Dear Workshop Participant:

We know that Professional Development is important to teachers, for reasons of personal growth, and also for re-certification purposes. Vernier Software & Technology, in partnership with Portland State University, is pleased to offer you the opportunity to earn 2 quarter credit hours (1.34 semester hours) of Graduate Science Credit for attending one of our workshops (four or more hours in duration) and completing additional coursework on-line.

Many of the program details are spelled out in the registration materials. Be sure to read the information carefully. If you have questions about this opportunity, please contact Angie Harr (e-mail: aharr@vernier.com, or call toll free (888) 837-6437.

Instructions for Enrolling to Receive PSU Credit

2 quarter hours (1.34 semester hours) of Graduate Education Credit, at a cost of $140 are available to attendees of Vernier Software & Technology Workshops that are 4 or more hours in duration.

To enroll in SCI 510: "Electronic Data Collection for Science Educators", complete the following forms:

(1) REGISTRATION INFORMATION FORM
- Bring a printed copy of this form to the workshop with you to obtain your instructor's initials verifying your attendance at the workshop.

(2) PSU QUICK ENTRY APPLICATION
- This form is necessary to enter your name into the PSU computer system so that you can have access to your transcript information

(3) SPECIAL REGISTRATION FORM
- Please fill out all fields noted as "required". Course is graded only on a "pass/no-pass" basis.

Payment Options:

Payment in the amount of $140 can be made by check or by credit card. If paying with a credit card, enter your card information on the bottom of the PSU Quick Entry Application Form. Be certain you have signed this form on "required" signature line and in the credit card information box if you are choosing this payment option.

Where to Send Your Application Materials:

Please send your application materials and payment to:

Portland State University
Center for Science Education
Attn: Vernier 510 Registration
P.O. Box 751
Portland, OR 97207-0751

Information for enrolling to receive graduate credit for attending Vernier workshop.

Please complete this form in its entirety and have your Vernier workshop facilitator sign that you have completed the workshop and are eligible to register for the on-line course to receive credit.

Your completed registration packet is sent to the Center for Science Education at Portland State University for processing. Please be aware that applications are submitted to the registrar in groups and there may be a lag time between your sending your paperwork and your actual registration.

When PSU processes your registration you will receive an e-mail notifying you the term and CRN (Course Registration Number) for which you have been enrolled.

YOU ARE FREE TO BEGIN COURSEWORK BEFORE YOU HAVE BEEN OFFICIALLY REGISTERED.

NAME: ______________________________

DATE OF WORKSHOP: ______________________________

LOCATION OF WORKSHOP: ______________________________

FACILITATORS NAME: ______________________________

HOURS OF TRAINING: ______________________________

SSN/PSU I.D.: ______________________________

EMAIL ADDRESS: 1. ______________________________

2. ______________________________

PHONE NUMBER: (home): ______________________________

(work): ______________________________

(other): ______________________________

The above named student has satisfactorily completed the Vernier workshop and is eligible to enroll and register for PSU credit.

____
(workshop facilitator signature)

Form must be completed if you have never been enroflled at Portland State University AND/OR you wish to pay with a credit card.

psu quick entry application

Quick entry application allows a maximum of eight credit hours per term and establishes your student record as a non-admitted student. Complete this form if you have not been registered at PSU since 1974 or if you have graduated from PSU since your last enrollment.

There is a one-time, $10.00 fee for Quick Entry application, payable at the time of Quick Entry application. Refer to the section on Quick Entry under Registration Basics in the *Schedule of Classes* for more information.

biographical information

1 SOCIAL SECURITY NUMBER* ☐☐☐ ☐☐ ☐☐☐☐

Do you have a baccalaureate degree? ___________

Dates of previous enrollment at PSU: ___________

2 LEGAL NAME

last (family) first middle

3 OTHER NAMES THAT MAY APPEAR ON YOUR ACADEMIC RECORDS

4 CURRENT MAILING ADDRESS

number & street county home phone ( )

city state zip country work phone ( )

5 PERMANENT ADDRESS

number & street county home phone ( )

city state zip country work phone ( )

6 GENDER ☐ male ☐ female 7 DATE OF BIRTH ___________ 8 E-MAIL ADDRESS ___________

9 ETHNIC IDENTITY (OPTIONAL)

The Oregon University System must seek to identify the ethnic background of applicants for admission in compliance with federal reporting requirements. You are encouraged to supply this information, but you may decline without prejudicing your application in any way.

specify ethnic group:

- A ☐ Asian
- H ☐ Hispanic
- P ☐ Pacific Islander
- B ☐ Black Non-Hispanic
- I ☐ American Indian/Alaska Native
- W ☐ White Non-Hispanic
- D ☐ Decline to respond
- O ☐ If none of the above is appropriate, write in your ethnic group ___________

residency information

10 CITIZENSHIP

nation of citizenship: ☐ USA

☐ other (specify) ___________

11 IF NON-US CITIZEN

type of visa ___________ date issued ___________

12 OREGON RESIDENCY

do you consider yourself an Oregon resident?

☐ yes ☐ no

Note: Students enrolled for fewer than nine credit hours per term are assessed resident fees regardless of resident status. Nonetheless, residency information is required for enrollment and may be audited. Students who apply for full-time admission to PSU at a later date will have their residency reassessed at that time.

____

applicant's signature *Required*

____

date *Required*

important information

QUICK ENTRY STUDENTS...

- may register for a maximum of 8 credit hours for Fall, Winter, and Spring terms.
- are not eligible for financial aid.
- are not entitled to incidental fee privileges, which include Health Services or insurance, subsidized use of the Helen Gordon Child Development center, free admission to most athletic events.
- must register after all admitted students (see Priority Registration Schedule in the current *Schedule of Classes*). Students may use the web system to register for classes.
- are entitled to library privileges, Student Development Center, and use of open recreational areas in the Peter Stott Center.
- are subject to the same deadlines and payment/refund schedules as full time students.
- are subject to the same Academic Standards (academic warning, academic probation, and academic dismissal) as full time students.

* Social Security Number requested but optional. If you choose not to use your SSN, an ID number will be assigned for you. Refer to the section on Social Security Numbers under Student Records in the *Schedule of Classes* for complete disclosure information.

Submit completed form to:

Admissions, Records, & Financial Aid
Portland State University
PO Box 751
Portland, OR 97207-0751

Fax: 503.725.5525

for payment by credit card:

Card Type: ☐ VISA ☐ MC

Name on card: ___________

Card Number: ___________

Expiration date: ___________

Portland State University
Registration & Records

CSE

SPECIAL REGISTRATION FORM

ID/SSN ______________ Required

This form supplements touchtone registration and is used to effect a course enrollment, adjustment or function not available by touchtone.
The form is processed in-person at the Registration & Records windows, Neuberger Hall lobby, after any required approvals.
Visit your schedule and account on the Internet via PSU's Homepage @ www.pdx.edu

Quarter/Year ______ Leave Blank

(Last Name) ______ Required (First Name) ______

(______) ______ (Area Code) Day Phone Required

I. ADD-DEPARTMENTAL APPROVAL

DEPT STAMP	CRN	SUBJ	CRSE. NO.	SEC. NO.	TITLE	CREDIT HOURS	*GRADE OPTION
	Leave Blank	SCI	510	VER	Electronic Data Collection	2	P/NP

*Audits not available before start of quarter

IV. TUITION & FEES
Tuition-any increase can be paid immediately at the Cashier's window.
Refunds-automatic during the refund period.

07/26/01

SCI 510: Electronic Data Collection and Analysis for Science Educators (on-line)

2 unit credit (quarter based) – graduate science level

Instructor: Dr. L. A. George, Portland State University – Center for Science Education
Contact Information: Phone (503) 725-3861; georgeL@pdx.edu

Course Description:

This course is designed for in-service and pre-service science teachers interested in utilizing electronic sensors and data collection in their classes to facilitate student investigations. The course assumes that you have successfully completed the hands-on Vernier workshop on electronic sensors and data collection and that you have already had experience working through one or more of the Vernier laboratory exercises. In this on-line course you will put to use electronic data collection skills to design and implement a scientific investigation of your own making. You will be working less as "students of science" than as scientists yourself.

This approach to science education can be characterized as "inquiry-based". However since this term is used for a wide variety of activities, we call this brand of science inquiry, research-based science inquiry. That is, the science inquiry is driven by non-trivial research questions developed by the student investigator. In this course you will design your own investigation and you will also have an opportunity to translate your experience into a brief lesson plan for implementation of the investigation into your curriculum.

The coursework should take about 15 - 20 hours to complete, including review of materials, experimentation, data analysis and writing.

Over forty teachers and college instructors have completed this course and have valued the opportunity to experiment with the probes and think about classroom implementation.

Course Goals:

- Learn how to design and conduct an investigation using electronic sensors.
- Learn how to make a scientific claim in a scientific presentation format.
- Develop a plan for utilizing inquiry-based investigations in the classroom.

Graded work:

1. The design, implementation and write-up of a scientific investigation.

and

2. A curriculum implementation plan to utilize an inquiry investigation in the class.

Assignments will be submitted over the web for review and grading .
Please make sure to state "SCI 510" in the subject line of any correspondence.

Course Outline:

I. Overview of Making Scientific Claims with Measurements
   a. Review on-line presentation about Electronic Data Collection.
   b. Review the on-line presentation about measurements, calibration and scientific writing
   c. On-line quiz about measurements (non-graded)

II. Make a Scientific Claim with Your Sensor
   a. Conduct "X factor" experiment
   b. Submit a short scientific report on your findings.

III. Inquiry in the Classroom
   a. Review the material on developing a classroom inquiry project
   b. Submit an “Inquiry Module” that utilizes one of the sensors that you have been working with.
      i .Examples
      ii.Template

IV. Course Assessment

Course Access Form

SCI 510: Electronic Data Collection and Analysis for Science Educators (on-line)

2 unit credit (quarter based) - graduate science level

Starting the course is easy...

Just connect to the website at:

http://www.cse.pdx.edu/linda.george/vernier/online-course.htm

Send your work to Dr. Linda George at georgeL@pdx.edu. The subject line of your email should be:

"SCI 510-VER-(your last name)".

You may begin as soon as you send paperwork and payment to Vernier. You will receive e-mail notification from The Center for Science Education at Portland State University when you are officially enrolled and registered.

You have a maximum of one year from the beginning of the term in which you are registered to complete the on-line course.

Electronic Data Collection's Frequently Asked Questions

1. How do I get my grades?

Portland State University has an online information system that all students may use to access their grades and unofficial transcripts. The address is:

http://banweb.pdx.edu

You will need to provide a username and password. If you haven't logged into the PSU information system before, your username is your social security number without the dashes (ex: 544443333) and your password is your six-digit birth date (ex: 050765). Once you log into the system for the first time, you will have to change your password.

2. How do I request my official transcripts?

Transcript Request forms are available online at www.ess.pdx.edu (the Enrollment and Student Services website).

3. **When can I expect to receive a grade after I submit my work and/or pay for the course?**

***** PLEASE MAKE SURE TO PUT "Vernier - SCI510 - (Last Name)" IN THE SUBJECT LINE OF EMAILS YOU SEND TO THE INSTRUCTOR TO HELP EXPEDITE GRADING *****

The University processes grades at the end of each quarter. If you enroll and submit your work early in a term, the grades will not be available on your transcript until the end of the quarter system. Unfortunately, the distance education paradigm has not effected how we deal with grades. Since Vernier workshops are being held independent of the PSU academic schedule, timely reporting of official grades is problematic.

Term	Transcripts Available On-line
Fall (late Sept-early Dec)	late Dec
Winter (early Jan-mid March)	late March
Spring (late March mid June)	late June
Summer (late June mid Sept)	late Sept

**Please refer to e-mail notification for your term and CRN (Course Registration Number). For question relating to registration, contact Maureen Shuman-Lanier at maureens@pdx.edu or (503) 725.4243.

Calibration and Vernier Sensors

What is a Calibration?

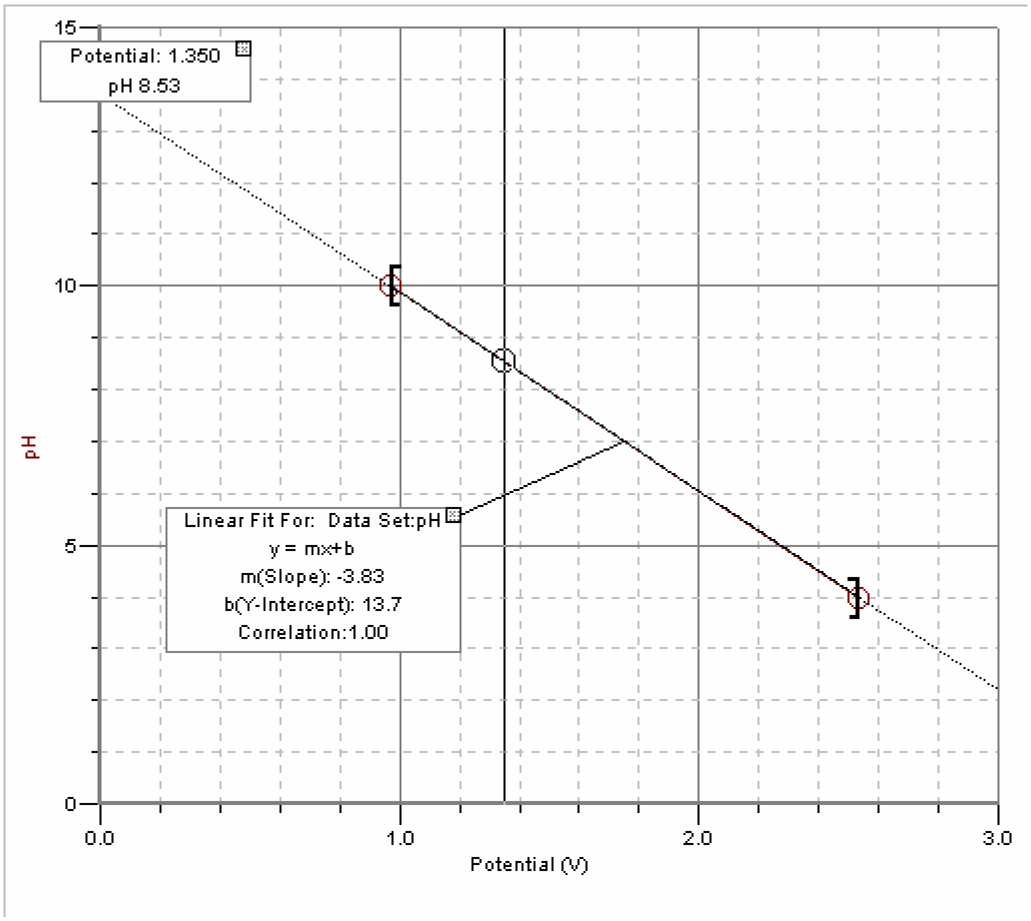
Vernier analog sensors each output a voltage that varies linearly with the parameter that is being measured by that sensor (referred to here as a "sensor value"). Since these voltages are not very useful by themselves, they must be converted to sensor values using a linear equation, in the form of :

$$y = mx + b$$

where y is the sensor value, m is the slope, x is the sensor output potential (voltage), and b is the y-intercept. Or put another way, for example:

If a pH Sensor has a slope of -3.838, and a y-intercept of 13.72, then the calibration equation (sometimes referred to as a *conversion* equation) would be:

$$pH = -3.838 \times voltage + 13.72$$



As a result, the voltage value that is output by this sensor can use this equation to obtain a pH value. For example, if this sensor outputs a potential of 1.35 V, then:

$$pH = -3.838 \times 1.35 + 13.72 = 8.539$$

All of the Vernier data-collection programs incorporate linear calibration equations, along with slope and intercept values, so that real-world sensor values are automatically calculated by the program.

When do Sensors Need to be Calibrated?

Here are several categories of sensors, according their need to be calibrated:

- **Sensors that never (or very rarely) need to be calibrated** Most Vernier sensors fall into this category. Examples are: Stainless Steel Temperature Probe, Light Sensor, Magnetic Field Sensor, Gas Pressure Sensor, Motion Detector, and many others.
- **Sensors that always need to be calibrated** These Vernier sensors always need to be calibrated. Even if we assign a calibration value to one of these sensors, by the nature of the sensor, there is too much variation from sensor to sensor to have a reliable, stored calibration. There are three Vernier sensors that fall into this category: Colorimeter, Turbidity Sensor, Ion-Selective Electrodes.
- **Sensors that *occasionally* need to be calibrated** The pH Sensor, Dissolved Oxygen Probe, CO_2 Gas Sensor, O_2 Gas Sensor are examples of Vernier sensors that can be used in many situations with the stored calibration, but in other more demanding situations might require calibration. For example, most common chemistry experiments can be performed using the stored calibration for the pH Sensor; however, in a few more advanced experiments (e.g., determining the Ka or pKa of a unknown acid, determining the pH of a freshwater sample), we recommend that a simple two-point calibration be performed. Similarly, many common biology experiments can be performed using the stored calibrations for a Dissolved Oxygen Probe, CO_2 Gas Sensor, or O_2 Gas Sensor. After all, many experiments using these sensors simply require determination of the *change in* the level of dissolved oxygen, CO_2, or O_2 concentration—and the *absolute value* for that sensor value is not as important as the change.

  One special case includes sensors that are used for water-quality measurements. Even though many of these sensors can use the stored calibration, organizations and individuals who make these kinds of measurements often require a more accurate calibration in order to compare readings taken on different days, or in different locations, taken by different people. A careful two-point calibration, using two *standards* (solutions with known concentrations), is often required for this kind of calibration. Vernier water-quality sensors that require this kind of calibration usually have these standards included with them when we ship them (e.g., Ion-Selective Electrode, Conductivity Probe, Dissolved Oxygen Probe, Turbidity Sensor).
- **Sensors that can be "zeroed" instead of doing a full calibration** With some sensors, it is only necessary to slightly adjust the y-intercept value, *b*, of the calibration, so that the sensor will actually read zero when it is in a situation where it should be reading zero. For example, it may be very important in some Microphone experiments for that sensor to read zero, when no sound source is close to the

Microphone, even though there is a considerable amount of classroom noise in the background. Zeroing the sensor simply shifts the y-intercept upward or downward (keeping the slope the same) to provide a zero sound reading even with the background classroom sound. Sensors that are sometimes zeroed include: Dual-Range Force Sensor, Magnetic Field Sensor, Voltage Probe, Motion Detector, and Microphone.

How are Sensors Calibrated?

There are three ways this is done:

1. **Calibrating a Sensor: "Perform New"** Vernier data-collection programs, such as Logger Pro, DataMate, and Data Pro, all provide a method for calibrating a sensor. To do this kind of calibration, it is necessary to have two known values for a particular sensor. Using the pH example presented above, a user would need to have two pH buffer solutions (buffer pH 4 and buffer pH 10, for example). Using Logger Pro software, you would choose Calibrate from the Experiment menu and click on the Perform New button.

    - For the first calibration point, you would be presented with a screen that displays a live voltage value, and an edit field into which you can type a known value. With the pH Sensor in buffer pH 4, you would enter a value of **4** in the edit field, wait for the voltage value to stabilize, then click Keep.

    - Then, for the second calibration point, the pH Sensor would be rinsed and placed into a buffer pH 10. You would enter a value of **10** in the edit field, and, when the voltage is stable, click on Keep. This calibration is now completed; that is, at two points along the calibration curve, you have now accurately linked a voltage with a sensor value (e.g., pH 4 with a potential of 2.53 V).

    The slope and intercept values for the calibration you just performed are always available in our data-collection programs. In Logger Pro, you could now click on the Details tab, and view the new calibration slope and intercept value. Instead of the values -3.838 (m) and 13.72 (b), you might now see values of -3.817 and 13.69. These values would presumably be better values than the stored Vernier values for that particular sensor, and you could use them immediately after performing the calibration. You may want to write them down, for future use with that pH Sensor, as described in the next section.
2. **Manual Entry of Calibration Values** All Vernier data-collection programs will allow you to manually enter a calibration value that is different from the stored calibration. For example, if you wrote down the sensor-specific calibration values (slope and intercept values) in part 1, you could use them two weeks from now by starting up the program, and advancing to Calibration in that program. There, you can find a place where calibrations can be manually entered. For example, in Logger Pro you would again choose Calibrate from the Experiment menu. Then you would click the Details tab, and click on Unlock (this unlocks the stored calibration). Now you can enter any value you wish into the edit fields for Slope and Intercept. Some teachers like to write calibration values on a piece of label tape on a sensor, so that students can manually enter these values.

3. **Saving a Calibration with an Experiment File (Logger Pro only)** With Logger Pro, if you wish to save a special calibration you have performed, this is done most easily by choosing Save As from the File menu, entering a name for the file, and saving the entire experiment file. This way, when that specific experiment file (for one particular sensor) is opened the next time, the special calibration that you have done and saved will be opened—this way, you would not need to manually enter these values.

Why are Some Sensor Calibrations more Reliable Than Others?

You can think of a stored Vernier calibration as an “average” value that can be used for many sensors of one kind. So the real question becomes: how much variation is there from sensor to sensor, and what causes that variation. The answer to this is not a simple one, but here are some factors that contribute:

1. **Manufacturer sensor specifications** Many of our sensors use an electronic sensing unit that is manufactured by another company. When we purchase these electronic sensing components, the supplier often provides us with specifications that we can use with the final Vernier product. This would include values for stored calibrations, as well as information that helps us determine how much sensor-to-sensor variation will occur, and therefore, whether or not a stored calibration will suffice (or whether we need to have customers zero or calibrate the sensor).
2. **Specification Principals** In some cases, the calibration (and its reliability) is based on a scientific principle. Many electrodes, such as pH Sensors, Ion-Selective Electrodes, and O_2 Gas Sensors, fall into this category. For example, with our pH Sensor, our calibration is based almost exclusively on the Nernst equation, which is a chemical principle that predicts the voltage output of a pH Sensor, based on a sensing half-cell, and a reference half-cell.
3. **Temperature** Many sensors will show some variation according to the temperature of the environment they are used in. In some cases (Dissolved Oxygen Probe and Conductivity Probe), the temperature variation is significant enough that we have built a small temperature sensor into the electrode; this way, the probe knows the temperature at which it is being used, and electronically corrects for any variation. In other cases, such as pH, we assume that most people use this electrode at or near room temperature, and store a calibration that centers around this temperature.
4. **Further Electronic Part Variation** Every electronic component that is added to a sensor has the potential of adding more variation from sensor-to-sensor. This includes any electronic part added to a printed circuit board that is part of a sensor. In some cases, we have added on very little, so variation is kept small, and the stored calibration works well. In other cases, just the opposite is true.
5. **None-linearity of Sensor Performance** In all discussions of calibrations so far, we have made an assumption that the sensor output is linear with respect to voltage. While this is a very good assumption, it is not equally true for all sensors. Some are more linear than others. Obviously, the more linear, the better the calibration is going to be. If there is significant variation from linearity, there will be less variation.

6. **Mechanical or Physical Variation** In some cases, unit-to-unit variation is affected by a mechanical or physical change in the sensor. A good example of this would be the reflex arm in the Dual-Range Force Sensor. After this sensor has been used a number of times, you may find that the reflex arm of this sensor does not always return to precisely the same position. This results in a slightly different y-intercept value, which causes some deviation from the stored calibration. This would require that the user zero (or calibrate) the sensor for better results.

Are there Sensors that have Non-Linear Calibrations?

Yes, Ion-Selective Electrodes and the Stainless Steel Temperature Probe have non-linear calibrations. As a result, they do not use the linear calibration method for calibration. Ion-Selective Electrodes use an exponential curve for calibration:

$$y = A*B^X$$

where y is the ion concentration, *A* is a constant, *B* is the base, and *X* is the voltage output of the sensor. This equation is built into all of our data-collection programs, accounts perfectly for the fact that the sensor is non-linear, so that you, the user, are shielded from this added complexity.

The Stainless Steel Temperature Probe uses a non-linear thermistor as its sensor, and the non-linear equation that describes the relationship between temperature and voltage output is actually built into the LabPro OS or CBL 2 OS. Again, you are shielded from this added complexity by having this built into the operating system of the interface. Note that the Stainless Steel Temperature Probe calibration does not allow you to calibrate the sensor or manually enter another calibration—the stored calibration must be used.

.