Vernier

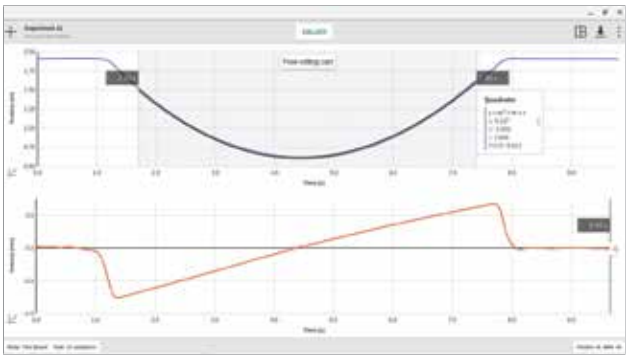
the CALIPER

FALL 2015 | VOL 32 NO.2

A PUBLICATION FOR USERS OF VERNIER PRODUCTS

in this issue

Graphical Analysis for Chrome™ Now Works with LabQuest® Mini



Motion Detector data collected using LabQuest Mini and Graphical Analysis on a Chromebook. A dynamics cart rolled up a ramp and then back down. The quadratic fit shows that the cart acceleration is essentially uniform.

Does your school use Chromebooks™? Whether you know Chromebooks inside and out or are just learning that Chromebooks do not run Windows® or Mac® software, Vernier has you covered. We have released an update of the free app, Graphical Analysis for Chrome, which is available in the Chrome Web Store.

In the Spring 2015 *Caliper*, we told you that Graphical Analysis for Chrome can collect data with a Go!Temp, Go! Motion, or Go! Link USB interface. We have now added support for LabQuest Mini, LabQuest, and LabQuest 2. Connect either LabQuest Mini or LabQuest 2 to a Chromebook via USB, and then collect time-based data from more than 40 different sensors, including a Motion Detector. Once you've collected data, you can perform curve fits and other analysis and save your data to Google Drive™. You can even export graphs for use in Google Docs™-based reports.
(continued on page 12)

Introducing the Sound Level Sensor

NEW Low-Cost Sound Level Sensor Makes Sound Experiments Easy

SLS-BTA, $69

Sound level is an engaging topic in physics, physical science, and middle school classes, and it just got easier—and less expensive—to explore! Use the new Sound Level Sensor to quickly and accurately measure sound level readings in a variety of environments.

As a follow up to the sound study we described in the Spring 2015 *Caliper*, we took our new Sound Level Sensor around the Vernier office to measure reverberation times in various rooms, including our classroom. In each case, we turned on a radio that was tuned to produce white noise, started data collection, and then quickly turned off the radio. The reverberation time is the time required for the sound level to drop by 60 dB (a factor of a million). In most situations, the sound level does not drop that far because background sounds create a noise "floor." However, by using Logger *Pro* to apply a linear fit to the falling sound level data, we were able to estimate the reverberation times for several rooms. *(continued on page 4)*

Video Analysis Tips: Shooting Good Video

Still frame from a video of a student throwing a basketball outdoors

Students doing video analysis of everyday motion can be a great way to bring physics into the real world. Due to the quality of some students' videos, they are sometimes difficult to analyze. Here are some tips for recording good videos for analysis:

1. **Support the phone or camera to keep it still.** Use a tripod, tape the phone to a box, or find another way to avoid the shakiness of hand-held video. This will also prevent the tendency to follow the motion with the camera.

2. **Record the event in a well-lit area.** Outdoors in daylight is the ideal environment, as even an overcast sky can provide more light than can be found indoors. However, going outside is not always practical. Old overhead projectors can provide a bright light that has no flicker, even when filming in high speed. The brighter the lighting, the less motion blur you will see in the video.

3. **Position the camera so the line of sight is normal to the plane of motion.** Ideally, all the motion would take place at a constant distance from the camera, but that is nearly impossible to achieve. Therefore, arrange the scene to have as little distance variation as possible. This is to make sure the scale you choose applies to as much of the motion as possible.

4. **Place a ruler, meter stick, or other scale item in the same plane as the motion being recorded.** Having the scale object at that same distance eliminates parallax error in scaling.

These and additional tips can be found at www.vernier.com/til/1464

AAPT Photo Contest

The 2015 AAPT Photo Contest, sponsored by Vernier, was held at the summer meeting of the American Association of Physics Teachers in College Park, Maryland. Students submitted photo prints that demonstrated physics concepts, along with essays explaining the physics concepts. AAPT members voted on the entries. Each year we are impressed by the creativity of the students who enter this contest. The eye-drawing composition of many of the images reminds us that art has both an important role in our lives and a valuable connection to science.

The winner in the Contrived Category is Kaylee Carr, who illustrated concepts of static equilibrium and center of mass in her photo Coin Bridge.

Emily Kurburski won the Natural Category with Waves of Winter, *an image of snow deposited by varying wind speeds caused by the presence of a building.*

For details about the contest, and to see all the photo winners for 2015, go to www.vernier.com/r153

NEW Vernier Circuit Board 2

VCB2, $129

The original Vernier Circuit Board has been updated to include more components and to provide more versatility for basic circuit experiments.

While the footprint of the Vernier Circuit Board 2 has the same dimensions as the original version (10 in. × 6.5 in. [25.5 cm × 16.5 cm]), the new board packs more experimental options into the space.

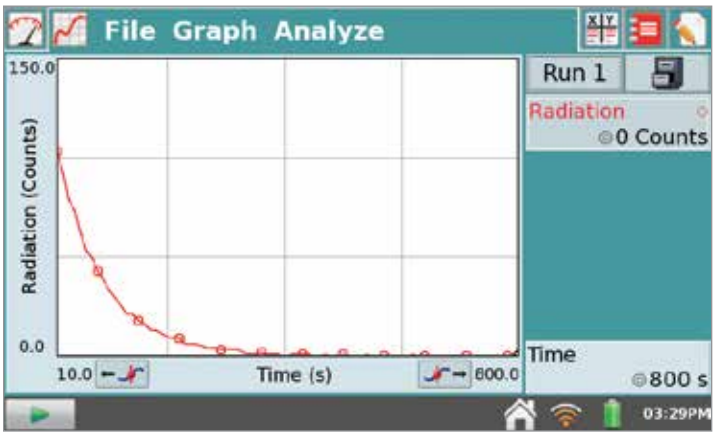
Improvements to the circuit board include
- Two capacitors instead of one
- Integrated inductor for RLC circuits
- The addition of a 1 kΩ potentiometer and a buzzer
- The option to use the LabQuest power supply (LQ-PS, $11) as a power source
- The option to use 1, 2, 3, or 4 AA batteries as a power source
- Speaker-style terminals instead of binding posts for connecting other components
- The option to add a small breadboard

The Vernier Circuit Board 2 comes with five #48 light bulbs (cylindrical, 2.0 V), five #50 light bulbs (round, 7.5 V), and 10 alligator clip leads. For more information, visit www.vernier.com/vcb2

Radiation Half-Life Simulator

The *Nuclear Radiation with Vernier* lab book has an experiment on measuring the half-life of radioactive isotopes. While it is a good experiment, the Cesium/Barium Isogenerator required to provide the short half-life radioactive material is expensive. The cost is over $230, and some instructors may have concerns about bringing radioactive sources into the classroom.

Richard Born, a retired professor from Northern Illinois University and a frequent contributor to this newsletter, devised a clever way to simulate this experiment using a SparkFun Redboard, an Arduino™-compatible board (ARD-RED, $25), and the Vernier Arduino Interface Shield (BT-ARD, $25). Dr. Born has written a program (called a sketch) that is loaded on the Arduino. The Arduino is connected to a Vernier interface using a Motion Detector cable (MDC-BTD, $5). This is all you need to collect very realistic radioactivity data. The simulation randomly selects one of several different simulated isotopes. The graph shows one sample run.



Data from a single simulated isotope

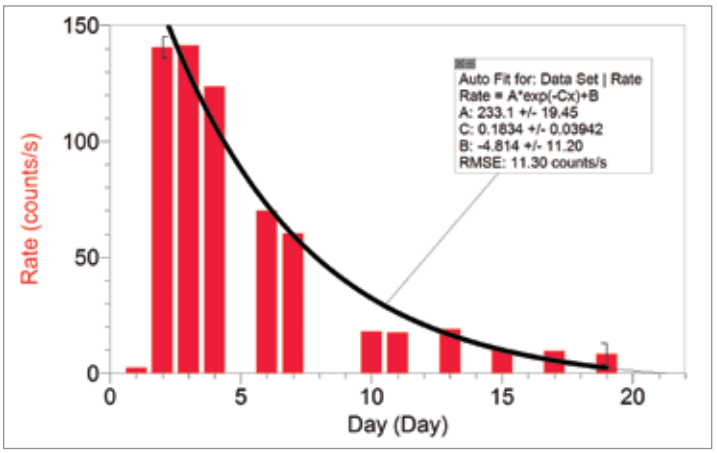
This simulation can also be used with Logger *Pro* or LabQuest App with a LabQuest or LabPro interface. A student handout, teacher notes, and the Arduino sketch needed is available at www.vernier.com/r154

Radioactive Kitty

By Gretchen Stahmer DeMoss

Rico, our 12-year old cat, was recently diagnosed with hyperthyroidism. Hyperthyroidism is a common endocrine disorder that is prevalent among older cats. A tumor in the thyroid gland causes overproduction of thyroid hormones, including thyroxine. Elevated thyroid hormone levels cause an increased metabolic rate, which puts stress on the heart, kidneys, and other organs. Treatment options include radioactive iodine (I-131), a lifetime of anti-thyroid medication, or surgery. We opted for I-131 treatment for Rico.

I-131 treatment involves intravenous administration of radioactive iodine. The cat and its waste are considered highly reactive for 7–14 days after treatment, so the treatment must be done at a specialized veterinary clinic. The half-life of I-131 is a little over 8 days. Rico stayed at the vet clinic for 10 days after his treatment.



For the next 18 days, a Vernier Radiation Monitor (VRM-BTD, $169) was used to collect 1800 s of data each day. The graph shows background radiation data in the house before Rico's return (Day 1). Day 2 shows the radiation count rate with the monitor placed next to his body. Measurements were made at approximately the same time of day with the radiation monitor in about the same orientation. (Note: Sometimes cats aren't cooperative during scientific investigations.) Data show an exponential decay over subsequent days. The fit corresponds to a half-life of about 4 days, different from the expected 8 days. We expected to measure a half-life somewhat less than the direct half-life of I-131, since the cat was losing I-131 by both radioactive decay and excretion of waste.

Rico's T_4 levels, the amount of circulating thyroxine in the bloodstream, were significantly lower at his one-month and three-month post-treatment blood tests. We're hoping his hyperthyroidism is gone for good.

Vernier in the Physics Journals

Using Research-Based Interactive Video Vignettes to Enhance Out-of-Class Learning in Introductory Physics

Priscilla W. Laws, Maxine C. Willis, David P. Jackson (Dickinson College), Kathleen Koenig (University of Cincinnati), and Robert Teese (Rochester Institute of Technology), *The Physics Teacher,* v53, #2 (Feb 2015), 114–117.
The authors explain how to use a series of short videos to enhance a physics class. The vignettes are based on physics education research and are distributed as free open-source software.

Light-Emitting Diodes: Solving Complex Problems

Gorazd Planinšič (University of Ljubljana and The House of Experiments, Slovenia) and Eugenia Etkina (Rutgers University), *The Physics Teacher,* v53, #5 (May 2015), 291–297.
This is the fourth in a series of articles by the authors on LEDs. The series, all of which can be found in *The Physics Teacher*, is a complete collection of uses for LEDs in physics teaching.

Introducing the Sound Level Sensor

(continued from the front cover)

Table of Reverberation Times		
Room	**Description**	**Reverberation Time**
Office	Small, carpeted, enclosed	0.5 s
Cubicle	Open, carpeted, high ceiling	0.75 s
Classroom	Large, rubber floor, "sound clouds" installed to dampen reflections	0.9 s

With the release of this new sensor, we have expanded our options for collecting sound-based data to include both the Sound Level Sensor and the Sound Level Meter (SLM-BTA, $165). The Sound Level Sensor is quick and easy to use and has a range of 60 to 110 dB, which covers the sound levels in a typical classroom. Its response is A-weighted, meaning it responds like the human ear to loudness, and it is accurate to ±3 dB. If you need a wider range (35–130 dB), greater accuracy (±1 dB), or a C-weighted response, the Sound Level Meter is the better choice.

Let There Be Less Light

An Environmental Engineering Challenge

We've all heard about light pollution and have seen images of the Earth at night. City streetlights are part of the problem, but they are also important for safety on our streets. Can anything be done to strike a balance? Christine O'Neill and Donna Mack, teachers at Lied Middle School in Las Vegas, NV, challenged their students to do just that. In small groups, students designed covers for streetlights to minimize light pollution, while maximizing illumination on the street below. They were also challenged to make their covers low cost, attractive, and innovative in their design and construction.

A Light Sensor is used to measure illumination under a model streetlight cover.

Students first investigated the reflectivity of various materials, such as colored paper and aluminum foil, using LabQuest 2 and a Light Sensor. Based on these data and their knowledge of light pollution, the groups designed covers for their streetlights, represented by flashlights. Paper and plastic cups, tape, yarn, foil, colored paper, Popsicle® sticks, plastic lids, cupcake wrappers, and straws were used to construct their designs.

Once the first prototypes were completed, the students used LabQuest 2 and a Light Sensor to assess the effectiveness of their design. To allow direct comparisons between student groups, all measurements were taken at 15 cm above the light, at light level, and at ground level. The iterative process of redesign and retesting allowed students to fully engage in engineering practices to refine their products.

On the final day, each group presented their cover to the class. Their classmates evaluated each design based on the criteria stated above.

The combination of physical science concepts and engineering practices makes this design challenge an outstanding learning experience. While originally developed for middle school students, the challenge could easily be tailored to students of any age.

4-H National Youth Science Day 2015

Motion Commotion Experiment Uses Video Physics App

This year's National Youth Science Day experiment was submitted by Oregon 4-H in collaboration with Oregon State University and Vernier. The experiment, "Motion Commotion," relates speed, stopping distance, and reaction time. Participants have the option of using the Video Physics app for iOS to analyze the motion of a toy car moving down a ramp and coming to a stop on a level surface.

Since 2008, the National 4-H has held a National Youth Science Day, in which 4-H members across the country do an experiment and learn science outside of their school classrooms.

This year's National Youth Science Day will be Wednesday, October 7th. To learn more about the 4-H National Youth Science Day, go to www.4-h.org/4-h-national-youth-science-day

Put the "E" in STEM

Using the Vernier Structures & Materials Tester to Study the Deflection of a Center-Loaded Beam

Engineering design is becoming an integral part of K–12 science courses, as well as high school and college engineering curriculum. Understanding the properties of the materials you are working with is an important component of engineering design.

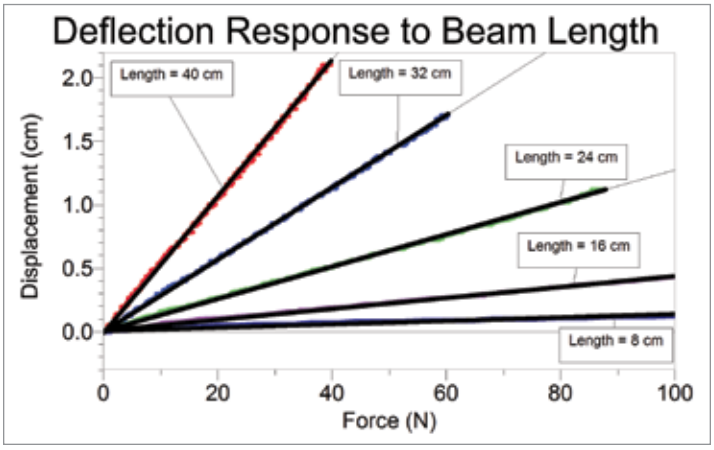
Richard Born, from Northern Illinois University, has developed a lab using the Vernier Structures & Materials Tester (VSMT, $999) to explore an aspect of the properties of materials. His investigation outlines the methodology for students to perform inquiry activities to determine the relationships of factors affecting the deflection of a rectangular center-loaded beam supported at both ends. The relationship that models these factors for a rectangular beam is

$$\Delta = \frac{FL^3}{4Ebh^3} ,$$

where Δ is the beam's elastic displacement at mid-span, *F* is the load, *L* is the span length, *E* is the modulus of elasticity, *b* is the width of the beam, and *h* is the height. This equation provides a perfect opportunity for students to experimentally investigate power relationships.

Students will understand most of the terms from prior experience, but they may need support to equate the modulus of elasticity to the type of material being used. From that point, students can design experiments to determine the actual model noted above, without knowledge of the equation. This allows students to engage in a variety of elements related to the NGSS Science and Engineering practices, including

- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data



Students determine how much data they will collect and how they will manage to isolate a single factor for evaluation. They can use Logger *Pro* to collect and analyze data and apply curve fitting techniques to determine the relationship between these factors and the deflection of the beam. It is a prime opportunity to demonstrate the value of dimensional analysis, as well.

For complete details, download the Innovative Use "Inquiry Investigation of Factors Affecting Deflection of a Center-Loaded Beam" at www.vernier.com/vsmt

Integrating Engineering Activities into Your Science Curriculum

The Next Generation Science Standards (NGSS) place a renewed focus on engineering practices and creative problem-solving in science curriculum. We've added and updated many activities on our website to make it easier for you to include engaging engineering activities in your classroom.

Science labs traditionally focus on a particular principle and specify which tools to use in the investigation. Engineering activities, on the other hand, typically present a problem and challenge students to apply creativity, scientific principles, and tools at their disposal to solve it. Including engineering activities in your science curriculum increases student engagement, provides context for science learning, offers an alternative form of assessment, and teaches problem-solving skills.

Whether you teach physics, chemistry, or biology, we have several engineering activities for you to include in your curriculum, depending on your needs and interests:

- **KidWind:** As a full science and engineering solution focused on renewable energy, the KidWind lab books, equipment, and competitions make it simple to add engineering projects into your classroom. www.vernier.com/kidwind
- **Bridges and Structures:** Bridge building is a popular engineering challenge and the Vernier Structures & Materials Tester (VSMT, $999) is a great way to collect and analyze data during testing. Check out the article "Deflection of a Center-Loaded Beam" in this edition of *The Caliper* for an example of the types of data analysis activities you can do with the VSMT. www.vernier.com/vsmt
- **Engineering Extension Activities:** These simple, single-class period engineering challenges are easy to drop into your current science curriculum. Students brainstorm ideas, build simple circuits, and test their creations. www.vernier.com/engineering/science-classrooms/extensions
- **Build Your Own Sensor Activities:** These more complex activities lead your students through the construction and testing of their own sensors. Students will gain a greater understanding of the capabilities and limitations of the scientific tools they use in your lab activities. www.vernier.com/engineering/science-classrooms/sensors
- **Engineering Projects:** Each of these engineering tasks covers a variety of science topics and requires multiple class periods. Students practice the entire engineering process as they address real-world challenges. www.vernier.com/engineering/science-classrooms/projects

Activities from each option include a variety of support materials, depending on the activity, but always include at least a student handout and comprehensive teacher information. Check them out. We bet you will find one you can use in your classroom this year.

Using Arduino™ and VPython to Explore PID Control

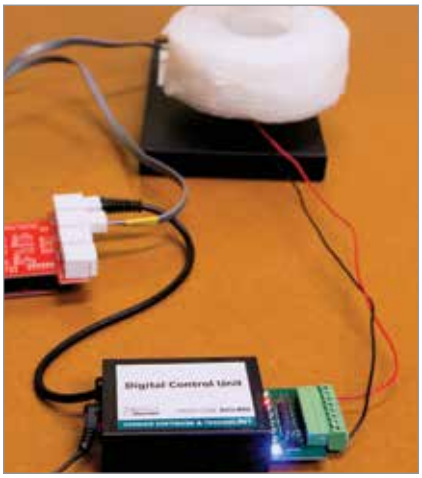
By Tom Smith

It started as an off-hand challenge. While observing a ping pong ball suspended in a clear tube below a Motion Detector and buoyed by a small fan—a favorite demonstration of how we can use our sensors with NI LabVIEW™ software—Dave Vernier said, "You know, I bet we could do this with an Arduino. Maybe you should look into that!"

I started with a quick refresher on Proportional, Integral, and Derivative (PID) control. Each of these components evaluates a characteristic of the difference between the set point and the location of the actual measured value. In my case, the set point was the height I wanted the ball to be in comparison to the actual location, as measured by the Motion Detector.

- Proportional takes into account how far off you are from your set point—the bigger the difference, the bigger the change in my fan speed.
- Integral considers the time and distance the ball is from the set point.
- Derivative looks at how fast the ball is responding.

These different factors are weighted (or tuned) and added together to create an algorithm to drive the fan speed.



I mounted the Vernier Arduino Interface Shield (BT-ARD, $25) onto the SparkFun® RedBoard (ARD-RED, $25) and then attached my Motion Detector (MD-BTD, $79) and Digital Control Unit (DCU-BTD, $61). The DCU was used to control the fan. With the physical setup and PID control research complete, I began programming.

Not feeling compelled to start from scratch, I copied our Arduino Sketch for the Motion Detector and searched the Arduino website (www.arduino.cc) for existing sample code. If you aren't familiar with the Arduino website, it has a wealth of libraries and sample code ready to be used. There was a PID Library in their reference materials that included a helpful tutorial advising how to import it. It took a little tinkering, but it was soon up and running.

I also found tutorials by Top Tech Boy for combining VPython with Arduino code. You can view those tutorials at www.toptechboy.com/using-python-with-arduino-lessons/

Eager to watch a visual representation of my PID-controlled floating ping pong ball, I ate lunch at my desk while I figured out how to get my real-time data into VPython.

Here's what I learned:

1. It is really easy to connect Vernier sensors and the DCU to an Arduino for creative and exciting projects.
2. There are a lot of easy-to-implement solutions for most any application using Arduino. You don't have to learn everything all at once. Many users share their code online to help other users get started. You and your students are bound to learn a thing or two in the modification process.
3. You never know where a project like this will take your students (or you)!

For more ideas of how to get started, go to www.vernier.com/engineering/arduino

Vernier Engineering Award

Win a $5,500 Award from Vernier

Tell us how you are using Vernier sensors in the classroom to teach engineering concepts and engineering practices, and you could win one of three $5,500 awards (one for middle school, one for high school, and one for college).

Are your students using Vernier sensors in the engineering design process? Maybe you are challenging your students to control digital output based on sensor input. Are you testing trusses and building bridges? Perhaps your students are writing NI LabVIEW™ or ROBOTC® code to read a Vernier sensor from a robotics platform such as LEGO®, VEX®, or Arduino™. Tell us about it so that you might win!

Each award will consist of $1,000 in cash, $3,000 in Vernier technology, and $1,500 toward expenses to attend either the 2016 NSTA STEM conference or the 2016 ASEE conference.

For complete rules, examples from past winners, and to submit an online application, go to www.vernier.com/grants/engineering

Map Data Using ArcGIS Online

Using Geographic Information System (GIS) software to map data can be a very effective tool for analysis. The steep learning curve with some GIS software can be intimidating. Fortunately, the free online version of ArcGIS from Esri is easy to use with data collected on LabQuest or LabQuest 2.

To illustrate, we investigated how temperature and light vary within Gabriel Park in southwest Portland. Temperature, illumination, latitude, and longitude, along with several other parameters, were recorded at each of five sites using the Data Matrix data-collection mode of LabQuest 2. The data were imported into Logger *Pro* computer software, then exported to the computer's desktop in GIS format.

At the Esri website, www.arcgis.com, we clicked on the Map button, then simply dragged and dropped the exported data file onto the resulting map. Symbols, with sizes determined by the magnitude of the *attribute*, e.g., temperature in the first figure, automatically populated on each site. The Base Map Gallery button allowed us to choose this satellite image.

The size of the circles in this graphic display shows at a glance that the tennis court was the warmest site and that the forest site was the coolest. Clicking on a site displays all the attribute data for that site. In this case, the forest site data included: illumination, 598 lux; relative humidity, 44.09%; UVB intensity, 17.30 mW/m^2; temperature, 23.80°C, UVA intensity, 170 mW/m^2; latitude, 45.47°; longitude, –122.72°; and altitude, 119.90 m.

With only two clicks, we changed the displayed attribute to illumination, creating the second figure. The yellow circles, representing the magnitude of illumination, show that the tennis court, meadow (east southeast of the tennis court), and garden (near the bottom of the image), had roughly the same amount of sunlight. Yet, we know the tennis court was the warmest site based on the first figure. Why were the meadow and garden cooler than the tennis court when they all received the same amount of sunlight? This is the type of question that GIS can help students answer.

For more details on mapping your data, see www.vernier.com/til/2802

Request a free ArcGIS Online organizational subscription for your school at www.esri.com/ConnectED

Vernier Sponsors NABT Ecology/ Environmental Science Teaching Award

Each year, Vernier sponsors the NABT Ecology/Environmental Science Teaching Award. The award includes $500 toward travel to the NABT Professional Development Conference and $1,000 of Vernier equipment. Applications for the 2016 Award will be available on the NABT website soon after the November conference, and the deadline for submission is March 15, 2016. Details can be found at www.vernier.com/grants/nabt

How Do You Use Vernier Technology?

Kick off the new school year by sharing how you use Vernier technology in your classroom or laboratory. Use the hashtag **#VernierST** or tag us and we'll repost or retweet our favorites throughout the fall.

@verniersoftware
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Vernier Software & Technology
www.facebook.com/VernierST

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NEW Sensors for Chemistry

Two exciting new chemistry products offer greater versatility for your college chemistry investigations.

Pressure Sensor 400

Our new Pressure Sensor 400 accurately measures absolute pressures from 0 to 400 kPa over a wide temperature range. The robust, metal fittings allow for a tight, leak-proof seal between the sensor and your reaction apparatus.

PS400-BTA, $189

The accessories kit that comes with the sensor includes:
- double-barbed, brass connector to fit flexible tubing
- nickel-plated-brass, push-to-connect connector to fit more rigid tubing
- two-foot section of rigid nylon tubing
- two-foot section of flexible PVC tubing
- tightening wrenches and plumber's tape to ensure a tight seal

Additional product information can be found at www.vernier.com/ps400-bta

Platinum-Cell Conductivity Probe

The two-cell, platinum sensing element and epoxy body of the Platinum-Cell Conductivity Probe ensures greater chemical compatibility when measuring the conductivity of stronger acids and bases and non-aqueous solutions. It has a range of 0 to 2000 µS/cm, and a switch to turn on and off temperature compensation, making it possible to investigate conductivity as a function of temperature. The Platinum-Cell Conductivity Probe is easy to use with its plug-and-play operation and has excellent accuracy. Two experiments for this probe, "Kinetic Analysis of the Hydrolysis of Ethyl Acetate" and "Investigating Fundamental Concepts in Solution Conductivity," are available for free download at www.vernier.com/conpt-bta

CONPT-BTA, $149

If you have questions about these new chemistry products, contact chemistry@vernier.com

General Tips for Using Ion-Selective Electrodes

Vernier offers five Ion-Selective Electrodes (ISEs):

- Ammonium (NH_4^+)
- Potassium (K^+)
- Calcium (Ca^{2+})
- Nitrate (NO_3^-)
- Chloride (Cl^-)

ISEs require careful use; follow these guidelines for best results:

- Calibrate ISEs very carefully and often. Two calibration standards ship with each ISE. It is important to soak the electrode in the High Standard solution for at least 30 minutes prior to calibration. If, at any time, the reported reading is a constant 1.0 mg/L (and the electrode is not in a 1.0 mg/L solution), you need to recalibrate.
- Be certain that your standards are uncontaminated. Because the High Standard is 100 times more concentrated than the Low Standard, it is very easy to cross-contaminate the solutions. To keep your standards from being contaminated, thoroughly rinse and blot dry the sensor tip prior to placing it in a standard. You can purchase fresh standards from Vernier or make your own using the instructions found in the sensor booklet.
- If you know the approximate concentrations of your samples, you will save time if you analyze them from lowest concentration to highest. If there is great variation in concentration from one sample to the next, it can take several minutes for the reading to stabilize.
- Choose a specific time at which to calibrate and take your reading for each sample. For example, if you calibrate when the ISE has been in a solution for 60 seconds, you should also collect data for your samples after the sensor has been in the sample for 60 seconds.
- The ISE actually measures voltages and then converts the voltage values to concentration values. This conversion is logarithmic, so keep in mind that a small voltage change can cause a large variation in the concentration reading.
- Replace the membranes of the Nitrate, Calcium, Potassium, and Ammonium ISEs as needed. Each of these ISEs has a PVC membrane with a limited life expectancy; depending upon the amount of use and how well they were taken care of, the membranes should give good readings for 1–2 years. If you notice distinctly different voltages or slowed response during calibration, it is probably time to replace the membrane module. The replacement modules have a limited shelf-life, so they should be purchased immediately prior to use.

If you have additional questions, email us at chemistry@vernier.com

Vernier in the Chemistry Journals

Using Conductivity Measurements To Determine the Identities and Concentrations of Unknown Acids: An Inquiry Laboratory Experiment

K. Christopher Smith and Ariana Garza
***J. Chem. Educ.* Article ASAP (As Soon As Publishable)**
Publication Date (Web): May 8, 2015
This article describes a student-designed titration experiment that uses LabQuest and a Conductivity Probe to identify unknown acids as being either HCl or H_2SO_4 and to determine the concentrations of the acids. Using an inquiry context, students gain experience with titrations, conductivity, procedural design, and analysis of results. The experiment is suitable for advanced high school or college-level general chemistry students.

Decay Kinetics of UV-Sensitive Materials: An Introductory Chemistry Experiment

Garrhett Via, Chelsey Williams, Raymond Dudek, and John Dudek
***J. Chem. Educ.* 2015, 92, 747–751**
A procedure that provides an innovative approach to undergraduate chemistry kinetics experiments is described in this article. Logger *Pro* and a SpectroVis Plus Spectrophotometer with the SpectroVis Optical Fiber are used to measure the reflection spectrum from an incandescent bulb off of a UV-sensitive bead or thread, both in its excited state (immediately after UV irradiation) and unexcited state (only incandescent illumination). First-order kinetic decay rates are obtained by measuring the time-dependent reflection spectra of ultraviolet sensitive objects as they return from their excited, colored state back to their ground, colorless state.

Demonstrations of Frequency/Energy Relationships Using LEDs

Graham T. Cheek
***J. Chem. Educ.* 2015, 92, 1049–1052**
In this article, the use of LEDs (light-emitting diodes) to demonstrate the relationship between frequency (or wavelength) and semiconductor energy level differences is described. LEDs can function as light detectors, and this ability is exploited to show the minimum light frequency needed to produce a voltage response in an LED. The light sources can be other LEDs or a flashlight with colored filters. A SpectroVis Plus Spectrophotometer with a SpectroVis Optical Fiber was used to measure visible LED wavelengths when nominal values were not available.

Boiling Water Demo: Much More than Meets the Eye

Jean Weaver
***Chem13 News*, 2015, 415, 8–9**
This article presents a demonstration to help students understand what happens at the microscopic level when water warms and boils. The setup uses Logger *Pro* and a Stainless Steel Temperature Probe to monitor the temperature of a beaker of water heated by a hot plate. The author explains how the activity allowed students to think critically about the relationship between kinetic energy, potential energy, heat, and temperature.

Which pH Sensor Should I Buy?

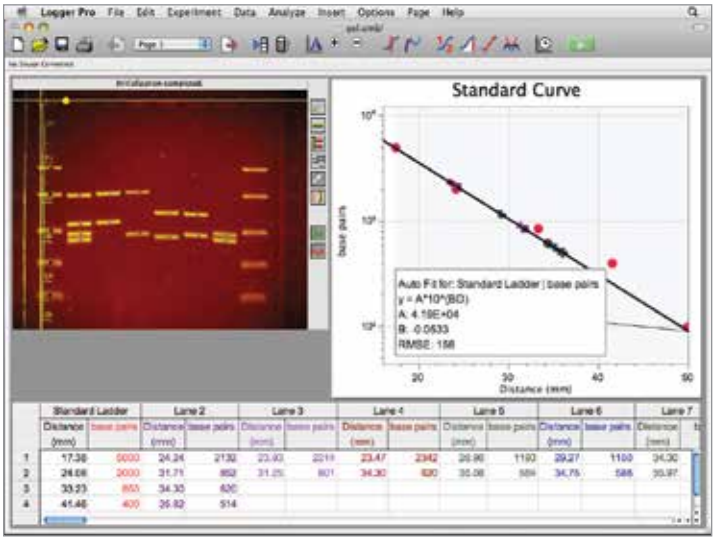
Years ago, in simpler times, if you wanted to buy a pH sensor from Vernier, there was one choice—the Vernier pH Sensor. These days, you have five options (including, still, the Vernier pH Sensor). All of our pH sensors have similar accuracy, response, and sensitivity, so which one should you buy? It depends on how and where you plan to use your pH sensor. Here is some information to help you choose wisely.

Electrode	Amplifier included?	Features
Vernier pH Sensor (PH-BTA, $79) 	Yes (built-in)	• Best choice for general use • Measure pH in aqueous solutions (e.g., observe acid-base titrations, monitor an aquarium, or investigate water quality in a stream or lake)
pH Electrode BNC (PH-BNC, $41) 	No*	• Detachable electrode makes replacement less expensive • Measure pH in aqueous solutions
Vernier Go Wireless® pH (GW-PH, $99) 	Yes (detachable)	• Collect pH data wirelessly • Measure pH in aqueous solutions
Tris-Compatible Flat pH Sensor (FPH-BTA, $99) 	Yes (detachable)	• Double-junction electrode allows measurement of the pH of solutions containing proteins, sulfides, or Tris buffers • Flat shape of the sensor tip makes it easy to clean, allows for smaller sample sizes, and measurement of pH of semisolids (e.g., food or soil slurries)
Glass-Body pH Electrode (GPH-BNC, $85) 	No*	• Measure the pH of aqueous and non-aqueous solutions • Can be used in solutions containing organic solvents and in highly concentrated acids or bases

* Electrode Amplifier (EA-BTA, $40) or Go Wireless Electrode Amplifier (GW-EA, $79) is required

To learn more, visit www.vernier.com/ph-sensors

What Vernier Technology is Available for Biochemistry?



If you teach biochemistry, you will find numerous Vernier experiments and products that can fit into your curriculum. Common experiments performed in introductory biochemistry labs include acid/base chemistry and buffer preparation, protein and enzyme purification, enzyme activity assays, analysis of carbohydrates and lipids, and gel electrophoresis. Experiments that cover many topics, such as the examples in the following table, are found in the following lab books: *Advanced Biology with Vernier*, *Advanced Chemistry with Vernier*, and *Organic Chemistry with Vernier*.

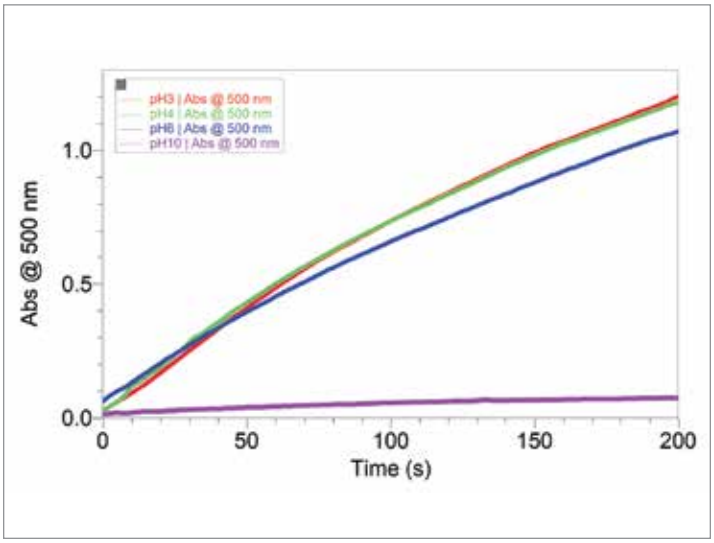
Topic	Vernier Equipment	Experiment
Acid/base chemistry and buffer preparation	pH Sensor (PH-BTA, $79) 	Experiment 19 from *Advanced Chemistry with Vernier*, "Buffers"
Gel electrophoresis	Vernier Blue Digital Bioimaging System (BL-DBS, $799) 	Experiment 6B from *Advanced Biology with Vernier*, "Analysis of Precut Lambda DNA"
Enzyme activity assays	Vernier UV-VIS Spectrophotometer (VSP-UV, $1999) 	"Malate Dehydrogenase Enzyme Assay," available for free download at www.vernier.com/vsp-uv

For a full list of recommend experiments and products, visit www.vernier.com/til/2330

Vernier and Flinn Team Up to Simplify Enzyme Experiments

Preparing enzyme extracts for your laboratory activity or demonstration can be messy and time-consuming, and it often leads to results that vary. With this in mind, the Biology Departments at Vernier and Flinn Scientific partnered to develop two simple solutions for teachers who want better results when performing experiments with enzymes.

Many teachers use our O_2 Gas Sensor or Gas Pressure Sensor to study the enzyme catalase. The enzyme is often purified from fresh liver, although a yeast suspension can be used. We have found the biggest obstacle to getting reliable results is the source of the enzyme. You will get much better results if you use purified catalase, which can be purchased directly from Flinn Scientific (Catalog Number C0359). This contains more than enough for multiple classes and can easily be used in both inquiry and non-inquiry activities. In addition, if your students want to investigate the effect of substrate concentration on this enzyme, they will need something stronger than the 3% hydrogen peroxide commonly found in the grocery store. Flinn Scientific also sells 6% hydrogen peroxide (Catalog Number H0028). For instructions on how to use catalase and other tricks for getting good results with enzyme activities, see www.vernier.com/r155



Increasing pH is associated with a decrease in reaction rate

Another great inquiry-based enzyme activity from Flinn Scientific is the Peroxidase Enzyme Activity—Advanced Inquiry Laboratory Kit (Catalog Number FB2039). The enzyme for this activity is easily isolated from turnips and is very stable at room temperature. This kit uses a colorimetric assay, so you can use our Colorimeter (COL-BTA, $115) or SpectroVis Plus (SVIS-PL, $469) to quickly determine reaction rates. Students can investigate the effect of pH on an enzyme because the kit includes various pH buffer capsules. For instructions on how to use this Flinn Scientific kit with the Colorimeter or SpectroVis Plus, see www.vernier.com/r156

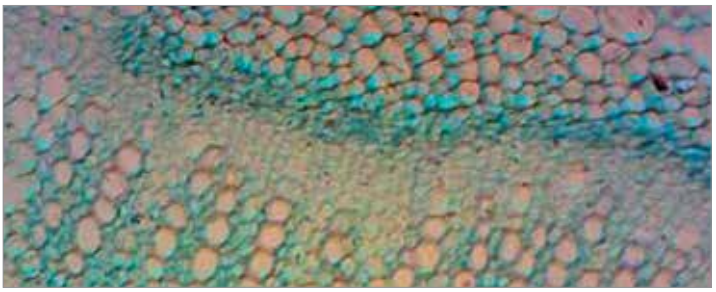
Visit Flinn Scientific at www.flinnsci.com

Capture Images with LabQuest 2

Did you know you can now use our digital microscopes and cameras with LabQuest 2? Our USB Digital Microscope (BD-EDU-100, $119) and the Celestron Digital Microscope Imager (CS-DMI, $79), a drop-in digital microscope camera, work with computers or Chromebooks. They have been very popular with biology teachers. We know that many schools can't have a computer at every microscope station, so we have added the ability to capture images from these cameras on LabQuest 2.

Starting with LabQuest App version 2.6, you are able to view and save images from both of these products. Simply connect the camera's USB cable to LabQuest 2 and launch the Camera App. You can get very clear images that are easy to see and save. With the addition of LabQuest Viewer computer software (LQ-VIEW, $79), you can project the image for the entire class to see or monitor what your students are seeing at each lab station without leaving your desk. LabQuest Viewer for iPad is also available on the App Store.

We know that many biology teachers use images from microscopes and dissecting scopes in their teaching, and we hope this new feature in LabQuest 2 makes it even easier!



Xylem and phloem tissue in a root cross-section at 600× total magnification

USA Biology Olympiad Uses Vernier Technology in Finals

This summer, Vernier was honored to be asked to provide technology for the 2015 USA Biology Olympiad (USABO) finals, the premier biology competition for high school students in the United States. Twenty finalists entered a 12-day residential training program at Purdue University, followed by two days of testing to decide which four students would advance to the International Biology Olympiad (IBO) in Denmark.

One portion of this year's practical exam was to conduct an amino acid titration using LabQuest 2 and the Tris-Compatible Flat pH Sensor (FPH-BTA, $99). The double junction in this electrode protects it from forming precipitates when used in proteinaceous solutions. The goals of this portion of the exam were to identify the amino acid, based on its observed pK_a, and to determine its molar mass, based on the amount of NaOH added to reach the equivalence point.

Grace Chen and Varun Mangalick, 2015 USA Biology Olympiad Gold Medalists, use Vernier technology during their practical exam.

Another part of the exam involved macromolecular biochemistry and the use of various biochemical tests and techniques to manipulate and identify lipids, carbohydrates, proteins, and nucleic acids. One particularly challenging portion of the exam involved a problem where the students were given a milk sample and had to design their own protocol to isolate the protein casein. Students found that an accurate pH determination is critical in this process. They found that the Tris-Compatible Flat pH Sensor was the right tool for the job. Abhijit Mudigonda, 2015 USA Biology Olympiad Biochemistry Practical author stated, "Vernier's LabQuests and pH sensors allowed the students to quickly and easily collect and analyze data crucial to their exams."

We congratulate all 20 students for making it to the USABO finals. The four USABO Gold Medalists, Grace Chen (Bridgewater-Raritan Regional High School, NJ), Yulin Du (Pullman High School, WA), Varun Mangalick (Mounds View High School, MN), and Boyang (Peter) Dun (Canterbury School, IN), went on to earn Gold Medals at the IBO in Denmark in July.

For more information on the USABO, visit www.usabo-trc.org

Go Wireless® Heart Rate Reviewed by *Tech & Learning* Magazine

GW-HR, $89

Tech & Learning *calls the Go Wireless Heart Rate "very powerful as a teaching tool."*

Frank Pileiro, technology director at Linwood Public Schools in Pennsylvania, wrote a review of Go Wireless Heart Rate for *Tech & Learning.*

> "The Go Wireless Heart Rate Monitor is a nice device that can be used in a variety of educational settings, from science class to physical education and sports training."

Pileiro tested Go Wireless Heart Rate for quality and effectiveness, ease of use, and suitability for use in a school environment.

> "The accompanying app is very easy to use and allows data points to be studied and compared. … Plus, the ability to export the information in a variety of ways gives students and teachers flexibility and collaboration capabilities."

Read the full review at www.vernier.com/gw-hr

Graphical Analysis for Chrome Now Works with LabQuest Mini

(continued from the front cover)

What's next? Having expanded the list of supported interfaces, we are now turning our attention to adding more data-collection modes, including Events with Entry, which is used heavily in chemistry. We will also add column calculations for data transforms. Transforms allow you to plot linearized graphs such as pressure *vs.* inverse volume for a Boyle's law experiment. Look for multiple updates before the end of this year.

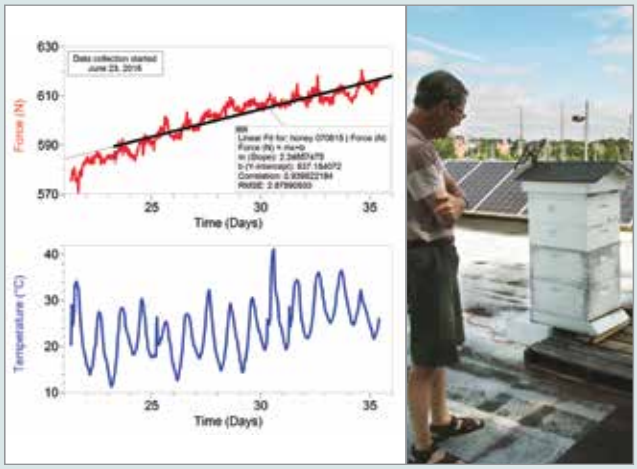
Combining Graphical Analysis for Chrome with our remarkable Data Sharing system allows you to collect data from any Vernier sensor that works with LabQuest 2 and then share that data with all members of a lab group. You can also manually enter values into Graphical Analysis for Chrome to graph anything you'd like.

To learn more about Graphical Analysis, visit www.vernier.com/ga-chrome

For an updated list of sensors supported by Graphical Analysis for Chrome, visit www.vernier.com/til/2871

Monitoring the Vernier Bee Hive

We often find ways to use our sensors in unusual ways around our building. One of our Technical Support/R&D specialists is a beekeeper, and a couple of years ago he talked us into placing a bee hive on our roof. Vernier employees enjoy learning about the bees and monitoring the hive with our data-collection equipment. This year, we placed the hive on a platform with about half of its weight supported by our Force Plate (FP-BTA, $245). This lets us track a rough measurement of the weight of the hive.



Variation in the weight of a bee hive over two weeks

In the force and temperature graphs, you can see data collected during a very warm, sunny period in June and July of this year. Note the daily variations in the force graph. We think these are caused by a number of things, including the bees going in and out of the hive and slight changes in the Force Plate's calibration caused by temperature variations. The Force Plate was designed to be used in a room-temperature lab. Overwhelming the daily force variation is a gradual increase in force. Based on the curve fit data and assuming half of the weight of the hive is on the Force Plate, we think that during the data-collection period, the hive gained about 0.5 kg (1 lb) per day, which we attribute to the pollen brought in by the bees and honey production.

Honey Bee Macro © 2015 Karunakar Rayker. www.creativecommons.org/licenses/by/4.0/legalcode

SCIENCE HUMOR

Q: Why does a burger have less energy than a steak?
A: A burger is in the ground state.

Pavlov is sitting at a restaurant enjoying dinner. Suddenly the phone rings, and he jumps up shouting, "Oh no! I forgot to feed the dog!"

They just found the gene for shyness. They would have found it earlier, but it was hiding behind two other genes.

Software Updates

We regularly release software updates to support new sensors as well as to add new features. Keeping up to date with software releases is one way to keep things running smoothly in your classroom or lab. Have you updated your Vernier applications recently?

Logger *Pro* 3.10.1

Logger *Pro* 3.10.1 was released in September 2015. This update is free to all users of any previous version of Logger *Pro* 3 and is available at www.vernier.com/lpupdates

The new version works with Windows 10 and has been tested against pre-release versions of OS X 10.11; it also adds support for new sensors. The entire curve-fitting library has been reworked, which allows for the introduction of weighted curve fits.

We recommend that all users of Logger *Pro* update to this release.

With an account on the Vernier website and a purchase history of Logger *Pro*, you can download the full installer at any time—you don't have to wait for a CD or download link.

LabQuest 2.6

LabQuest 2.6 for LabQuest 2, with support for Go Wireless Link (older LabQuest 2 hardware also requires an additional Go Wireless USB Radio), was released in September 2015. The release adds support for new sensors and extends the list of compatible printers. A new Camera App for LabQuest 2 works with the Celestron Digital Microscope Imager, as well as the USB Digital Microscope (see page 11 for details).

This free update to LabQuest 2 is available at www.vernier.com/lq2updates

We recommend that all users of LabQuest 2 update to this release.

LabQuest 1.7.4

LabQuest 1.7.4 for the original LabQuest was released in September 2015. The new version adds support for new sensors.

For more information about this free update, see www.vernier.com/lqupdates

Logger Lite 1.8

Logger Lite 1.8 was released in March 2015. The new version adds support for the *Investigating Wind Energy* lab book, as well as OS X 10.10. The free update is available at www.vernier.com/llupdates

LabQuest Viewer 2.0

LabQuest Viewer 2.0 for OS X and 2.01 for Windows were released in February and March, 2015. This significant update adds the ability to display and control multiple LabQuest units simultaneously. The free update is available at www.vernier.com/lqvupdates

Video Physics for iPad, iPhone, and iPod touch

The current version of Video Physics is 3.0.2, updated in March 2015. This new version includes an object auto-tracking feature; it is also easier to mark points, delete points, adjust the origin, and set the scale. As in earlier versions, we include the important ability to export video analysis data to Graphical Analysis for iOS. Once in Graphical Analysis, you can perform selections, add annotations, perform curve fits, and create high-resolution graphs.

Updates to Video Physics are always free and are available in the App Store.

Graphical Analysis for iPad, iPhone, and iPod touch

Graphical Analysis for iPad, iPhone, and iPod touch, version 2.3.2, was released in July 2015. In the last few months, Graphical Analysis has added support for Go Wireless Link. You can also rename experiments. Graphical Analysis is available for free in the App Store.

Graphical Analysis for Chrome

We released Graphical Analysis for Chrome 1.6 in September 2015. Graphical Analysis will collect data from a directly-connected USB Go!Temp or Go! Motion sensor, and it will work with any of over 40 sensors when used with a Go! Link or LabQuest interface. Manual entry of data is now possible. Graphical Analysis continues to work as a Data Share client. Graphical Analysis is available for free in the Chrome Web Store.

Graphical Analysis for Android

Graphical Analysis for Android, version 2.2, was released in September 2015. Similar in features to the iOS version, but crafted for Android, Graphical Analysis brings history, curve fits, and data collection to this popular platform. Go Wireless sensors and the Go Wireless Link are supported on Android tablets with compatible Bluetooth hardware. Graphical Analysis is available for free in the Google Play store.

LabQuest Viewer for iPad

LabQuest Viewer for iPad, version 2.0, released in February 2015, adds significant new capabilities, including the display and control of multiple LabQuest units simultaneously. The app is available in the App Store.

Apple Volume Purchase Program

Purchasing apps for iOS devices can be a challenge for schools. Did you know that your school or department could purchase vouchers to distribute apps, such as Vernier Video Physics, to multiple devices?

This is a way to distribute iOS apps to both school-owned and student devices. You can use purchase orders or a credit card, and school purchases are tax-exempt. You receive a 50% discount when purchasing 20 or more copies of Vernier Video Physics or LabQuest Viewer. www.apple.com/itunes/education

NSTA Recommends Go Wireless® pH

Go Wireless pH received a positive review from Martin Horejsi, who writes for the National Science Teachers Association blog. His review provides a detailed account of the use of Go Wireless pH in experiments contained in a chemical hood and during water quality sampling.

Martin constructed a raft to float Go Wireless Temp and Go Wireless pH away from shore

With the sensor raft floating 4 m from shore, data were recorded on an iPad using the Graphical Analysis app

"By going wireless, the probe opens some interesting doors to creative and safe exploration and experimentation. One of the big advantages of a wireless probe is the same advantage we experienced when telephones and microscopes went cordless. No longer did we trip over cords, knock over containers when moving the cords, or dredge off the top of counter tops and desks with the cord acting like a giant chain stripping the surface down to bare ground."

Read the full review at www.vernier.com/r157

Applications Open for Annual Vernier/NSTA Technology Awards

Vernier Software & Technology and the National Science Teachers Association (NSTA) are now accepting applications for the annual Vernier/NSTA Technology Awards. The 2016 awards program will recognize up to seven educators—one elementary teacher, two middle school teachers, three high school teachers, and one college-level educator—who promote the innovative use of data-collection technology.

Prizes include $1,000 in cash, $3,000 in Vernier products, and up to $1,500 toward expenses to attend the 2016 NSTA National Conference in Nashville, TN. Award recipients will be chosen based on their application, which is judged by a panel of NSTA-appointed experts. All applications must be submitted by November 30, 2015.

For more information about the award and to read about this year's winners, visit www.vernier.com/grants/nsta

Award Winner Profile: Christine Gleason, Greenhills School

2014 Vernier/NSTA Technology Award winner, Christine Gleason, a teacher at Greenhills School in Ann Arbor, Michigan, expanded her end-of-year unit to continue teaching and applying energy concepts beyond the classroom walls. Gleason's lesson evolved from a conventional non-renewable energy sources focus to an emphasis on weighing the advantages and disadvantages of alternative, renewable options, as environmental sustainability awareness increases.

During the unit, Gleason's 8th grade students compared the use of various renewable and non-renewable resources for generating electricity. Students worked in groups researching energy sources, presented their findings to the class, constructed tabletop wind turbines, and they learned how to take energy measurements using data-collection technology. The students tested the energy output of other appliances and then began the actual construction of their own alternative energy system. Their system needed to power a vehicle, machine, or other structure. Students then used the Vernier Energy Sensor (VES-BTA, $69) to measure the electrical power output of their system.

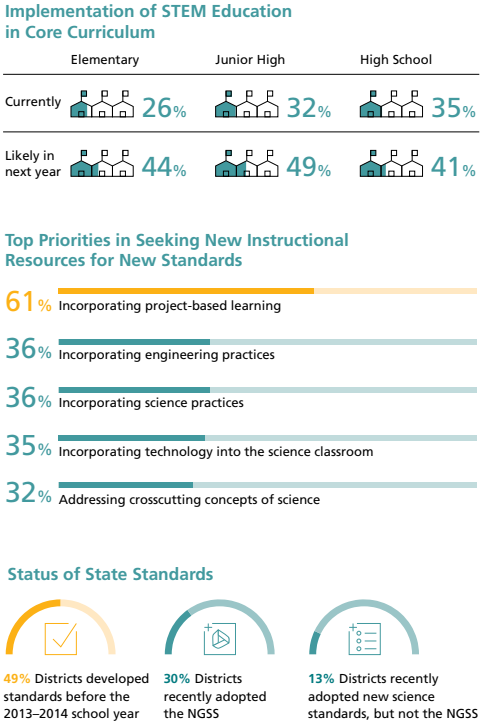
"Vernier has provided students with a hands-on way to collect data, and, in this specific unit, learn how current and voltage are related as part of Ohm's law," said Gleason. "Using these data, they are able to learn about the advantages and disadvantages of different power sources, improve their designs, and apply the engineering design process."

Complementing the award-winning unit—and connecting the concepts learned during the unit to a real-world application—students have the opportunity to measure the energy produced by their school's rooftop wind turbine, which was purchased in 2006 and also incorporates sensors and supporting Vernier software and hardware. In addition to the Energy Sensor, Gleason and her students use temperature probes, the Soil Moisture Sensor, the Current Probe, LabQuest 2 and LabQuest Mini devices, Watts Up Pro, and KidWind wind turbine kits to identify temperature, wind condition, and weather trends. They also learn how renewable energy helps meet the school's needs.

To view the complete lesson plan, visit www.vernier.com/r158

"The technology received from the Vernier/NSTA Technology Award has greatly impacted what we can do—and what we plan to do—in the classroom," continued Gleason. "It has allowed students to explore STEM concepts as part of real-world applications and really helped to make the learning experience more meaningful for them."

NEW STEM Report Provides Educators with Valuable Insights on NGSS and STEM Priorities



The *2015 Educator Edition: National Survey on STEM Education* provides educators with valuable insights on the current landscape of science and STEM education in the United States. The report provides thoughts and perspectives from more than 5,000 science and STEM educators nationwide regarding state science curriculum standards, including the adoption of the Next Generation Science Standards (NGSS), STEM initiatives in districts and schools, priorities for science and STEM courses, and challenges facing STEM education in the United States.

The report is written by IESD, Inc., an independent market research firm. MCH Strategic Data, an independent compiler of education data, provided the list of educators from which the sample was drawn.

Download the full report at www.vernier.com/stem_report_ee

25 YEARS AGO IN *THE CALIPER*

In 1990, we announced our first email addresses (on MCI Mail, Delphi, and AppleLink). In the same issue, we discussed using our products for MS-DOS on Tandy and PCjr computers. We also noted that the price of the upcoming Macintosh LC with a monitor was to be $3,100. Adjusted for inflation, that would be over $5,000 today! Ironically, the "LC" stood for "Low-Cost Color." A lot has changed in the computer world in 25 years!

Professional Development

FREE Hands-On, Data-Collection Workshops

Calling all science educators! Join us for a four-hour exploration of the latest and greatest in Vernier probeware and data-collection technology. You will conduct hands-on experiments using various sensors with the LabQuest 2 interface and our Go Wireless® sensors. For more information, go to www.vernier.com/training/workshops

Perfect for science educators who
- Want to evaluate our award-winning technology
- Are new to data collection
- Need a refresher course on Vernier equipment
- Want to learn from an expert

Attendees receive
- Four hours of free training
- Light lunch or dinner
- *Workshop Training Manual* download
- Savings on a workshop package

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IN	Indianapolis 9/19
KS	Wichita 9/26
KY	Lexington 9/16; Louisville 9/15
MA	Boston 10/26, 10/27; Worcester 10/28
MI	Detroit 10/22; Grand Rapids 10/21
MN	Minneapolis 10/7, 10/8
MO	Kansas City 9/28; St. Louis 9/21
NE	Omaha 10/3
NH	Manchester 10/24
NY	Albany 10/15; Buffalo 10/13; Syracuse 10/14
OH	Cincinnati 9/17; Cleveland 10/24
OK	Oklahoma City 9/24; Tulsa 9/23
PA	Pittsburgh 10/26
TX	Austin 9/14; Dallas 9/15; Ft. Worth 9/16; Houston 9/8, 9/9; San Antonio 9/10, 9/12
WI	Green Bay 10/1; Madison 10/3; Milwaukee 10/5

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Go Wireless® Link

Expands Wireless Capabilities to 42 Vernier Sensors

Go Wireless Link
GW-LINK, $99

Named "Best of Show" at ISTE, the International Society for Technology in Education conference, Go Wireless Link was recognized for providing students with a way to wirelessly transmit data from a supported Vernier sensor to tablets and other mobile devices.

TECH&LEARNING BEST of SHOW AT ISTE 2015 WINNER

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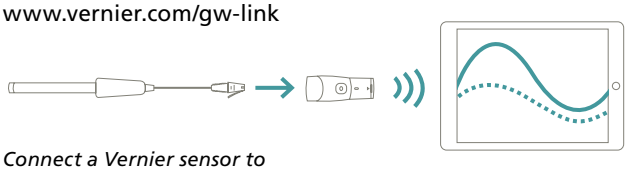

Connect a Vernier sensor to Go Wireless Link.

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