The Concord Consortium
Realizing the educational promise of technology
Fall 1999

@CONCORD.ORG

INSIDE

1 **Probing Untested Ground**
Second and fifth graders learn to use handheld computers.

3 **A Computer in the Palm of Their Hands**
What's so great about handheld computers?

4 **The Electronic Curator**
Using a handheld computer as a museum guide at the Exploratorium in San Francisco.

7 **CILT Contest: Educational Software for Handhelds $10 000 in Prizes**

8 **Monday's Lesson**
Force and Acceleration.

10 **A Billion Computers**
Using inexpensive computer technology to improve worldwide literacy.

11 **Creating International Neighborhoods**
Linking fourth graders internationally.

14 **Three New Grants**
Virtual High School, Hands On Physics, and Modeling receive new funding.

15 **Perspective: Equity**
Leveling the playing field with small handheld computers.

16 **info@concord.org**
Free software for sustainable development education; Virtual Middle School planned.

Two second graders from Morse School in Cambridge, Massachusetts, were part of a pilot program to test the use of handheld computers by young children.

Probing Untested Ground

Young Students Learn to Use Handhheld Computers

by Carolyn Staudt

The recent explosion of handheld computers – small, personal, portable computers with touch screens – has made its way into the education market. As part of the research of the Center for Innovative Learning Technologies (CILT) Ubiquitous Computing Project, several initiatives at The Concord Consortium have started to study the grade-appropriate use of these computers with K-6 students.

A pilot study conducted this past summer was designed to see if younger grades would benefit in note taking and data collection on the Palm™ handheld computer. Using this type of computer with young students is untested ground, so we selected two classes in Massachusetts to pilot their use: a second grade at Morse School (Cambridge Public Schools) and a fifth grade at Farley School (Hudson Public Schools).

(continued on page 2)

LINKS ON THIS PAGE
CILT—www.cilt.org
Palm—www.palm.com
Hudson Public Schools—www.hudson.k12.ma.us
Cambridge Public Schools—www.cps.ci.cambridge.ma.us

The Concord Consortium

Editor
Robert F. Tinker

Managing Editor
Lee McDavid

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

The Concord Consortium
37 Thoreau Street, Concord, MA 01742
(978) 369-4367, FAX (978) 371-0696
info@concord.org
http://www.concord.org

The material in @CONCORD is based on work supported by National Science Foundation grant numbers CDA-9720384, ESI-9896068, ESI-9730301, ESI-9554162, GEO-9801806, REC-9896075, REC-9813485, REC-9725524, REC-9554198, REC-9553639, REC-9553438 and U.S. Department of Education grants R303A70182 and R303A60571. We also receive donations from corporations, private foundations, 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.

Untested Ground

continued from page 1

Initial response

The second graders were paired up and given one Palm to share. Prior to starting the study, we had reviewed available Palm software and it appeared that few programs were suitable for the younger age group, and, in fact, many of the applications used Grafetti™, a pen-based shorthand that might interfere with the learning of cursive writing. But we found that the second grade students were immediately engaged by the Palm's different applications (e.g., Date Book, Address, To Do List) and spontaneously shared with each other their methods of getting from one application to the next. Some students stopped using the pen pointer, finding it easier to tap on the screen with their fingers. But any frustration they voiced was not with the pen or the small size of the screen but with the fact that it wasn't in color.

Initially students were guided through the performance of specific tasks. They were later encouraged to do more open-ended investigations. Some students moved from one group to another to show off a new application they had discovered. When a student occasionally tapped into an endless loop, she simply clicked the main screen to investigate another Palm application.

Two fifth grade students from Massachusetts use a probe and the Palm, a small handheld computer, to test water and air temperature along a streambed.

Student investigations

When a handheld computer with an attached temperature probe using an ImagiWorks™ interface box was used by pairs of second graders, almost all the students were able to work as teams to ask questions, design procedures, take notes on the Palm and gather data. The technology enabled students to engage in active, creative and reflective investigation of the environment.

For example, two boys first took the temperature of the air, then looked around for areas on their playground that might be different. It was a sunny day, so they investigated the shady area around a tree, the temperature down a drainage hole, and both the basketball blacktop and the white line that bordered the court. After taking notes on the Palm and discussing the differences, the students turned to the shoes they were wearing. How different is the temperature of the air from my shoe? How does the temperature of my shoe compare to the temperature in the shade?

But it didn't stop there. They were intrigued by things that made the temperature change. As the two stood and reviewed the readings, they compared and discussed differences. Then they verbalized their own experimental procedure: Let's test the temperature of the air, our shoes, and our shoes while we walk. As a result, they discovered that a probe is ideal for real-time mea-

continued on page 6

LINKS ON THIS PAGE
Palm—www.palm.com
ImagiWorks—www.imagiworks.com

A Computer in the Palm of Their Hands

by Kate Crawford and Carolyn Staudt

Students using temperature probes attached to handheld computers can collect data from the air and water and then compare and analyze the information immediately.

Schools are under new pressures to prepare young people for a world in which human activity involves more creative and diverse forms of social expression, critical evaluation, negotiation and problem solving. In order to successfully realize these new community expectations, schools must be able to use new information and communication technologies to their advantage.

Thinking and learning possibilities

Although many routine tasks are accomplished by technology, many of the software applications available for students do not focus on learning the necessary skills of personal inquiry. We need to pay more attention to cultivating human capabilities and awareness through experiences in designing, testing, questioning, and understanding the meaning of the data we now are able to gather so easily. Allowing students to develop these skills of inquiry helps them become more confident and self-directed learners.

New portable devices, like the Palm™ and the Royal daVinci™, have captured the public imagination and are changing society. Witness the sale of these small computers – already in the millions – and the growing number of business people who daily use them to plan, schedule, calculate expenses and take notes. Portable data logging probes (or sensors) that can be attached to these devices are offering new opportunities for awareness and analysis of data. Adults in many fields already use compact data logging instruments to collect valuable information, such as monitoring the temperature of refrigerated trucks hauling meat for long distances or tracking the heart rate of at-risk patients with portable heart monitors. Electronic probes make it possible to become aware of small changes that could not be experienced through the senses alone.

When used in combination with a handheld computer, probes offer an immediate and portable feedback system, which provides information about levels and changes in temperature, pH, and voltage through computer-based graphical representation. The system allows for immediate measurement and accurate representation of the smallest changes over time. Using this combination of handheld computers and probes, students can graph changes in air temperature near their nostrils as they breathe; observe a graphical representation of variation in pH throughout a 24-hour period in a pond; or detect different levels of voltage produced by a solar cell throughout the day.

True "personal" computers

Because desktop computers are developed primarily for business and research, they usually have a combination of price and performance features that make their use in schools economically unfeasible or, for the nation's poorest districts, impossible. These products have been designed for thinking within the limits of current business practice, rather than to meet the needs of education. Desktop computers do not meet students' learning needs for mobility within and outside classrooms. Nor were they designed to empower students to take their technology with them for field testing, thus providing them with both a sense of ownership of the technology and ownership of their own learning process. Moreover, even if the students have a space on the school's network to store their work, thoughts, ideas, data, and drawings, this information is not usually available to the student at

continued on page 12

LINKS ON THIS PAGE
Palm—www.palm.com
Royal da Vinci—www.royal.com

The Electronic Curator

Using a Handheld Computer at the exploratorium

by Stephen Bannasch

Consider this: a successful museum exhibit draws a museum-goer's attention for only two minutes; many visitors spend even less time. A hands-on interactive exhibit, on the other hand, might encourage visitors to spend a great deal more time than two minutes exploring a math or science phenomena.

With this goal in mind, the Exploratorium Museum of Science, Art, and Human Perception in San Francisco, Calif., and The Concord Consortium have been awarded an 18-month grant from the National Science Foundation to develop an Electronic GuideBook that uses networked handheld computers. The project will be looking at ways of enhancing and extending a museum-goer's experience by outfitting that person with a handheld computer that will communicate with the Exploratorium's interactive exhibits over wireless networks.

Our goal is to extend the museum experience by giving visitors deeper access to the concepts embodied in an exhibit and connecting these phenomena with the guests' real-world experiences. A handheld computer or "electronic assistant" made available to museum guests before, during, and after a museum visit will add to an individual's museum experience.

The Electronic GuideBook will support just-in-time learning by making many exhibits far more interactive than possible without the handhelds. We envision a visit to the museum to be very different from what one might have experienced in the past. Come along as we show you how a visit to the Exploratorium by two groups could be different.

An hour after the doors open, a school class arrives, part of a field trip from a public high school 60 miles away. A family also arrives. Each of these groups has signed up to use the Exploratorium's new learning tool, the Electronic GuideBook.

Prior to their field trip, the kids had looked at the Exploratorium web site at school. Their 9th grade science teacher had led them in brainstorming questions about the electricity and magnetism phenomena they will study. Together they planned a visit to specific Exploraotrium exhibits that would help them explore these topics. The teacher has divided the class into teams to share their tasks.

The kids and their teacher are welcomed into the Learning Studio, a workshop adjacent to the exhibit floor that serves as a home base for the Electronic GuideBook visit. Here they are issued their handheld computers to use in teams. They discuss their questions and ideas with the Learning Studio Leader, who also shows them an overview of how to use the handheld devices. The teams map out their visit to the exhibits, and agree to rendezvous at the Learning Studio in 90 minutes.

The students have already studied the relationship between electricity and magnetism in class. They decide to use the handheld with data probes at the Generator Effect exhibit to measure the current produced when the coil of wire passes through the magnetic field. Looking at the graph of the data, one student asks, "How does the current depend on the speed of moving the coil? What would have happened if we had moved it slower?" While some students move on to the next exhibit, one curious student uses her handheld to peruse the exhibit information available on the network and discovers, in a section on the history of electricity, that scientists were puzzled by the same question over 100 years ago. A link to a nearby exhibit is proposed for further exploration.

The whole class returns to the Learning Studio to turn in their handheld devices and discuss what they found. Some participants gather at the tables, talking over what they have seen. Some head straight for the computer, where they can enter their name to see a detailed record of their visit in the form of a series of web pages of each exhibit visited. These web pages are created automatically with links to the graphs the museum guests created, background information about the phenomena they observed, and questions and ideas for further exploration. Some students are typing notes to accompany a picture they took of an exhibit. Others are digging into online materials about the properties of electricity or the discovery of magnetism.

The family's experience is slightly

LINKS ON THIS PAGE
Exploratorium—www.exploratorium.edu
National Science Foundation—www.nsf.gov

different. They have visited the Exploratorium before, but they left feeling a bit overwhelmed by the variety of exhibits. Now they want to focus their return visit on specific topics, and so they signed up the day before on the Web to use the Electronic GuideBook. In response to the resources they found at the web site, they began forming questions about what they wanted to see at the museum.

The family's approach to the museum is more open. They haven't decided on a specific plan, just the topics they want to learn more about. Upon arriving at the museum, they too start at the Learning Studio. The Learning Studio Leader talks with them about the exhibits they are about to explore and asks a few questions about their areas of interest, one of which is electricity.

In the electricity exhibit, their curiosity leads them to explore a particular exhibit in detail. Using their handheld computers, they capture the exhibit text and images for later viewing on the network. They also access – through the Electronic GuideBook menu – a set of additional materials that introduce them to the phenomena and principles demonstrated in the exhibit and a video clip of the exhibit designer discussing the ideas that resulted in the exhibit. A set of questions guides them to learn more at the exhibit.

Back at the Learning Studio the family returns their handheld devices and later, at home, uses the Internet to access the Exploratorium web site, where they access the online record of their visit. Seeing the record and the photos of themselves at the exhibits, they are reminded of several ideas they had at the museum, and they add annotations to the web pages. They also remember several questions that had not even emerged until they were on their way home. Following links to the rest of the Exploratorium's web resources, they discover mini-experiments they can try at home, background material on electricity and the history of its discovery and use.

As a result of their visit, both groups may discover answers to their questions, but perhaps they will form new questions to explore, whether at school, at home, or on a future museum visit.

This scenario is possible, but first we need the right handheld computer for the job. Although there have been significant developments in this area, the ideal system is not yet available. Our research will begin with an in-depth review of handheld and tablet computers that support wireless communication. Features we'd like to see in the ideal platform include:

- Small size: a child should be able to comfortably hold a computer in one hand, so that the free hand could either use a pen or fingertip to interact with the computer or the exhibit itself. A pen or touch-screen interface is a simple and direct operation on a handheld computer.
- 16-bit color screen: images can be a powerful way to both record and investigate the world around us. Having an excellent color screen will make the images displayed on the handheld that much more appealing and real.
- Infrared networking (IrDA): the handheld must be able to detect its location within the museum, in order to provide context-appropriate guidance. One simple method is to outfit all the pertinent exhibits with IrDA networking pods. That way, when a visitor walks up to an exhibit, all they need to do is point their handheld at one of the IrDA pods and the display will instantly update to reflect the options and information appropriate to that exhibit.
- Radio frequency wireless networking: this is not strictly necessary when the IrDA networking is working well. However, our goal is to support reflective conversations at other venues in the museum. The material viewed and collected should be available on the handheld while eating lunch at the museum cafeteria or otherwise away from the exhibits, in meeting rooms or classrooms, for instance. The best way to enable these conversations and extended investigations is to have the handheld always connected to a network that can provide this information.
- Multimedia capabilities: the handheld must have the capacity to represent audio, video, and animated information as well as still images. We will support visitors using exhibit cameras to take images. Supporting the collection of video and audio data would be equally valuable.

At this time, we won't be able to get everything we want in one platform. Multimedia support on the Palm and Microsoft Windows CE™ handhelds is primitive. Although tablet-sized computers usually come with a complete Windows installation, including multimedia support, these systems are larger, harder to carry around, and much more expensive. But we've just begun. Our aim is to make a visit to the Exploratorium the best learning experience possible. @

Stephen Bannasch is director of technology for The Concord Consortium.
stephen@concord.org

LINKS ON THIS PAGE
Palm—www.palm.com
Microsoft Windows CE—www.microsoft.com/WindowsCE

Untested Ground

continued from page 2

surements that change over time. And the handheld makes this possible in the field because of its size and portability.

Amazed by the differences in temperature, the two boys became eager to write down possible reasons on the Palm. If something is in the shade, shouldn't it be cooler? Is my foot warming the probe? Although this age group does not yet formalize the idea of friction and heat, these two young boys were well on their way to developing an understanding based on the context of their investigation.

Fifth grade experimentation

The fifth graders were similarly paired up and each student was provided with a handheld computer equipped with a temperature probe. Two preparatory lessons were given to ensure that all members of the class were able to use the computers and temperature probes and the teachers understood how to encourage independent investigation.

Like the younger learners, the fifth grade class willingly shared their discoveries within their group and were curious about every change on the Palm screen. They quickly adjusted to using the small pen to tap their way around the applications. However, very few of the fifth grade students moved outside of their own pair until asked to share with another group. Students asked questions and listened for group instructions, but the atmosphere didn't hold as much excitement and students didn't share as much as the second grade class had. The older students appeared more focused on completing teacher-directed challenges quickly.

After the students felt comfortable with the equipment, the whole group investigated a shallow pond near their school. Each pair was assigned a location around the pond, and while one took notes and drew their location on the Palm, the other collected temperature data. It was early spring and the water was covered with pollen. After a few days of warm sunny weather, a cool breeze was blowing.

Within their groups, the students took the temperature of the air, the pollen-covered surface of the water, and just below the surface. The results were unexpected. The water was warmer than the air and the deeper the probe went into the water, the more the temperature increased.

Second grade students tested the temperature inside their shoes using a probe attached to a Palm handheld computer (above). At left is a closeup of how the boys inserted a probe and recorded the data.

The students did not believe their results. They expected the water to be cooler. Several groups repeated the measurements. Why the difference in temperatures? Did it matter if the day before was sunny? Does a slight breeze affect evaporation at the surface of the pond? Would the evaporation change the temperature of the pond?

Students started off by saying that the pollen acted as a blanket over the pond. But was this really true? After taking several readings at their locations, the students decided to collaborate with other teams. Was the data the same for your location? Did the temperature always increase in deeper water? They shared theories and, just as the second graders had, started to design methods for testing their assumptions. One group climbed on top of a big boulder so that they could reach and test water that was exposed directly to the sun and not covered with pollen. One boy yelled to his partner and other teams that the temperature of the water without the pollen cover was cooler and that the temperature increased more slowly as he tested further below the surface of the pond.

Meanwhile, other teams started to investigate areas not covered by water. What was the temperature in the trees around the pond? Was the temperature on the ground also cooler on the surface of the ground or below the leaves that covered the ground. Students soon found that the ground

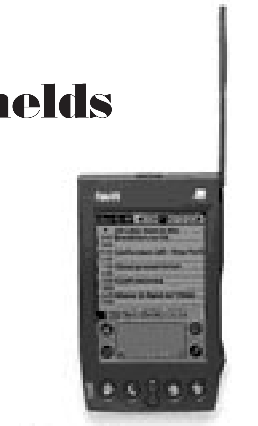
continued on page 13

LINKS ON THIS PAGE
Palm—www.palm.com
ImagiWorks—www.imagiworks.com

The CILT Contest

Educational Software for Handhelds

$10,000 in Prizes!



PalmVII
Connected Organizer

Educators!

What would you like a handheld computer to do?

Programmers!

What ideas do you have for educational applications for handheld computers?

The Center for Innovative Learning Technologies (CILT) is proud to announce a contest for the best educational applications for handheld computers, specifically for the Palm III™ Computing Platform.

CONTEST

CILT believes that affordable handheld computers such as the Palm III™ when placed in the hands of students and teachers can be a low-cost solution to the growing information technology gap in education.

Whether you are an individual, a team, an educator or a developer, we invite you to submit an innovative educational application that demonstrates the new and exciting educational uses of inexpensive handheld computers.

JUDGING

Entries are judged on several criteria. Applications that are flexible and applicable to a range of learning areas are preferred over applications that are targeted to a narrow topic or idea or are drill-style applications. Desirable characteristics include: a high level of interactivity, a user-friendly interface, multiple representations, and automatic collection of student performance indicators.

Final judging takes place in a live webcast from the Exploratorium in March of 2000. Judges will select a winner from each category and award prizes, including Palm V™ computers. The Grand Prize winner receives a Palm VII™ Connected Organizer, the Code Warrior™ development environment, first round Platinum Certification, and other prizes.

Register at:

http://kn.cilt.org/palm99

by

January 15, 2000

Entry categories:

Assessment Tools

Assessment tools that aid school administrators or teachers in assessing and evaluating student performance, understanding, and progress.

Collaboration Tools

Groupware applications that can be used within a classroom or around the world using the Internet.

Edutainment/Games

Activities with clear goals that involve thinking and solving problems in an important domain area. The activity may be competitive, but non-competitive games have a broader appeal.

Science and Mathematics Applications

Open-ended tools using graphics and graphing, or tools for generating numerical models or visual representations of the models.

Sensor or Control

Applications that would collect and display data or control an object — or both — in real time.

Eight and Under

Includes all categories above. Applications must be specially designed to meet the interests and educational needs of children age eight and under.

The Concord Consortium is a founding member of CILT.

Monday

Force and A

by Robert Tinker a

It is now easy to take probeware out of the lab. To demonstrate the flexibility of this we took a handheld computer with probes (see Figure 1) to a playground. We were looking for a real-life situation where we could easily demonstrate the relationship between the force on an object and its acceleration. Using probes it is possible to record force and acceleration at the same time, and so we looked for such a situation.

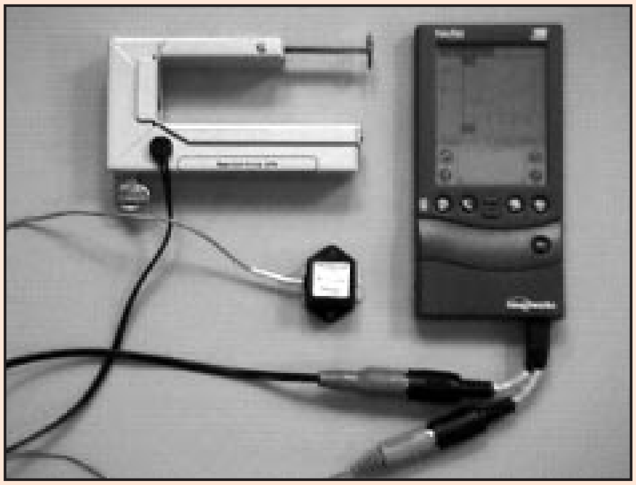


Figure 1. Palm computer with an ImagiWorks interface and Vernier probes.

Our equipment was very easy to assemble and operate. We started with a Palm™ handheld computer. We used the “Low-g” acceleration probe and the “Student Force” probe from Vernier. The interface and software was from ImagiWorks. Both probes connect to the Palm through the interface. We also used ImagiWorks software on the host Macintosh computer to upload the results using Palm’s “Hot Sync” system software and cradle.

The ImagiWorks software is remarkably sophisticated, growing out of research The Concord Consortium did with Elliot Soloway and ImagiWorks founder Wayne Grant. Groups of datasets are stored with calibration data, notes, and sketches in file structures called experiments. This makes the software a complete record-keeping package that is ideal for fieldwork. The software also communicates with PCs for later analysis.

Measuring force and acceleration at the same time isn’t as easy as it sounds because we had to measure all the forces on the object being accelerated. At first we tried pushing a person across the floor in a wheeled chair, but the force of friction was hard to measure. We had to find a situation with less friction.

That’s what led us to a playground swing, which is a very low friction device. We velcroed the acceleration probe to the seat of a “rocking horse” swing (see Figure 2) and pushed it forward with the force probe. The result should be that the acceleration is proportional to the force ($F=m*a$).

One problem to take into consideration is the force of the support rope. The only time that it doesn’t exert a horizontal force is when the swing is at its lowest position. To get the best data, we started pushing the empty swing just before it reached its lowest point, and continued pushing until it reached the same distance on the other side of the lowest point.

Figure 3 shows some data from our experiment

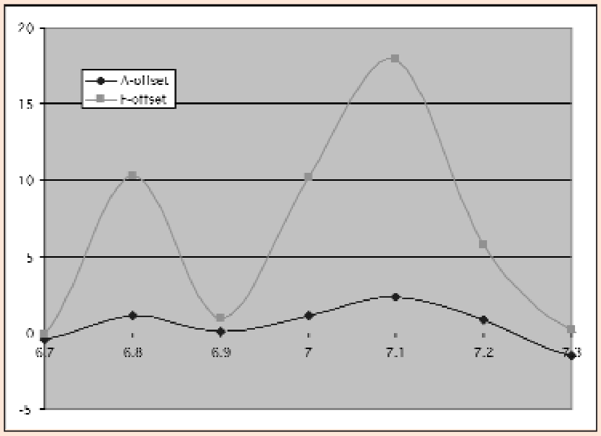


Figure 3. The effect on an empty swing of force (as measured by the force probe) and acceleration (as measured by the acceleration probe).

LINKS ON THIS PAGE

Palm—www.palm.com
Elliot Soloway—hi-ce.org
Vernier—www.vernier.com/probes
Swing—www.backyardadv.com
Imagiworks—www.imagiworks.com

s Lesson

cceleration

Carolyn Staudt

extracted from a spreadsheet program. You can see at a glance that the upper force curve and the lower acceleration curve are similar. In fact, they are proportional, with the force being between seven and nine times the acceleration. There is some error in the measurement because of the force applied by the support rope that we didn't measure. Still, these data are convincing direct evidence that force causes acceleration and that the ratio between them is the mass.

To test this further, we put a child on the swing (see Figure 2). Now, a much greater force should be needed for the same acceleration. The ratio of force to acceleration should be larger, reflecting the added mass of the person. And, in fact, the acceleration was so small that we couldn't put it on the same graph (see Figure 4) with the force without multiplying the acceleration by a factor of 170 (compared to the factor of seven to nine that worked for the empty swing). As you can see, the two lines of the graph don't quite line up. In fact, the acceleration seems to be ahead of the force and the visible

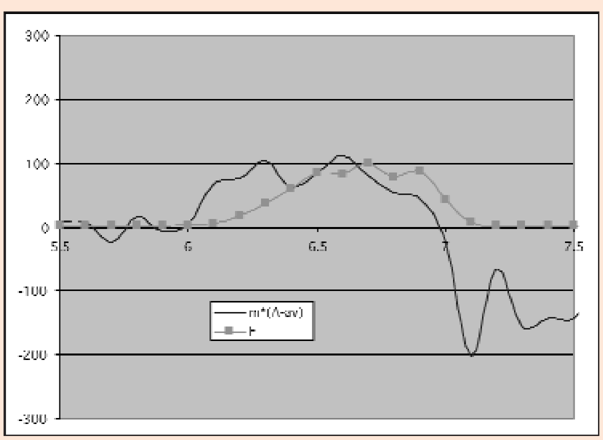


Figure 4. The effect of force and acceleration on a swing with someone sitting in it. Acceleration is multiplied by the mass.

Figure 2. The accelerator probe is attached to the seat of the swing.

bumps between the two lines on the graph appear to be delayed. Possible reasons might include that the child anticipated the push and that he shifted his weight as the swing moved forward. The two lines are about the same height, showing that more force is needed for the same acceleration when the mass increases.

These two experiments make it clear that:

Force and acceleration are proportional.
More mass makes it harder to accelerate.

We are not the only ones fascinated by the acceleration sensor. At the grand finale of a recent keynote address, Steve Jobs had a colleague jump 20 feet into an air bag clutching their new portable iBook™ attached to an accelerometer. They used the wireless networking capacity of the iBook to successfully send the data in real time to a stationary iBook. We don't recommend this for students, however!

We hope readers will continue experimenting on their own. Can you get better force and acceleration data on a swing or another device? Be sure to visit our Probe Sight web page for more information on probes and how they can be used. @

Robert Tinker is president of The Concord Consortium. Carolyn Staudt is a curricuclum developer and a teacher professional development specialist for The Concord Consortium.
bob@concord.org
carolyn@concord.org

LINKS ON THIS PAGE
Probe Sight—probesight.concord.org
iBook—www.apple.com/ibook

What To Do With a Billion Computers?

Teach the World to Read

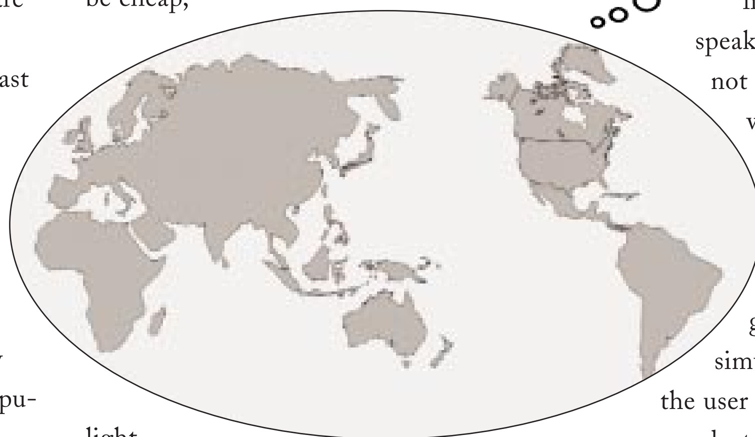
by Robert Tinker

At the inauguration of a new millennium – the so-called Information Age – there are approximately one billion illiterate people in the world, including at least ten million in the U.S. Illiteracy almost universally affects only the poorest – those who would benefit most from its power. It has been shown that people who read are healthier, have fewer children, earn more money, and, for farmers, grow more food. In contrast, illiterate populations are a huge cost to the world economy in the form of medical care, welfare, and lost opportunities. The cost of substantially reducing illiteracy could be a few billion dollars, representing a tiny fraction of what the U.S. alone spends on foreign aid.

Imagine this solution: inexpensive handheld computers, paid for by nations with more resources, in the hands of each illiterate world citizen. Absurd? Maybe not.

Although a broad implementation effort based on this technology would not wipe out illiteracy, if the right populations were reached with the right supports, and provided software that both entertains and yields immediate payoffs, low-cost computer technology could make a huge dent in the literacy problem.

What would the technology look like? First, the computer should be cheap,



light, durable, low powered, and operated from solar cells and batteries. As it would have few moving parts, the cost to manufacture huge numbers of the portable devices would be trivial. It is difficult to estimate the eventual cost of making a billion computers, but since they would be made primarily from sand, plastic, and metal, most of the cost is in the design. Handheld computers have, so far, been made in the millions and their list price is approaching $100 each, which represents several times their manufacturing cost. Applying Moore's Law to the manufacture of very large quantities suggests that comparable computers might cost as little as two dollars to make by 2002, and less in the next decade.

How could this technology foster literacy? Someone who speaks a language but cannot read or write needs a way to correlate the spoken word with the text. The computer could contain dozens of engaging games, puzzles, and simulations that require the user to recognize and pronounce words; to write text based on pictures and animations; and to read for comprehension. For this to happen, the computer would need to have speech recognition, text-to-speech software, and handwriting recognition.

With the exception of good speech recognition, these features are currently available on handhelds. And as demand from business users drives the market, speech recognition is sure to follow soon. Much of the complexity of speech recognition software is related to its ability to parse words that run together in fluid speech. Software that requires the user to separate words would be an educational advantage. THE, USER, WOULD, HAVE, TO, SPEAK, LIKE, THIS. Not only would such an approach simplify the technical problem, it would force the

We have the technology and the resources to make global literacy a reality.

LINKS ON THIS PAGE

Moore's Law—www.cs.uoregon.edu/classes/cis629/Readings/moore.html user to do the parsing, thereby helping that person to recognize how speech is divided into words.

Like all meaningful education, literacy learning needs to be embedded in relevant topics such as farming, health, family planning, and cooking and treated in a way that is sensitive to the local culture. This content could be developed locally, in appropriate languages. A global effort could supply generalized tools and templates that could be localized efficiently, even if dozens of local languages need to be supported.

The computer should also provide alternative means of communication, at least by sharing files between computers using infrared. Low-cost or free wireless access to the Web is also feasible.

Experience in previous literacy programs has demonstrated the importance of outreach. Few people will learn in isolation, no matter how great the technology is. An outreach system that provides incentives, certification, and recognition for learners needs to be established. Perhaps the computer would link to self-help learning groups or live chat rooms on local topics. Outreach could also provide technical assistance and ways of supplying the handhelds with software updates and additional learning materials. Although such a program could easily be more expensive than the computers, most countries already have education, health, or agriculture outreach systems that could support this technology-based approach.

It is utopian to dream of greatly reducing illiteracy, but we have both new technologies that could help in the battle for literacy and the resources to make the vision a reality. With the compassion and will to undertake a major effort to overcome global illiteracy, perhaps Utopia is on the other side of the millennium? @

Robert Tinker is president of The Concord Consortium. bob@concord.org

Creating International Neighborhoods

Grade Schools Will Link Up On the Web for Futures Project

The Beacon International Neighborhoods Project has as its goal linking together fourth grades in four schools, each located in a different part of the world. A grant from the Department of Education of New York State to the South Avenue School in Beacon, New York, has helped initiate the project this fall.

"International Neighborhood" students will work together on the Web and in hands-on, minds-on explorations of issues in sustainability. Topics are matched to key state and national science standards, and include activities related to the environment, energy resources, neighborhood design and transportation. The goal of the project is to transform one's neighborhood into a neighborhood of the future, linked with other neighborhoods in an international network.

Beacon International Neighborhoods will use materials developed by the Education for a Sustainable Future (ESF) project at The Concord Consortium (see page 16). In addition, Concord Consortium staff will work with Beacon teachers to develop activities for use with temperature, light and other probes.

The project will be using Alan and Michelle Shaw's "Connecting Up Villages" software, which provides email, conferencing, a shared calendar, chat, and many other features that support community collaboration. The project will also use TERC's CLEO for student investigations.

At the end of the year, after exploring their neighborhood resources, students will build a physical model of their "neighborhoods of the future," a model which will feature energy saving houses and vehicles. There will also be a web-based model of all the neighborhoods. @

For more information contact Barbara Tinker or Carolyn Staudt.
barbara@concord.org
carolyn@concord.org

LINKS ON THIS PAGE
Department of Education New York State—www.nysed.gov
Beacon International Neighborhoods Project—ccservices.concord.org/showcase
Education for a Sustainable Future—csf.concord.org
TERC—www.terc.edu

Palm of Their Hands

continued from page 3

home or in their neighborhood. Finally, training and maintenance of the rapidly changing systems requires a high degree of technical savvy and investment. Clearly the desktop computer/application/network software model is widespread in schools not because it satisfies educational requirements, but because inertia conspires against better alternatives.

A technological revolution is under way. There are many promising alternatives based on inexpensive handheld computers, wireless networking, and interoperable software components. It is certainly possible that some of these leaner and far less expensive alternatives could be better suited for education. Such devices could be made available to more (if not all) students on a far more equitable basis than desktops. New handheld technologies, coupled with inexpensive networks, could enable students to carry personal tools of inquiry into the field,

between their classes, and between school and home. They could empower collaboration and networking regardless of location.

The Concord Consortium is keeping abreast of this revolution by scanning the technological horizon, anticipating implications for learning, and providing feedback to the marketplace. We are developing prototypes that exemplify the potential payoff of alternative strategies for integrated technology use. We believe that by creating a compelling prototype of how people can use technologies in new ways to learn and solve problems, the reluctance of educators to abandon their reliance on traditional methods will be overcome. Like breaking a logjam, once the significance of innovative combinations of commercial products and research offerings begins to be recognized, many other imaginative educational applications will follow.

Active learning in the field

In the past, portability was limited to data collection in the field with note taking and analysis performed at a later time. When students are confronted with data in this way - in isolation and out of context - they do not experience the benefits of learning in context. Handheld computers, in contrast, provide an integrated system of inquiry: since they are equipped with a drawing program and a facility for taking notes, they link the thoughts and design of the student-initiated questioning to the data gathering process. As new questions arise, new investigations can be carried out.

The options afforded by handheld computers make it convenient for students to predict changes by drawing a graph of their expectations and also taking notes on the results of their measurements as they're making them. The combination of a handheld computer and probe allows changes in the practical limits of time, access, and place, and provides the additional possibility of multiple investigations at the same place.

Handheld computer enhancements promise to provide flexibility and tools that are limited only by the imagination of the students and the roles and expectations of learning communities. Through our initial research (see "Probing Untested Ground," pg. 1) we have found that:

- Students have no fear of the handheld technology and use it effectively to facilitate complex investigation activities.
- Students in second and fifth grade classes found the active mode of problem solving, asking questions, defining the task, predicting and evaluating results engaging and attractive.
- The very focused hand-eye coordination and kinesthetic input of a small handheld computer clearly suited the younger age group.
- A drawing program provided a useful medium for creative representation of predictions.
- Graphical representation was interpreted well when used often and in close relation to data gathering activities.
- The portability of the equipment allowed even young children to inves-

LINKS ON THIS PAGE
Prototypes—probesight.concord.org

tigate relatively complex and challenging environmental data in ways that were satisfying.

- The integrated note taking option was used effectively as an authentic support for thinking and systematic investigation.

Handheld computers provide a possibility for seamless data collection and note taking, allowing students to design and question in creative new ways. Inquiry focuses on motivating the students to take an active role in their own learning. Ownership is the key to this process. This requires dynamic involvement instead of passive memorization. By placing a handheld computer with attached probes in the hands of each student, the focus of instruction shifts to inquiry and investigation. Students can design their own investigations given the proper tools and knowledge base to explore phenomena around them. And wouldn't that be a great start to education in the twenty-first century? @

Kate Crawford is on the education faculty at the University of Sydney, Australia. Carolyn Staudt is a curriculum developer and teacher professional development specialist at The Concord Consortium.
katecis@ozemail.com.au
carolyn@concord.org

Untested Ground

continued from page 6

was colder than the water.

By now several groups were working as one team. They shared data, discussed theories, and formulated further tests. The final test that the students designed involved a partially dried-up vernal pond, several meters from the larger pond. Would the vernal pond experience the same temperature difference as the larger one? The students discovered that the further away from the large pond they tested, the cooler the temperature readings.

After returning to the classroom, the students wrote their data on a white board. Their joint drawing allowed them to share theories and data and to formulate a group understanding. After the groups shared and discussed their findings with each other, they concluded in their own words that water appeared to hold more heat than the earth or air. They had begun to explore without knowing the terms heat capacity, convection currents, solar radiation, evaporation, etc. What a great opportunity for a science teacher to guide students to further investigations.

Comparing classes

Since the pilot classes were from fifth and second grades, part of the research study was focused on comparing the readiness of different age students to use handheld computers. During the introductory class, the major difference between the second and fifth grade class was the speed at which they investigated the Palm. While both groups were clearly at ease with the technology, the fifth graders covered almost twice the number of tasks as the second graders.

Significantly, the first and second lessons differed markedly in the lack of student collaboration, especially in the second grade class. Whereas only a week earlier students had been easily and naturally sharing the handheld computers, they now sat separately from their partners and were noticeably bored unless a Palm was in their hands. In some groups, one student in the pair chose to let the other have time with the Palm while he or she wandered around the room, until it was their turn to hold the Palm.

It appeared that in order for the students to be engaged and to develop a sense of ownership, they needed their own handheld computers. We tried this during the third week and it seemed as though the students became more actively involved.

New learning possibilities

It is the nature of young students to question their environment. Even very young learners can create and design their own procedures when they are provided with the opportunity to analyze data within a meaningful investigation.

Both the second and fifth grade classes were undaunted by the technology. They easily moved between note taking and data collection. And the handheld computers gave students the opportunity to connect their questions and investigations to the data while in the field. This pilot project suggests that portable technologies and software - in the hands of young students - provide enhanced opportunities for systematic investigation, critical thinking and cooperation. @

Carolyn Staudt is a curriculum developer and a teacher professional development specialist at The Concord Consortium.
carolyn@concord.org

LINKS ON THIS PAGE
University of Sydney—www.edfac.usyd.edu.au
Palm—www.palm.com

Realizing the educational promise of technology with three new grants

by Cynthia McIntyre

The Concord Consortium has recently been awarded three grants to expand the reach of the Virtual High School; to evaluate and disseminate the Hands On Physics project; and to link models and experimental data in the study of weather, climate, and global change.

Virtual High School

The Noyce Foundation, based in Palo Alto, Calif., has generously agreed to support the Virtual High School (VHS) project in order to create a nonprofit business that could be funded entirely from fees for services, royalties, and other income. Currently funded by a U.S. Department of Education Technology Innovation Challenge Grant, VHS offers online courses for high school students across the country, in a cooperative exchange program in which for each teacher offering a VHS course, 20 students at the participating school can enroll in a VHS course. The Noyce Foundation grant will allow VHS to restructure its operations, thus reducing operating costs and costs to users; to expand its potential audience; and to develop curriculum materials and proprietary software.

VHS will develop short modules in high-demand technical multimedia areas. These modules, taken sequentially, could form a course; they may also be offered in self-study mode or for teacher-authors to incorporate into their own courses. Administrative functions, such as registration and grade reporting, will be streamlined with software to be developed. The grant will also allow additional sites and individual, high-ability, disadvantaged students to participate in the VHS.

Hands On Physics

The Hands On Physics (HOP) Evaluation and Dissemination project is made possible with funding from the National Science Foundation (NSF). The materials and curriculum development for the HOP project were originally funded by NSF. HOP is an inquiry-based approach to physics instruction for high school and college students. The curriculum has been used by INTEC, Concord Consortium's online professional development course for math and science secondary teachers, and in the Virtual High School. The HOP Evaluation and Dissemination project will create a complete implementation package of seven HOP units and supporting materials to be delivered over the Web. The Concord Consortium will also update the HOP project web site and provide teacher assistance in implementing a new approach to their physics curriculum. To date, project evaluations have been formative, intended to guide materials development. Funds from the new NSF grant will allow a broader summative study, to evaluate the educational effectiveness of the HOP curriculum.

Models and Data in Science Education

The National Science Foundation has also funded a new project entitled Linking Models and Data in Science Education. The Concord Consortium will collaborate with faculty members from Boston University and Boston College to implement this project. Seventh and eighth grade students in Boston and Maynard, Mass., will work with computer models and experiments in the context of the variation of temperature in solids, liquids, and gases. Students will use temperature probes to produce real-time displays of the data, and compare these to the output of computer models that they themselves have constructed. As the experiments become more complex, the students will be forced to make their models more sophisticated. Eventually, they will apply their knowledge to improve their understanding of such real-world phenomena as weather patterns, seasonal variation, and global climate change. Longitudinal studies are planned to assess how students who have participated in the program succeed in their later science classes.

Foundations and individuals have made significant contributions to these and other projects of The Concord Consortium. If you are interested in supporting the work of The Concord Consortium, please contact us at info@concord.org. @

Cynthia McIntyre is project coordinator for INTEC. cynthia@concord.org

LINKS ON THIS PAGE

National Science Foundation—www.nsf.gov
Hands On Physics—hop.concord.org
Virtual High School—vhs.concord.org
Challenge Grant—www.ed.gov/Technology/challenge
INTEC—intec.concord.org

Perspective

Equity Computers: the Handheld Alternative

by Robert Tinker

Why is "technology in education" synonymous with personal desktop computers? Why spend $1,350 or more on a computer when a $135 computer would do as well or better? Does a fourth grader really need a 400 MHz, 64MB machine with a 10GB drive?

In many learning situations, a handheld computer provides all the computational power needed – a huge savings compared to personal computers. Handhelds typically feature megabytes of storage, easy communication with a host computer, and an intuitive pen-based graphical interface. They support spreadsheets, word processors, graphics and probeware (see "Monday's Lesson," page 8). This makes them at least as powerful as the second-generation Macintoshes which were widely used in education.

Palm™ computers now dominate the handheld market and cost as little as $135. The similar Royal daVinci™ sells for $100. Competitors are flooding the market and driving down prices. Handheld sales, which reached 3.9 million units in 1998, are expected to increase and may surpass PC sales by 2002, when their cost could drop below $50. These could be "equity computers" – the educational right of every student.

> **"Does a fourth grader really need a 400 MHz, 64MB machine with a 10GB drive?"**

Handhelds offer more than an inexpensive substitute for a PC, they offer portability. Students can use them in and out of the classroom, in the field, and at home. This brings student investigations to where the questions are and gives context often missing in the classroom.

Through our Science Learning in Context (SLiC) project and the Mobile Inquiry Technology (MIT) project, for which we are a collaborator with Hudson Public Schools in Massachusetts, we have been exploring the educational value of portability for four years, first with the Newton, then the eMate, and more recently, the Palm computers. And through the Center for Innovative Learning Technologies (CILT), we have launched research projects in California and Massachusetts to study student use of handhelds for water quality activities. This research has convinced us that handhelds have at least a role in elementary science education (see "Probing Untested Ground," page 1).

Still, additional research and development is needed before handhelds can be widely used. Right now, there is only one integrated package that includes software, curricula, server support, and teacher materials – the probeware from ImagiWorks™. As a result, using handhelds in the classroom for anything but probes puts a huge burden on the teacher for both technical and educational support.

It is time both educators and vendors woke up to the possibilities. Educators should be demanding support for handhelds from vendors, and vendors should be supplying far more options that use handhelds. To stimulate these developments, we are sponsoring an educational software contest through CILT (see "CILT Contest," page 7).

The profession needs far more research on educational applications, not just for today's handhelds, but for the entire spectrum of low-cost devices just over the horizon. One of the most dynamic areas of consumer electronics is the move toward low-cost computer-based products with less power than PCs, but which are easier to use and have better connectivity. Phones, pagers, and handheld computers are going to merge. Once we decide on standards, these devices will be connected all the time to the Web. One could call up a field guide while outdoors or share data with other students anywhere. Standards will also solve the problem of providing software for each new handheld; they would all execute the same Java programs obtained from the Web.

We need to create prototype systems and begin to lay the foundation for widespread use of today's and tomorrow's "equity computers" in education. @

Bob Tinker is president of The Concord Consortium. If you want to join in a discussion of equity in education, join our Open Forum.
bob@concord.org

LINKS ON THIS PAGE

Palm—www.palm.com
Open Forum—openforum.concord.org
SLiC—slic.concord.org
CILT—www.cilt.org
Imagiworks—www.imagiworks.com
Royal da Vinci—www.royal.com
MIT—mit.concord.org

info@concord.org

Join Us Online

Free Software for Understanding Sustainable Development

Sustainable development involves complex, interdisciplinary issues that would be impossible to bring to precollege education without technology. Education for a Sustainable Future, a project of The Concord Consortium's Center for a Sustainable Future, has developed three new software tools for visualizing and exploring possible futures.

What-If Builder

The 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." A model consists of short sections of narrative, each ending with a choice for the reader that determines what happens next.

Visual Community Designer

The Visual Community Designer is a spatial modeling and visualization tool for community design and evaluation. You define the objects of the model, such as houses, and the variables associated with the objects, such as number of people or water usage. Variables can be set to default averages, or customized for specific objects, such as "my house." Visualization tools let you do calculations over a community (e.g., total population, electricity use, jobs available, unemployment rate) and perform "what if" experiments (e.g., the net effect of everyone turning their thermostat down a degree or using public transportation).

Ecological Footprint Calculator

The Ecological Footprint Calculator measures our use of nature by calculating how much land is required to produce all of the resources we consume, and absorb all of the waste we produce. The concept is described in the book "Our Ecological Footprint: Reducing Human Impact on the Earth" by William Rees and Mathis Wackernagel. We are developing the Ecological Footprint Calculator as a tool for students to calculate their own ecological footprint, and to visualize their footprint in various ways. The tool also provides information to students about how the ecological footprint is calculated, and what are the different land uses that make up their footprint (crops, grazing land, forest, developed land, etc.).

http://csf.concord.org/esf/Software.cfm

Virtual Middle School™ Planned

We are planning a Virtual Middle School (VMS™) patterned on the highly successful VHS model. Help us shape the face of VMS to serve your needs. This is your chance to get involved at the ground level. What content should we offer? How long should the classes be? Answer these and other questions at our web site. Sign on and contribute your comments to the ongoing conversation there. Make VMS the kind of school you want.

http://vms.concord.org

The Concord Consortium
37 Thoreau Street
Concord, MA 01742

PHONE 978.369.4367
FAX 978.371.0696

COMPLEMENTARY COPY
to subscribe go to
http://www.concord.org/library

Nonprofit
U.S. Postage
PAID
Boston, MA
Permit No. 97