Elliot Soloway, Cathleen Norris,
Phyllis Blumenfeld, Barry Fishman,
Joseph Krajcik, and Ron Marx

Handheld Devices are Ready-at-Hand

Like its predecessors—the pencil, paper, and calculator—computers must be within arm's reach, mobile, and palm-accessible in order to make a difference in the classroom.

Critics [3–5] claim there is essentially no hard evidence computers have had a significant impact on learning in K–12 education.[1] Given the significant costs involved in putting technology into schools and given the potential to harm young children, one prominent report calls for "An immediate moratorium on the further introduction of computers in … elementary education" [3]. Rather than getting defensive, gesticulating wildly, and dragging out that favorite story about how one child we personally know accomplished an amazing thing with a computer, it's time to come out of the closet: children simply aren't using computers in K–12 schools and that's why there isn't substantial data on the impact of computers in K–12 education.

Let's look at some basic statistics about availability and use of computers in K–12:

- Henry Becker, a professor at the University of California, Irvine, has been monitoring the spread of computers in schools for almost as long as computers have been in the schools. In a 1998 nationwide survey [1], Becker attempts to assess the density of computers in schools. He reports that fewer than 20%

[1] While there are hundreds of studies documenting the positive impact of computers on teaching and learning, these studies are not typically carried out in large-scale contexts as are studies in, say, medicine and public health. We have surveyed over 100 of these focused studies in K–12 science education (hice.eecs.umich.edu/convergentanalysis/science) and writing education (hice.eecs.umich.edu/convergentanalysis/writing); they all agree that under the right conditions, computers do indeed lead to enhanced learning.

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of the schools meet the following criteria: "having at least one computer of any kind for every four students enrolled, one Pentium or Power Macintosh computer for every six students, one CD-ROM-equipped computer for every six students, and having at least half of all instructional rooms connected to the Internet by a high-speed, direct connection."

- Conducting 20-question, online Snapshot Surveys of educators in Nebraska, Pennsylvania, and New York during 1999–2000 [6], we found that of the 6,000 respondents, approximately 60% reported they had none or one computer in their classroom.
- But Becker [2] observed that "frequent [computer] use was closely associated with having computers accessible in the teacher's own classroom."
- From our Snapshot Survey, approximately 45% of teachers report that their students use a computer less than 15 minutes a week. Similarly, Becker [1] reports that 70% of the teachers in his nationwide survey allow their students to use computers zero, one, or two times a week.
- In our work in middle schools in Detroit, we found that in-class availability of computers is strongly associated with gains in student learning [5].
- Computers are sequestered predominantly in labs.
- Limited though computer access is, Becker observes that the primary use of computers in K–12 schools is for word processing: computers are being used as typewriters.

As long as computer labs are down the hallway and up the stairs, teachers will consider them irrelevant to learning and teaching.

So computer availability, access, and use is dismal in schools. But what about their availability in the home? Here's what we found:

- In households where the annual income is lower than 50,000, the U.S. census reports that approximately 25% of these families have computers in the home. In contrast, where annual income is above $50,000, approximately 60% have computers. In Detroit about 70% of the children are on free or reduced-fee lunch program. Thus, in our efforts in Detroit's middle schools, we can't count on children having access to computers or the Internet at home to do their schoolwork.

In U.S. K–12 schools, the availability and use of Internet-connected computers is about 20%–30% less than for stand-alone computers.

Bottom line: it's unreasonable to expect computers to have a positive impact on learning and teaching if students and teachers have limited access to them.

The Prognosis

The German philosopher, Martin Heidegger, distinguished between things "present-at-hand" (not available for work) and things "ready-at-hand"—things essentially within one's reach and that truly get used. In the white-collar workplace, PCs are ready-at-hand. Indeed, while K–12 schools talk about "students per computer," those in the business world talk about "computers per person," (a desktop at work, a laptop for travel, a home computer used for work, a handheld device, a two-way pager, and an Internet-enabled cellular phone per person).

As we have said, the term "personal" computer is an oxymoron in K–12 schools. A so-called personal computer is used eight periods a day, five days a week, by eight to 24 different children each period. That is, when the PC is running, which is maybe 70% of the time, since the settings are constantly being changed, inadvertently or not.

The reality is this:

- The Detroit Public Schools

administration is not going to buy a $1,000 PC for each of its 167,000 students nor is the Plankinton, SD, administration going to buy one for each of its 604 students.
- Communities are not going to earmark enough money, on a continuing basis, to buy and keep the ratio of PCs down to even 2 students to 1 computer, let along a 1-to-1 ratio in the next few years. Do the math and the costs are staggering.

As long as computer labs are down the hallway and up the stairs, teachers will consider them irrelevant to learning and teaching. As long as the ratio of students to computers is 4–7 to 1, the effort needed to use them is simply too high, given all that has to be accomplished in a school day. As long as computers are not ready-at-hand, they will not be used in a routine, day-in, day-out fashion; the impact of computers on K–12 education will continue to be essentially zero.

The Answer's Right in the Palm of Your Hand

Don't despair; hope springs eternal from the well of technological innovation.

Handheld devices can be the PC of choice for K–12.

We are talking about those overgrown, playing-card-sized gadgets that adults use as modern-day appointment books. Oftentimes referred to as personal information managers (PIMs) or personal digital assistants (PDAs), these devices come in a variety of flavors: Palm Computing, Inc started out with Palm Pilots and now sell $150 M100's; Handspring, Inc. makes the Visor, which also runs the PalmOS; PocketPC's run a version of Microsoft's Windows OS and are made by Hewlett-Packard, Compaq, and Casio.

While small in stature, these handheld devices, when equipped with appropriate software, can do much more than keep track of addresses and phone numbers. Indeed, we believe the following: *each and every child should be provided with a $100 handheld device.* This amount of money is available if we look hard enough.

Impossible dream? No. Each of 1,700 students and 65 teachers in all three high schools in the Consolidated High School District in Illinois (see www.d230.org/Handheld/) uses handheld devices made by Palm Computing, Inc. Eminence Middle School, in Eminence, KY has all 50 of its 12- and 13 year-old students use PocketPCs for schoolwork.

Yes, handheld devices have significant limitations. For example, the computational zorch (power) tends to be so low multimedia is problematic; writing extended documents via pen-input is taxing, especially for the younger students, and the screen is too small. But, inasmuch as the alternative is essentially access to no zorch and no screen, the handheld device is, for K–12 students, a quantum leap in computational availability.

Core Applications and Supporting the Curriculum

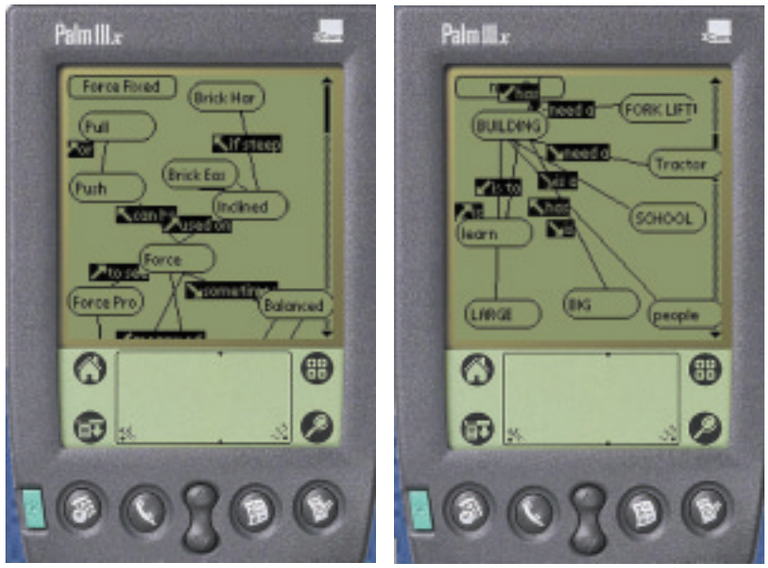
Reading, writing, and arithmetic are all available on handheld devices. From the included Notepad, a vanilla text editor, to the more decked out Handango Professional Users Suite (www.handango.com) for $89.95, all the normal office productivity tools are available on handheld devices.

While having children use the built-in calendar to record the due dates of their assignments is actually a good idea, the personal information manager functionality of handheld devices isn't what will sell educators on these devices. Teachers are held accountable for curriculum. Thus, compelling applications are those that support the teaching and learning of the curriculum. Check out the following applications being developed in our group at Michigan. They are being used by upward of 2,000 students in middle and high school classrooms in the U.S.

Selling the Solution

Now that we believe handheld devices are the answer to the access challenge in K–12 education, we need to sell this solution to the schools. It took years to convince schools to purchase graphing calculators; getting math educators to share their new-found power to switch over to purchasing handheld devices will take some doing. Our strategy is to demonstrate there are enough provocative, educational handheld applications

Figure 1. Examples of PicoMaps created by students.



that enable learning and teaching.

And (here is the really important bit) link those applications to existing curricular materials so educators essentially already know how to use the handheld devices. Having enough applications that have educational utility is strong ammunition in arguing for a switch from graphing calculators, a definite one-trick pony, to handheld devices. Here then, are our candidates for some effective handheld applications.

PicoMap. PicoMap is a concept mapping tool for handheld devices. Figure 1 presents several PicoMaps created by 10- to 12-year-olds in Detroit during a unit on the physics of heavy machinery. PicoMap goes beyond paper-and-pencil concept maps in the following ways:

- First, children beam their PicoMaps to each other. For example, children will pair up and, in a group brainstorming activity about, say, water quality, one child will identify sources of chemical pollution (nitrates) in their local river while the other child will identify sources of physical pollution (sewage). Then the children beam each other their ideas to support the ensuing discussion.
- Since each child has a handheld device ready-at-hand, children naturally revise their PicoMaps. In contrast, if their documents are on a desktop computer accessed only one hour per week, children will not engage in the critically important process of iterating and revising their documents.

Children can print out their PicoMaps, allowing the teacher to track what the children are doing and give feedback, while parents use the printouts for refrigerator decorations. Classroom management issues are not to be taken lightly; making printing straightforward makes teachers comfortable with having each of their 30 students equipped with a handheld device. (If only syncing 30 handheld devices to one desktop computer was as simple.)

Palm sheets. For better or worse, worksheets are a fixture in K–12 classrooms. But a handheld device's worksheet has numerous advantages over its paper cousin: the handheld device can immediately check a student's input and provide feedback. After the data from the worksheet are transferred to a desktop computer, the data can be automatically aggregated and and graphs presented that depict all the students' answers. Figure 2 shows an 11-year-old filling out an Air Quality Inventory worksheet.

Cooties. How do germs spread? Drawing on the work at the MIT Media Lab with SmartBadges, we developed a socio-kinesthetic simulation on handheld devices to help children understand this process. Children "meet" each other by walking around a classroom with a handheld device and beaming each other either a digi-

Figure 2. Filling out an inventory worksheet.

tal-germ-free or a digital-germ-laden message. (The teacher sets up the initial conditions for the experiment, distributing digital-germs via beam to the children's handheld devices.) After the spread of the digital-infection, students can study the transmission pattern of the "meetings" by viewing a PicoMap depicting the history of the meetings. This exercise enables children to see that meeting one person really means meeting all the people who that person has met previously. Based on this experience, it is much easier to understand how disease spreads and how difficult it is to determine how a disease is spread in a population.

Fling-It. Inasmuch as children don't necessarily have ready access to desktop machines with the Internet at school or at home, they need to be able to take away with them at least some of the content when they do get the opportunity to access the Internet. So, after finding a useful Web site, a child can click on the Fling-It icon and that Web page is scrunched down and sent to their handheld device which is sitting in a cradle next to a desktop computer.

Typically, it's been found that 11- to 14-year-old children are not big on reading. (The reasons for this situation need examination, but that's for another time.) But if the Internet is going to have an impact on learning, there is no escaping the need to read. Perhaps, at home, with adults and siblings to help and with Fling-It-provided reading material on their handheld device, these children will find reading more approachable.

CritterVille. CritterVille is an ecosystem populated by creatures created by students on their handheld device. The actions of a Critter are transmitted wirelessly to the Web site that hosts CritterVille; the implications of one Critter's actions then is distributed wirelessly to Critters on other handheld devices. One learns pretty quickly how difficult it is to keep one's critter alive and healthy in a complex ecosystem.

Children will not use all the applications all the time. The goal, however, is to have enough educa-

tional applications available to support a range of learning opportunities.

Preliminary Observations From the Field

"This is the funnest day of the week." That observation is representative of how the students feel about using the Palm computers and Handspring computers in about a dozen classrooms in Detroit, Hartland, and Ann Arbor, MI. There is essentially no hesitancy and no intimidation; the kids press the on button and start tapping away. They pick up PicoMap in a snap. Now, making a good concept map is still an acquired skill (for example, putting meaningful labels on links and getting the directionality straight is definitely difficult for the children), but PicoMap per se is invisible. To make writing extended paragraphs easier, the children oftentimes plop their palm computer into a keyboard. And the children treat their handheld devices with respect and care; while a few have felt the force of gravity, it is as likely that an adult did the dropping as did a child.

But in truth, few of the teachers using the handheld devices would share the sentiment expressed at the outset of this section. From hardware breakdowns to curricular questions, integrating handheld devices into the everyday fabric of the classroom is a challenge. Some teachers reserve the handheld devices solely for doing a three-day stint with Cooties during a communicable disease unit, while others, who regularly do concept mapping with their children, use the handheld devices on a more routine basis. In some of the classes, the children are permitted to take their handheld computers home, where some schoolwork does occur, but, to be completely candid, game playing is the dominant activity.

When PCs were introduced into the school, children took to them, while educators felt the challenges. As handheld devices are being introduced into the school, children are gobbling them up while educators are again feeling the pressures. Why will the use of handheld devices in K–12 be different from the use of personal computers in K–12?

Conclusion

As long as the ratio of computers to children remains in the multiple children to one, we are not going to see major use of computing technologies in K–12 schools. Extracting benefits for learning and teaching of using computing and Internet technologies in such a situation requires a disproportionate amount of effort. And, the ratio of children to computers is not going to dramatically decrease in the next five years.

K–12 will take computing technologies seriously only when they are as available as pencils. When computing technology is literally ready-at-hand, when students whip out handheld devices from their backpacks and desks instead of pencils and paper, only then will education and educators move to using the technology in a routine, day-in, day-out manner. And, with the cost of handheld devices down to acceptable consumer price levels, the proliferation of these handheld devices will skyrocket over the next five years.

The mainframe computer, the personal computer, and the Internet are tidal waves that have wrought profound change in all manner of organizations. But those technologies have only lapped gently at K–12's shores. It is appropriately ironic, however, that those technologies that fit into the palm of a child's hand—the pencil, the paperback book—are really the technologies that bring about revolutions in education. C

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Elliot Soloway (Soloway@Umich.edu) is a professor in the College of Engineering, School of Information and School of Educations, University of Michigan, Ann Arbor.

Cathleen Norris (Norris@unt.edu) is a professor in the Department of Technology and Cognition in the College of Education at the University of North Texas, Denton.

Ron Marx, Phyllis Blumenfeld, and Joe Krajcik ({ronmarx, blumenfe, krajcik}@umich.edu) are professors in the School of Education at the University of Michigan, Ann Arbor.

Barry Fishman (fishman@umich.edu) is an assistant professor in the School of Education at the University of Michigan, Ann Arbor.