

Hardware Matters

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In trying to develop new models of how technology can be used to improve teaching and learning, common knowledge dictates that we start from goals and objectives, then identify content, tools, and procedures, then software to present/manage/give access to all that, and only then consider what hardware is required to support all this. But the hardware does matter. Here's why.

No matter what online resources and tools we put out there on our servers, it's useless to students and staff who don't have ready access to the hardware that delivers it.

It's one thing to consider a networked computer in every staff member's office or classroom; this takes care of access for staff (at least while they're at school.) We can even consider several labs on every campus and, say, three or four computers in every classroom. A number of schools are there already—or closing in fast. But this does *not* provide “ubiquitous” on-site access for students.

Consider the typical well-equipped high school today. During class periods, Jane is only going to be able to be sure of “getting on” a computer if her teacher has scheduled to bring the whole class to the lab that day, or if she's lucky enough to get to one of the four—or even twenty—in the library media center (LMC) on a day the class is there for research. If the teacher has a particular unit/lesson/activity which is designed to allow four students to work on the classroom computers while the rest of the class is productively occupied with other learning activities which those four can “miss” or “pick up” at another time, then Jane can get on as her turn comes in rotation during that unit. (Depending on the course and curricular area, it can be quite difficult for a teacher to design units that accommodate this.)

Outside of class (before/after school, lunch, any unassigned periods Jane might have, etc.), Jane's only shot at getting on is one of the three labs on campus, the few computers in the LMC, or perhaps one of the four in one of the classrooms (before/after school only here)... if the teacher is willing to stay in the room before/after hours to supervise and let students drop in (some are, most aren't, none can be required/expected to.) There are three labs of 35 computers each (we'll assume the school's budget supports paying for their supervision all day, including before/after school and lunch), 20 more in the LMC, and let's say ten teachers willing to let students have at it before/after school for awhile. There are 2,000 students at Jane's high school. This makes 155 computers available (each of the ten teachers in those classrooms is using one of the four computers there him/herself) for 2,000 students. $2,000 \text{ divided by } 155 = 0.0775\dots$ Jane has a 7.75% chance of getting on a computer outside of class (at least at the times all other students also want to use one.)

For the kind of online content and tools I think we're envisioning, every student needs to have his/her own networked “computer” in (and outside of) every class, every day. And if we're going to expect them to use these resources at home, they need it there, too. Hardware matters.

We can buy a wireless-network-enabled notebook computer for every student and blanket every campus with wireless access points (WAPs). Check the notebook out to them at the beginning of the school year, check it back in at the end. We still have the problem of network access from

home, where many will have to commandeer the phone line and be limited to low bandwidth, downloading in advance what they can when at school, but the bulk of our problem is solved. Well, that was easy (albeit expensive.)

Not so fast. What happens when Stewart loses his school-loaned notebook, or drops it, or has it stolen or purposely smashed by somebody who's got it out for him? Few of our poorer students' families can afford to pay to repair/replace a \$1,500 computer if any of these sorts of things happen... and you know they will. And you know even parents who can afford it are going to argue until they're blue in the face about the various reasons it wasn't Stewart's fault and there's no way they're paying the school \$1,500. (I'm responsible for circulating all textbooks at La Jolla High School; you should hear some of our wealthy parents when their child loses or damages a \$60 textbook.) That said, I remember reading several years ago that Coronado purchased a notebook computer for every student, and a recent article reveals a small district in Maine is piloting a similar project. The notebook-for-every-student is being done; only time will tell how broadly successful it proves.

I've been paying increasing attention to ebooks recently. "Ebooks? Oh yeah, I think I remember when everybody was talking about how they were going to take over and print books would soon be collectors' items. Well, *that* certainly turned out to be a flash in the pan... obviously never going to happen." Personally I'm not so sure. The hardware still isn't there yet to support ebooks' true potential—hyperlinked text and multimedia including everything from animated graphics to full-motion video with sound—but higher education is looking hard at them to replace those \$100-a-pop, replaced-by-the-new-edition-every-year college textbooks, and I think it may trickle down to at least secondary schools in the next five years or so.

Books—especially textbooks—have been one of the most basic tools of education ever since the printing press was invented. They continue to be so today. Textbooks are neat, portable packages of focused information, collected and written specifically for particular courses of study or to meet specific educational goals. Etextbooks can serve the same purpose but more powerfully, by including features whole generations of monks slaving away over illuminated manuscripts could never have imagined.

A new or unfamiliar word or phrase? Tap on it to hear it pronounced, read and hear a definition, or read and hear it used in several other sentences illustrating its meaning. Want to hear this poem read aloud by the poet or a professional reader? Tap on it. Reading about a process you'd like to see illustrated? Tap for the animated graphic or video that demonstrates it. Full-color photos are of course only a tap away (if it's not important that they be displayed simultaneously with adjacent text, in which case no tap required... unless you'd like to see that sculpture pictured from other angles, in which case a tap-and-hold will rotate it through 360 degrees and zoom in/out as you wish.) Need to do a keyword search through the entire contents for a word or phrase? Tap, write, tap-to-search. Want to bookmark or highlight a section? Tap tap tap (or drag.) Write a note in the margin? Who needs margins anymore? Tap and... type? No, just hand-print into the scrolling box that popped open where you tapped; it'll turn into a little colored blip in the text when you're through, waiting only a later tap to pop it open again for you to read. If necessary, you can easily create a hyperlink in your note to another note or bookmark anywhere in that text.

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Hardware matters. You notice I've said, "tap" instead of "click." That's right—we're talking a touchscreen here... not a keyboard in sight (unless you want to sit at a desk and connect one.) The form factor is not that of a clamshell notebook computer, it's a textbook-sized (but thinner) tablet. However, there is a considerable amount of processing power and storage capacity in this little baby (has to be for all that multimedia.) I don't have to wait two minutes for it to boot or even wake up when I go to use it; like a PDA, it comes instantly to life in exactly the same state as when I last switched it off. Its screen is almost as bright and has almost as high contrast, resolution, and color depth as a printed page, it's also about 7" x 10" in size so I can see as much at once as I could on the typical printed textbook page, and it's transfective for both indoor and outdoor reading. If I'm going to be carrying it around with me all the time and holding it to read (with one hand if I happen to want to write notes or highlight with my stylus and there aren't a table and chair handy at the moment), it's got to be light—no more than about two pounds—and not too big (but not too small either—that screen size is important if I'm going to be reading books on it all day.) It's fairly shock-resistant, too: it can take the occasional getting knocked off the desk onto the floor, and it's got a stiff protective screen cover which folds 180 degrees to lie flat against its back while I'm using it. Of course I can't be running out of juice in the middle of sixth period (or when I'm studying after school in the library, outside waiting for a ride, on the hour bus ride home, etc.), so I need it to have a good eight to ten hours of fulltime-use juice so I can get away with only plugging it in to recharge before I go to bed every night. Oh yeah... and if I lose or break it, it only costs about \$300 for another one.¹ (Developers, you've got your work cut out for you!)

I don't think we're going to ever have enough network drops or enough AC power outlets to have a computer for every seat in every classroom, even if we supply every student with a notebook computer (as we know it today.) And notebooks are too heavy, fragile, awkward to read books on, and expensive anyway. However, if Moore's law continues (recent developments indicate no sign of it slowing down for the next decade or so), given the development of PDAs' power I'm seeing, such a device seems just around the corner. Screens, batteries, and cost are probably the biggest obstacles, but they're coming along too. I'm not the only one thinking along these lines. Take a look at the goReader (www.goreader.com); while it's still way too expensive to qualify as our ideal student tablet, it's an attempt to provide many of the features I've been talking about.

When such ERDs are readily available, etextbooks are going to take off big time (or not—predicting the future is always a risky business.) Students will ditch the 30-lb. backpacks in a heartbeat (albeit to orthopedists' dismay.) As school districts invest in an ERD for every student (plus spares for replacement), economies of scale will kick in and the etextbooks will cost no more per copy (and eventually less) than their dead-tree ancestors. School library media teachers can once more focus all their time and energy on teaching information literacy (eventually in an

¹ At La Jolla High School, the average cost of all the textbooks checked out to each student during the school year is about \$300. This is not to imply that we can simply trade the cost of supplying textbooks for that of supplying ERDs; publishers of e-content still have to be paid for every copy of an etextbook provided to a student or staff member. Providing an ERD to every student *will* be an additional—and significant—expense.

all-ebook world?) and be relieved of the time-suck of being textbook acquisition, inventory, and circulation managers.²

If you think this scenario is at least plausible, stick around and let's keep going. By the time we've got the technology to produce such ERDs, adding the wireless connectivity to afford them ubiquitous broadband connection to all our online resources shouldn't be too hard.³ And now you have every student with his/her own "computer", all day every day, in and out of class, affording him/her ubiquitous access to all educational "materials" (bits, not atoms) and the tools necessary to use them. (I'm ignoring, of course, materials which can never be replaced by bits and which will remain necessary for a truly quality education that produces well-rounded students: musical instruments, art supplies, hand and power tools, athletic equipment, etc.)

We're not finished yet. Once all students have these devices (no longer just "ebook reading devices"), it will make sense for *all new books* the school purchases to be ebooks... including those purchased for the school library. Over time, the "elibrary" grows while the print collection ages and deteriorates. Research—even pleasure reading—is increasingly done with elibrary books instead of those on the (nonvirtual) shelves. Eventually, the print collection becomes largely irrelevant and is done away with. Students accustomed to reading books in e-format grow up and graduate, and as adults, any time they want to read a new book, don't even think about purchasing those old heavy, space-gobbling, dead-tree pagey things. Economies of scale now kick in big-time. Publishers gear their whole production to digital distribution infrastructure and format, producing reference, nonfiction, and fiction ebooks for the general public which are as rich in the hyperlinks, multimedia, and other features as the etextbooks they cut their teeth on. (Magazines and newspapers of course will have gone all-digital some time ago.) Public libraries go the way of school libraries and supply limited numbers of simultaneously-"checked out" copies of their large library of e-titles to registered users for free during the standard checkout period (no late fines or having to pay for that book you lost or damaged, though: when it's due, *Poof*... it disappears from your device and is now available for someone else to "check out" and download.)⁴ Print books become quaint collectors' items, relics treasured by those of us still alive who grew up with books and got hooked on the look, feel, and smell of them.

Well, it's been quite a ride, hasn't it? While predicting the future is fun (and notoriously unreliable), it's time to refocus. As we attempt to create and implement technology systems which can significantly improve teaching and learning in K-12 schools in San Diego County, it's all too easy to focus on the content and the delivery systems while assuming the hardware to

² Hey, I can dream, can't I? Of course someone will have to manage acquisition, inventory, and circulation of all these ERDs. Oh well, better one ERD—the same model—for every student than four-to-fifteen different textbooks out of an inventory of hundreds of titles. And in the school of the future no one would dream of saddling the library media teacher—a credentialed, experienced teacher with Master's-level professional skills in teaching information literacy—with this strictly clerical job. Of course coordinating with the textbook publishers to set up and manage etextbook downloading for students is another story, and this could wind up being assigned to the LMT, in which case we've traded one clerical task for another that is somewhat more high-tech but still essentially managerial/clerical.

³ On campus at least... Can we convince the community to subsidize local telecommunications providers so they will provide municipal-area broadband wireless or wired network access to students at home?

⁴ NetLibrary already has a system in place which supports this, although only for "true" computers—not handheld devices.

access it all is essentially already available: networked computers. That's how *we* all access networked resources, and it's the model we naturally think in terms of. Sure, there aren't enough computers at school sites to provide every student with the ubiquitous access required, but that's just a matter of finding enough money to purchase and install them. We feel wise when we realize we don't want to turn every classroom into a computer lab with a desktop taking up all the desk space at every student seat (and we can't afford to replace all those tablet-arm "desks" with real ones anyway), so we decide purchasing wireless-equipped notebook computers and checking them out to the students will solve the problem. Disregarding cost, hardware now seems the easy part.

I'm arguing that's not the case. When we look at "the last 30 feet", getting that pipe full of data from the router or network drop in the classroom to every student all the time, so they can use it whenever necessary—during class, outside of class, and at home—then we have to give every student his/her own device at the end of that pipe. For the reality of today's average K-12 student's life, even today's notebook computers just won't serve: they're too expensive, too unwieldy, too fragile, too time-consuming (boot-shutdown or even wake-sleep times), and too short-lived (battery life) to do the job. If we could provide something like the ERD I've described only use it for a network access as well as a textbook-reading (and annotating) device, it might be just the ticket.

However, if we can't *replace* textbooks with all-digital content, then we're adding yet another object to an already-overstuffed, way-too-heavy backpack... an object which costs at least as much if not considerably more than all the textbooks already weighing it down. But if we can provide students with one book-size, lightweight tablet device which not only contains all their textbooks but serves as their interface to all the networked content and tools we're envisioning, *now* they've got something which fits conveniently into their lives and is a manageable way for schools to provide every student ubiquitous access to *all* digital educational content and tools.

Hardware matters. The device I've described here doesn't exist yet... but it's tantalizingly close. I suggest we consider such a device in our plans (SAIC and other partners, are you listening?) I also suggest that at the same we develop online content and tools, we seriously pursue ways to have all required (at least State and district-"adopted" grade 6-12) textbooks provided in e-format such that students can download and use them on this device—even when not connected online. This will relieve kids of the huge, unhealthy burdens they currently have to lug around daily and ensure familiarity with and encourage use of the devices. Most importantly, it will ensure ubiquitous access to all the other resources we're hoping to provide to them online.

Some considerations follow. Access to the Internet at large may *not* be something we want to enable on this device, at least at first; nor may we want to make it possible for a student to connect it to a computer. For one thing, publishers are very wary of the possibility of copy piracy when publishing in e-format... in fact, that's one of the things that have prevented ebooks from taking off, and piracy has been primarily responsible for the "formats jungle" which has arisen with its varying encryption schemes attempting to ward off widespread distribution of copies without payment. If a kid can send a copy of his downloaded etextbook to someone else, the publisher is *not* going to provide it to the schools in e-format. And visions of kids instant-messaging, browsing the Web at random, playing online or downloaded games, and trading email during class are enough to make any teacher wary. Initially, I think we want to design the hardware and software of these devices so they can *only* access the tools and resources we intend. This will require considerable planning and design efforts.

Then of course there's the hardware itself. To recap, it must be big enough to display the equivalent of an entire average-textbook-sized printed page (7"x10"), and lightweight (no more than two pounds.) The screen must be very bright (visible even outdoors under shade) and have high contrast, very high resolution, rich color depth, be capable of displaying full-motion video, and be touch-sensitive. The device must have considerable memory/storage—I'd say on the order of four GB or more. Battery life must be such that it can be used for at least eight hours on a full charge at full brightness. Accurate natural handwriting or hand-printing recognition is a must... in both English and Spanish (must recognize accented characters, etc.) It must use an instant-on/off operating system similar to Palm or Pocket PC (though it will probably need more processing power than even the 206MHz ARM processors currently used by the Pocket PC devices.) It must accommodate both a keyboard and mouse connected simultaneously (infrared? Bluetooth?) It has both a built-in speaker and microphone. It must be rugged (aluminum/magnesium/titanium case), with a sturdy fold-back cover. And it must connect wirelessly to any on-campus wireless access point ⁵, as well as via either its built-in modem or Ethernet ports for home access via phone line or DSL/cable modem... to download textbooks (or upload them with student markups for safekeeping) and to access the other online resources we plan to provide. Finally, it can't cost the schools more than about \$300 per device.

I know, it sounds impossible today... especially at that price. But technology continues to forge ahead with amazing advances every month it seems, and such a device may not be as far out there as some of us think. Too, if a San Diego County Education-level initiative calls for such a device for every student, the potential market could spur industry to ramp up development efforts.

Hardware matters. I think that the ultimate success of what we're considering depends on ubiquitous access to digital educational resources for students in the context of their day-to-day reality at school and at home. I don't see that even wireless-equipped notebook computers for them all is an option, given their current expense and limitations... and the necessity of wiring every classroom and LMC with at least an AC-supplied, DC-transformed wire for every seat to be sure they work throughout the school day. The tablet device I've described seems to me the best option for making available to our students what they'll need to use the digital content and tools we want to make available to them for powerful learning.

⁵ Probably something like 802.11g, to allow sufficient bandwidth for the many devices which might all be within range of a given wireless access point at one time