Mobile Technology in 2020: Predictions and Implications for K–12 Education

Cathleen A. Norris
Elliot Soloway
Contributing Editors

While "mobile learning" has gained recognition in K–12 as a category in educational technology, the authors argue that, between 2010 and 2015, at least, its impact hasn't matched the hype. But between 2015 and 2020, hardware, software, and network technologies will mature sufficiently such that educational technology's Holy Grail for K–12—a computing device—a mobile device—for every child, 24/7—will be realized. The authors, though, argue that K–12's dominant pedagogy—direct instruction—must give way to an inquiry, learn-by-doing pedagogy in order for learners to truly benefit from universal access to mobile computing. Unfortunately, their article is less sanguine on the probability of K–12 educators making that transition.

1. Introduction

At the ISTE 2010 Conference, during our spotlight presentation, we made the following prediction:

Cathleen A. Norris, a Contributing Editor, is Regents Professor, Department of Learning Technologies, the University of North Texas, Denton, Texas. Her university research agenda has been shaped in part by14 years of teaching in K–12 classrooms. She has been President of the International Society for Technology in Education (ISTE) and President of the National Educational Computing Association (NECA), organizers of the National Educational Computing Conference (NECC). Dr. Norris is co-founder of Collabrify.IT, Inc. (e-mail: cathie.norris@gmail.com). **Elliot Soloway**, a Contributing Editor, is the Arthur F. Thurnau Professor, Department of Computing Science and Engineering, the University of Michigan, Ann Arbor, Michigan. For the past 15 years, his research has been guided by the vision that mobile, handheld—and very low cost—networked devices are the only way to achieve truly universal 1:1 learning in schools, all across the world. Dr. Soloway is a co-founder of Collabrify.IT, Inc., a uMich spinoff enabling apps and Websites to move from Web 2.0 (asynchronous collaboration) to Social 3.0 (e-mail: soloway@umich.edu).

- *Within five years every student in every grade in every school in the U.S. will be using a mobile computing device, 24/7.*

At the time, with cellphone bans in schools, and with the relative high cost of smartphones, our prediction was met with skepticism—at best. Fast forward: 2015 is upon us, and "mobile learning" has most definitely become a real category in educational technology. So, in 2015, what is the status of our 2010 prediction?

In order to better understand our 2010 prediction, and the new predictions we will make in Section 4 about 2015–2020, we will first look back at those early—and heady—days (2000–2010) when handheld, mobile devices were exploding onto the consumer electronics scene.

Next, we reflect on our current epoch: 2010–2015. Simply put, the skeptics were right: our 2010 prediction was too optimistic (i.e., we were wrong). Indeed, it was wildly optimistic (i.e., we were wildly wrong), since as we argue below, we, for good reasons, do not consider a 10-inch-screened iPad to be a "mobile device." As K–12 has a tendency to miss good opportunities, it invested in a range of non-mobile technologies, described in Section 3, that are now being viewed as either detours or downright dead-ends.

Finally, we will sneak a peek into the near future, 2015–2020, and update our 2010 prediction. While our track record on predictions isn't particularly stellar, we guarantee you can take this one to the bank:

- *Within five years (by 2020, but probably during the 2017–2018 school year) every child will have his or her own personal, mobile, computing device, 24/7.*

While K–12 students will, without question, experience universal computing access—the K–12 Holy Grail of Educational Technology—we are less sanguine that our children will reap the educational benefits of such universal access. The real benefits for learning with mobile computing devices become available in an inquiry-oriented or project-based classroom. But K–12's track record for transitioning from direct-instruction pedagogy to inquiry-oriented or project-based pedagogy is…. But we are getting ahead of our story. First, let's talk technology.

2. 2000–2010: The Very Early Days of Mobile Computing and Mobile Learning

With the launch of the Palm Pilot in 1997 and its subsequent cousins, the diminutive m100, the color-screened Palm IIIC, etc., some educators saw the opportunity for finally providing a computing device for each and every child—in the developed as well as developing nations. Prices would surely drop and the devices were programmable—those devices could support educational software, not just the phonebook

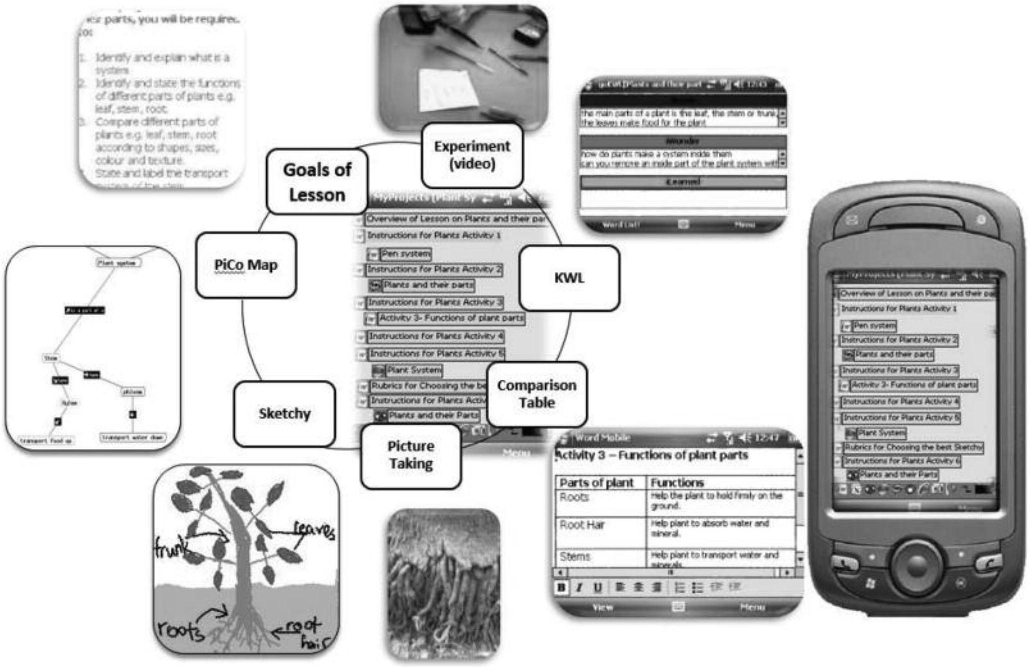

Figure 1. A lesson on the plant cycle in the Handheld Learning Environment.

and calendaring software that the Palms were targeted to run. Most importantly, the Palm devices were kid-sized—not a hulking gray box that weighed more than a third-grader—and they were truly light-weight, hand-held, *and mobile*. Finally, here was a computer that could support not just anytime, anywhere learning, but all-the-time, everywhere learning!

2.1. Palm Devices: Educational Software Development

To fill the need, then, for educational software, in 1997 we formed HI-CE—the Highly-Interactive Computer Environments R&D group based at the University of Michigan—and we developed the Handheld Learning Environment (HLE) with a range of productivity apps, e.g., PicoMap (concept mapping). Skektchy (drawing and animating), Fling-It (Web-based content), and iKWL (KWL charting).

But, as techies—as software developers who are not involved in day-to-day K–12 experiences—"we" didn't see the need to develop curriculum for HLE. We assumed that the teachers would figure out how to use HLE on their own. And, indeed, some teachers—the early adopter, artisan teachers—*were* able to take their existing curriculum—be it science, math, social studies, or language arts—and find ways to productively use the HLE apps. Universally teachers and students found Sketchy, a very simple drawing and animating app, to be a powerful tool for self-expression. From 2003–2010, GoKnow, Inc. (see Section 2.2) ran an international "Sketchy Contest" (Vincent, 2006), where students and teachers would submit their "Sketchy's—and prizes would be awarded. GoKnow literally received thousands of entries each year. (Full disclosure: "we" didn't listen to CN, who had been a K–12 classroom teacher for 14 years, when she said, in a quiet voice: "we NEED curriculum; we can NOT put HLE on the backs of teachers who are already too busy and not trained in curriculum development!" As noted below, in hindsight, "we" should have listened to our very own classroom teacher.)

In ***Figure 1***, we depict a lesson on the plant cycle that was used in sixth-grade science at Nan Chiau Primary School, Singapore. Using the Handheld Learning Environment's "LessonLauncher" app, a teacher created the lesson for the children in the class; a lesson was made up of learning activities (e.g., create a concept map that defines the anatomy of a plant and shows the relationships between the parts; create an animation to illustrate understanding of the growth cycle of a plant), and Internet-based resources (e.g., a video clip, an animation). For example, when a child tapped, with his or her stylus, on the "create a concept map" rectangle, the LessonLauncher would open the concept mapping app, PicoMap, and the child would create his or her own concept map. Upon closing PicoMap the child would be taken back into the lesson in the LessonLauncher. Without exception, students who used HLE found that having all their artifacts and resources for a lesson in one place was a valuable feature. Teachers, too, found it easy and productive to create a lesson by simply tapping on icons (that represented learning activities, such as create a concept map, create an animation or media resources) and then arranging the icons on a screen in a suggested order of enactment. There is something to be said for "keeping it simple"—a lesson is made up of a set of learning activities and media resources, all of which fit onto a small screen.

It was during the initial enactment of the plant cycle lesson at Nan Chiau Primary that a child's serendipitous learning triggered our thinking about how critically important it is for children to have a truly personal, *mobile* device.

- One of the third-grade students, who was on the three-student team in charge of knowing everything about "roots of trees," was walking home from school. She happened to see the convoluted roots of an old, old Banyan tree. She had her Nokia 710, the device that contained her lesson on plants and, as depicted in ***Figure 1***, all the artifacts she had been creating to address that lesson, ready-at-hand: she took the Nokia from her pocket, snapped a picture of the Banyan roots, and on the next day in school offered it up to her team for inclusion in the team's report.

Here, then, is a litmus test for "mobile device": If a computing device could serve in the above situation—could be ready-at-hand on the walk home from school—then that device is a *mobile* computing device (Norris & Soloway, 2013a, 2013b).

By the above litmus test, then, a 10-inch-screened tablet is definitely not a mobile device, since such a device would not be ready-at-hand. At best a 10-inch-screened tablet would be inside a case, inside the child's backpack. In fact, more likely, the device would be safe and secure inside a charging cart inside the student's classroom. A 10-inch-screened tablet may well be a *transportable* computing device—but it is not a *portable, mobile* computing device. On the other hand, a 3.5-inch-screened smartphone, like the Nokia 710, clearly passes the litmus test for a mobile device. The questionable case is a 7-inch-screened tablet. Is it mobile? Can it be ready-at-hand in a way that its 10-inch-screened Big Sibling isn't? We will return to this question later in the article.

2.2. Tech Transfer: From University Research to the Commercial Sector

While an academic research group like HI-CE is a good place to create innovative software, it is not a good place to maintain that software and support real classroom use, e.g., fix the software when it breaks, provide enhancements, etc. So, in 2000 we spun-off, from HI-CE, a company, GoKnow, Inc., to maintain HLE and service the educational community. From 2000–2006, over 40,000 licenses to HLE—which morphed quite naturally into MLE (Mobile Learning Environment) when we ported HLE to the Windows' PocketPC device—were bought by educators in the U.S., U.K., and Singapore. Unfortunately, the Palm technologies imploded as Palm tried to transform itself into a cellular handset developer, while the Windows PocketPC technologies just never matured. With schools not buying Palm or PocketPC devices, GoKnow, in 2006, failed.

While financially GoKnow, Inc., was a flop, the core question that it asked—can a mobile device be a pedagogically effective device—was answered in the affirmative. The early adopting teachers—and their students—found the mobile devices with MLE to most assuredly support learning, e.g.,

- "Using handhelds, I've been able to move through my curriculum faster than in years past, while probing deeper into the content. That's how much the handhelds have raised efficiency in learning" (Norris & Soloway, 2010).

We also learned this: GoKnow should have produced curriculum for its software! While early-adopting teachers were able to create classroom uses for the GoKnow software, the next tier of teachers were, not surprisingly—in hindsight—expecting well-laid out, classroom-tested curriculum. The lack of supportive curriculum was, in the end, the arrow that pierced GoKnow's heart: in every school where GoKnow tried to move from early-adopting teachers to the general teacher population—the scale-up failed. That is, while those next-tiered teachers initially tried to develop their own curriculum, that sort of extra effort was not sustainable. Thus, after a short while, the mobile devices fell quietly into disuse. We need to be clear: blame for the scale-up failure lies squarely with GoKnow and not with the teachers. The availability of high-grade curricular materials is a necessary condition to scale an educational technology; GoKnow learned that lesson the hard way.

2.3. The iPhone: Kickstarting the Age of Mobilism

In 2007, Apple offered the 3.5-inch-screened iPhone to the world—and the world changed! The device was gorgeous, easy to use, and it connected its user to the Internet. Wi-Fi was in its early days and not ubiquitous, so Apple required that an iPhone purchaser also purchase a cellular Internet connection for his or her iPhone from a telco such as AT&T. While Palm and Microsoft, with their Windows PocketPC, had given some a taste for mobilism, and while the iPhone was relatively expensive, thus limiting its initial popularity, the future was clear: the introduction of the iPhone ushered the world into the Age of Mobilism! And with the arrival of the Android OS, a free, open-source, operating system for mobile devices, the stage was set for realizing Jeff Hawkins's (Butter, 2002) prescient observation from 1991: "It is inevitable that all computing will be mobile."

3. 2010–2015: Mobile Learning: Failure to Thrive

Starting about 2010, mobile learning, as a type of educational technology, came into its own, e.g., mobile learning conferences sprang up, books on mobile learning were published, educational apps for mobile devices, by the thousands, appeared at app stores. So, what about our prediction?

3.1. Mobile Computing Devices in K–12

There are roughly 55 million K–12 students in the U.S. (Roberts & Stark, 2012).

- Apple claims to hold 94% of the tablet sales and reported sales up to 2013 of 13 million iPads in K–12 and higher-education (Molnar, 2013). Unfortunately, there is no breakdown of just K–12 sales, and there is no breakdown of 7-inch iPad vs. 10-inch iPad sales. But, since 10-inch iPads are not mobile devices, and the question on 7-inch iPads is still out, they don't count with respect to our 2010 prediction.
- From a survey in 2013 (Cavanagh, 2013), it appears that about 25% of K–12 students bring smartphones to school. But "…a significant portion of mobile devices are just being turned off when students get to school, or are being used under the radar," observed Peter Grunwald, the president of Grunwald Associates, the company that carried out the survey.

Bottom line: Our 2010 prediction was wildly off! While there are conferences on mobile learning, books on mobile learning, and educational apps, the use of truly mobile devices for learning simply has failed to thrive.

Why? Before we answer that question (Section 3.3.), let's first look at where K–12 did spend considerable sums of money.

3.2. Detours and Dead-ends: Interactive White Boards, Tablet Computers, and BYOD

3.2.1. Interactive White Boards: Dead-End

While K–12 schools could have purchased mobile devices for their students, instead they are spending $2 billion per year on purchasing interactive whiteboards (IWB) and associated material. Approximately 75% of the teachers in the U.S. report that they have access to their own IWB (Simba Information, 2014). During the early days of IWB buying, the hype surrounding them was great:

- "IWBs engage children's imagination and encourage them to collaborate, while accommodating visual, kinesthetic, and even auditory learners" (O'Neill, 2014).
- "Interactive whiteboards facilitate multisensory learning whether it is a collaboration exercise for math problem solving or a Google Earth tour of the Amazon rainforest. …recent U.S. studies report increased student engagement, school attendance, and higher test scores" (NEA).

More recently, however, reports are less glowing:

- "Interactive boards are on their way out," agreed Sam Farsaii, chief technology officer for the Coppell Independent School District in Dallas (Thompson, 2014).
- "[an IWB] pretends to be interactive, but the most interactive you can be is two kids standing at the board and 18 watching. It's the opposite of an experiential activity." Assistant Principal Jen LaMaster Brebeuf, Jesuit Preparatory School (Thompson, 2014).

3.2.2. Tablets: Detour

What we didn't foresee in 2010 was the dramatic rise of iPad ownership in K–2 schools. At $400 or so per tablet, we just didn't believe schools would see iPads as economical—especially when laptops were going for $400–$700. But, as we pointed out in 3.1., K–12 schools, too, have found the iPad virtually irresistible. However, tablet sales to the general public—especially iPads—have recently taken a dramatic downturn (Kim, 2014; Norris & Soloway, 2014a). But tablet sales into K–12 are increasing (Greenough, 2014).

Education is like a huge oil tanker: it takes a while to get going, but once it is moving, it is hard to slow it down. School districts have convinced parents that iPads are the way to go and in so doing have issued municipal bonds to buy iPads by the carload. While Los Angeles did precipitously drop their iPad 1:1 program, not many school districts could make such a quick pivot. However, consistent with the buying pattern of the general public, we should see school purchases of iPads slowing down over the next 2–3 years (Norris & Soloway, 2014b).

3.2.3. BYOD: The "Bring Your Own Device" Detour That Ultimately Will Win the Day

In 2011, with the growing proliferation of student-owned, personal computing devices, IT staff pushed the idea of "BYOD"—Bring Your Own Device (Panagos, 2013). School administrators liked this idea, since now the school was no longer responsible for buying computing devices for students. But for classroom teachers, the heterogeneity of the classroom devices was a real challenge. How was a teacher to make an assignment, e.g., write a book report, that all students would be able to do on their devices—

when there was no way to guarantee that a device had appropriate software? And how were 30 students to turn in their assignment so the teacher would be able to give feedback on it and grade it? What has actually happened is that, to accommodate the range of devices, teachers tend to go to the lowest-common denominator of functionality, and use the devices simply as Internet search tools. While BYOD has its challenges today, as we argue in Section 4, the next turn of the software crank will enable apps to be written that are truly device-agnostic—solving the hardware heterogeneity problem posed by BYOD.

3.3. Failure to Thrive: It's Not About the Technology— It's about the Pedagogy!

With all the "Sturm und Drang" around technology, it is easy to lose track of the real reason why technology is important: the point of using computing devices—from IWBs to truly mobile devices—in K–12 is to support pedagogy—to support teaching and learning!

Now, technology itself is pedagogy-neutral. For example, while IWBs were initially touted as supporting a more active learning pedagogy, in the end, the way they have come to be used is to predominantly support a direct-instruction pedagogy. And while a mobile device—being ready-at-hand, being able to support artifact construction as well as artifact viewing, and being able to access the Internet on the go—may be particularly well suited to support an inquiry-oriented or project-based pedagogy, it still can be used to support a direct-instruction pedagogy. Indeed, with 80% of the apps (Shuler, Levine, & Ree, 2012) on Apple's App Store focusing on drill-and-practice, using iPads—10-inch-screened or 7-inch-screened—direct-instruction-type learning activity is the path of least resistance.

Mobile computing devices' failure to thrive, then, is not about the technology, but about deciding to make the transition from direct instruction to inquiry or project-based learning—and staying the course when the inevitable bumps are experienced. Exploring the tension—one might even call it a war—between those who feel that direct instruction is a cost-effective, pedagogically-effective strategy and those that feel that a learn-by-doing, inquiry-oriented, or project-based pedagogy is the direction in which to head is beyond the scope of this article. For the purposes of this article, then, we believe our 2010 prediction failed primarily because direct instruction remained the dominant pedagogy during 2010–2015.

That said, in Singapore, where its Ministry of Education's policy (Singapore Ministry of Education, 2008) is directing schools to move from a direct-instruction pedagogy to an inquiry-oriented pedagogy, mobile computing devices, as we have documented elsewhere (e.g., Norris, Hossain, & Soloway, 2011), have played a catalytic role in supporting teachers and students in making that transition. Interestingly, both smartphones and 8-inch-screened tablets are being used to support inquiry pedagogy. Thus, it might be argued that the smaller-screened tablets can be ready-at-hand and can pass our litmus test for mobility.

And, in schools that are trying to encourage a more active learning pedagogy, iPads—even the 10-inch-screened ones—are just a detour, not a dead-end. iPads are coming into America's classrooms; that's a fact. So, as the expression goes: "If you have lemons, make lemonade." *Inside* the classroom, 10-inch-screened iPads can support inquiry; and, with careful planning, e.g., field trips, 10-inch-screened tablets can even support *some* outside-the-classroom inquiry. Of course, the 10-inch-screened devices, not being ready-at-hand, will make it more difficult to take advantage of those serendipitous learning opportunities that occur while walking in the mall, while riding in the bus, or while talking at the dinner table. The "inquiry journey" using 10-inch-screened iPads will be more time consuming and less effective—but they are a detour, not a dead-end.

4. 2015–2020: The Holy Grail–and More—Is Finally Within Reach!

As we look to the second half of this decade, buying patterns of "mobile" devices are dramatically changing. The 10-inch-screened tablet that experienced explosive sales growth during 2010–2015 is seeing a comparably explosive decline in sales, while a new category of consumer device—the "phablet"—is the device category experiencing explosive growth. A smartphone whose screen is 6-inches or larger is being called a "phablet"—a combination phone and tablet (Bolkan, 2014). Interestingly, Steve Jobs felt that consumers would find such larger-screened devices unwieldy:

- "You can't get your hand around it…no one's going to buy that." (Ziegler, 2010)

This one time, at least, Jobs' keen sense for consumer tastes missed the mark.

The demand for bigger-screen smartphones comes because people are using their smartphones more frequently for an increasingly broader range of tasks (Bott, 2014). While tablets will surely not disappear—they can be used as media viewing devices—the bigger-screened smartphone is becoming an individual's personal information hub. And manufacturers in India and China are churning out low-cost smartphones, e.g., a 5-inch-screened Android OS handset can be purchased for about $100 (Whittaker, 2014).

For K–12 youth, a smartphone is fast becoming a must-have, not a nice-to-have. From providing entertainment to supporting communications, from providing personal security to supporting social interactions, K–12 students will be equipping themselves, during 2015–2020, with smartphones—especially when they can be purchased for less than a pair of trendy tennis shoes!

Universal Access to Mobile Computing: Based on changes in device costs and use patterns, we can update our 2010 prediction:

- *Within five years—by 2020, but probably during the 2017–2018 school year—every student in every grade in every school in the U.S, will be using a mobile computing device, 24/7*.

Universal access to computing—the Holy Grail of Educational Technology for K–12—will finally be achieved.

Device-Agnostic Applications: Hardware alone, of course, does not provide the needed functionality. Indeed, as we mentioned in Section 3.2.3., the problem with BYOD, with its heterogeneity of devices, was a teacher's inability to count on all the students having the same software. But, just as hardware technology continues to improve, software development technology also continues to improve. During 2015–2020, using maturing technologies such as HTML5/Javascript, developers will produce truly device-agnostic applications. Thus, in a heterogeneous BYOD environment, the software can be homogeneous, e.g., whether a student has a Windows Phone 8 or a Mac laptop, both can be running the same word processor or concept mapping app, and storing their student-produced artifacts in a cloud-based repository.

Making Collaboration the Norm—Collabrified Apps: "Two heads are better than one." Research bears out this folk wisdom. But to gain the full benefit of synchronous collaboration, collaborators have needed to be co-located. The telephone—or its Internet cousins (e.g., Skype)—is useful—but only to a point. But just as hardware and software technologies continue to improve, wireless networking continues to improve as well. Finally, the widespread, ready availability of significant bandwidth will make support for *synchronous collaboration*—not just asynchronous collaboration—the norm. Here is another prediction, in fact:

- *Within five years, virtually every educational mobile app and browser-based app will be "collabrified."*

By "collabrified" we mean that an app will support two or more users, who are simultaneously working, each on their own device, inside the app, all the while talking verbally with each other. The Google Docs Editor is the canonical example of a collabrified app—multiple individuals can write together, conversing all the while. Now, since collabrification technology is device-agnostic, it won't matter what devices the students (or teachers) are using. And, using VoIP (Voice over IP), the collaborators need not be co-located; in fact, it will be more typical that collaborators are not in the same physical space.

In the successor to HI-CE, the Intergalactic Mobile Learning Center, we are focusing on collabrifying a broad range of apps for K–12. Anchoring our effort is the WeCollabrify Platform, a suite of collabrified educational productivity apps (WeWrite+, WeMap, WeKWL, WeSketch+, WeTimeline, etc.) that work cross-platform on iOS and Android. So, using WeMap, a concept-mapping tool, for example, two or more students can work (creating/editing nodes/links) simultaneously, on the same concept map, having a verbal conversation, while all students are in their bedrooms in their respective homes.

Another app that uses our underlying collabrification technology is Cooties+, a participatory simulation that helps students understand how diseases are spread—by actually participating in spreading a digital germ. Each student with his/her own iPad walks around the room and "meets" another student by tapping their iPads together. During the meeting a germ-free or a germ-laden message is passed. The teacher seeds the class by making one of the iPads "sick" and through the multiple meetings, eventually everyone becomes infected. "Who made me sick?" "I can be made infected by someone I never personally met!" Cooties helps children learn how infectious diseases are spread.

Consider, then, this hypothetical scenario: With the goal of surveying CO_2 emissions in the parking lots on "football Saturday," four teams of middle school students have been placed in four parking lots ringing the University of Michigan's "Big House"—its fabled and exceptionally large football stadium.

- Each team is comprised of three students out in one of the four parking lots and one more team member who is stationed in the science room back at their Ann Arbor school.
- Each student in the three-person team has a CO_2 sensor attached to his or her smartphone, while also running WeAnalyze, a collabrified, data analysis tool.
- The fourth team member, the parking lot coordinator, is also a member of their team's collaborative session and can thus also participate in real time in his or her team's collaboration session, e.g., talk to the team in the parking lot, add input through WeAnalyze, see others adding input, etc.

Using WeAnalyze, then, each team of three students in a particular parking lot is "in" a collaborative session, which means:

- not only can they talk verbally with each other through WeAnalyze,
- they can *all* interact with WeAnalyze *at the same time,* e.g., see the data as they are being read by the CO_2 sensor for that group's parking lot, view

a data plot of the CO_2 for all four parking lots, simultaneously add notes to the graph, etc.

The parking lot coordinators, stationed at the school, direct team members in the parking lots in order to get a good sample of vehicles; based on what vehicles have already arrived, and based on the CO_2 profile of a particular vehicle, the parking lot coordinators direct students to monitor specific vehicles—always taking care to position the students safely.

At the end of their study, the students will have participated in an authentic scientific study, using sophisticated—but low-cost—tools. The data they collect and their analyses of those data would definitely be welcomed by the scientific community on man-made, CO_2 discharge.

Today, this is hypothetical, but in short order it will all be doable!

For a more prosaic situation that calls for a collabrified solution, consider, then, this scenario:

- A learner, sitting alone at his or her kitchen table working on a math project, invariably will hit a situation where a misunderstanding or confusion causes the learner to become "stuck." Today, getting assistance takes enough steps that most learners simply wait until school the next day to get help. However, with a collabrified app, the learner need only press the "Let'sWorkTogether Button" and, immediately, the learner is connected to a peer, a teacher, or a tutor in order to work/talk through the problematic situation.

This scenario is not hypothetical—it is doable today! We have built YesWeKahn, a 7-inch-screened Android tablet, held horizontal in landscape mode, and put a window on one half of the screen that contains a Khan Academy video (or a flipped classroom video) while the other window contains a collabrified drawing tool, a collabrified writing tool, etc. Indeed! A Learner no longer ever needs to learn alone! THAT is an enormous change—an enormous opportunity. Will K–12 miss this opportunity?

5. Concluding Remarks

From a technology standpoint, we have painted an exciting picture of learners, supported by mobile technologies, engaged in inquiry, learning all the time, everywhere. And, by 2020, we predict—with full confidence—that the *technological* picture we have painted will be realized in the marketplace.

However, as we pointed out in Section 3.3., the real challenge to using mobile computing devices in K–12 is the challenge of changing from K–12's long-standing, direct-instruction pedagogy to an inquiry-oriented or project-based, learn-by-doing pedagogy. Indeed, for today's teachers college-based training in anything other than direct instruction is a hit-or-miss affair, and yesterday's teachers almost certainly received no college-based training in inquiry or other pedagogical approaches. Moreover, inquiry and project-based are more demanding on a teacher: knowing the content, having good classroom management skills, and feeling comfortable with the technology are all needed in order to successfully enact an inquiry-oriented or project-based pedagogy. Still further, with the pressures on school administrators to reduce costs and increase student achievement, it is less likely that a district or school can adopt what, in the short run at least, may well be a more costly pedagogy.

Losing heart is not an option, from where we stand. K–12—public education—is arguably the greatest invention of democracy. While costs must certainly be monitored, we as a democratic nation need to ensure the effectiveness of our educational system. A democracy needs an educated populace; cynicism needs to be parked at the door. Learn-by-doing—the strategy parents attempt to impart to their children—needs to become the dominant pedagogy of the next decade. We need to teach our children well; we need to teach our children how to inquire. Fortunately, the mobile devices that they will be equipping themselves with will actively support their question asking, their collaborations and conversations, and their constructions. As techies, we are ever optimistic! □

Acknowledgments. The work described here is supported in part by the National Science Foundation under grant numbers NSF 1123965, 1249312, and 1345231 and a Graduate Research Fellowship. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect those of the NSF. We would also like to acknowledge the support from Qualcomm Wireless Reach for our efforts at Nan Chiau Primary School in Singapore.

References

Bolkan, J. (2014). Phablet sales to top laptops this year, tablets in 2015; *http://thejournal.com/articles/2014/09/04/phablet-sales-to-top-mobile-laptops-this-year-tablets-in-2015.aspx* .

Bott, E. (2014). When it comes to smartphones, size matters; *http://www.zdnet.com/when-it-comes-to-smartphones-size-matters-7000033885/?s_cid=e539&ttag=e539ftag=TRE17cfd61* .

Butter, A. (2002). Piloting Palm: The inside story of Palm, Handspring, and the birth of the billion dollar handheld industry; *http://www.dmmserver.com/DialABook/978/047/122/9780471223399.html* .

Cavanagh, S. (2013). Smartphones a standard for majority of students by high school, survey finds. *Education Week; http://blogs.edweek.org/edweek/DigitalEducation/2013/05/more_than_half_of_students_car.html* .

Greenough, J. (2014). Tablet demand is growing in the education sector; *https://intelligence.businessinsider.com/as-overall-tablet-growth-slows-demand-for-tablets-in-education-is-increasing-2014-9* .

Kim, G. (2014). Tablet sales slow dramatically, slow replacement sales, phablets, are issues; *http://www.techzone360.com/topics/techzone/articles/2014/08/06/385878-tablet-sales-slow-dramatically-slow-replacement-sales-*

phablets.htm .
Molnar, M. (2013). iPad commands 94 percent of ed. tablet market, researcher says. *Education Week; http://blogs.edweek.org/edweek/marketplacek12/2013/11/ipad_commands_94_percent_of_ed_tablet_market_reseacher_says.html* .
NEA. Interactive whiteboards enhance classroom instruction and learning; *http://www.neamb.com/professional-resources/benefits-of-interactive-whiteboards.htm* .
Norris, C., Hossain, A., & Soloway, E. (2011). Using smartphones as essential tools for learning: A call to place schools on the right side of the 21st century. *Educational Technology, 51*(3), 18–25.
Norris, C., & Soloway, E. (2010); *http://web.archive.org/web/20101116163914/http://www.goknow.com/index.html?pg=sketchy* .
Norris, C., & Soloway, E. (2013a). Marty Heidigger might well have used a smartphone for learning; *http://thejournal.com/articles/2013/01/28/marty—heidigger-might-well-have-used-a-smartphone-for-learning.aspx?-THE21* .
Norris, C., & Soloway, E. (2013b). Is a laptop a mobile computer? And why is that even an important question? A litmus test for mobility; *http://thejournal.com/articles/2013/06/05/is-a-laptop.aspx* .
Norris, C., & Soloway, E. (2014a). Tablets are a fad—they'll largely disappear in 2–3 years; *http://thejournal.com/articles/2014/07/31/tablets-are-a-fad.aspx* .
Norris, C., & Soloway, E. (2014b). The great American iPad buying binge has commenced; *http://thejornal.com/articles/2014/07/16/ipad-buying.aspx* .
O'Neill, L. (2014). The mainstreaming of interactive whiteboards in the classroom; *http://www.k-12techdecisions.com/article/the_mainstreaming_of_the_interactive_whiteboard _in_the_classroom* .
Panagos, T. (2013). The future of education: BYOD in the classroom; *http://www.wired.com/2013/09/the-future-of-education-byod-in-the-classroom/* .
Roberts, A., & Stark, C. (2012). Back to school by the numbers. CNN; *http://schoolsofthought.blogs.cnn.com/2012/09/04/back-to-school-by-the-numbers/* .
Shuler, C., Levine, Z., & Ree, J. (2012). iLearn'II, an analysis of the education category of Apple's App Store; *http://edlab.tc.columbia.edu/files/ilearnii.pdf* .
Simba Information. (2014). National survey of interactive whiteboard usage 2014; *http://www.simbainformation.com/National-Survey-Interactive-8103294/* .
Singapore Ministry of Education. (2008). MoE's Masterplan 3; *http://ictconnection.edumall.sg/cos/o.x?c=/ictconnection/pagetree&func=view&rid=665* .
Thompson, G. (2014). 4 keys to designing the classroom of the future; *http://thejournal.com/Articles/2014/10/15/4-Keys-to-Designing-the-Classroom-of-the-Future.aspx?Page=2&p=1* .
Vincent. T. (2006); *http://learninginhand.com/blog/2006/3/13/2006s-sketchy-animation.contest.html* .
Whittaker, Z. (2014). Google's sub-$100 'Android One' devices said to be unveiled on September 15; *http://www.zdnet.com/googles-sub-100-andoird-one-devices-said-to-be-unveiled-on-september-15-7000033197/* .
Ziegler, C. (2010). Apple's Steve Jobs: 'no one's going to buy' a big phone; *http://www.engadget.com/2010/07/16/jobs-no-ones-going-to-buy-a-big-phone/* .

Towards a SIM-less Existence: The Evolution of Smart Learning Networks

Ali M. Al-Khouri

This article proposes that the widespread availability of wireless networks creates a case in which there is no real need for SIM cards. Recent technological developments offer the capability to outperform SIM cards and provide more innovative dimensions to current systems of mobility. In this context of changing realities in the domain of mobility, this article examines the future impact of mobility in the education sector, in the case of its usage, and the future of learning technologies.

Introduction

We are in a world of digital mobility. Work is no longer tied to just one location. It is becoming increasingly easy, even when on the move, to do and get work done. Keeping pace with this mobility is the technology being utilized in the education sector. Learning is no longer constrained within the four walls of a classroom. Distance learning is no longer limited by broadcasts or podcasts. The growth of mobile technology has revolutionized learning systems, and contributed to the widespread access to knowledge content.

Mobile devices have become an integral part of our daily lives with an estimated 6.8 billion mobile phones for a total world population of 7.1 billion people (ITU, 2013). The extent of the penetration of mobiles is so

Ali M. Al-Khouri is Director-General of the Emirates Identity Authority, a federal government organization in the United Arab Emirates. He is Professor of Identity and Security at the Institute of Technology and E-commerce in London, UK. He is also a special advisor to the European Union, and an active member of the Global Agenda Council, World Economic Forum. Dr. Al-Khouri holds an Engineering Doctorate (EngD) from Warwick University in the UK, and has published many books and over 80 scientific research articles in international peer-reviewed journals in the past 12 years (e-mail: Ali.AlKhouri@emiratesid.ae).