The Concord Consortium
Realizing the educational promise of technology
Volume 6, No. 1, Winter 2002

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INSIDE

Probeware has been around for a long time and its educational value is well documented. New innovations have improved their availability and usefulness. To learn about new educational probeware developed by the Concord Consortium, see page 7.

The Open Source Library for Educational Tools: OSLET

by Robert Tinker

The Concord Consortium has recently launched an online library of free software called Open Source Library for Educational Tools (OSLET).* We are seeding the library with several powerful applications and associated materials developed at the Concord Consortium. In time, we plan to add more tools as well as contributions from other sources. The library is intended only for software that was developed through research and has proven educational value. We believe that OSLET could become the basis of an entirely new approach to integrating technology into education.

OSLET should be of great interest to professionals in all areas of education:

- For faculty, teachers, and administrators, OSLET provides high-quality, research-based educational software. These are tools that have been proven to enhance student learning. And they cost nothing.

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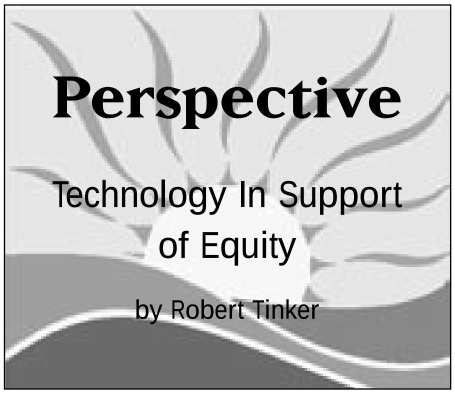
OSLET—concord.org/go/116



Perspective

Technology In Support of Equity

by Robert Tinker

While the debate over the digital divide continues, many educators are convinced that the most crucial gap is really the digital **learning** divide. This has more to do with inequities in the way technology is used. While some students use computers for drill-and-practice, others are exploring models of scientific phenomena or exploiting online resources. At the Concord Consortium we are addressing the learning gap by breaking down barriers to the use of technology and creating new, low-cost mechanisms for disseminating technology-based solutions. This issue of @CONCORD describes several of these efforts.

> Many educators are convinced that the most crucial gap is really the digital learning divide.

Breaking Down Barriers

The best uses of educational technology require curriculum redesign and renewal. Few schools can undertake this from a cold start. A long-term strategy is needed that meets the current curriculum goals with better, technology-enhanced materials. For example, we are developing substitution units using computer-based models and tools in our Modeling Across the Curriculum project (see page 19). We will implement at least one substitution unit per semester for three years of standard secondary science courses in a dozen schools. By monitoring student learning closely with our Pedagogica technology, we hope to demonstrate the power of this model-based learning strategy. Modeling Across the Curriculum is our massive, long-term study of this implementation strategy.

Hardware will never be free, but there is much that can be done to improve its benefit/cost ratios. One under-utilized strategy is to use the less-expensive handheld computers we have termed "equity computers." Currently under $200 and soon to be below $100, they are actually better in many contexts than desktop computers. Two ways in which handhelds excel are described in this issue: field work and collaboration.

Probeware, the use of sensor-equipped computers for real-time data acquisition and analysis, is one of the most powerful applications of computers in mathematics and science. The latest results of the National Assessment of Educational Progress show that probeware is associated with better student performance in science. High school seniors who reported using probes (even less frequently than once a month) had significantly higher scores on average than those who never used probes. There was an even higher jump in the scores of students who used probes one to two times per month (see the NCES Nation's Report Card, 2000). In this issue we describe our current efforts to reduce the barriers to wider use of this technology, an approach that involves using handhelds (see page 4), new probeware (see page 7), and open source software (see page 1).

Making Software Free

We think that government-funded materials like ours should be free. The prevailing view is that such materials should be licensed to commercial distributors who will generate enough income from sales to maintain the materials. This strategy may work for some materials, but not for sophisticated tools and materials, which commercial developers find too costly to produce profitably.

An exciting precedent for making powerful software available comes from the experience of the GNU/Linux operating system and applications based on it. The lesson is clear: make it free and if it is good enough, a self-appointed community will support and improve the software. We are convinced that this is how larger educational applications should be distributed. We are so certain of this that we are launching

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Equity Computers—www.concord.org/pubs/1999fall/perspective.html

Pedagogica—concord.org/go/118

Nation's Report Card—www.nces.ed.gov/nationsreportcard/pdf/main2000/2002452.pdf

GNU/Linux—www.linux.org

Modeling Across the Curriculum—concord.org/go/117 the Open Source Library of Educational Tools (OSLET) (see page 1). This experiment in free distribution of educational technology contains an impressive group of tools and models as well as supporting curricula in the form of Pedagogica scripts.

By providing free software, a project like OSLET could be a boon to educators serving poorer communities. We encourage all developers to improve the software and materials in OSLET and to contribute their own developments. Developers planning new projects should start by looking at OSLET because there are free components there that can reduce the cost of new software development. The resulting code must be contributed to OSLET, adding to its ability to improve education worldwide.

Organizing for Impact

The Concord Consortium exists to improve education and equity of access through innovations in technology. We want our advances to be used and have an impact, not to gather dust on a shelf as so often happens in research. A small group like ours, however, can easily be overwhelmed by attempting to serve even a tiny fraction of the colleges and schools that would like to implement our innovations. Furthermore, the institutional structure required for innovative research and development is incompatible with a service-oriented dissemination effort.

How do we balance the need to support innovative research and development with dissemination, service, and outreach? We have come up with a strategy borrowed from the for-profit sector: create alliances. We are in the process of creating the CC Group, a collection of affiliated companies that provides specialized dissemination services.

CC Group

- **KidSolve**
  Offers teacher professional development and curricula in science.
- **Metacourse**
  Provides online course design consultation.
- **Metacursos**
  Presents metacourses in Spanish.
- **OnLine Learning International(OLLI)**
  Offers consulting for online training to businesses.
- **Virtual High School, Inc. (VHS)**
  Operating independently since October 2001, VHS offers online courses to high schools worldwide.
- **EdTech Exchange (ETX)**
  When complete, this Web site will disseminate developments from CC research so that they are more immediately useful to educators.

Technology has much to offer schools that serve poor communities. No one questions that there is a divide in access to powerful desktop computers. However, the low-cost resources discussed above could easily be made available to even the most financially strapped schools, enabling them to take advantage of the best learning opportunities that technology has to offer.

Two keys to this will be educational solutions based on tools and models that are supported with online teacher professional development. We believe that these strategies and tools hold the key to revolutionizing education. Teachers who want to address the digital learning divide will find innovative, valuable, affordable resources within the CC Group. @

Robert Tinker (bob@concord.org) is president of the Concord Consortium.

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The Concord Consortium

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@CONCORD is published two times a year by The Concord Consortium, a nonprofit educational research and development organization dedicated to educational innovation through creative technologies.

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The projects described in this newsletter are supported by National Science Foundation grants REC 0115699, CDA 9720384, ESI-9986419, U.S. Department of Education grant R28A000006, and a grant from the Noyce Foundation. We also receive donations from corporations and individuals. All opinions, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the funding agencies. Mention of trade names, commercial products or organizations does not imply endorsement.

Handhelds Track Student Progress

Instant Feedback Through Beaming Identifies Student Misconceptions

by Carolyn Staudt

When the Apple Newton was released in the early '90s we recognized that small portable computers had the power to change education.[1] We chose the Newton, a portable computer a student could hold in one hand, in 1996 for our Science Learning in Context project in order to test the impact on student learning of portability and simple, easy access to a computer.

While the first handheld computers lacked educational support, the new generation of handhelds now emerging are smaller, more powerful, and have educational applications in all subject areas.[2] Their potential to improve education is so significant, we call them "equity computers": low-cost computers that can open the door for all students, regardless of circumstances, to quality education.

One of the most exciting advances in handheld computers is the incorporation of wireless communications. Using an infrared beam built into each handheld, students can share their work through wireless communication with each other and the teacher. "Beaming" has opened up new opportunities in the classroom for collaboration and student assessment.

How It Works

In order to test the utility of personal computers and beaming, we distributed handhelds to a middle school mathematics class working on linear equations. Each student was given a Palm computer with Imagigraph equation graphing software and infrared beaming capabilities. Having a personal computer allowed each student to independently test theories, collaborate and share work with other students, and document their process. At the end of class students could send their results to the teacher's computer using a serial port in the handheld.

The class objective was to understand linear equations through explorations of positive and negative slopes and y-intercepts. The handhelds allowed students to write equations that were translated into visual graphs on the screen.

Students were given the following equation:

$$y = mx + b$$

The slope is "m" and the y-intercept is "b." On the blackboard the teacher drew an intersecting x-axis and y-axis and a line with a positive slope and asked the students to write an equation that reproduced the line on their handheld computers. Using the graphing software and working in groups of four, students were able to formulate the correct linear equation, which was shown as a positive sloping line on their screens. They even went a step further and displayed two equations simultaneously (see Figure 1). It is important to note the eagerness with which they worked on the problem.

Promoting Individual Student Thinking

While this type of investigation is nothing new in classrooms that use graphing calculators, the teacher with the handhelds could now go a step further and test student understanding.

Many handhelds contain a writing/drawing tool for writing notes. The teacher asked the students to explain the terms "slope" and "y-intercept" and to identify each value on their individual graphs by writing in the Notes section of their handhelds (see Figure 2). (The Palm has a digital alpha-numeric keypad and handwriting recognition software that allows students to enter information with a stylus.) This information was then saved individually in a way that allowed identification of the author. The descriptions and graphs were then

Figure 1. Students can write equations and test the results immediately, even displaying two equations at the same time.

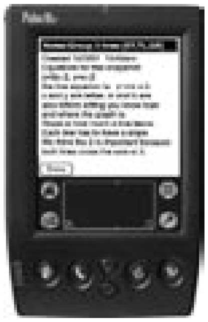

Figure 2. Definitions for slope and y-intercept were entered in their handhelds using the Notes function.

Figure 3. Saved notes and graphs were shared with other students using the infrared "beaming" capabilities of the handheld.

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Apple Newton—www.oldschool.net/newton/

Science Learning in Context—slic.concord.org

Palm—www.palm.com

Equity Computers—www.concord.org/pubs/1999fall/perspective.html

Imagigraph—www.imagiworks.com

beamed to students in other groups who were able to test and manipulate the results, learning from each other's work (see Figure 3).

The teacher then asked each group to come up with a common definition for slope and y-intercept. These group definitions were then beamed to the teacher who shared them with the entire class. The ensuing discussion unveiled new terms such as "coefficient" and "vertical axis" based on the students' own operational definitions, but these terms were introduced only when needed to help students understand their graphs.[3]

The importance of immediate feedback to the teacher was enormous. It quickly revealed misperceptions that could be corrected and also identified concepts that the students understood.

Guiding Student Interpretation and Reasoning

To further test student collaborative definitions of mathematical terms, the teacher drew another x- and y-axis on the board, but this time a line with a negative slope. Students were again asked to formulate an equation on their handheld computers that would reproduce the teacher's line.

Students were more perplexed this time and tried formulas using lesser or greater positive slopes and y-intercepts. Many students placed negative signs randomly in their equation. Through trial and error, and being able to immediately view the results of their equations, at least one member within each group managed to create an equation that displayed the teacher's line.

As students beamed their results back and forth, they realized that a descending line had a negative slope. The teacher asked the students to revise their definitions for slope within Notes and encouraged them to cite examples. For the first time, they understood the significance of sign, both for slope and y-intercept values.

The students were then given yet another challenge. The teacher drew an x- and y-axis on the board, but this time she drew a flat line that intercepted the y-axis at the number 3. The students were again asked to reproduce the line in their Palms by writing a function. After several minutes, one student yelled, "I've got it!" When he beamed his solution, $y=3$, to his group, they looked puzzled (see Figure 4). His formula did not fit the normal equation format. The teacher encouraged them to think about how slope and y-intercept related to this particular line, and revise their definitions. Remarkably, each group prepared a written explanation that included a definition of zero slope and the conclusion that "any number multiplied by zero is zero."

Testing Student Understanding

At this point the teacher was confident that a workable understanding of slope had been achieved, but could students master the concept of y-intercept? The teacher drew yet another set of axes on the board and two sloping lines, one negative and one positive, that intersected the y-axis at -3.

Initially, several students in each group mistakenly placed the intercept at positive 3, but they quickly realized their error when they saw the line graphed by the software. It only took a short time for every student to reproduce the teacher's graph accurately. Students then spontaneously produced more equations for others in their group, showing that they understood the concept of y-intercept (see Figure 5).

Relating to Real World Phenomena

One more activity was presented, and its outcome demonstrated the unique importance of handhelds to mathematics. Each group was provided with an Imagiworks Sonar Ranger (release date March 2002), a device that looks like a small egg and attaches by a phone cord to the interface box that fits onto the bottom of the Palm. Holding the Palm in one hand and the

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Handhelds that include capabilities such as beaming enable the teacher to make a rapid assessment of each student's comprehension of the concepts within the classroom experience.

Figure 4. Students took longer to reproduce a line with a zero slope, but seeing the result of their trial and error efforts helped.

Figure 5. By reproducing a y-intercept at -3 for both a positive and a negative line, the students demonstrated that they understood the concepts of slope and y-intercept.

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Imagiworks Sonar Ranger—www.imagiworks.com

HANDHELDS TRACK PROGRESS
CONTINUED FROM PAGE 5

Sonar Ranger in the other, it generates a graphical display of motion (see Figure 6). The Sonar Ranger transmits a sound pulse and receives its reflective beam, much like a radar gun. While experimenting with the Sonar Ranger by walking up to and away from a wall, students watched a graphical representation of their movements displayed on the handheld.

After these preliminary investigations, the teacher drew a set of axes on the board, but this time labeled the y-axis "position" and the x-axis "time." She then drew a positive sloping line in the first quadrant. Students were asked to reproduce the line by walking in front of the Sonar Ranger. During this investigation, they described their movements in Notes and tested their ability to mathematically describe their physical movements using the graphing application. By relating the motion of their own bodies with a graphical representation, they were meeting one of the National Science Standards that is typically hard to achieve: the concept that motion can be measured and represented on a graph.

Figure 6. The ImagiWorks Sonar Ranger attaches to a Palm handheld computer. It allows a student to experiment with the concept that motion can be measured and represented on a graph.

Teachers Monitor Individual Student Understanding

How do you assess student understanding when using handhelds? We are addressing this concern by embedding assessment capabilities within learning materials that reside on the handheld computer. Our assessment tool allows students to not only select answers but provide justifications for their choices.[4] These justifications can be beamed between group members or directly to the teacher, who uses them to decide how to proceed with the lesson. The reasons students select their answers are often as meaningful to the teacher as the answers. Our research has shown that this type of embedded assessment can also prompt students to discuss differences among themselves, which serves to further test their beliefs and theories.[5]

Handhelds with beaming capabilities enable the teacher to make a rapid assessment of each student's comprehension of the concepts. It allows the teacher to build on the current state of student understanding in order to provide on-going challenges that enhance each student's conceptual model. And it frees the teacher to analyze student weaknesses and strengths, misconceptions, and process skills—all during the lesson. @

Carolyn Staudt (carolyn@concord.org) is a curriculum and professional development specialist for the Concord Consortium and president of KidSolve.

The first handheld computers lacked educational support. The new generation of handhelds now emerging are smaller, more powerful and have educational applications in all subject areas.

NOTES

1 Tinker, R. and Krajcik, J., eds. (2001). Portable Technologies: Science learning in context. New York: Kluwer Academic/ Plenum Publishers.

2 See the Concord Consortium's Palm Applications in Education database reviewed by teachers.

3 Alerting the teacher to commonly held student ideas is one of the criteria in the AAAS Project 2061 "Middle Grades Science Textbooks Evaluation: Criteria for Evaluating the Quality of Instructional Support."

4 For more information, see our Technology Enhanced Elementary and Middle School Science (TEEMSS) project

5 For more information, see our Data and Models project.

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Project 2061—www.project2061.org / newsinfo / research / textbook / mgsci / criteria.htm
National Science Education Standards—www.nap.edu / readingroom / books / nses / html / 6d.html#ps
TEEMSS—www.concord.org / teemss
Palm Applications in Education—pie.concord.org
Data and Models—www.concord.org / themes / data-models /
Kluwer—www.wkap.nl

Probeware Takes a Seat in the Classroom

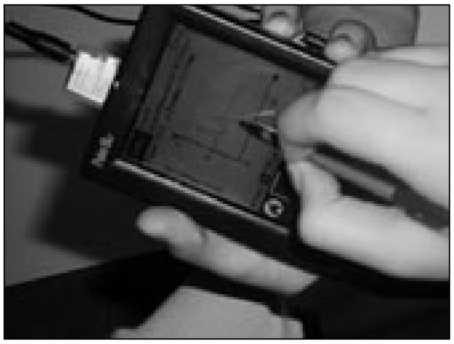
Educational Impact of Probes Improves with Time and Innovation

by Stephen Bannasch and
Robert Tinker

For many years we have been developing probeware—probes, sensors, interfaces, supporting software, and related curricula for classroom lab activities. However, we have never seen anything like the burst of creativity that is currently driving innovation in this area. Eventually, these new developments will drive down the costs, increase the usability, and greatly improve the educational impact of probeware.

Over the last year the Concord Consortium has developed an open source application called CCProbe that is scriptable, configurable, and supports probe-based visualization, analysis, and calibration components. CCProbe also includes components for folders, text, drawings, and images, which all can be integrated with the probeware to create curricular activities, and a lab book portfolio in which work can be saved and shared.

Although probeware has been around for a long time and its educational value is well documented, it is not widely used by teachers. We have identified several barriers to its broader adoption that our current work addresses:



A Palm handheld used with probeware can provide graphing capabilities.

The CCSmartWheel probe, attached to a Palm handheld computer, uses an optical encoder on a CD-ROM wheel to record motion. The wheel can be easily attached to a cart, meter stick, or pulley, making it very versatile.

Cost of computers

Many schools feel they can't afford the computers necessary for an entire class to use probeware. CCProbe will run on almost any handheld or desktop computer. Schools can take advantage of the inexpensive handheld computers or use their older desktop computers, and the hardware uses a serial port that is a standard part of most computers.

Cost of probeware

Previously, the major cost in equipping a lab with probeware was the cost of the probes, which can run $100 or more each, but our new interface box can use probes that are inexpensive to manufacture. Students can even make their own probes for the cost of parts ranging from 50 cents to five dollars each. Furthermore, the software is available free in our Open Source Library of Educational Tools (OSLET).

The learning curve

Another perceived barrier is that probe software is so complex that it is difficult to master for both teachers and students. Investigations with CCProbe can be designed like Web pages in order to contextualize and simplify use of the tools. We have worked hard to make the software intuitive and easy to learn, with on-screen help and guidance. In addition, we are developing online short courses for teachers on the use of the materials.

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CCProbe—concord.org / ccprobeware

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Integration

Although some teachers feel it is difficult to integrate probeware into their teaching, we are creating standards-based science activities using probes that are easily modified by teachers on a desktop computer. These activities appear on desktop or handheld computers. Initially, we will support teacher review of student work on the desktop versions of CCProbe. Later the desktop software will be integrated with Pedagogica, which can provide scaffolding, guidance, and more embedded assessment.

Assessing student work

While it once was difficult to record and assess student work with probeware, CCProbe supports the CCLabBook system which allows all student work to be saved, reviewed, and commented on by the teacher.

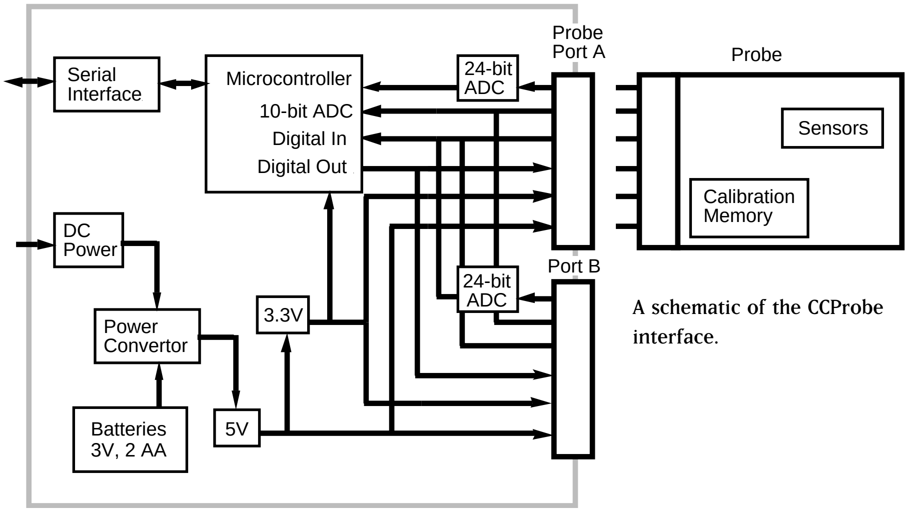
By addressing these barriers, we have created affordable probeware with unprecedented flexibility, portability, and educational value.

The Software

CCProbe is an elegant and powerful probeware application that can be used by students to heighten their understanding of the world around them by combining measurement with the computer's ability to display, record, and communicate visualizations of the measured data.

Learning, however, requires more than a good tool. Students need to be guided, challenged to predict, and encouraged to reflect. CCProbe uses the organizing principle of a lab notebook, which contains both curricular activities and a portfolio of student work. While CCProbe includes many traditional probeware tools such as real-time graphing, analysis, calibration, and saved datasets, it also includes software objects for taking notes, drawing sketches, answering questions, and displaying images. Additionally, CCProbe supports folders and compound objects similar to Web pages in which the basic objects can be combined together into activities.

This functionality that CCProbe is built upon is what we call the CCLabBook system. All the activities and student work are saved in one place. At present we create activities using a structured XML-based editing system from which CCLabBook objects, HTML Web pages, and printed PDF versions of the activities are automatically generated. Soon, teachers will be able to easily modify the activities or create their own using a Web-based authoring system. Once generated, an activity can be distributed to all students. An individual CCLabBook can be easily moved between handheld and full-size computer systems allowing students to investigate, edit, and organize information anywhere.



A schematic of the CCProbe interface.

After a class of students has completed an activity the work collected in individual CCLabBooks is combined on the teacher's computer where it can be browsed, critiqued, and archived. Additionally, the teacher can place new activities in the student CCLabBooks.

Runs On Most Computers

CCProbe and the CCLabBook system are written in Waba (an open source variant of Java) and run on a wide range of operating systems including PalmOS, WinCE, PocketPC, Windows, MacOS Classic, MacOS X, Linux and other Unix operating systems. This means that our software runs on almost any computer made in the last five years. As new computers are created, the software will quickly run on those, as well. No longer will our software become hostage to a machine that is discontinued, as happened with the Apple Newton and e-Mate. Another advantage is that teachers who learn to use our software on one computer can easily transfer their knowledge to any computer their school chooses to supply.

An essential design goal of the CCLabBook system is to support transparent communication of portfolio objects between all these systems. For example, after using CCProbe on a Palm computer to collect temperature and light data in the field, the LabBook on the Palm can be saved onto a server where it is accessible from other locations such as computers in the computer lab.

Beyond communication we are working on consolidation of student work for review and assessment. As the CCLabBook architecture and capabilities grow we are calling

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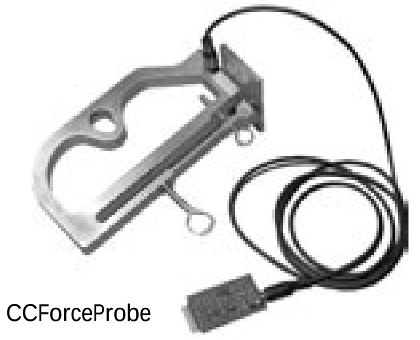
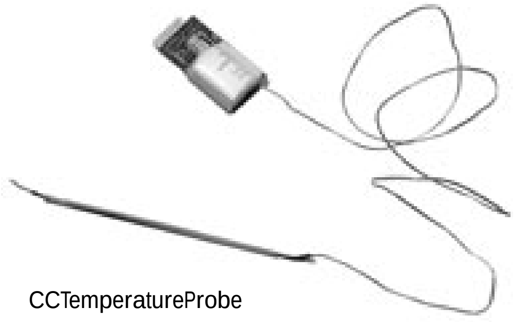
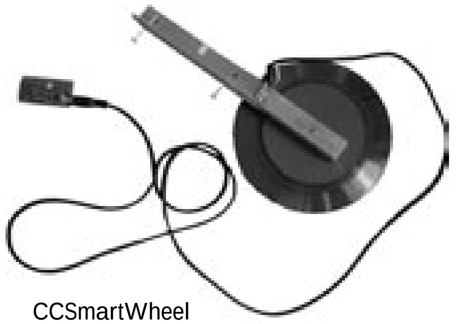
Palm—www.palm.com
Apple eMate—www.apple.com
Apple Newton—www.oldschool.net / newton /


CCForceProbe


CCLightProbe


CCVoltageCurrentProbe


CCTemperatureProbe


CCSmartWheel

Probes developed by the Concord Consortium contain a memory chip that holds identification and calibration information. These probes can be attached to a portable computer and used in the classroom or in the field to collect data that can be analyzed immediately within the class.

this expanded system CCFolio. Work is progressing on integrating the CCFolio system with Pedagogica.

The Interface

The interface is the box that goes between the computer and probes (see schematic on page 8). Our latest design, called the CCProbeInterface, is built with the latest low-power, low-cost, precision electronic components. Its design reduces the cost of probes that are used with it. The interface has batteries to allow use of power-hungry probes as well as portable unattended datalogging operation. However, if the batteries are dead or missing, it can still communicate with the CCProbe software and inform the user.

The CCProbeInterface contains two kinds of voltage sensors. One is fast and moderately sensitive, while the other is extremely sensitive but slow. The fast one can sense two inputs, to within five millivolts, ten thousand times per second. This is good for detecting sound, the forces in a collision, or the flash from a bulb as it burns out.

The slow voltage sensor can detect four inputs to within a microvolt, about three times a second. This high sensitivity is valuable because we can dispense with the cost of electronics often used in input circuits. For instance, we can make a highly sensitive temperature sensor from two wires of different metals, a so-called thermocouple. The junction of a typical thermocouple generates a few tens of microvolts for every degree temperature change. This means that two wires can be made into a very sensitive thermometer, a sensor anyone can build.

Probes

As illustrated above, we have developed some exciting new probes, which are described in more detail on our CCProbeware Web site. Each of these probes has a memory chip that holds identifying and calibration information about the probe.

CCSmartWheel We have improved on the ultrasonic motion detector that we developed 16 years ago. The new probe is less expensive and easier for beginners to understand. It uses an optical encoder on a CD-ROM wheel. This wheel can be easily attached to a cart, meter stick, or pulley, making it quite versatile for measuring speed.

CCForceProbe We dusted off the old idea of using a Hall effect sensor next to a magnet on a metal arm—all quite inexpensive. When the sensor is midway between the poles of the magnet and one-half pole separation away, it is linear in displacement parallel to the probes. Since the displacement of the arm holding the magnet is proportional to force, this makes a very sensitive probe.

CCTemperatureProbe This probe uses the tiny tip of a thermocouple to measure temperature. It can be used for many experiments that were impractical when using an ordinary temperature probe. This sensor responds so quickly to changes in air temperature that the vertical temperature profile in a room can be determined in one 30-second experiment.

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CCProbeware—concord.org / ccprobeware

Monday'

The Handheld Comp

Barbara Tinker, Carolyn

Illustrations by J

When a New Jersey student joined her class in a walk through the woods, she later told her teacher that she enjoyed her experience. Yet when the teacher asked, "What in particular did you notice?" the student answered, "Lots of details." She could not, however, remember any of those details. This student's experience was not unusual. Our finer-grained observations tend to slip away unless there is some way of focusing our attention more sharply and recording details immediately so that we can more easily revisit them.

Now imagine that same student on a field trip with her class, this time with new tools. The students are divided into teams of two, and each team is equipped with an inexpensive, lightweight handheld computer. The handhelds are all loaded with software that enables the teams to perform specialized tasks. For example, one team might have a checklist that encourages careful observation. Yet another might have a database that students constructed themselves. This can help them organize and analyze the information they collect. All groups use a sketching tool that allows them to capture their impressions while at the site. The computers all have an aerial map that helps students place their data precisely in the correct geographical context. When the students return to the classroom, they beam their data to a central database on a desktop computer where they consolidate their findings.

Handheld computers allow students to process more of their work in the field, closer to their immediate observations. Powerful software programs have recently become available that make these portable tools ideal companions for fieldwork. Although field guides have traditionally been used to study the natural world, they can easily be adapted to human-built neighborhoods, as the questions are not really very different: "Who lives here?" "Where and how do they live?" "What behaviors can we observe?" "What changes do we see?" Assisted by these tools, students can assemble a rich set of data about life in their own back yard, becoming local area experts-in-the-making. Local field guides can even become a legacy from one classroom to the next. More important, projects such as this help students discover real-life connections for their study of mathematics and science.

The following describes some of the software that can be used for fieldwork. You can mix and match these applications to fit your needs and budget. Adapting these to your local geography and data collection needs takes some effort, but this can be assigned to students as part of the lesson.

Using Mapping Applications to Define Your Site

Maps can now be entered and annotated on a handheld computer and carried into the field. (Watch for offerings from Mapquest, Terraserver, the MapTap Atlas and others.)

A GPS (Global Positioning System) unit would be necessary to define precise boundary points by latitude and longitude. While a school might want to invest in one GPS add-on, it is not necessary for creating a local field guide. There are lower cost handheld applications that you can use to draw coordinates on a grid overlay, which is superimposed on your map. As students enter data, they can correlate those data to these coordinates.

Identifying Characteristics with Checklists and Database Applications

Whether students are building a local field guide in an urban or rural setting, checklists or surveys, software such as SurveyMate, can help them focus on particular characteristics. For example, a

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LINKS ON THIS PAGE

SurveyMate—www.thinkdb.com

MapTap Atlas—www.mobilegeographics.com / maptap

MapQuest—www.mapquest.com

Terraserver—www.terraserver.com

’s Lesson

uter as Field Guide

audt and Dick Walton

n Bredin-Price

checklist of indicators of cultural diversity in a city block can refine student observations of their local neighborhood. Can they hear different languages? How many and how often? Can they find signs written in another language? Students can build useful checklists, which can be then shared by beaming to one another.

For a nature study, a checklist of animal track characteristics is useful. This pushes an observer to go beyond recording the simple track pattern, and to further notice details such as gait, registration, and direction of tracks. A checklist of animal signs encourages students to look 360 degrees about them to scan for habitats, food droppings and unique signs that might not come to mind if they are simply ambling through a study site.

A good checklist can become the basis of records that are transferred to a larger database. This "mother" database is kept on a classroom desktop computer. Subsets of this database can be transferred to a team's handheld for fieldwork. Individuals can follow their particular interest. Groups, such as classrooms and after school clubs, can pool their interests and observations to build a thorough description of their local area.

Databases for the handheld computer extend from little more than a fancy memo pad through mid-range databases. Examples of available products include MobileDB, which offers a reasonable set of fields and field types, and Filemaker MobileDB, which offers fewer field types at this writing but provides easy exchange with Filemaker, a commonly used desktop database application. One more professional application, thinkDB, offers a wide range of field types and includes a good drawing tool.

Tracking Change with Counting Applications

One of the easiest applications for handheld computers allows a student to count and time events. Available as shareware, the Count It tool is easy to use, and its data can be transferred into a database or spreadsheet. If students are studying regional plant density and diversity, they can rely on the counts they place on a map. Keeping track of counts over time can help students assess change. Are animal populations decreasing? How much open land is being lost to development? Students with the same program on different handheld computers can track related data. For example, one student could count compact cars, while another counts SUVs, and yet another the number of cars with only one passenger. By correlating related sets of data, students can engage in a more complex analysis of their object of study.

Recording Impressions with Drawing and Photography Tools

Drawing programs such as DrawIt and TealPaint have become flexible tools for the handheld computer. These applications let you vary color, texture, and even the size of brush. Sometimes these drawing tools are included in a database program. This means you can sketch images and save them in the database. A relatively inexpensive add-on digital or video camera can be clipped onto the handheld computer and used for taking, importing, and annotating digital pictures. BugMe! is a software application that that can be used for jotting down handwritten notes, and also for annotating pictures taken directly on the handheld computer.

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LINKS ON THIS PAGE

MobileDB—www.handmark.com / support / mobiledb
Filemaker MobileDB—www.filemaker.com / products / mbl_home.html
CountIt—www.palmspot.com / software / detail / ps4244a_98104.html
thinkDB—www.thinkingbytes.com
TealPaint—www.tealpoint.com / softpnt.htm
BugMe!—www.bugme.net / bugme
DrawIt—freewarepalm.net / graphics / drawit.html

MONDAY'S LESSON:
CONTINUED FROM PAGE 11

Classifying Data with an Identification Key

To help them identify species, naturalists use keys that provide pictures of various features of a plant or animal. When trying to identify a species in the field, Web sites such as eNature are a good resource. It offers online field guides for specific areas (based on zip code).

It is preferable, nevertheless, to have students build their own identification key for their particular area. The free What-If Builder[1] can be used for this purpose on desktop and handheld computers. This is a branching tree program that can include images. It can also be joined with other decision trees, published on the Web, and beamed between handhelds.

Keeping Up With Handhelds

The world of handheld computers is changing at a dizzying rate. New applications helpful for building a local field guide will certainly be available by the time this article is published. One way to stay current is to check the Web site, Palm Applications in Education.[2] @

Barbara Tinker (barbara@concord.org) is a project manager and consultant for the Concord Consortium. Carolyn Staudt (carolyn@concord.org) is a curriculum and professional development specialist and president of KidSolve. Dick Walton is a consultant in video technology.

NOTES

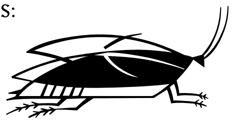
[1] What-If Builder is a tool to create decision-tree models, also known as "Action Mazes," "tree literature," "plot branching," or "choose your own adventure."

[2] Palm Applications in Education Web site contains reviews of applications for the Palm (a project funded by Palm, Inc.). The following sites also contains reviews:
www.palmgear.com
freewarepalm.net
www.palmspot.com

Building an Identification Key with What-If Builder

1. After students have gathered information (about trees, animals, insects etc.), have them make a list of their key characteristics. If they have collected samples or taken photos, they could place them on a table.
2. Ask students to examine their data and consider the features that could be used to divide their collection into two or three groups, without any left over. Write them in the What-If Builder. For example, a collection of insects could be divided into the following categories:

   Insects with wings
   Insects with one pair of wings
   Insects with two pairs of wings
   Insects with no wings or just vestiges of wings



3. Divide the class into two or three groups, and assign each group to study one of the categories. Each group carefully examines the samples in its category and further divides it into two (or more) subcategories. As categories are further divided, the new units do not have to be the same size, just completely divided. Write these divisions as questions in What-if Builder. (Does it have 2 wings? 4 wings?)
4. Continue the process until all of the specimens are sorted.
5. Print out the What-if branches, or join them together.
6. (Optional) Compare your students' key with those of professionals, such as the authors of Audubon guides.

You will need to keep adjusting your key, but ultimately you will have something of value for your entire school to use on field trips. Younger students might like to practice with a collection of leaves or even more simple objects.

The What-If Builder also supports a wider set of activities, including projections about the future. What if there is a decrease in our water supply? What if the population increases by 5%? What if it increases by 10%? Using What-If Builder, students can work their way through various sets of alternatives.

LINKS ON THIS PAGE

What-If Builder (desktops)—csf.concord.org / esf / Software.cfm
What-If Builder (handhelds)—www.kidsolve.com
KidSolve—www.kidsolve.com
Palm Applications in Education—pie.concord.org
eNature—www.enature.com

Online Courses That Work . . . and Some That Don't

Not all online courses are created equal

by Sarah Haavind, Raymond Rose, Alvaro Galvis, and Robert Tinker

In light of our successes with online learning, we are concerned about the widespread skepticism regarding the viability of this promising development. There is, of course, reason for skepticism because so many online courses are poorly designed and inadequately supported. Almost every educator has taken an unsatisfactory online course or heard someone's horror story. Others have tried to offer online courses and found them overwhelmingly complex and time-consuming.

It is unfair, however, to base policy on such anecdotal data. We have extensive research findings and several successful programs that belie the skeptics. In fact, we have found a small subset of potential designs that really work. Designs that don't work are those that fail to take full advantage of the technology. Below we describe these different models.

The online supplement model. Not an online course at all.

Most online courses are not actually complete courses, but online supplements to face-to-face courses. For the online component, supplementary materials often include a class syllabus, homework assignments, an optional discussion board, or recommended Web sites. Courses that truly overcome the barriers of place and time are entirely online.

The online self-paced model. A poor use of the technology.

Many online courses are actually correspondence or self-paced courses. The best of these provide a structured learning experience that leads the student through a series of activities and challenges with little or no personal assistance. While there is a role for this design, it hardly takes advantage of the technology.

The online lecture. Almost as good as a lecture course.

Another major group of online courses is modeled on the lecture hall. The emphasis here is on recreating the presence of a lecturer with audio and video, often accompanied with some form of real-time feedback. Without feedback, this ends up providing the same experience as TV or film lectures, approaches that have not been widely accepted.

Most online courses using lecture hall pedagogy employ some synchronous technology such as whiteboards, shared applications, or multi-way audio or video. Providing real-time feedback sounds like a good idea, but is often expensive. It creates huge scheduling problems while succumbing to the weakness of the lecture model. If there are many listeners, each gets very little interaction with the lecturer and has little time to formulate a thoughtful question.

Guided collaboration. Realizing the promise of technology with an affordable, high-quality model.

We are excited about a different model for online learning that is closer to a well-run seminar. The key idea is that participants create their own learning through thoughtful conversation and collaboration, guided by a knowledgeable teacher who is expert in facilitating online groups. This design is pedagogically superior to other designs because it is based on social constructivist learning principles: having learners create their own understandings based on group conversations.

When group-based learning is implemented online, inexpensive asynchronous technologies (typically, threaded discussion groups) are not only satisfactory, they are superior to synchronous ones. This online learning environment can be better than a seminar, because each participant has time to think about the conversation as it unfolds in slow-motion and to make thoughtful contributions. Because students must contribute to online discussions, well-designed online collaborations are more inclusive than typical classes. Add to this a few other design principles we have identified, and you get a model for online courses that really works.

For this design to be successful, the teacher must be an effective facilitator of the online conversations. Inexperienced online instructors tend to jump into the middle of the online conversation, hijacking the student's learning process. They are soon overwhelmed by the resulting volume of private email messages and cannot keep up their end of all the conversations.

The secret to success is abandoning the "sage on the stage" role and becoming an effective "guide on the side." This is hard for many teachers accustomed to performing. Not

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LINKS ON THIS PAGE
Facilitating Online Learning—www.concord.org/publications/fol

The CC e-Learning Model

Years of research and development have made Concord Consortium a leader in online education. In 1994, we conducted a survey of the existing approaches to online course development to determine what worked well and where problems existed. That research became the foundation for our subsequent work in designing, delivering, and studying online learning. From this work, we have developed a model for e-learning that we have found is highly effective and affordable.

The Concord Consortium e-Learning Model grew out of the International Netcourse Teacher Enhancement Coalition (INTEC). Funded by the National Science Foundation, INTEC delivered a graduate-level teacher professional development course that helped over 600 secondary science and mathematics teachers incorporate inquiry into their teaching.

Building on the INTEC experience, we created the Teachers Learning Conference (TLC) for the Virtual High School (VHS). The TLC became the key to the success of VHS because it prepares classroom teachers to become online course developers and facilitators through direct use and modeling of the Concord Consortium e-Learning Model. Over 300 teachers have completed the TLC and created successful courses of their own.

Our e-learning model, which incorporates student collaboration, good instructional design, and alternative assessment strategies, is an effective way to deliver most course topics. Because it offers the promise of "anytime, anywhere" education, it could democratize education and greatly increase the educational opportunities available to all.

The following principles define our approach to delivering quality e-learning. The first three describe the asynchronous, scheduled model that is widely utilized. We have found that the remaining characteristics are essential for the success of this model.

Asynchronous collaboration. The core learning strategy is based on group discussions and collaborative problem solving. Participants do not have to be logged on to the course simultaneously; they can work most effectively in an asynchronous environment.

Explicit schedules. Online courses that rely on collaborative discussions require detailed schedules so participants can share similar experiences and insights.

Limited enrollment. Between 12 and 25 participants are enrolled in a class or section for effective collaborative learning.

Expert facilitation. Online courses are led by a qualified person specifically trained in online facilitation.

Inquiry pedagogy. Courses are designed so that participants learn through guided inquiry. Many specific design elements that contribute to inquiry-based learning are required.

Community building. Course designers and facilitators design and nurture a community culture in which participants are supportive, honest, and willing to take intellectual risks.

High-quality materials. Courses include the best materials and utilize the widest feasible range of media and activities to accommodate different styles of learning.

Purposeful virtual spaces. Online courses are structured so that different kinds of communication are clear.

Ongoing assessment. Online assessment is a continuous, ongoing process. This leads to more authentic assessment and avoids problems of monitoring tests remotely.

Online Learning
continued from page 13

only is the teacher off stage, he or she must carefully prepare to schedule a series of key experiences that all course participants bring to each online seminar topic. And then the teacher must know how to foster a new kind of collaborative learning among participants who also have to learn how to jump in and stop waiting for the sage to do the thinking.

In practical terms, effective facilitation entails reading all postings, but intervening only occasionally to provide strategic guidance to the direction and tone of the conversation. An online course based on this design requires no more time than a typical face-to-face course: 20% of a teacher's time for a 20-participant course, or 1% of a full-time equivalent teacher per student. Our experience of preparing facilitators is described fully in our book, **Facilitating Online Learning**.

Online activities can be designed to foster authentic, embedded collaboration among participants, whether they are students, teachers, or employees. The resulting learning is powerful and memorable.

This model of e-learning has the potential to not only improve education, but to democratize it as well. There are many benefits to be realized with online learning: flexible scheduling, unlimited potential for collaboration, courses that address specialized needs, and customization to local curriculum, to name a few. An unprecedented variety and quality of online courses can be delivered at the secondary and tertiary level. Any student anywhere can enroll in these courses. Advanced and specialized courses can be made available to the poorest school. Geographically isolated schools in any country can be reached. Because this design requires no more teacher time, the courses are no more expensive to teach than current face-to-face courses, once the course design is complete.

The implications for teacher professional

LINKS ON THIS PAGE

Facilitating Online Learning—www.concord.org / publications / fol
VHS—www.goVHS.org
INTEC—www.concord.org / intec
CC e-Learning Model—concord.org / courses / cc_e-learning_model.pdf

development are equally impressive. Online courses can be taken while participants apply what they are learning to their teaching. Forward thinking school districts that are already creating virtual communities of teachers engaged in lifelong e-learning will reap the benefits of a highly sustainable professional development plan—one that enables all teachers to keep pace with current knowledge in their content areas, as well as relevant pedagogies and technologies.

Online Collaboration at Work

Early on in our experience with Virtual High School (VHS), we taught an online professional development course for high school teachers who wished to develop their own online classes. We detected a degree of trust among the participants that resulted in a level of teacher collaboration never before encountered. In a virtual "Teacher's Lounge" discussion area, a teacher in California asked for other teachers-in-training to go into her new course and check it out. "Is it interesting? Does it flow? Do the links work? Does the content make sense?" she wanted to know. Within a week several teachers from around the country had given her the requested feedback and had asked that their own courses be similarly scrutinized. Before long all thirty teachers were receiving feedback from their peers in twenty-two other states. We asked them all if they had a natural tendency to walk down the hall in their brick and mortar schools to have peers review their lesson plans. Not one had ever done that. "Well, then, why are you doing it online?" one of us asked. The reply came from another California teacher, "Because I can't hear anybody laughing at me here."

While we are confident that asynchronous, scheduled online courses can be effective and economical, additional research and development is needed. Many courses can be made more effective by the better integration of technological tools. New administrative arrangements such as the cooperative structure of the Virtual High School (VHS) help solve some of the issues raised by online courses, particularly budgeting and employment. To help you assess your own courses, see our Web site for references and other useful sources of information. @

The authors all work for the Concord Consortium. Sarah Haavind (sarah@concord.org) is an online instructional designer. Raymond Rose (ray@concord.org) is vice president. Alvaro Galvis (alvaros@concord.org) is co-project director of the Seeing Math Telecommunications Project. Robert Tinker (bob@concord.org) is president.

PROBEWARE

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CCVoltageCurrentProbe This probe can be used to measure voltage or current. Further processing of these values in the CCProbe application allows the recording of electrical power and energy.

CCLightProbe This measures visible light levels in either an indoor or outdoor illumination range.

Availability

As mentioned earlier, CCProbe is free software that can be downloaded from the OSLET Web site, copied, and used as you wish. At this writing, CCProbe hardware is not yet commercially available. We are working with several vendors who have shown a strong interest in manufacturing the interface and probes at a reasonable cost. Check our Web site for the latest information on availability of the interface and compatibility with other interfaces.

At this stage, these innovations should be of immediate interest to researchers, publishers, hardware vendors, and programmers. It would be easy to support more interfaces or dataloggers in the software. We think this should make CCProbe very appealing to manufacturers of probeware or dataloggers who are interested in supporting their hardware with free software that runs on almost any computer.

CCProbe and the CCLabBook system should also be valuable to other educational researchers who could use a portfolio software system that also has probeware capabilities. For a small investment, new capabilities can be added, which can be both used and distributed by the research project and contributed back to the CCProbe community. If you need to add some functionality, but don't have access to programmers who can achieve this, please contact us.

We have a few prototype hardware sets consisting of a CCProbeInterface and the five standard probes available at $750 each. This is much higher than their eventual cost to users, because they were produced in a small quantity pilot production run. We would be delighted to make these available to anyone interested in extending our work, undertaking related educational research, or developing compatible products.

We hope that, in time, the CCProbe set of tools will become so inexpensive that any student can have access to them. As more teachers develop their own curricular activities using probeware, these devices will become familiar learning tools in every science classroom. @

Stephen Bannasch (stephen@concord.org) and Robert Tinker (bob@concord.org) have been working together on probeware and related curricula for the past twenty-five years, the last eight of which have been at the Concord Consortium where Stephen is director of technology and Bob is president.

LINKS ON THIS PAGE

Virtual High School—www.goVHS.org

References—concord.org / go / 115

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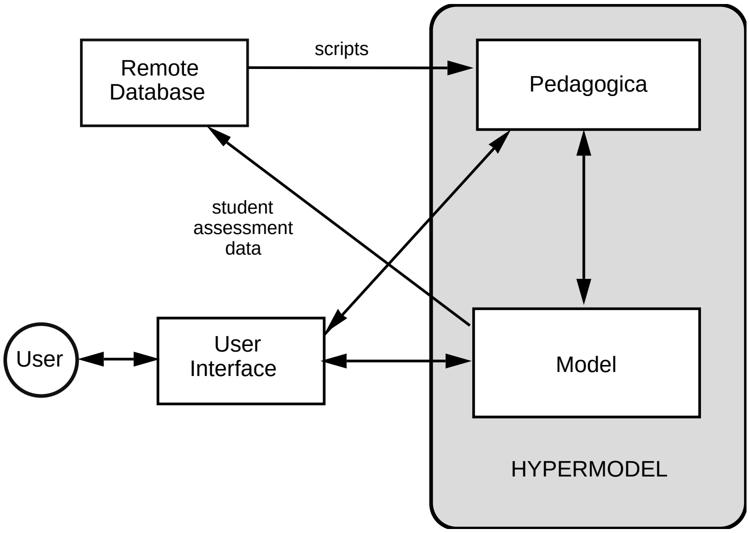
- School and college system administrators, as well as commercial technology providers, will appreciate having so much value packed into just a few titles. And because the software is free, there are no licenses to track.
- For educational researchers, the OSLET software can easily be modified for specific experiments and used to collect feedback from students in remote classrooms.
- For professional developers, OSLET creates many opportunities for inexpensive, effective, technology-based teacher enhancement and action research.
- Computer science professionals and students will like the structure of the OSLET code. Furthermore, OSLET presents an opportunity for developers to contribute their own compatible software, providing it has significant educational merit.
- For publishers, the free OSLET components can be the basis of proprietary curricular materials that are far more sophisticated than any single publisher could generate on its own.



Pedagogica allows tools and models to be controlled by scripts and incorporated into lessons.

OSLET Software Criteria

Our library starts with five titles. We don't expect it to grow to include the thousands of titles usually associated with the term "library." This is because we are restricting the library to high-capacity modeling software and tools (applications for sensors and probes) that are research-based and written in specific software languages.

The educational reason for restricting OSLET to these applications is that we believe they have the greatest long-term impact on education. Models and open-ended tools could result in breakthroughs in student learning because they provide an alternative and more accessible way of understanding abstract concepts. If students are struggling to grasp fundamental ideas through complex formal methods, they can more easily gain an understanding of the same material by interacting with a suitable tool or model. By exploring a model of atomic structures, for example, students gain a better understanding of the subject than they would through reading about them. All students can expect a deeper learning experience in any field, whether it is genetics, macro-economics, chemistry, evolution, climate change, epidemiology, or urban planning, to name a few.

There are other, more practical, reasons for restricting the OSLET holdings. The library fills a need that is not being met by commercial distribution channels, which are unable to support larger, more complex, educational tools. Conversely, there is no point in having OSLET compete with the thousands of smaller

Platforms Currently Supported by OSLET

OSLET Tools	Windows	Mac Classic	Mac OSX	Linux	Handhelds
Pedagogica	yes	yes	yes	yes	no
BioLogica	yes	yes	yes	yes	no
Molecular Workbench	yes	soon	yes	yes	no
CCProbe	yes	yes	yes	yes	yes
CC Client	yes	yes	yes	yes	no

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OSLET—concord.org / go / 116

educational packages that are commercially available. When educators log onto OSLET, they are not confronted with a daunting array of products, but rather a select group of tools with high impact.

Guided Exploration and Student Assessment

All the tools and models available through OSLET are interfaced with Pedagogica. At present, Pedagogica can be interfaced only with applications written in Java, Waba, and Flash. As a result, OSLET holdings will be restricted to applications written in those programming languages.

Pedagogica is a software environment that converts tools and models into hypermodel inquiry-based lessons, providing guidance to students and assessing their progress (see page 16). We see Pedagogica as the key to taming powerful software tools and models and making them practical, effective educational curricula. It does this by controlling the appearance of the tools as well as the options that are available. Pedagogica is itself controlled by a script that can be easily modified and delivered over the Internet. This means that Pedagogica scripts are an effective way of delivering tool-based curricular materials and tracking student progress.

We have found that the easy modification of Pedagogica scripts allows us to make quick improvements to our curricular materials. Classroom testing on one day can reveal the need for changes that can be made in time for the following day's class. The changes can be propagated easily to all students over the Internet using CC Client. This rapid cycling of testing and revising allows anyone using OSLET materials to quickly generate effective, classroom-tested lessons.

Different Pedagogica scripts addressing the same content can be easily developed. We will soon be able to target students with different versions of material that have the same learning objectives. We will use this capacity in our research, but it could also be used to address the needs of students with different learning styles or special needs.

Contained within the library are Pedagogica scripts for BioLogica and the Molecular Workbench that provide guided exploration and student assessment. BioLogica scripts support learning of Mendelian genetics. The Molecular Workbench scripts support standards-based learning in physical science, chemistry, and biology. CCProbe has not yet been integrated with Pedagogica, but has another mechanism for guiding computer-based lessons.

Platform Compatibility

Our goal is to have OSLET tools run on the widest feasible range of computers. The table on the previous page summarizes the current platform compatibility.

Users are naturally concerned that any software they acquire will be supported. In the case of free software, the question of who will provide the maintenance often arises. Because the source code is available to all, we expect that a community of users will fill this need. This certainly has been the case for GNU/Linux and its compatible open source applications. GNU/Linux, which has always been open source, is the most stable, compact operating system now available, and it runs on more hardware platforms than any other system. If enough users depend on OSLET tools, there is a good chance that the community will maintain them.

Advantages for Developers

Although OSLET holdings are open source, publishers and other companies can base proprietary products on them. For instance, a publisher of a genetics text could develop its own Pedagogica script that was keyed to the treatment in the text. If developed from scratch and not from modifying an OSLET script, the script could be copyrighted and used exclusively by the publisher. This is true even if the proprietary script required open source components from OSLET. The result could be an outstanding learning tool that

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OSLET TOOLS

All the OSLET tools are available free for any use. The source code for these is also available at no cost under a modification of the standard open source copyright, the GNU Public License (GPL). This allows anyone to modify the software, but only if they also release their modifications under the GPL copyright. We hope users will add new language support, add features, change scripts, and contribute new tools. Our only restriction is that these changes be added back to OSLET under the terms of the GNU Public License, so that the collection will continue to grow.

Pedagogica is the software interface that provides guidance and assessment.

BioLogica is a model for teaching genetics. It enables students to manipulate processes dynamically at the level of molecules, genes, and individuals. Like its predecessor program GenScope, BioLogica has associated modules and student activities that embody increasingly elaborate models of the parts, processes, and mechanisms of genetics.

Molecular Workbench is a rich computer-based environment that makes the atomic level familiar, predictable, and connected with the macroscopic world. By exploring models of atomic-scale situations, students learn about this world through guided exploration of the model.

CCProbe is data collection and analysis software that includes an electronic lab notebook. Currently CCProbe requires a lab interface that is under development at CC, but it can easily be adapted to other interface hardware. CCProbe runs on handhelds as well as desktop computers. CCProbe lessons are available for energy conversions and motion (see page 7).

CC Client manages Pedagogica scripts and associated tools. It can download and store locally the appropriate software and automatically update this software over the Internet.

LINKS ON THIS PAGE

BioLogica—concord.org / go / 117
GNU / Linux—www.linux.org
CCProbe—concord.org / ccprobeware
Molecular Workbench—concord.org / go / 114
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OSLET
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would be far more sophisticated than anything the publisher could develop on its own.

The OSLET library contains code objects that can greatly simplify software development projects. These objects can be linked to other code and controlled by Pedagogica, yielding sophisticated tool-based lessons economically. Suppose, for instance, that you want to develop educational software tools in statistics. The core tool might be a simulated urn from which samples could be drawn in various ways to illustrate statistical concepts. If this tool was developed in Java, then Pedagogica could control how the urn tool was used in any one lesson and link it to graphing and other tools already in the library. The only software coding required would be the development of the software urn tool. As a result, a complete software learning package, based on guided inquiry could be created quickly and economically.

Better Assessment

Pedagogica scripts can provide detailed feedback on student progress. The time spent at each step, the screens viewed, the options explored, and the tools used can all be noted automatically. Open-ended responses can be requested, predicted graphs sketched, and other kinds of student input can be elicited as the lessons are underway, giving detailed, embedded assessment of student learning. This assessment data can be sent over the Internet to the student, teacher, or researcher, as appropriate. This creates the possibility of better assessment that is less obtrusive and requires less class time. Embedded assessment provides a richer picture of a student's ability to solve problems and understand a domain than can be obtained from typical tests consisting of a series of short, unrelated questions.

Many of the advantages of OSLET accrue primarily to researchers, developers, and publishers. While educators are welcome to obtain the tools and scripts directly from OSLET, many will find our nonprofit affiliate The EdTech Exchange (ETX) to be a more supportive environment where the same software is available. By next year, ETX users will be able to create, deliver, and share Internet-based instructional activities based on a variety of technologies, including all the OSLET software. Thus, we hope ETX will become the user-friendly point of access to the OSLET holdings.

The Future

Over the next year, we hope to add additional tools and scripts to OSLET. These will include software tools developed for past projects. All future software developments at the Concord Consortium will become OSLET holdings. We invite developers to contribute educational models and tools as well.

We are especially interested in international contributors. Certainly, educators in developing countries are not going to want to buy expensive commercial software and should not be undertaking parallel, duplicative efforts to create similar free software for each country. It will be far faster and more economical to use OSLET tools and then localize the lessons based on these tools by modifying Pedagogica scripts.

We are also in contact with a growing number of "early adopter" schools that are willing to experiment with new releases and give us feedback on software and scripts as they emerge.

If this idea takes off, at some point OSLET will reach a critical mass. At that time, it should be far easier for anyone developing inquiry-based educational software to use OSLET components than to create their own software. By drawing from OSLET code, each developer will then have to contribute their new components, fixes, and enhancements. Even publishers with copyrighted scripts would be motivated to help maintain the open source software their scripts require. This sharing and mutual interdependence will strengthen the OSLET collection, making it even more attractive to subsequent developers and users.

By exploring a model of atomic structures, for example, students gain a better understanding of the subject than they would through reading about them. All students can expect a deeper learning experience in any field . . .

genetics
macro-economics
chemistry
evolution
climate change
epidemiology
urban planning
...to name a few.

The sooner we can reach a critical mass of interested schools, developers, and authors, the sooner the OSLET collection will begin having an impact on education. Whether you are a developer, researcher, or educator, if you would like to get involved, go to our OSLET Web site and register your interest.

Robert Tinker (bob@concord.org) is president of the Concord Consortium.

* In the Spring 2001 issue of @CONCORD, we wrote about our research involving a molecular and atomic modeling engine that we had named Oslet. This software is a component of the Molecular Workbench project and is still under development. Future versions of that application will be released under a new name, since OSLET is the acronym for the Open Source Library for Educational Tools.

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Pedagogica—concord.org / go / 118
@CONCORD—concord.org / newsletter
EdTech Exchange—concord.org / go / 119
Molecular Workbench—concord.org / go / 114
OSLET—concord.org / go / 116

Do Modeling Tools Help Students Learn Science?

New Research Brings Us Closer To an Answer

by Janice Gobert and Paul Horwitz

Computer models help students visualize scientific concepts that are not observable in the real world. Researchers have consistently found that modeling applications, such as those used by scientists to predict population growth or climate change, have tremendous potential for science learning. If used effectively, we believe these tools can help improve science learning for all students. However, there have been no large-scale, in-school studies to confirm this, up until now.

In November 2001, we launched Modeling Across the Curriculum (MAC), a ground-breaking $7 million research project, in partnership with Harvard University, Northwestern University, the Center for Learning Technologies in Urban Schools (LeTUS), and the Massachusetts public schools in Lowell and Fitchburg. This project is an in-depth, long-term investigation of the effectiveness of models and tools in improving science learning. The research will involve students in dozens of secondary schools throughout the country. This presents the challenge of determining the best strategies for using modeling tools in large numbers of diverse classrooms.

Once the classroom research starts, we will measure gains in content learning and modeling skills over a three-year period in sequential physical science, chemistry, and biology courses. In each of the three courses we will substitute the standard curriculum units with two instructional modules. Each substitution unit employs some combination of five different modeling tools: molecular dynamics software, NetLogo, Probeware, BioLogica, and Model-It.

Embedded Assessment

The substitution units will be delivered through online lessons. Each lesson is embedded with guidance to help students use the software, as well as an assessment tool that will collect data on student learning. This powerful methodology, developed at the Concord Consortium, is one of the most exciting aspects of the research project. Implemented through our Pedagogica software environment, it affects all aspects of a learner's interaction with the computer. It tailors, as necessary, the available options, the nature of the scaffolding, the instructions, and the assessments. Pedagogica can automatically report, via the Internet, students' progress through a sequence of activities. This provides us with real-time, fine-grained, educationally significant data on student learning. In time, we plan to create professional development courses that will train teachers to use these data as a formative and summative assessment tool. This will help them identify the conceptual areas in which their students are having difficulty, enabling them to provide appropriate "just in time" remediation, rather than having to wait for test results that appear only after the instructional unit is completed.

Substitution Units and Modeling Tools for Modeling Across the Curriculum

COURSE	UNITS
Physical Science	**Gas laws**. Molecular dynamics, NetLogo and Probeware. **States of matter**. Molecular dynamics. Probeware.
Biology	**Genetics**. BioLogica. **Population dynamics**. Model-it and NetLogo simulations.
Chemistry	**Chemical reactions**. Molecular dynamics, NetLogo, Probeware **Chemical kinetics**. Model-It , Molecular dynamics, NetLogo, Probeware

The Modeling Across the Curriculum project is funded by the National Science Foundation (NSF), the U.S. Department of Education, and the National Institutes of Health (NIH). @

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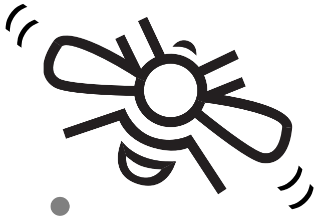

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