine the pH level of several brands of consumer hair shampoo.
Population Dynamics	A colorimeter is used to estimate the population growth of yeast.
Watershed Testing	A dissolved oxygen, temperature, conductivity, and pH sensor is used determine the quality of water.



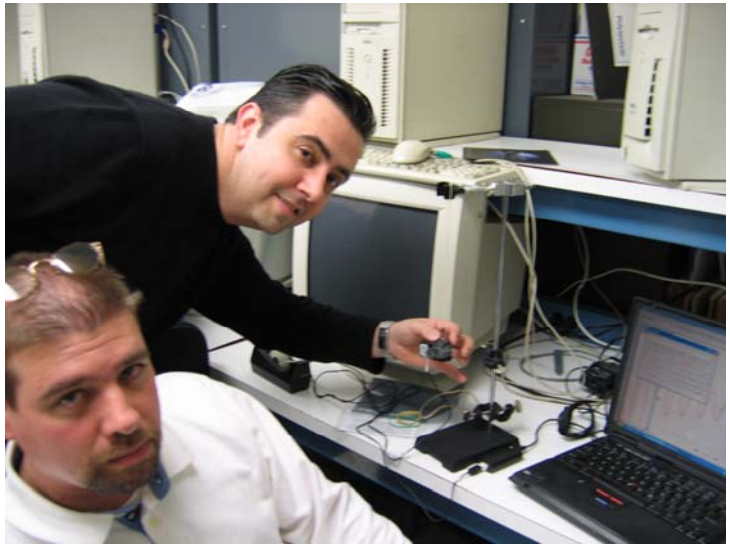
Aerobic Respiration



Anaerobic Respiration

Events

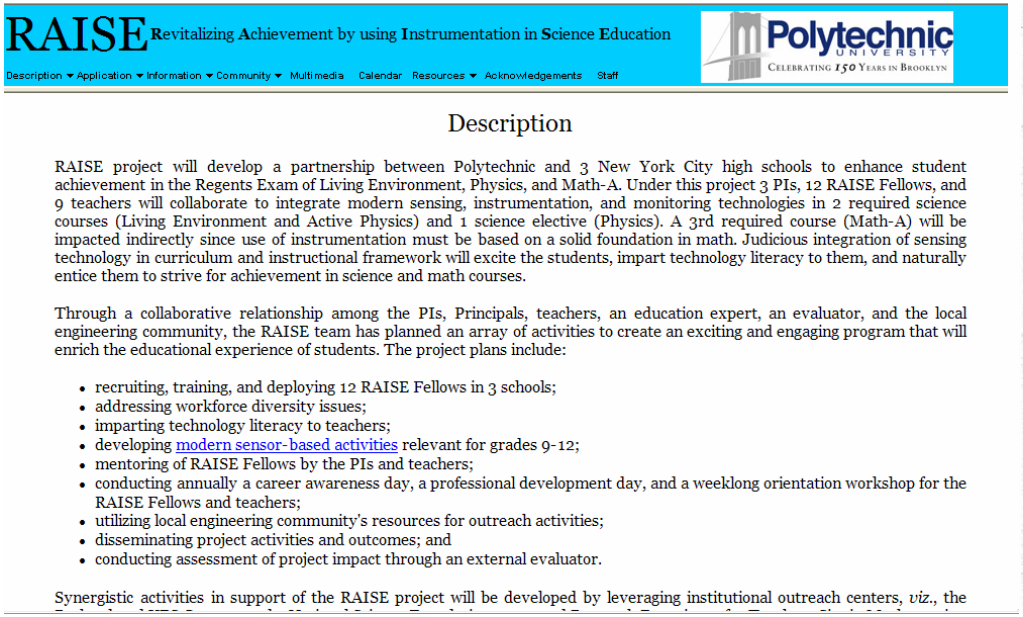
- Election day PD workshop @ George Westinghouse HS:
  - On November 2, 2004, the RAISE fellows conducted a PD day at the request of Dr. Philip Raju (Assistant Principal for Math and Science)
  - 20 teachers attended the event
- RAISE PD day workshop @ Polytechnic University:
  - Funding: NY Space Grant Consortium $12,410 and Polytechnic University $12,410
  - On January 22, 2005, 19 public school teachers participated in the event (from more than 70 who applied)
  - Teachers learnt to use sensors and instrumentation concepts, and techniques for incorporating measuring devices into their lessons
  - Participating teacher received the following equipment:
    - Vernier's Go!Link Interface, light sensor, magnetic field sensor, stainless steel temperature probe, and low-g accelerometer
  - 3 RAISE teachers assisted as "Master Teachers"
- Reviews from both PD workshops were exceptional
- Teachers commented that introduction of sensors in their classroom would be beneficial to students



Pictures from the RAISE PD day

Results

- **RAISE fellows have gained the respect of students and increased the productivity of class/lab sessions**
- **Students are finding sensor-based experiments more fascinating and easier to understand**
- **A paper submitted by the RAISE fellows to the 2005 American Society for Engineering Education (ASEE) Annual Conference and Exposition has been accepted for publication**
- **Initial reports from an independent evaluator are generally positive and are being used for program enhancement**



RAISE Revitalizing Achievement by using Instrumentation in Science Education

Polytechnic UNIVERSITY Celebrating 150 Years in Brooklyn

Description ▾ Application ▾ Information ▾ Community ▾ Multimedia Calendar Resources ▾ Acknowledgements Staff

Description

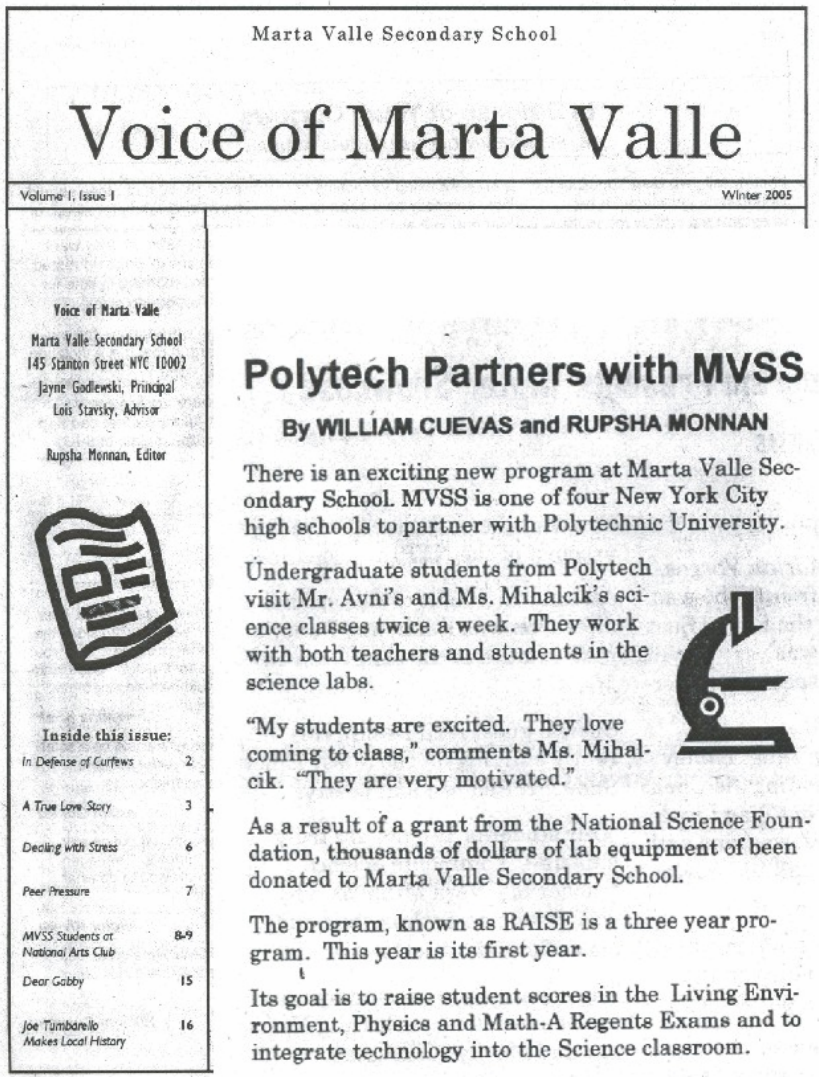
RAISE project will develop a partnership between Polytechnic and 3 New York City high schools to enhance student achievement in the Regents Exam of Living Environment, Physics, and Math-A. Under this project 3 PIs, 12 RAISE Fellows, and 9 teachers will collaborate to integrate modern sensing, instrumentation, and monitoring technologies in 2 required science courses (Living Environment and Active Physics) and 1 science elective (Physics). A 3rd required course (Math-A) will be impacted indirectly since use of instrumentation must be based on a solid foundation in math. Judicious integration of sensing technology in curriculum and instructional framework will excite the students, impart technology literacy to them, and naturally entice them to strive for achievement in science and math courses.

Through a collaborative relationship among the PIs, Principals, teachers, an education expert, an evaluator, and the local engineering community, the RAISE team has planned an array of activities to create an exciting and engaging program that will enrich the educational experience of students. The project plans include:

- recruiting, training, and deploying 12 RAISE Fellows in 3 schools;
- addressing workforce diversity issues;
- imparting technology literacy to teachers;
- developing modern sensor-based activities relevant for grades 9-12;
- mentoring of RAISE Fellows by the PIs and teachers;
- conducting annually a career awareness day, a professional development day, and a weeklong orientation workshop for the RAISE Fellows and teachers;
- utilizing local engineering community's resources for outreach activities;
- disseminating project activities and outcomes; and
- conducting assessment of project impact through an external evaluator.

Synergistic activities in support of the RAISE project will be developed by leveraging institutional outreach centers, *viz.*, the

RAISE homepage: http://raise.poly.edu



Marta Valle Secondary School

Voice of Marta Valle

Volume 1, Issue 1 Winter 2005

Voice of Marta Valle
Marta Valle Secondary School
145 Stanton Street NYC 10002
Jayne Godlewski, Principal
Lois Stavsky, Advisor

Rupsha Monnan, Editor

Inside this issue:

Polytech Partners with MVSS

By WILLIAM CUEVAS and RUPSHA MONNAN

There is an exciting new program at Marta Valle Secondary School. MVSS is one of four New York City high schools to partner with Polytechnic University.

Undergraduate students from Polytech visit Mr. Avni's and Ms. Mihalcik's science classes twice a week. They work with both teachers and students in the science labs.

"My students are excited. They love coming to class," comments Ms. Mihalcik. "They are very motivated."

As a result of a grant from the National Science Foundation, thousands of dollars of lab equipment of been donated to Marta Valle Secondary School.

The program, known as RAISE is a three year program. This year is its first year.

Its goal is to raise student scores in the Living Environment, Physics and Math-A Regents Exams and to integrate technology into the Science classroom.

From Marta Valle HS Newspaper