pockets of potential

Using Mobile Technologies to Promote Children's Learning

Carly Shuler, Ed.M.
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The Joan Ganz Cooney Center at Sesame Workshop

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Attn: Publications Department
The Joan Ganz Cooney Center
Sesame Workshop
One Lincoln Plaza
New York, NY 10023
p: 212 595 3456
f: 212 875 7308
cooney.center@sesameworkshop.org

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foreword

Education policies have helped promote advances in student achievement in the past two decades, but not yet at a level suitable to prepare a U.S. workforce with the skills and knowledge demanded by universities and employers in a global economy. In some urban school districts, more than half of all students will drop out before earning their diploma. American students, more generally, are lagging behind many of our international competitors in college attendance and completion rates.

The trajectory for academic and life success is established in the preschool and primary years, when children are developing new habits for learning and social development. This is where the ubiquity of children's engagement with media is so critical. According to the Kaiser Family Foundation, children as young as eight years old spend as many hours engaging with various "screens" as they do in school. Health and development experts and concerned parents are increasingly asking whether this is a harmful phenomenon. The Center's perspective is that the primacy of digital media in children's lives is here to stay. While concerns about health and safety must be addressed, a new emphasis on the potential of digital media to aid learning, especially for low-income children, is overdue.

The report *Pockets of Potential: Using Mobile Technologies to Promote Children's Learning*, by Cooney Center Industry Fellow Carly Shuler, makes the case that our nation's leaders should not overlook the role mobile technologies can play, if well deployed, in building human capital and in helping to stimulate valuable innovation. As *Sesame Street* has proven over four decades of remarkable work, exposure to research-tested educational media starting early in life, can accelerate children's skills, while producing enduring economic benefits to society.

Pockets of Potential argues that despite legitimate public concern about the "disruptive track record" of mobile devices in schools, there is reason to be excited about their potential. As an analysis of key industry trends, opportunities, and challenges, including small-scale studies of academic and industry projects, the paper recommends a series of urgent action steps for key sectors to consider. Of particular note are the promising innovations developed by an international group of mobile technology thought leaders — from Silicon Valley to Seoul to sub-Saharan Africa — whose pioneering work is featured in this report and its appendices.

The report joins a series of studies the Cooney Center has undertaken since launching one year ago. We hope to stimulate a new debate that will lead industry, funders, scholars, and caregivers to consider how the devices children now rely upon as their social currency may one day help them learn essential skills needed for success. As Mrs. Cooney recently noted, "Now is the time to turn the new media that children have a natural attraction to into learning tools that will build their knowledge and broaden their perspectives." Unless we do, the gulf between what children do informally and in school will widen, diminishing the educational opportunities all of our children need and deserve.

Michael H. Levine, Ph.D.
Executive Director, Joan Ganz Cooney Center at Sesame Workshop

executive summary

Just as *Sesame Street* helped transform television into a revolutionary tool for learning among young children four decades ago, advances in mobile technologies are showing enormous untapped educational potential for today's generation.

This report, undertaken by the Joan Ganz Cooney Center at Sesame Workshop, draws on interviews with a cross-section of research, policy, and industry experts to illustrate how mobile technologies such as cell phones, iPod devices, and portable gaming platforms might be more widely used for learning. More than half of the world's population now owns a cell phone and children under 12 constitute one of the fastest growing segments of mobile technology users in the U.S. Examining over 25 handheld learning products and research projects in the U.S. and abroad, the report highlights early evidence and examples of how mobile devices may help re-define teaching and learning in the decade ahead.

The current state of mobile learning

As mobile technologies become increasingly prominent in the lives of children worldwide, national ministries and local schools are experimenting with the use of these popular devices for a range of different teaching and learning purposes. This report presents an inventory of more than 25 handheld learning projects in the U.S. and beyond. It shows how mobile devices can help promote the knowledge, skills, and perspectives children will need to compete and cooperate in the 21st century. Projects focusing on deepening children's mastery of key literacy, world languages, STEM (Science, Technology, Engineering, and Mathematics) subjects, collaboration, and critical thinking skills, both inside and out of school, are featured.

The inventory highlights numerous inspiring examples of mobile learning. Some employ the most innovative features of mobile devices; others rely on more standard ones. Some capitalize on the personalization capabilities of handheld technologies; others show how these devices can encourage collaboration when used by a team. Some exploit mainstream devices, others use devices developed specifically for education. While this diversity opens up future opportunities, it also reveals tensions in the field of mobile learning, with consequent trade-offs on issues such as distribution vs. innovation and mass-market vs. education-specific.

Our experts were disappointed by the lack of well-financed, coherent, or highly visible efforts in mobile learning in the U.S. compared to our economic competitors, especially in Europe and Asia. Education leaders, perhaps sensing limited public or policy support, have not yet developed a strategy on how mobile learning should be deployed, or even if it should be used at all. Model initiatives are fragmented and lack resources to scale-up. While notable efforts have spawned innovative "pockets" of mobile learning, multi-sector leadership is needed to connect disparate efforts in educational research, industry, teacher professional development, and policy-making.

Key opportunities in mobile learning

The report highlights five opportunities to seize mobile learning's unique attributes to improve education:

1. Encourage "anywhere, anytime" learning
Mobile devices allow students to gather, access, and process information outside the classroom. They can encourage learning in a real-world context, and help bridge school, afterschool, and home environments.

2. Reach underserved children
Because of their relatively low cost and accessibility in low-income communities, handheld devices can help advance digital equity, reaching and inspiring populations "at the edges" — children from economically disadvantaged communities and those from developing countries.

3. Improve 21st-century social interactions
Mobile technologies have the power to promote and foster collaboration and communication, which are deemed essential for 21st-century success.

4. Fit with learning environments
Mobile devices can help overcome many of the challenges associated with larger technologies, as they fit more naturally within various learning environments.

5. Enable a personalized learning experience
Not all children are alike; instruction should be adaptable to individual and diverse learners. There are significant opportunities for genuinely supporting differentiated, autonomous, and individualized learning through mobile devices.

Key challenges in mobile learning

A number of critical challenges must be addressed to unleash the educational potential of mobile technologies. Five key challenges outlined in the report include:

1. Negative aspects of mobile learning
Cognitive, social, and physical challenges must be surmounted when mobile devices are incorporated into children's learning. Disadvantages include: the potential for distraction or unethical behavior; physical health concerns; and data privacy issues.

2. Cultural norms and attitudes
Though many experts believe that mobile devices have significant potential to transform children's learning, parents and teachers apparently are not yet convinced. A 2008 study done by the Joan Ganz Cooney Center in collaboration with Common Sense Media found that most teachers see cell phones as distractions and feel that they have no place in school.

3. No mobile theory of learning
Currently, no widely accepted learning theory for mobile technologies has been established, hampering the effective assessment, pedagogy, and design of new applications for learning.

4. Differentiated access and technology
Wide diversity among mobile technologies represents a challenge for teachers and learners who wish to accelerate academic outcomes as well as the producers who seek to facilitate such learning.

5. Limiting physical attributes
Poorly designed mobile technologies adversely affect usability and can distract children from learning goals. Physical aspects of mobile technologies that may prevent an optimal learning experience include: restricted text entry, small screen size, and limited battery life.

Relevant market trends and innovations

The mobile market is one of the most rapidly evolving industries in the world. Over the last decade, as power and functionality have increased, devices and their prices have decreased. The report outlines a number of market developments that could have the greatest impact on children's learning:

Extreme convergence
Almost all cell phones are now built with features that used to be the expensive add-ons, such as color screens, cameras, and mobile web. There is also a move from "feature phones," on which certain functions like making a call or taking a picture can be performed, to smart phones that have an operating system just like a computer.

Location, location, location
By October 2009, about half of the phones in the U.S. will have GPS, and there are other emerging technologies that enable mobile devices to receive location-based data. The educational potential enabled by these applications — especially when used in combination with social networking applications — are significant.

Consolidation at last
It has been extraordinarily difficult to develop software applications for mobile phones due to proprietary platforms, and the mobile phone industry has been slow to address this problem. Now, through mobile operating systems — some of which are open-source — a number of different platforms are consolidating.

The 21st-century button
Users have traditionally interacted with mobile devices via buttons and keypads, which prevent children from achieving full control of pocket-sized devices. Developments in touch screen and gestural input may significantly improve the way children interact with mobile devices.

Goals for mobile learning

The report outlines five goals: learn, develop, promote, prepare, and stimulate — and an action plan to transform mobile learning from a state of uneven and scattered innovation into a force for dynamic educational impact.

1. Learn: understand mobile learning as a unique element of education reform

Handheld technologies and their learning applications require a systematic research inquiry to determine how they can become an important driver of technology integration in education. Public and private sector support for needed R&D should:

- ***Invest in understanding the development of "mobile kids"*** – Researchers, educators, and parents have entered new territory in digesting the implications of children's ubiquitous involvement with technology. Key developmental and health issues should be carefully researched.

- ***Develop new theories and models for leveraging mobile technologies*** – Existing applications of mobile learning tend to employ design and evaluation principles taken from traditional or e-learning theories. This results in "mobile versions" of established approaches and fails to take into account the unique affordances of learning through mobile technologies.

- ***Learn from other countries*** – Mobile education offers an interesting case for cross-national learning and collaboration. Developed nations have the opportunity to learn from developing countries, where program developers have little or no track record of e-learning to contend with and are skipping immediately to mobile technologies because of their low cost and ubiquity. In addition, some European and Asian countries have large-scale, government-funded mobile learning initiatives.

2. Develop: Build mobile learning interventions

Mobile devices have features that are distinctive, and developers of applications must leverage unique mobile assets and surmount special challenges. Industry should be given more powerful incentives to:

- ***Design educational innovations to capitalize on unique affordances of mobile*** – It is entirely ineffective to take educational applications that have been developed for a big screen and simply shrink them down to be used on mobile devices. Developers need to discern what is special about mobile devices and design interventions that take advantage of those attributes.

- ***Counter the disadvantages and limiting physical attributes of mobile devices*** – Mobile technologies have numerous disadvantages (e.g., can be distracting) and limiting physical attributes (e.g., difficult text entry) that — if not taken into consideration — might detract from the learning experience.

- ***Avoid constant defaults to the latest technology*** – In order to develop scalable models, it is important to emphasize features that will become ubiquitous. Relying on features that are more common on less-expensive phones will help ensure that mobile technologies can help close rather than amplify the digital divide.

- ***Create development tools for educators*** – Most development tools are oriented toward industry and computer scientists, and not accessible to educators or learners. Once there are more practical tools that conform to how educators design instructional materials, the opening up and consolidating of cell phone platforms could greatly accelerate the use of mobile devices for children's learning.

3. *Promote: Engage the public and policy-makers in defining the potential of mobile devices for learning*

Though numerous studies and a growing number of experts believe that mobile devices have significant potential to transform children's learning, most parents and teachers do not yet view these devices as educational allies. To promote public understanding and prepare for the effective use of such devices, government, industry, and philanthropic organizations should expand resources to:

- ***Scale up and disseminate innovative exemplars of mobile learning*** – Federal and state education agencies should place priority on identifying and disseminating mobile technology and learning innovations that can advance educational goals. A national "best practices" initiative to disseminate effective uses of mobile technology for education should be established with support from philanthropic and policy leaders.

- ***Provide incentives for needed infrastructure*** – To help economize and accelerate school adoption of mobile devices, we must move away from an approach in which schools exclusively provide educational hardware and introduce ways to use the mobile devices many children already own. For students from low-income households, we should press forward with expansion of needed infrastructure, including new investment in E-Rate, to achieve digital equity.

- ***Develop educational standards for industry*** – As mobile applications for children's learning proliferate, federal regulatory bodies, industry groups, and parent advocates should collaborate on a consumer protection initiative to better describe educational effectiveness in interactive media products for children.

4. *Prepare: Train teachers and learners to incorporate mobile technologies*

Often the bulk of spending in incorporating technology into education is on the technology itself; however, preparing teachers and learners to use these technologies effectively should be a higher priority. National, state, and community leaders should:

- ***Build capacity: Digital teacher corps*** – Teachers cannot teach what they do not know, and most have not been trained to use new technologies in their classrooms or afterschool settings. It is not just a matter of showing teachers how to use the devices; rather, it is crucial to provide them with methodologies for ways in which they can incorporate technologies within their curriculum. Professional development is essential to the future of mobile learning. To build professional capacity, we recommend the creation of a "digital teacher corps," which would be established to enable educators to help students learn to transform information for discovery and problem-solving by working with a range of digital media.

- ***Modify and gradually eliminate classroom bans*** – Most school districts limit cell phone use in classrooms and some have banned their use altogether. We recommend the gradual introduction of mobile devices in schools. By devising established norms of behavior, we can build acceptance among teachers, parents, and students themselves to discover mobile devices' educational value.

- ***Integrate mobile themes in media literacy curricula*** – State and school leaders should educate students on mobile etiquette and capabilities, expanding media literacy to include a new "mobile literacy."

5. *Stimulate: Generate new leadership support for digital learning*

As a new administration that has committed to improving education and rebuilding public infrastructure for economic renewal begins, we recommend that priority be placed on how mobile technologies in particular, and digital media more generally, can advance children's learning in the global economy. The new administration should:

- ***Create a White House initiative on digital learning*** – The President and new administration should convene a White House Initiative on Digital Learning, beginning with an audit of current government investments in digital technologies for learning. The report also calls for a White House Summit and a digital investment fund to accelerate education reform and promote mobile innovation to help benefit the economy.

Mobile devices are an integral part of children's lives and they are here to stay. The social and cultural phenomena, market opportunity, and, most importantly, the "pockets of educational potential" documented in this report must not be dismissed. Our national debate must shift from *whether* to use these devices to support learning, to understanding *how* and *when* they might best be used. Just as *Sesame Street* introduced generations of children and their families to the potential of television as an educational medium two generations ago, today's children will benefit if mobile becomes a force for learning and discovery in the next decade.

introduction: making the case for mobile learning

Perhaps the most ubiquitous technology in children's lives today are mobile devices — tools such as cell phones, iPod devices, and portable gaming platforms that traverse home, school, and play via the hands and pockets of children worldwide.

Forty years ago, a revolution in communications technology began in an unlikely place. Or perhaps it would be fitting to say it began on an unlikely street. On November 10, 1969, *Sesame Street* premiered on open-circuit televisions across the U.S. Today, as the longest-running children's program in American history, *Sesame Street* has been viewed by millions of children in more than 140 countries worldwide, and is the single largest informal educator in the world. Countless educational media programs, products, research studies, and learning innovations derived from the original concept behind *Sesame Street*: the idea that a mass communications technology — television — could and should play a role in children's learning. In today's digital world, children can watch *Sesame Street* anytime, anywhere, on devices the size of chocolate bars that they can carry around in their pockets.

Box 1: Children's technology on the move

- Almost all children in the U.S. have access to a mobile device, with 93% of 6-to-9-year-olds living in a home with a cell phone. (Sesame Workshop, 2007)
- Many children have a mobile device of their own. Over 50% of 6-to-9-year-olds have their own portable video game player, 30% have their own cell phone, and 20% have their own digital music player. (Sesame Workshop, 2007)
- Mobile device ownership among children ages 4-14 has experienced double-digit growth since 2005. (NPD Group, 2008a)

Perhaps the most ubiquitous technology in children's lives today are mobile devices — tools such as cell phones, iPod devices, and portable gaming platforms that traverse home, school, and play via the hands and pockets of children worldwide (see Box 1). While these devices are undoubtedly a source of fun and entertainment, proponents of mobile learning believe they have significant potential to be a key ally in supporting learning experiences. However, in contrast, most parents and educators are skeptical about the educational potential of such devices (Joan Ganz Cooney Center & Common Sense Media, 2008), and with due cause (see "Negative aspects of mobile learning," p.25). But what is not up for debate is the fact that mobile technologies play a significant role in children's lives. With one third of American fourth-grade children not able to read at grade level (Lutkus, Grigg, & Donahue, 2007), and school failure the norm in many urban communities, it is now critical to explore the role that promising new technologies and tools — including mobile devices — can play in children's learning.

For the purposes of this study, we interviewed a diverse group of experts — proponents of mobile learning who are directly involved in the research, design, development, or implementation of educational mobile technologies for children. We asked them to share not only their experiences with mobile learning but also their hopes and concerns for its future. We did not attempt an exhaustive literature review; rather, we sought to dig deeper on selected issues raised by interviewees through consultation of recent scholarship and news sources.

This report summarizes these interviews and the corresponding literature, and makes a case for strategic investment in mobile learning. It begins with a broad view, examining the current state of mobile learning. It then narrows its focus, identifying both the opportunities in using mobile devices for children's learning and the challenges that will be encountered along the way. Finally, it makes recommendations to key sectors on how to transform mobile learning into a force for dynamic educational impact, challenging the sentiment that mobile technologies are not yet ready to emerge as an educational tool and suggesting that they can be part of a more effective paradigm for learning in the 21st century.

the current state of mobile learning

Today, mobile technologies — originally marketed as communication and entertainment devices — have come to play a significant role in society at large. But what role do they play in children's lives, and how are they currently being leveraged to advance learning?"

Pervasive mobile technologies are being used to increase public productivity in numerous key sectors (see Box 2). Relying on mobile technologies, citizens have become global reporters, spreading news to mass audiences, or narrowcasting personalized information. One study found that a country's GDP rises 0.5 percent for every additional 10 mobile phones per 100 people (Waverman, Meschi, & Fuss, 2005). Today, mobile technologies — originally marketed as communication and entertainment devices — have come to play a significant role in society at large. But what role do they play in children's lives, and how are they currently being leveraged to advance learning?

Mobile devices have become increasingly prominent in the lives of American children. Since 2005, ownership of portable digital devices has experienced double-digit growth among children ages 4-14 (NPD Group, 2008a). The Center on Media and Child Health predicts that 54 percent of American 8-to-12-year-olds will have cell phones within the next three years. Even among our youngest children, more than 10 percent of 4- and 5-year-olds use a cell phone (NPD Group, 2008a). As these already prominent devices become increasingly popular, proponents of mobile learning argue that the benefits of handhelds as an educational tool can be profound.

Some local authorities and schools are investigating the use of handheld technologies for a range of different teaching and learning purposes. A group of teachers in California, for example, is using iPod devices paired with Belkin recorders to improve student reading (see Appendix A, p.40). They've observed that struggling students show increased motivation to improve fluency skills when they hear what they sound like reading aloud. Other innovative teachers are tapping into popular mobile trends to deliver more powerful instruction. North Carolina's 2008–2009 teacher of the year asks her sixth- and seventh-grade students to translate passages from classic literature into "texting speak" to demonstrate their comprehension and to create a kind of multilingual focus, similar to how learning a foreign language can enhance a student's understanding of his or her native tongue (Bernard, 2008).

Box 2: Mobile devices in key public sectors

Education is lagging in the use of mobile devices for learning and behavioral change; other major sectors have shown innovative advances in this area.

Health: Public health workers in South Africa now send text messages to tuberculosis patients with reminders to take their medication. In Kenya, people can use text messaging services to ask anonymous questions about culturally taboo subjects like AIDS, breast cancer, and sexually transmitted diseases, receiving prompt answers from health experts for no charge (Corbett, 2008). And India's Freedom HIV/AIDS initiative uses mobile phone games to educate people about HIV/AIDS. The games were initially launched on 9 million handsets and later were scaled up to 40 million handsets. (Freedom HIV/AIDS, 2008)

Banking: In February of last year, Vodafone rolled out a mobile-banking program in Kenya, with the goal of adding 200,000 new customers in the first year; they reached that number within a month. One year later, the program has 1.6 million subscribers, and Vodafone is now set to open mobile-banking enterprises in a number of other countries, including Tanzania and India. (Corbett, 2008)

Politics: Text messaging went mainstream for political campaigns this year, as Barack Obama announced his choice of vice president to supporters via text message and activated a wide-reaching campaign operation. (Kornblut & O'Keefe, 2008)

Citizen Journalism: Some of the most intimate, immediate, and widespread images and news about Mumbai's fall 2008 terrorist attacks came from cell phones equipped with cameras and video recorders. Many witnesses used Twitter to update networks of friends and acquaintances around the world with real-time accounts. (Caulfield & Karmali, 2008)

While some innovative districts and teachers experiment, educational researchers are beginning to generate a body of evidence that indicates the learning potential of mobile technologies. Project K-Nect (see Appendix A, p.43), for example, is a pilot education program using smartphones with advanced mobile broadband technologies to deliver educational material to ninth-grade students in North Carolina. According to project director Shawn Gross, 75 percent of participating classes outperformed other cohorts in math subjects in the recently completed first phase of research. Students also displayed increases in average study time, drops in breachment of the smartphone's acceptable use policy, and significant gains in parental involvement.

Box 3: Industry response to mobile learning

As educators and researchers attempt to unleash the educational potential of mobile devices, mass-market toy and game companies are developing educational products directed at both formal and informal environments:

- For formal learning, GoKnow Inc. has created a mobile learning environment (see Appendix A, p.41) that lets teachers create coordinated, curriculum-based learning opportunities. Multi-activity assignments let students view and construct documents of many media types (text, graphical, spreadsheet, animations, etc.).
- An informal scan of Toysrus.com in December 2008 showed that all of the top five best-selling electronic learning platforms for children were handheld toys.
- According to *BusinessWeek*, while education sales account for only a small sliver of iPhone device sales now, they could reach 20 to 25 percent of the market in the coming years (Kharif, 2008). Apple's App Store already offers more than 500 educational applications (Prabhu, 2008) that help teach a variety of skills such as telling time, reading, or learning a foreign language.
- According to LeapFrog's Director of Learning, Jim Gray, "Our new connected strategy affords learning through mobile devices, web environments, intergenerational interactions and connections among them."

The use of handhelds for learning is not only an American trend; other nations are attempting to capitalize on these devices as well — some in ways strikingly ahead of the U.S. As the University of Nottingham's Mike Sharples, founder of the mLearn international conference series, told us, "Because of differing cultures, history, and infrastructure, countries around the world have differing perspectives on mobile learning." In the U.S., mobile devices have primarily been explored via small-scale projects in formal environments. The U.K., on the other hand, has mainly focused on learning outside of school, or learning that bridges the formal and informal. Its largest project — Learning2Go (see Appendix B, p.45) — is currently being scaled up to impact the entire district of Wolverhampton. In parts of Africa such as Nigeria, where there is virtually no fixed-line infrastructure, mobile learning often consists of using standard cell phones for managing, coordinating, and administering learning. In Japan, where many families don't have home desktops, cell phones have been used as the main computing device for quite some time. And countries such as Chile are doing advanced research into how handheld devices may be used for collaborative learning. The good news, as Sharples further articulated, is that "we are starting to get a global perspective on mobile learning. National examples are being shared. There is a real opportunity to learn from each other in this field."

The aforementioned products and projects are but a few examples of mobile learning. Appendices A and B present an inventory of more than 25 handheld learning projects in the U.S. and beyond. We have made no attempt to assess the quality or effectiveness of any specific product or project, nor does the sample represent an exhaustive list of everything available. Rather, the inventory highlights examples of mobile learning research, projects, and products based on what we heard from experts, arrayed as follows:

- Appendix A: Mobile Learning Examples and Research Projects (U.S.)
- Appendix B: Mobile Learning Examples and Research Projects (Non-U.S.)

This inventory highlights numerous inspiring examples of mobile learning — including promising preliminary evidence that these devices can transform education. The examples are distinct and diverse. Some employ the most innovative features of mobile devices, like transporting students to augmented realities based on their real-world location; others rely on more standard features, such as using text messaging to send literacy tips to parents of preschoolers. Some capitalize on the personalization capabilities of handheld technologies, counting on each student having her own device; others show how these devices can encourage collaboration when used within a team. Some use mainstream devices; others use devices developed specifically for education. And while this diversity suggests great opportunity, it also reveals tensions in the field of mobile learning, with consequent trade-offs on issues such as distribution vs. innovation, one-to-one vs. one-to-many, and mass-market vs. education-specific.

Many experts were disappointed by the lack of well-financed or highly visible efforts in mobile learning in the U.S. In numerous cases, it is being pushed ahead by an innovative teacher, a passionate researcher, a risky developer, or an inspired parent. Efforts are fragmented and unsupported, and leaders have not yet developed a strategy on how mobile learning should be deployed, or even if it should be used at all. While such haphazard initiatives help spawn innovative instances of mobile learning, multi-sector leadership is needed to connect disparate efforts in academia, industry, professional development, and policy-making. In the meantime, these devices are — in an educational sense — sitting idly in the pockets of millions of children.

key opportunities in mobile learning

Mobile devices are everywhere children turn, and innovative examples of mobile learning are popping up worldwide. But where should educators, developers, and companies focus their resources now?

Mobile devices are everywhere children turn, and innovative examples of mobile learning are popping up worldwide. But where should educators, developers, and companies focus their resources now? Outlined below are five opportunities to seize mobile learning's unique attributes to improve education.

1. Encourage "anywhere, anytime" learning

Mobile devices allow students to transcend the barriers imposed by a classroom's four walls without losing their ability to gather, access, and process information. As Liz Kolb, author of *From Toy to Tool: Cell Phones in Learning*, said, "Mobile devices bring the real world into the classroom, and they bring the classroom into the real world." Two key benefits of anywhere, anytime learning include promoting situated knowledge and helping to bridge barriers between home, school, and afterschool.

> Mobile devices bring the real world into the classroom, and they bring the classroom into the real world.

Promote situated learning

If a child can align her learning with actual situations, scenarios, and environments, basic concepts and vocabulary are clearer and easier to remember and transfer (Gee, 2008). Research in the learning sciences shows that situated learning is most effective when accompanied by scaffolding that is "just in time (when learners are able to apply it) and on demand (when learners know they need it and want it)" (Shore, 2008). Because mobile devices don't wed a child to the classroom or a desk, they complement just in time and on-demand learning. Furthermore, the incorporation of global positioning systems (GPS) in many new mobile technologies vastly increases a device's strength to promote situated learning by tying learning to place and embedding virtual information and experiences into the real world. As Okhwa Lee of South Korea's Chungbuk National University said, "When a child waits, they lose interest in learning or forget what they wanted to know, and learning does not happen. You have to get the secret right there, and with the help of the handheld device, you can have that power."

> When a child waits, they lose interest in learning or forget what they wanted to know. You have to get the secret right there, and with a handheld device, you can have that power.

The GeoHistorian project (see Appendix A, p.41), for example, utilizes wireless mobile technologies to link classrooms with local historical landmarks. Children use mobile phones to take photos, videos, and audio clips of local landmarks, which are then translated into videos and uploaded to the Internet. Then, using QR codes (see p.29), regular citizens passing by these historical landmarks can access the student-created content. This innovative example capitalizes on mobility to provide situated learning opportunities for students, both in the creation of their own content and in the on-demand learning experience.

Break the barrier between home, school, and afterschool

Many students experience a disconnect between their learning in school and in home and community environments. Especially for struggling learners, there is a need for a 360-degree approach to learning, in which the experiences that underlie in-school learning are aligned with those in afterschool and home settings (Shore, 2008). The ubiquity of mobile technologies may allow new breakthroughs in scaffolding learning across different settings. As Jim Gray, LeapFrog's Director of Learning told us: "Mobile devices help kids make connections between different spheres of their everyday world. It can help connect what they're doing in school with what they do in an afterschool program with what they do at home."

Mobile devices help kids make connections between different spheres of their everyday world. It can help connect what they're doing in school with what they do in an afterschool program with what they do at home.

In Singapore, for example, the priority in mobile learning is to enable students to learn whenever they are curious, switching between formal and informal contexts in what they refer to as "seamless learning." Chee-Kit Looi and his team at Nanyang Technological University are working on a research project that gives handheld devices to third-grade students to see how they would use them outside the classroom (see Appendix B, p.47). These investigators aim to fill a research gap, which has "typically focused on either formal or informal settings and failed to examine the integrated and synergetic effects of linking these two contexts or environments of learning" (Sharples, 2006, as cited in Looi, in press). Looi contemplates that if the project goes as expected, "mobile devices will help bridge what children do in school — formal learning — and what they do outside of school — informal learning."

The U.K.'s MyArtSpace project (see Appendix B, p.47) provides another example of mobile's potential, combining mobile phone and web-based service to support learning between schools and museums. On arriving for a museum visit, children are loaned mobile phones running the MyArtSpace software. They can view multimedia presentations of museum exhibits, take photos, make voice recordings, write notes, and see who else has viewed the exhibit. After each action, the content is automatically transmitted over the phone connection to a website that stores a personal record of their visit. Back in the classroom, they can review their visit and the media they have collected, share material with other children, and create presentations.

2. Reach underserved children

Because of their relatively low cost, handheld devices can help serve the pressing need to advance digital equity, reaching and inspiring populations "at the edges" — children from economically disadvantaged communities and those from developing countries.

Reach children from disadvantaged socioeconomic groups

Cell phones are already a popular option for projects aimed at helping disadvantaged students. These devices, compared to equipment such as laptops, are less expensive and more likely to already be present in children's homes compared to personal computers.

For example, mobile technologies have been found to help low-income children learn essential literacy skills through interactions with their caregivers. The PBS KIDS Ready to Learn Cell Phone study (see Appendix A, p.43) focused on the ability of cell phones to deliver educationally sound *Sesame Street*–themed parenting tips, audio messages from Elmo, and literacy-related *Sesame Street* videos to lower-income households (Horowitz et al., 2006). The program provided information to parents who were busy and "on the go." Instead of having to find the time to log onto a website or attend a meeting, parents would receive messages on their cell phones. Tips revolved around everyday literacy activities that the parent could engage in with the child (e.g., while waiting in line at the grocery store or at home in the living room). The study found positive outcomes in parents' ability to scaffold aspects of their children's learning, resulting in increased knowledge from pre- to post-intervention and increased enthusiasm among parents and children.

Reach underserved children worldwide

Mobile phones have also been tapped for education in developing countries that do not have an extensive communications infrastructure but increasingly have access to cellular networks. Eighty percent of the world's population now lives within range of a cellular network, which is double the level that existed in 2000. By the end of 2006,

68 percent of the world's mobile subscriptions were in developing countries. And as a family's income grows — from $1 per day to $4, for example — their spending on telecommunications increases faster than spending in any other category, including health, education, and housing (Corbett, 2008).

Perhaps the most groundbreaking mobile learning initiatives are happening in underdeveloped areas of Africa, where access to personal computers is limited but mobile devices are inexpensive and increasingly available (Aderinoye, Ojokheta, & Olojede, 2007). Half of the existing telecommunications lines there are concentrated in capital cities, which account for only 10 percent of the continent, and the largest cities of several countries have more than 70 percent of the total telecommunications lines (Aderinoye, Ojokheta, & Olojede, 2007). Mobile phones, which have penetrated even remote areas, have the ability to offset these disproportional numbers between cities and rural areas.

The Nigerian National Council for Nomadic Education, founded in 1989, seeks to improve the educational opportunities for those primary school-age children lacking in adequate shelter, food, and health care. The Council, dissatisfied with the results of traditional distance education methods, recently began integrating mobile technologies into its curricula. Preliminary reports suggest increased literacy among target populations and support the suitability of mobile technologies for nomadic lifestyles (Aderinoye, Ojokheta, & Olojede, 2007). The MOBI Project of South Africa (see Appendix B, p.46) delivers mathematics content to students and provides mobile access to tutors (Matthee & Liebenberg, 2007), and the School Empowerment Program (see Appendix B, p.47) of Kenya uses mobile technologies to remotely provide primary school teachers in rural and urban areas with training, support, and materials (Traxler, 2005).

3. Improve 21st-century social interactions

Some observers have asserted that immersion in mobile technologies can be detrimental to a child's social interactions. They draw a picture of an isolated child, alone in her room, focused solely on her cell phone, or a classroom of children sitting quietly at their desks, heads hunched over individual small screens. On the contrary, research has shown that, if used properly, mobile technologies have the power to promote and foster collaboration and communication, which are deemed essential for 21st century success. In the 21st century, traditional literacies such as reading, writing, and arithmetic continue to be crucial skills, but they are not sufficient to achieve success in today's globally competitive world. Organizations such as the Partnership for 21st Century-Skills and the National Council of Teachers of English have developed new practice principles, including frameworks that articulate the skills, knowledge, and expertise students should master to succeed in the 21st century (Partnership for 21st Century Skills, 2007; National Council of Teachers of English, 2009). Mobile technologies have the potential to help "level the playing field" in gaining these gateway skills and competencies if they are deployed fairly to advance digital equity. But more specifically, mobile technologies have, perhaps, unique potential to advance 21st century skills such as collaboration, communication, and global awareness.

Collaboration

Collaboration skills have always been imperative to the healthy emotional and cognitive development of children. However, the current generation of students will enter a workforce where they will be expected to share responsibility with diverse, global teams working together to accomplish common goals as never before. Though any web-enabled device can facilitate online collaboration, and physical collaboration doesn't require technology at all, mobile devices have the distinctive ability to bridge the gap between virtual and physical collaboration. Eric Klopfer of the MIT Teacher Education Program and the Education Arcade has designed, developed, and researched mobile learning games for a variety of platforms, including Palm OS, Windows Mobile, and cell phones. These games include location aware "Augmented Reality" games as well as casual multiplayer games that involve player-to-player interaction. These latter games, known as

participatory simulations (see Appendix A, p.43), include science, math, and social science–based games that are meant to be played by the whole class. Interactions between players in the game are mediated by peer-to-peer beaming.

In one of the participatory simulations called Discussion, a statement such as "Technology has succeeded in changing classroom practices" is presented to the students, who must log in their agreement or disagreement with the statement and provide a brief rationale on their PDAs. Players must then make their case to others and track how their own opinion and rationale changes in response to feedback. In this case, the mobile device is acting as a mediator for collaboration and communication.

Communication

The ability to articulate thoughts and ideas clearly and effectively through speaking and writing has never been more necessary or complex. Communication has now become open, social, global, and asynchronous (Alexander, 2006), and handheld technologies are particularly good at enhancing these skills.

From a practical point of view, numerous communication options are embedded on a single mobile device (voice, text messaging, e-mailing, mobile IM) and are readily available, as an integrated part of most children's lives. Mobile technologies, particularly the new generation of smartphones, can communicate effortlessly with other devices through Bluetooth, thus providing more opportunities for information exchange (Traxler, 2005). From an instructional theory perspective, mobile technologies facilitate what some researchers call "conversational learning," in that they naturally support an environment where people "can converse with each other, by interrogating and sharing their descriptions of the world" (Naismith, Lonsdale, Vavoula, and Sharples, 2004). Using mobile devices, children have improved ways to form their own learning networks as they communicate through conversations, texting, e-mail, and social-networking applications with both peers and teachers (Field, 2005).

Box 4: Mobile devices and language learning

One key element of communication is language, and the benefits of mobile technologies for English Language Learning is being recognized in the U.S. and around the world.

For example, Sesame Workshop has recently rolled out extensive free **podcasts** featuring Muppet characters that teach young children (and second language learner adults) the essentials of reading and language skills.

Other inspirational examples focus on helping low-income neighborhoods outside the U.S. **The MILLEE project** from UC Berkeley provides cell phones filled with interactive and engaging instructional English games and vocabulary to elementary and middle school children in India. Meant to complement in-school curriculum of underserved, isolated populations, this project recognizes that learning English as a child not only increases global awareness, but also determines access to elite academic institutions and a higher standard of living. (Kam, Rudraraju, Tewari, & Canny, 2007) A similar **Mobile-Based Interactive Learning Environment (MOBILE)** project in Taiwan found that elementary-age students increased their English vocabulary and were more enthused as a result of the mobile platform (Tan & Liu, 2004).

Both MILLEE and MOBILE projects are based in rural populations where access to formal education may not be adequate, and take advantage of children's interest in mobile devices, cell phones in particular.

4. Fit with learning environments

Educators and learners often face a love-hate relationship with technology. On the one hand, computers and the Internet can bring a wealth of information; on the other, hardware and software can be fickle, hard to maintain, and disruptive to the flow of learning. Mobile devices can help overcome many of the challenges associated

with larger technologies, as they fit more naturally within various learning environments of a child's life, both in and out of the classroom.

Learning in the classroom

Around the world, digital and mobile technologies are rapidly changing the way young people learn, showcase their knowledge, and share their ideas outside the classroom. Still, few students have the chance to apply these skills to their classroom learning. As Pearson Foundation's Mark Nieker has observed through his work with the Mobile Learning Institute (see Appendix A, p.42), "Children are experts at using these devices — they love using these devices — but in most cases none of that expertise or engagement currently has currency inside the classroom."

Children are experts at using these devices — they love using these devices — but in most cases none of that expertise or engagement currently has currency inside the classroom.

The portability of mobile technology may be an attractive choice in the classroom for several reasons. Mobile technologies by definition move with the child. They can be used anywhere the child is, making a special trip to the computer lab or a return to the desk unnecessary. Additionally, the price of mobile technologies is significantly lower than even micro-laptops, making the one-to-one paradigm recommended by many experts increasingly feasible. Finally, mobile devices enable students to control the public-private boundary within the classroom, something that larger technologies can make difficult. Students can easily transition from their individual tasks to sharing their work with instructors or peers, which helps to maximize collaborative learning. As Jeremy Roschelle said, "When it's in your hands, you can control what you want to be private and what you want to share, whereas with a desktop, it's really hard to turn the screen around."

Informal learning

Mobile technologies can empower kids to explore a whole range of environments, from the outdoors to public spaces, as loci for learning. There are numerous games specifically designed for mobile devices that require continuous movement from place to place and have the benefit of creating an authentic, hands-on learner experience (Dembo, 2006; Games Atelier, 2008). The majority of such applications involve museums, though some incorporate an entire town or city.

One such project, Yellow Arrow, began in 2004 as a street art project on the Lower East Side of Manhattan. It is built around the general philosophy that every place is distinct and engaging if seen from a unique perspective. Participants place uniquely coded Yellow Arrow stickers to draw attention to different locations and objects. By sending a text message from a mobile phone to the Yellow Arrow number beginning with the arrow's unique code, Yellow Arrow authors connect a story to the location where they've placed their sticker. Messages range from short poetic fragments to personal stories to game-like prompts to action. When another person encounters the Yellow Arrow, she sends its code to the Yellow Arrow number and immediately receives the message on her mobile phone. The website yellowarrow.net extends this location-based exchange by allowing participants to annotate their arrows with photos and maps in the online gallery of Yellow Arrows placed throughout the world. Yellow Arrow is currently in more than 35 countries and 380 cities globally and has become a powerful way to experience and publish ideas and stories via text messaging on mobile phones and interactive maps online.

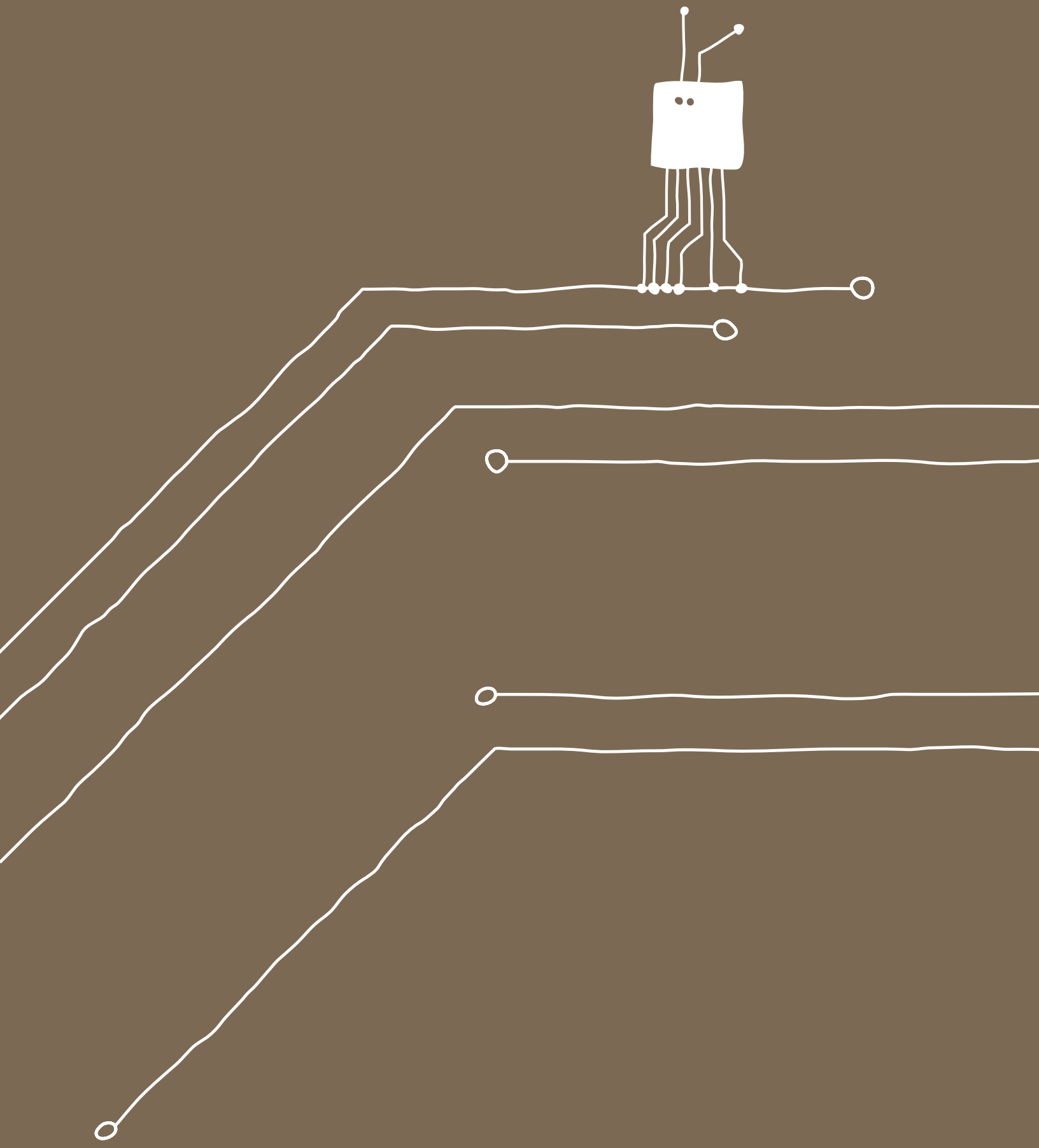
5. Enable a personalized learning experience

As Kurt Squire told us, "Mobile devices enable kids to develop passions and interests via their own personalized, media-enhanced environments that can transport them to different times and places." Not all children are alike; in an ideal world, instruction should vary and be adapted in relation to individual and diverse learners. Differentiated instruction is a process to approach teaching

and learning that recognizes learners' varying background knowledge, readiness, language, preferences, and interests, and reacts responsively. The intent of differentiating instruction is to maximize each student's growth and individual success by meeting them where they are and assisting in the learning process (Hall, 2002). There are significant opportunities for genuinely supporting differentiated, autonomous, and individualized learning through mobile devices.

Mobile devices enable kids to develop passions and interests via their own personalized, media-enhanced environments that can transport them to different times and places.

Sesame Workshop's iREAD project (see Appendix A, p.41) is a highly personalized, media-based literacy intervention system that targets the instructional needs of each individual student. The project assesses a student's literacy challenges in order to develop an individualized intervention, made up of classic video footage from Sesame Workshop's award-winning series *The Electric Company* and newly created interactive games based on that footage. The effectiveness of this prototype system will be evaluated in a large-scale national study that is currently under way, with support from the Workshop and the Corporation for Public Broadcasting. Results of a pilot study indicate significant promise.



key challenges in mobile learning

Devices such as mobile phones, iPod devices, and handheld video game consoles have features that can help children develop important skills they'll need to succeed in the 21st century. But along with their potential comes difficult social, technological, and resource concerns that must be addressed.

Devices such as mobile phones, iPod devices, and handheld video game consoles have features that can help children develop important skills they'll need to succeed in the 21st century. But along with their potential comes difficult social, technological, and resource challenges that must be addressed. Below, we explore five key concerns in using mobile devices for learning.

1. Negative aspects of mobile learning

Though mobile technologies offer rich opportunities to promote children's healthy development and learning, the devices pose potential pitfalls. There are a number of cognitive, social, and physical challenges to surmount when these devices are incorporated into children's learning. Some of these serious concerns, which have led to controls such as cell phone bans in many school districts, include:

- Increasing the "screen time" that is already so prevalent in children's lives.
- Difficulty monitoring children's access to and sharing of inappropriate content.
- Potential for students to become distracted, diminishing educational engagement.
- Growing acceptance of texting slang/ abbreviations and concern about the negative effects on children's writing.
- Enablement of cheating via text messaging.
- Possibility that the devices will be used for "cyberbullying."
- Concern, largely speculative, over whether too much cell phone use may negatively affect children's health.
- Data privacy issues, such as concern from schools that assessment and other proprietary data could leak onto children's personal devices.

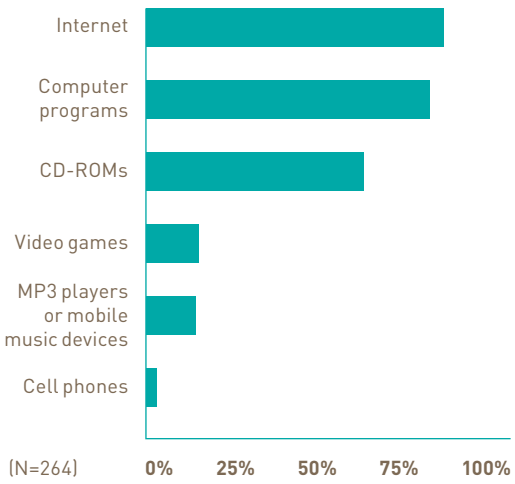
Unless mobile learning initiatives actively attempt to understand, take into account, and counteract these disadvantages, the devices could potentially do greater harm than good.

2. Cultural norms and attitudes

Though many experts believe that mobile devices have significant potential to transform children's learning, parents and teachers apparently are not yet convinced. A 2008 study done by the Joan Ganz Cooney Center at Sesame Workshop in collaboration with Common Sense Media and Insight Research Group reported that parents and teachers were skeptical about the educational value of mobile technologies. The study found that teachers see the Internet, computer programs, and CD-ROMS as having more educational potential than mobile forms of digital media (see Box 5). Furthermore, more than half of teachers see MP3 players solely as entertainment devices (54 percent) and feel they have no place in school (69 percent), and almost all teachers (85 percent) see cell phones as distractions, with 64 percent agreeing they have no place in school.

Box 5: Digital media's potential as an educational tool

How much potential do you feel the following kinds of digital media have as educational tools?



3. No mobile theory of learning

As Liz Kolb told us, "Frankly, we haven't grown up seeing models of cell phones being used in school, so we don't even consider it a potential learning tool and teaching tool. Even the pre-service teachers who are 18, 19, or 20 years old, who grew up with cell phones for the most part, they never, never — not to this day — ever consider using a cell phone in learning. And the number-one reason is that they never saw models of it." Only once we have a theory for learning with mobile technologies in different settings and different populations can these devices be used to their full potential.

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Numerous researchers have called for a learning theory specific to mobile technologies that will allow for effective assessment, pedagogy, and design of mobile applications (Klopfer & Squire, 2003; Zurita, Nussbaum, & Sharples, 2004; Naismith, Londsale, Vavoula, & Sharples, 2006). The potential for mobile technologies to contribute to lifelong, dynamic, contextualized, and social learning rests on the establishment of principles that highlight and exploit the specific characteristics of learning with mobile technologies.

Sharples, Taylor, and Vavoula (2005) propose the following standards against which a theory of mobile learning should be examined:

- Is it significantly different from current theories of classroom, workplace, or lifelong learning?
- Does it account for the mobility of learners?
- Does it cover both formal and informal learning?
- Does it theorize learning as a constructive and social process?
- Does it analyze learning as a personal and situated activity mediated by technology?

4. Differentiated access and technology

In September 2008, there were 311 different cell phones available for purchase on Amazon.com — and that doesn't include the multitude of handheld video game consoles, computers, MP3 players, and other such devices that compose the realm of mobile technologies. This diversity represents a challenge for both the teachers and learners attempting to capitalize on mobile learning and the producers seeking to develop software applications to facilitate such learning.

Another important and related concern is how to prepare school curricula around such diversity. Mobile learning advocates often compare a cell phone or other device to a pencil and paper. However, when a teacher asks students to "take out their pencils," she can be fairly confident that though the pencils may look different, they will all have the same capabilities. All will have some sort of graphite or ink that can be used to mark paper. All will be thin enough for a child to easily hold and manipulate to facilitate drawing and writing. Most will have an eraser that can be used to correct mistakes. Mobile technologies, on the other hand, don't offer this type of standardization. One student may bring an iPhone device, which touts a phone, web browser, MP3 player, GPS, camera, and full-color touch screen among its many features. The next student may have an older cell phone with just calling and text messaging capabilities. And some students may enter with no device at all. Even in the future, when some predict nearly all children will carry mobile phones, there will always be the students who forget their phone, whose parents don't allow them to have a phone, or who simply can't afford one. A mobile learning approach that can accommodate this flexibility will have the best chance of success.

5. Limiting physical attributes

Poorly designed mobile technologies adversely affect usability and can distract users from their learning goals. These limiting physical attributes could become even more problematic if developers try to take educational technology interventions that have been developed for a full-sized computer and simply shrink them down to be used on mobile devices.

Physical aspects of mobile technologies that may prevent an optimal learning experience include:

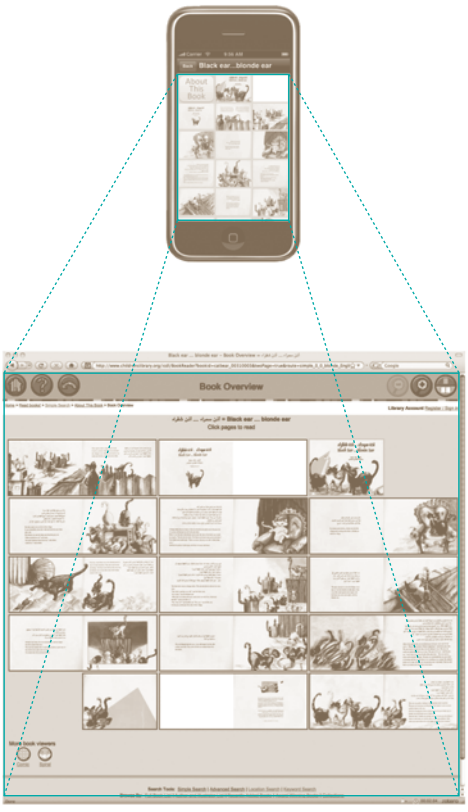
Text entry
Entering large amounts of text is impractical given the dexterity needed to operate the smaller controls.

Small screen size
Screens are by necessity smaller on mobile devices. Unless applications are built specifically with mobile devices in mind (see Box 6), screen content (images and text) may be either too small and cause eye strain, or too large and require constant scrolling. This limiting factor may also make some educational enhancements more difficult, such as encouraging complex literacy experiences.

Limited battery life
Mobile applications should run on as little power as needed. Keeping 30 mobile devices in a classroom sufficiently charged could be difficult for any educator to manage.

Box 6: The International Children's Digital Library – creating the iPhone edition

The International Children's Digital Library (ICDL; www.childrenslibrary.org; see Appendix A, p.42) holds the world's largest and most diverse collection of digitized children's books freely available online. Dr. Allison Druin and Dr. Ben Bederson at the University of Maryland's Human-Computer Interaction Lab launched the library in 2002, when large-screen web browsing was the norm and social networking was still a fringe activity. As Druin articulated, "When we first began the development of the ICDL, 9-year-olds didn't have their own Facebook pages, 3-year-olds weren't watching videos on daddy's iPhone, Google hadn't begun digitizing the world's books, and digital libraries for children were rare" (Druin, in press). For the past two years, Druin and her team have been developing new versions of the ICDL that can live on the iPhone device, which has a small screen and touch interface. The team involved children, as they always do, in their design efforts, adapting what they had created for a big screen to work within the limitations of a small one. The figures to the right compare the two versions.



relevant market trends and innovations

The mobile market is one of the most rapidly evolving industries in the world. Over the last decade, as power and functionality have increased, device size and prices have decreased. These devices continue to get smaller, and their potential for learning seems to get bigger.

The mobile market is one of the most rapidly evolving industries in the world. Over the last decade, as power and functionality have increased, device size and prices have decreased. These devices continue to get smaller, and their potential for learning seems to get bigger. This bodes well for mobile learning, because, as Intel Research Psychologist Richard Beckwith put it, "Kids are the ones who are most in need of powerful devices, but at the same time they are the least likely to get them." Experts outlined a number of developments that could have the greatest impact on children's learning.

Extreme convergence

Convergent devices offer a range of features that "lessen your need for other things, including a watch, alarm clock, calculator, camera, video camera, home stereo, television, computer, or, for that matter, a newspaper" (Corbett, 2008). Now, almost all cell phones are built with features that used to be the expensive add-ons, such as color screens, cameras, and mobile web. There is also a move from "feature phones," on which certain functions like making a call or taking a picture can be performed, to smartphones that have an operating system just like a computer. According to the NPD Group, smartphone sales to U.S. consumers reached 9 million units from January through July 2008, a year-over-year increase of 84 percent. Even as overall handset sales and revenues declined in the U.S., smartphone revenue increased 71 percent — reaching nearly $1.7 billion (NPD Group, 2008b).

Individually, features like wireless capability, web browsers, cameras, microphones, audio recorders, and video recorders are useful as teaching aids; when bundled together, the sky's the limit. University of Michigan's Elliot Soloway has pointed out that "For kids, the issue of multimodal input and multimodal self-expression is paramount." The Center for Children & Technology calls the Nintendo DS a "pocket-sized laboratory" and considers the device's many features well-suited for in-class collaboration, language support, observation recording, and creative "project-based" learning (Box 7, p. 31).

Location, location, location

By October 2009, about half of phones in the United States will have GPS (Tedeschi, 2008). On the consumer front, the big advantage of GPS has traditionally been directions- and map-based functions; however, researchers are putting it to other uses in the realm of kids and education. The possibilities enabled by these applications — especially when used in combination with social networking applications — are significant. For example, Eric Kloper of the MIT Teacher Education Program uses location data in augmented reality games (see Appendix A, p.40) that engage students in simulations that combine real-world experiences with additional information supplied to them by handheld computers.

Another innovative and increasingly popular use of location-based data in handheld devices is Geocaching (www.geocaching.com), a high-tech treasure-hunting game played in over 100 countries by adventure seekers equipped with GPS devices. The basic idea is to locate hidden containers, called geocaches, outdoors and then share your experiences online. While this novel concept was not developed for educational purposes, innovative teachers from around the world have documented successful use of this concept with their students.

While GPS may present much educational potential, there are other ways that mobile devices can receive location-based data and context sensitivity.

QR codes/mobile tagging

A camera in a mobile device is able to read and identify a two- or three-dimensional barcode called a QR code that can contain various data types, with URL being the most common. At present, mobile tagging is most prevalent in Asia and Europe.

Visual search engines

Evolution Robotics VIPR visual search technology allows the user to take a photo of any movie poster, CD, or book cover, and receive an e-mail with information and links pertaining to that image. It was deployed in Japan last spring and is expected to make an appearance in the U.S. soon.

Consolidation at last

Traditionally, it has been extraordinarily difficult to develop software applications for mobile phones due to proprietary platforms, and the mobile phone market has experienced a long-standing lack of a collaborative effort to fix this problem. Developers commonly needed to create numerous versions of the same application for the multitude of handsets on the market. Now, through mobile operating systems like Windows Mobile, iPhone, Symbian, and Android, a number of different platforms are consolidating. The hope is that this consolidation will bring developers on board to develop a diverse array of applications — including educational applications — that may have been cost-prohibitive before.

A major force behind consolidation is Google's Android, the first open and fully featured mobile platform. Android enables developers to create their own mobile devices and applications at lower costs — causing proponents to predict that this may lead to a wider selection of affordable phones.

The 21st-century button

Humans control their machines via input devices, which, for mobile technologies, have traditionally consisted of buttons and keypads. However, the dexterity required for such control has prevented children from achieving full control of pocket-size devices. Recent developments in this area include:

Touch screen
Perhaps the most prominent innovation in this category is the touch screen, a feature that industry experts have often noted as one of the defining success factors for market leader Nintendo DS. Touch screen hardware and software have finally matured to the point where the screens are showing up in mainstream consumer products en masse. Touch screen displays are found today in airplanes, automobiles, gaming consoles, machine control systems, appliances, and handheld display devices of every kind. Due in large part to the popularity of the iPhone device, the touch screen market for mobile is projected to be $5 billion in 2009 (ABI Research, 2008).

LeapFrog's Leapster Learning Game System is an educational handheld game console aimed at 4-to-10-year-olds that features a touch screen with a stylus that enables young users to interact directly with the screen.

Gestural input
Popularized by Nintendo's Wii, the ability to control devices via physical motion clearly resonates with kids. This concept is enabled primarily via accelerometers, which measure acceleration and gravity-induced reaction forces, and are increasingly present in portable electronic devices and video game controllers, most notably the iPod Touch and iPhone devices.

Box 7: Classroom Affordances: Portable game systems — pocket-sized laboratories

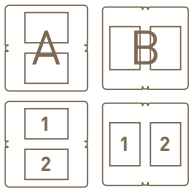
Portability
The Nintendo DS' small dimensions (5.24 in. x 2.90 in. x 0.85 in.) enable students to carry the device easily from class-to-class, to home, to field settings.

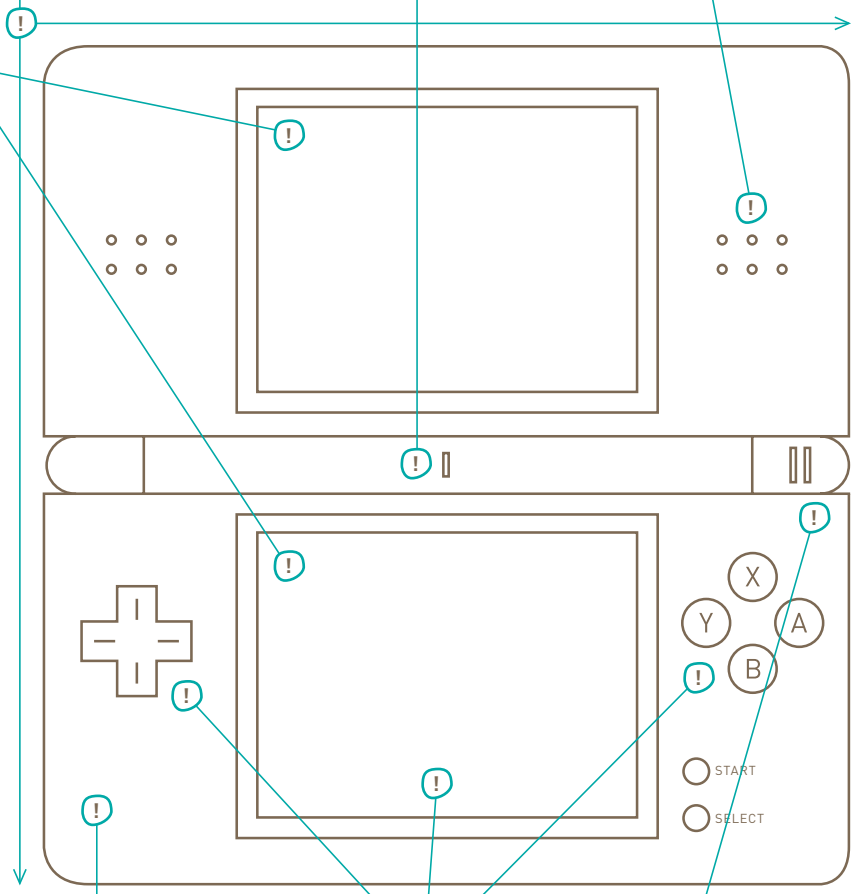
Record observations
Students can record research notes and observations as well as capture sounds in the field, then upload their scientific data to the class wiki. (Microphone)

Language support
Struggling language learners can hear text spoken, providing an important literacy scaffold. (Speaker)

Multiple points of view
The Nintendo DS, in particular, has two screens, supporting multiple orientations that can be used to create visually complex and engaging student experiences. (Dual screens)

1. Activity can flow across both screens.
2. Activity and point of view can be separated, such as one screen displaying a cross section of the pond and the other providing an inventory of scientific instruments to study the pond environment.
3. Finally screens can be viewed in portrait (left column) or landscape (right column) mode.





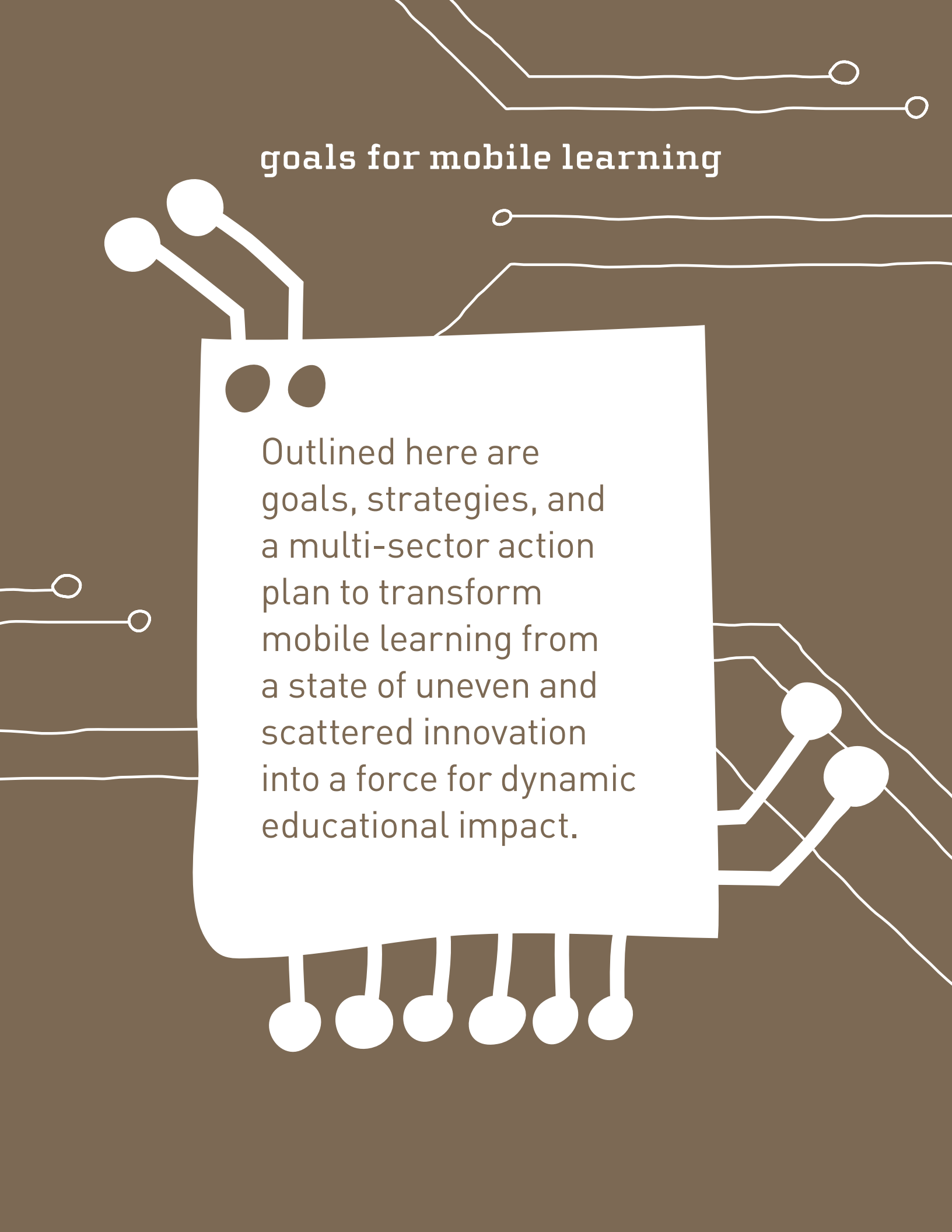
Internet access
The Nintendo DS includes a web browser (Opera) built especially for the platform, enabling students to search the web and teachers to assign web-based research to students. (Web browser)

Multiple entry points
Directional pad, contact sensitive touch screen, and four-button control offer multiple ways of engaging with game. (Directional arrows, touch screen, buttons)

Collaboration
With wireless capabilities built into each device, students and the teacher can communicate with each other without requiring a school-wide wireless network. (Built-in Wi-Fi)

(Source: Center for Children & Technology)

goals for mobile learning



Outlined here are goals, strategies, and a multi-sector action plan to transform mobile learning from a state of uneven and scattered innovation into a force for dynamic educational impact.

According to a recent report of the Benton Foundation, "Too often, America educates its children for the challenges they will face in the global, knowledge-based 21st century using 20th-century technology and methodology. Other nations provide students with laptop computers, fast broadband connections, and state-of-the-art digital applications, infusing technology and innovation throughout their educational experiences" (Benton Foundation, 2008).

This report makes a case for wider experimentation and new investments in the design and deployment of mobile technologies to advance children's learning in the U.S. Building on their market power and established engagement with the next generation, and the need for new innovation in the U.S. economy, there is a timely opportunity to advance mobile learning. Outlined below are goals, strategies, and a multi-sector action plan to transform mobile learning from a state of uneven and scattered innovation into a force for dynamic educational impact.

1. Learn: Understand mobile learning as a unique element of education reform

Handheld technologies and their learning applications require a systematic research inquiry to determine how they can become an important driver of technology integration in education. Public and private sector support for needed R&D should:

Invest in understanding the development of "mobile kids"

As Kurt Squire suggested, "With handheld devices, kids today can be online with an Internet connection all of the time, unless they specifically try to get away. What is it like when you've been raised in an environment where you don't know what it's like to ever be offline?" Researchers, educators, and parents have entered new territory in digesting the implications of children's involvement with technology. Key developmental issues that should be carefully researched include:

- The impact of mobile technologies on brain and behavioral functioning. For example, how will uses of these devices affect children's memory and the ability to find information or manage multiple projects?
- Are there negative health risks to children?
- Usability issues at various ages and stages. For example, how do children's abilities with handheld devices evolve over time? Can they use multiple features?

With handheld devices, kids today can be online with an Internet connection all of the time, unless they specifically try to get away. What is it like when you don't know what it's like to ever be offline?

Develop new theories and models for leveraging mobile technologies

Existing applications of mobile learning tend to employ design and evaluation principles taken from traditional or e-learning theories, and the outcome results in "mobile versions" of established approaches. This design approach fails to take into full account the unique affordances of learning through mobile technologies. Some fundamental questions in building a theory of mobile learning include:

- How can mobile technologies help address important educational gaps in skills, such as learning to read and write, promoting access to rich scientific and technical content, and second-language development?
- How can mobile technologies help enable a 360-degree approach to learning?
- What design principles and features lead to learning from mobile devices?
- Which instructional practices best leverage mobile devices?
- What kinds of devices work best, under which circumstances, and for whom?
- Do mobile technologies enable children to be more or less creative? Reflective?

Learn from other countries
Though some European and Asian countries have large-scale, government-funded mobile learning initiatives, the U.S. is significantly behind in providing a supportive R&D infrastructure for exploring the use of mobile technologies to advance children's learning. Mobile education offers an interesting case for cross-national learning and collaboration. Developed nations have the opportunity to learn from developing countries, where program developers have little or no track record of e-learning to contend with and are skipping immediately to mobile technologies because of their low cost and ubiquity.

2. Develop: Build mobile learning interventions

As John Traxler asserted, "In places with widespread Internet and digital infrastructure, mobile learning is often conceptualized as a continuation of e-learning, so mobile learning applications are often designed within the traditional technology-in-education paradigm." But as this report highlights, mobile devices have features that are distinctive, and developers of mobile learning applications must leverage both unique mobile assets and surmount special challenges. Industry should lead and be given more powerful incentives to:

Design educational innovations to capitalize on unique affordances of mobile
Our experts unanimously agreed that it is entirely ineffective to take educational technology interventions that have been developed for a big screen and simply shrink them down to be used on mobile devices. Developers need to discern what is special about mobile devices (e.g., portability, ubiquity, personalization) and design interventions that take advantage of those attributes.

Counter the Disadvantages and Limiting Physical Attributes of Mobile Devices
Mobile technologies have numerous disadvantages (e.g., can be distracting) and limiting physical attributes (e.g., difficult text entry) that — if not taken into consideration — could detract from the learning experience.

Avoid constant defaults to the latest technology
While it is important to understand how the latest innovations in mobile technologies — GPS, QR Codes, and accelerometers, etc. — can be used for education, in order to develop scalable models, one should also consider features that will become ubiquitous. Relying on features that are more common on less expensive phones will help ensure that mobile technologies can help close rather than amplify the digital divide. Such an approach will be easier for developers and school leaders as keeping up with rapidly evolving hardware can be jarring and costly.

Create development tools for educators
As Stanford's Roy Pea told us, "Android is what both the industry and the academic development community are most enthusiastic about, and rightly so." However, at the moment, the development tools are oriented toward industry and computer scientists, and are not accessible to an education graduate student, teacher, or faculty team. Higher-level development tools that are closer to how people think when they design instructional materials would open up development significantly to the education sector.

3. Promote: Engage the public and policy-makers in defining the potential of mobile devices for learning

Though research shows, and experts believe, that mobile devices have significant potential to transform children's learning, most parents and teachers still view these devices as serving social, communication, and entertainment purposes. But, as Eric Klopfer put it, "I do think that cell phones have the potential to be a negative in schools. Yes, students can send text messages to each other about what's on the test, and, yes, students can send disrespectful videos of their teacher to YouTube. But those types of harmful activities have been happening in schools for a very long time. We don't ban pencils and paper because students pass notes." We need to engage the public to view these devices as more than a means of communication and entertainment.

Cell phones have the potential to be a negative in schools. But we don't ban pencils and paper because students pass notes.

To promote public understanding, and prepare for the effective use of such devices, government, industry, and philanthropic organizations should expand resources to:

Scale up and disseminate innovative exemplars of mobile learning
Our inquiry uncovered dozens of exciting new mobile innovations that deserve wider scrutiny and possible adoption. Currently a lack of collaborative effort to study or scale up innovation in this arena is a major obstacle. Therefore we must provide opportunities for public agencies and industry leaders to discover and disseminate evidence of what works.

We recommend that federal and state policymakers place priority on identifying and disseminating mobile technology and learning innovations. Philanthropic initiatives to allow teacher experimentation and parent engagement with mobile technologies should be expanded. Finally, a national "best practices" initiative to disseminate effective uses of mobile technology for education should be established by a research entity, with support from philanthropic and policy leaders.

Provide incentives for needed infrastructure
Many of the experts we spoke to suggested that, in the long term, we should move away from a culture in which schools provide the hardware and instead use the mobile devices so many children already possess. If students were allowed to capitalize on their own devices, a significant proportion of money spent on hardware could be redirected to software and curriculum development that could help move the needle on the use of mobile technologies to promote children's learning. As Elliot Soloway speculated, "Imagine the day when kids will come with their Motorola, their Nokia, whatever it is they may have, and the teachers are going to say 'Okay, kids, we're going to load up your mobile with this software that's going to make it educational.'" To promote such seamless learning, we recommend that E-Rate funding for low cost Wi-Fi be targeted to low-income communities to enable school and library access to the Internet through mobile devices.

Develop educational standards for industry
The Joan Ganz Cooney Center's 2008 report *D is for Digital* found that digital media are too often marketed by companies that lay claim to substantial educational impact despite weak evidence. That report recommended that regulatory bodies such as the Federal Trade Commission, voluntary industry groups, and parent advocates such as Common Sense Media should collaborate on a consumer protection initiative to better describe educational effectiveness in interactive media products for children. As mobile applications for children's learning proliferate, we reaffirm the importance of such an effort to protect consumers.

4. Prepare: Train teachers and learners to effectively incorporate mobile technologies

Dan Sutch of Futurelab told us that, "Often the bulk of spending in incorporating technology into education is on the technology itself; however, preparing teachers and learners to use these technologies and helping them develop practices to incorporate them should actually be the priority." National, state, and community school leaders should:

Build capacity: Digital teacher corps
Teachers cannot teach with devices they do not understand. Professional development is essential to the future of mobile learning. Perhaps most important is to avoid a problem that has often occurred with the incorporation of technology into education in general: It is not just a matter of showing teachers how to use the devices; rather, it is crucial to show them how to use them within their curriculum. For example, as part of the Mobile Learning Institute (see Appendix A, p.42), Nokia and the Pearson Foundation sponsor the Mobile Learning Institute Leadership Network, a

nationwide professional development effort that helps teachers develop skills and strategies to integrate digital and mobile technologies into their classroom practice.

To build professional capacity, we recommend the creation of a "digital teacher corps." First proposed by the literacy and digital technology expert James Paul Gee, the corps would be established to work in the lowest-performing schools and in afterschool settings throughout the country. The goal should be to enable educators to help students learn to transform information for discovery and problem-solving. Teachers can learn to do this by working with a range of digital media, including mobile ones, which invite students into an environment that teaches skills, knowledge, and new ways of thinking.

Modify and gradually eliminate classroom bans
Mobile technologies such as cell phones, Tamagotchis, and DSs have long been banned from schools nationwide, based on educator and parent concerns over distraction, rambunctious behavior, and even cheating. School leaders and many parent advocates argue that the ban is instrumental in preserving a safe and ethical learning environment.

While student safety is paramount, classroom bans are not a realistic long-term policy. Step-wise experimentation is needed to help teachers to capitalize on the potential these devices have demonstrated and to expand new inquiry. School policies should be updated to introduce experimental use of mobile technologies in classroom and afterschool settings as learning tools. By devising established norms of behavior, we can build acceptance among teachers, parents, and students themselves. As mobile devices begin to overtake laptops as powerful learning platforms, modification of classroom bans will become more natural and logical. For example, in South Korea, where a striking 80 percent of elementary school students have cell phones, the appearance of these devices in school is imminent. As Okhwa Lee of Chungbuk National University reported, "These things will be in schools, so it becomes a matter of whether we will let kids use them for good. Korean schools are allowing cell phones in schools, simply because they are so prominent."

Integrate mobile themes in media literacy curricula
Less than a decade ago, media literacy was a term rarely used in American education. The Partnership for 21st Century Skills has established a well-regarded map of the new knowledge and skills, including "ICT literacy," required to effectively compete and cooperate in a global economy. Recently, the New Media Literacies Project at MIT and Common Sense Media have independently defined and gained needed attention for integrating media technologies in school curricula. State and school leaders should press for expanding media literacy while defining a new "mobile literacy," creating examples of the state of the art while educating students on mobile etiquette and capabilities.

5. Stimulate: Generate new leadership support for digital learning

Finally, as a new administration that has committed to rebuilding public infrastructure for economic renewal takes office, we recommend that priority be placed on how mobile technologies in particular and digital media more generally can advance children's learning in the global economy. The new administration should:

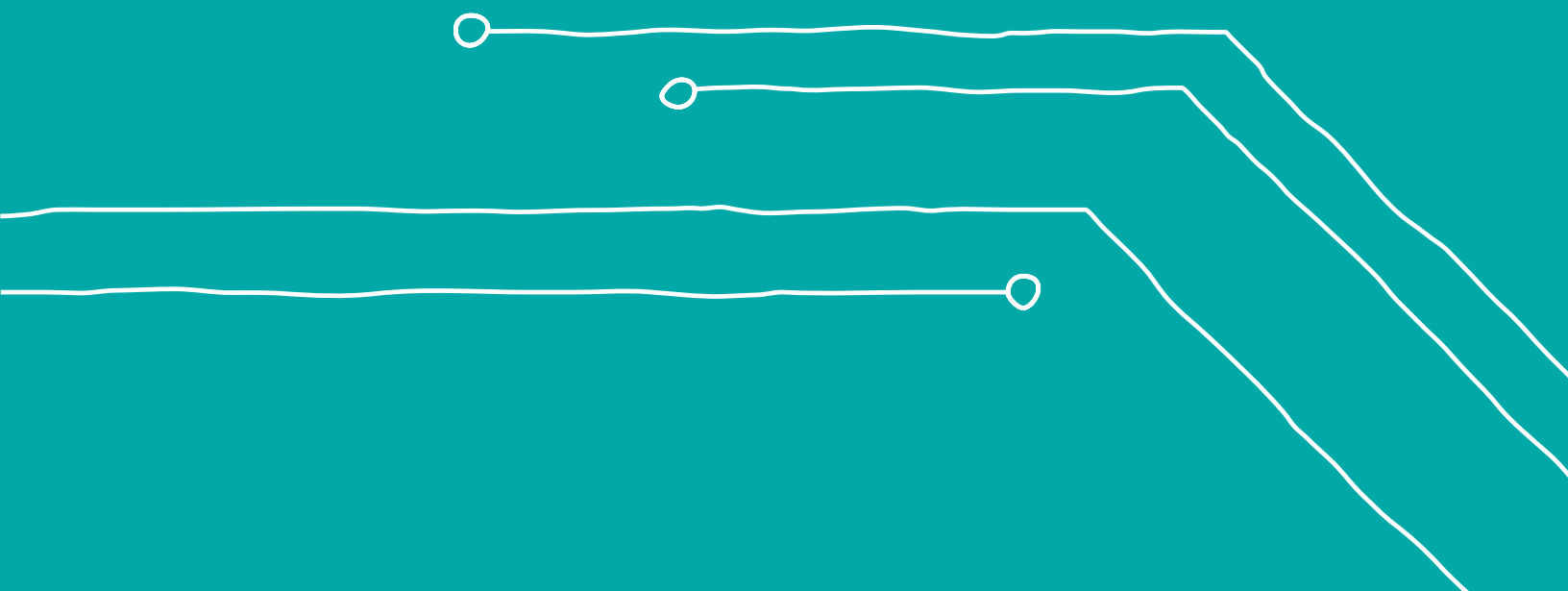
Create a White House initiative on digital learning
Experts we interviewed argued that a new federal investment and a high-level policy strategy will be imperative to gaining real momentum in using digital media to address learning gaps. As a first step in developing a national commitment to using effective digital innovations in education, we recommend that a White House Conference on the Future of Learning be held, to be followed by State Summits modeled on the national effort. The conference would assess existing evidence of impact, the future potential, and needed new investments in digital technologies for children's learning.

In preparation for the White House Conference and State Summits, we recommend that the President's Chief Technology Officer and state education agencies each conduct a funding and program audit to determine how mobile and other digital learning R&D initiatives are currently being approached. Industry leaders should be challenged by the President to announce their own new R&D initiatives to help stimulate creativity in the learning enterprise. Finally, the President should enhance his plan for expanding technology uses in schools and libraries with a new public-private innovation fund to further experimentation with digital technology for learning.

conclusion: pockets of potential

"The kids these days are not digital kids. The digital kids were in the '90s. The kids today are mobile, and there's a difference. Digital is the old way of thinking, mobile is the new way."

As Elliot Soloway expressed, "The kids these days are not digital kids. The digital kids were in the '90s. The kids today are mobile, and there's a difference. Digital is the old way of thinking, mobile is the new way." As usual, adults have not yet caught up to the kids. The bulk of public sentiment surrounding mobile devices and learning today is largely unenthusiastic, with many educators and parents concerned that they can cause distraction and other harmful behaviors. But the social and cultural phenomena, the market opportunity, and, most importantly, the "pockets of educational potential" documented in this report should not be dismissed. The debate in the coming decade should no longer be *whether* we should use these devices to support learning, but about exploring *how* best they can be used. Just as *Sesame Street* introduced children and their families to the potential of television as an educational medium two generations ago, today's children will benefit if mobile becomes a force for learning and discovery in the next decade.



appendix a: mobile learning examples and research projects (u.s.)

This appendix presents current examples of teaching and learning with mobile technologies directed at American children aged 3 to 11. It does not assess the quality or effectiveness of any specific product or project, nor does it represent an exhaustive list of everything available. Rather, it provides an overview of different types of mobile learning research and projects.

Project	Description
Augmented Reality Games	Augmented reality simulations engage people in games that combine real-world experiences with additional information supplied to them by location aware handheld computers. The first of these games, Environmental Detectives, was an outdoor game in which players using GPS-guided handheld computers tried to uncover the source of a toxic spill by interviewing virtual characters, conducting large-scale simulated environmental measurements, and analyzing data. This and other augmented reality games have been run at sites ranging from zoos and nature centers to schools and cities. Research has shown that this mode of learning is successful in engaging university and secondary-school students in large-scale scientific investigations, and is particularly appropriate for investigating socio-scientific issues such as those involving environmental and public health concerns. **Collaborators** The MIT Teacher Education Program, in conjunction with the Education Arcade. Led by Eric Klopfer. (www.educationarcade.org/node/356 and http://education.mit.edu/ar)
Escondido Union School District's Project iRead (I Record Educational Audio Digitally)	A group of pilot teachers in Escondido Union School District are exploring the use of iPod devices, GarageBand, and iTunes to improve student reading. Using the iPod's voice memo and a Belkin recorder, students can record and then hear themselves reading, which improves motivation and helps them work on fluency and comprehension. Teachers can also import student recordings into their iTunes library and create time-stamped digital portfolios (via playlists) that they can use to track progress over time. Data collected from a small group of fourth-graders has found that using iPod devices to practice fluency resulted in more rapid improvement rates compared with a control classroom. **Collaborators** Apple Distinguished Educator Kathy Shirley, in conjunction with teachers in the Escondido Union School District. (www.eusd4kids.org/edtech/iRead.html)

Project	Description
GeoHistorian Project	The goals of the GeoHistorian project are to investigate mobile phones as educational tools inside and outside the classroom, reduce the barriers between schools and community resources such as zoos and museums, and above all, to give students the opportunity to create digital resources for their community. The project utilizes wireless mobile technologies to link classrooms with local historical landmarks. Technologies include mobile phones with video capturing capabilities, built-in GPS, wireless Internet access, and Internet-based media-sharing sites such as PocketCaster. Using these technologies allows students to become video historians, creating and sharing a living history of real people and real places. **Collaborators** Mark van't Hooft and Thomas McNeal, Kent State University
GoKnow Mobile Learning Environment	GoKnow Inc. has created a mobile environment that lets teachers create coordinated, curriculum-based learning opportunities. Multi-activity assignments let students view and construct documents of many media types (text, graphical, spreadsheet, animations, etc.). Applications are available for Windows XP, M&A Companion PC, Windows Mobile, Palm OS, Nova5000 devices, and many cell phones. **Collaborators** Elliot Soloway, University of Michigan and Cathleen Norris, University of North Texas. (www.goknow.com/index.php)
iREAD (Interactive Reading Experience with Adaptive Delivery)	The goal of this research project is to develop a highly personalized, media-based literacy intervention system that targets the instructional needs of individual students. Each student's DIBELS scores are used to develop an individualized intervention for that student, drawing on classic video footage from Sesame Workshop's award-winning series *The Electric Company* and newly-created interactive games based on that footage. The effectiveness of this prototype system will be evaluated in a large-scale study in four U.S. cities in spring 2009. **Collaborators** Sesame Workshop, Wireless Generation, Jersey Cow Software, and Atimi Software. This project is funded under the U.S. Department of Education's Ready to Learn initiative through the Corporation for Public Broadcasting and PBS. Principal Investigator is Dr. Glenda Revelle, Sesame Workshop.
JUMP into Reading for Meaning	JUMP focuses on the development, delivery, and evaluation of a supplemental vocabulary instructional game for the Nintendo DS Lite. The curriculum targets low-performing fourth-grade students enrolled in supplemental educational services programs. The JUMP game is a hybrid vocabulary instructional program and role-playing adventure game designed to teach and assess word-learning strategies and to increase the student's vocabulary through an innovative mix of teaching methods, storytelling, and game play. The game involves exploring 10 diverse environments, overcoming robot challenges, completing engaging quests, and solving thought-provoking puzzles. **Collaborators** A collaboration between Hawaii's State Department of Education, Berkeley Policy Associates, Aloha Island, Inc., and Stanford University. Primary contact is Javier Elizondo. Funded by a Star Schools grant from the U.S. Department of Education. (www.prel.org/programs/care/jump.aspx)

Project	Description
Million Motivation Campaign	A pilot program launched in seven New York middle schools, serving approximately 2,500 students, designed to help students internalize connections between education and success. Participating students received a free cell phone, with opportunities to earn minutes and other rewards by achieving academic goals established by school principals. The phones were also used as a platform to communicate directly with students by teachers and administrators and to "rebrand" achievement through a messaging campaign and mentoring program. The project was recently discontinued due to insufficient funding. **Collaborators** New York City Department of Education, in conjunction with Harvard Economist and Chief Equality Officer for the NY Department of Education, Dr. Roland Fryer. (www.nytimes .com/2008/ 09/25/education/25educ.html?ref =nyregion)
Mobile International Children's Digital Library	The International Children's Digital Library (ICDL), the world's largest collection of children's literature available freely on the Internet, recently announced the release of the ICDL for iPhone application. Available free-of-charge on Apple's iPhone App Store, the ICDL for iPhone application allows users to take advantage of the advanced capabilities of the iPhone and iPod touch user interface to read a selection of books from the ICDL's master collection, which today represents thousands of children's stories from 60 countries. The children's books can be read in their native language and in English. **Collaborators** Tim Browne, Allison Druin, Benjamin B. Bederson, and Ann Carlson Weeks (www.childrenslibrary.org)
Mobile Learning Institute	Mobile Learning Institute delivers engaging, personalized, project-based learning right to classrooms and community centers across the U.S. By sharing mobile and digital technologies students use everyday outside the classroom, the Mobile Learning Institute helps teachers and students develop important 21st-century skills while creating presentations that add their own personal voice and perspective to their academic curriculum. **Collaborators** Pearson Foundation and Nokia (www.mobilelearninginstitute.org)
Mobile Media: Ubiquitous Learning for Global Citizenship	This recently started research project seeks to document, understand, and theorize new learning practices around mobile media by: connecting and organizing cutting-edge work on mobile media and learning via an online hub that will connect practitioners, educators, and youth; developing case studies of learning with mobile media occurring inside and outside of formal learning environments, with an emphasis on how students learn with mobile media across home, school, and community settings; conducting design-based research on prototype curricular materials with partnering educators; and proactively sharing and documenting findings through an online repository for research findings. These four activities will help to build a broad research agenda for the field, exploring how mobile media is expanding the ways that people learn. **Collaborators** Managed and run by the ADL Academic Co-Lab working together with MIT and one or two international partners. Principal Investigator is Kurt Squire. Funded by the John D. and Catherine T. MacArthur Foundation.

Project	Description
PBS KIDS Ready to Learn Cell Phone Study: Learning Letters with Elmo	The goal of this study was to develop a mobile-phone-based intervention that would encourage parents to engage their children in daily literacy-learning activities. The intervention content included text messages for parents, audio messages for parents and children, and *Sesame Street* letter videos for children. Messaging to parents suggested real-world activities that they could use to engage their children in learning letters. Pre- and post-interviews indicated a significant increase in the frequency with which parents reported engaging their children in literacy activities after participating in this study. In addition, 75% of lower-income participants and 50% of middle-income participants reported that they believed watching the *Sesame Street* letter videos helped their children learn letters. More than 75% of participants reported believing that a mobile phone used in this way can be an effective learning tool, since mobile-phone delivery made it extremely easy to incorporate literacy activities into their daily routines. **Collaborators** Funded by U.S. Department of Education, through PBS Ready to Learn supplemental funds. (pbskids.org/read/research/cellphone.html)
Panwapa World for the iPhone	Sesame Workshop recently launched a worldwide initiative called *Panwapa World*, designed to foster global citizenship in children ages 4-7. A *Panwapa World* mobile application was prototyped on the iPhone to conduct user experience and usability research with children, and to explore children's interest in and understanding of location-based mobile social media. Users were immediately able to see themselves on the "Panwapa Map" mapped to the GPS grid, and explored it using the swoop interaction to spin and the pinch interaction to zoom, and were able to embed their own photos of cultural items from their local environment (currently homes, food, signs, animals, trees, flowers) or browse the photos that other users around the world had embedded. Researchers worked one-on-one with 21 children, ages 4-7, and found overall that *Panwapa World* Mobile had high usability and appeal for children in that age range. **Collaborators** Led by Dr. Glenda Revelle at Sesame Workshop.
PDA Participatory Simulations	Casual multiplayer games that involve player-to-player interaction on Palm OS or Windows Mobile handheld computers. The immersive simulations include science, math, and some social science–based games that are played as a whole class. Interactions between players in the game are mediated by peer-to-peer beaming. This idea is currently being re-envisioned as "ubiquitous games" that can be casually played on a variety of devices over long periods of time. **Collaborators** MIT's Teacher Education Program. Led by Eric Klopfer. (education.mit.edu/pda and education.mit.edu/myworld)
Project K-Nect	Project K-Nect is a pilot education program that uses smartphones with advanced mobile broadband technologies to deliver educational material to ninth-grade students in North Carolina, with the hopes of improving math proficiency levels in the state. **Collaborators** North Carolina Department of Public Instruction, Digital Millennial Consulting, Qualcomm, Drexel University, Choice Solutions, SOTI, Florida State University, Psymes Consulting. Project director is Shawn Gross. Contributing sponsors include the Wireless Foundation, the Futures Channel, BrainPop, and Motricity. (www.projectknect.org)

Project	Description
***Sesame Street* podcast**	*Sesame Street* Podcast is a series of free portable video episodes featuring various *Sesame Street* Muppets. The use of podcasting facilitates anywhere, anytime learning, since users may subscribe to a feed and choose when and where they want to watch or listen to a program. Once subscribed, the audio or video files can be played on a variety of mobile devices such as an MP3 player, smartphone, or video-enabled portable media player, thereby easily turning any moment into a learning moment for a child. **Collaborator** Sesame Workshop (www.sesamestreet.org/podcasts/)
Super Sleuths: Supporting Science Instruction with the Nintendo DS	This research project examines how game-based activities can aid science and literacy instruction, through the development and pilot-testing of a series of game modules — built around the Nintendo DS — that infuse inquiry-based game activities into traditional classroom practice. **Collaborators** Center for Children and Technology and Center for Science Education (both part of the Education Development Center, Inc.) and Electric Funstuff. Funded by the U.S. Department of Education. Principal Investigator is Cornelia Brunner. (supersleuths.edc.org)
TechPALS (Technology-Mediated Peer-Assisted Learning)	TechPALS aims to improve fourth-grade students' mastery of rational numbers by integrating research-based strategies of peer-assisted learning and feedback through the use of handheld computers (HP iPAQ Pocket PCs). **Collaborators** Originally developed by Professor Miguel Nussbaum of the Universidad Catolica of Santiago, Chile. Adapted by SRI under Principal Investigator is Jeremy Roschelle. Funded by the U.S. Department of Education's Institute for Educational Sciences. (www.sri.com/news/releases/061108.html)

appendix b: mobile learning examples and research projects (non-u.s.)

Project	Description
DfES/Becta PDA Project U.K.	This project was developed through Becta and the Department for Education and Skills to examine the use of PDAs in schools. The aim was to evaluate initial issues in the use of PDA-type devices in schools both for managing workload and for supporting teaching and learning. Participating schools were equipped with a variety of technological equipment, and then teachers were trained to use the material. The ultimate focus of the project was to analyze the potential of PDAs to manage teachers' workloads and support teaching and learning. A summary of the results can be found at: publications.becta.org.uk/display.cfm?resID=25833&page=1835. **Collaborators** Becta ICT Research Group and the Department for Education and Skills. Led by David Perry. (www.becta.org.uk/technology/infosheets/index.html)
Game Based Learning Scotland	This randomized study involves 600 students and 32 schools using Dr. Kawashima's Brain Training (aka BrainAge), a Nintendo DS game meant to boost math ability. In a small-scale pilot study with three classes of 11- and 12-year-olds, children who used the game showed positive results compared to a control. **Collaborators** Learning and Teaching Scotland, led by Derek Robertson. (http://www.ltscotland.org.uk)
Learning2Go U.K.	The Learning2Go initiative is currently the largest collaborative mobile learning project for pupils in the U.K. The initiative, coordinated by the e-Services team of Wolverhampton City Council, shows how successfully mobile learning can be used to give students access to "anywhere, anytime learning." Learning2Go uses mobile handheld computers to engage learners by delivering multimedia content, Internet, and authoring tools to the palm of a young student's hand. Schools are given mobile devices to disseminate to their students; teacher and student training are provided. Additionally, the Wolverhampton local authority works with lead hardware and software manufacturers and also lead academics and government agencies that seek to research the impact and development of mobile learning. **Collaborators** Wolverhampton Local Authority. Led by David Whyley, Jill Purcell, and Andi Bourne. (www.learning2go.org/)

Project	Description
Making Playful Learning Visible U.K.	The Making Playful Learning Visible project aims to help parents in Britain see the many ways in which their children learn. The purpose of the project was to develop a robust methodology to inform and guide parents and caregivers in observing their children's learning and to create a searchable database of video observations to be used as the basis of research worldwide. Both of these aims were successfully met during the project. While video cameras and video-enabled mobile phones were used by parents to record observations, the focus was not on using one type of technology for documentation, but on determining what forms of technology enabled parents to make observations. **Collaborators** The Next Generation Foundation. Led by Siobhan Thomas and James Bradburne. (www.ngf.org.uk/)
MOBIlearn Worldwide	MOBIlearn is a worldwide, European-led research and development project exploring context-sensitive approaches to informal, problem-based, and workplace learning by using key advances in mobile technologies. It explores new ways to use mobile environments to meet the needs of learners, working by themselves and with others. An ultimate goal of the project is the development of a new m-learning architecture that will support creation, brokerage, delivery, and tracking of learning and information contents, using ambient intelligence, location-dependence, personalization, multimedia, instant messaging (text, video), and distributed databases. **Collaborators** The MOBILearn Consortium. Led by Giorgio Da Bormida and Giancarlo Bo. (www.mobilearn.org/)
MOBI Project South Africa	This project was conducted by the University of Pretoria in various South African secondary schools. It uses an educational software package which offers students mobile math learning. MOBI math provides learners with various options to access its content and allows the learner to conduct a multiple-choice assessment to determine proficiency in the subject and establish their stage in the national curriculum. Once the learner has been assessed, the MOBI application can automatically lead her to areas of mathematics where they are weakest — or run them through the whole curriculum for review. Tutorials take the form of streamed videos and examples aimed at precisely explaining different math concepts and tutorials for math skills development. **Collaborators** IT School Innovation Company, Department of Informatics at the University of Pretoria. (www.mymobi.co.za/mobi_signin.php)

Project	Description
MyArtSpace U.K.	MyArtSpace is a combined mobile phone and web-based service to support learning between schools and museums in the U.K. On arriving to a museum, children are loaned mobile phones running the MyArtSpace software. They can view multimedia presentations of museum exhibits, take photos, make voice recordings, write notes, and see who else has viewed the exhibit. After each action, the content is automatically transmitted to a website, which stores a personal record of their visit. Back in the classroom, they can review their visit and the media they have collected, share material with other children, and create presentations. MyArtSpace has been deployed in three museums for a yearlong trial during which more than 3,000 school students used the service on organized visits. Studies have shown that MyArtSpace had a positive impact on school museum visits and identified areas for improvement in the technical and educational aspects of the service. **Collaborators** MyArtSpace was designed and developed by TheSEA and funded by Culture Online, part of the U.K. Department of Culture, Media, and Sports. The service is now a commercial service, branded as OOKL. (www.ookl.org.uk)
Seamless Learning in Third Graders Singapore	This is a research project that involves giving handheld devices to third-grade students to see how they would use handheld devices outside the classroom. Their use of handhelds will be closely observed, to better understand the notion of seamless learning, where learning is continuous and on the move. The mobile device represents a possible bridge between what students do in school (formal learning) and what they do outside of school (informal learning). **Collaborators** Learning Sciences Laboratory, National Institute of Education, Nanyang Technological University, Singapore; Principal Investigator is Chee-Kit Looi.
School Empowerment Program Kenya	The School Empowerment Program uses bulk SMS text messaging as in-service training for primary-school teachers and local support cadres across rural and urban areas, linking into other media used in their courses. The program takes advantage of the fact that mobile phone ownership and coverage is high across the country, so that the maximum amount of people can have access to much-needed pedagogical materials. One aspect of the SEP is a distance-learning course designed to develop the capacity of the whole school by training head teachers and key resource teachers to deal with the challenges of free primary education in Kenya. The materials include print-based resources supported by multimedia features. **Collaborators** Department for International Development, Imfundo, and the Kenyan Ministry of Education, Science, and Technology. (www.dfid.gov.uk/research/imfundo-kenya.asp)

Project	Description
The MILLEE Project India	The MILLEE research project from UC Berkeley aims to foster literacy among children of school-going age in developing parts of India. More specifically, the study aims to complement the formal schooling system by applying mobile learning technology to augment educational opportunities in out-of-school settings. Since English is widely seen as a key to socioeconomic success in India, fluency in English can almost be equated with membership in the middle and upper classes. The MILLEE project addresses this issue by developing interactive English-language games specifically for mobile phones. Initial results indicate that ESL learning games on cell phones is feasible for developing regions and merits further study. **Collaborators** UC Berkely Computer Science Department, National Science Foundation, and John D. and Catherine T. MacArthur Foundation. Led by Matthew Kam and Divya Ramachandran. (www.cs.berkeley.edu/~mattkam/millee/index.html)
The Mobile-Based Interactive Learning Environment (MOBILE) Project Taiwan	The MOBILE project examined how the use of mobile devices could aid elementary school Chinese children in learning English. Consisting of a mobile learning server and mobile learning tools, the MOBILE environment supported in- or outdoor learning activities, such as field trips and library visits. Experimental results obtained from post-tests and questionnaires indicated that the MOBILE project may significantly increase students' interest in learning English. **Collaborators** National Taipei University of Technology, Computer Science Department. Led by Tan-Hsu Tan and Tsung-Yu Liu.
Three Rs Singapore	This project is investigating the use of handheld computers to facilitate students' inquiry-based learning of environmental issues. Using handheld computers during field trips, 480 primary students examined how wastes are produced and what impact the "Three Rs" (Reduce, Reuse, and Recycle) can have on protecting the environment. The handheld computers were used to support, guide, and extend the student thinking process within and out of classroom. Research data were collected from two classes of students (n=79). Pre- and post-tests measured awareness and knowledge of the Three Rs; pre- and post-surveys explored attitudes and perceptions of the role of the handheld computers in learning. The resulting data indicated that the use of handhelds improved students' understanding of the Three Rs. **Collaborators** Learning Sciences Laboratory, National Institute of Education, Singapore; Principal Investigator is Chee-Kit Looi.

list of interviewees

For the purposes of this report, we interviewed experts who are directly involved in the research, design, development, or implementation of educational mobile technologies for children. We would like to thank the following interviewees for taking the time to share their experiences with mobile learning, as well as their hopes and concerns for its future.

- Richard Beckwith, Research Psychologist, People and Practices Research Group, Intel
- Cornelia Brunner, Deputy Director, Center for Children & Technology
- Warren Buckleitner, Founder and Editor, *Children's Technology Review*
- Linda Burch, Chief Program and Strategy Officer, Common Sense Media
- Jan Chipchase, Principal Researcher, Nokia Research Center
- Katherine McMillan Culp, Senior Research Scientist, Center for Children & Technology
- Sébastien Doré, Line Producer, Games for Everyone, Ubisoft
- Allison Druin, Director, Human-Computer Interaction Lab; Associate Professor, College of Information Studies and Institute for Advanced Computer Studies, University of Maryland
- Jim Gray, Director of Learning, LeapFrog
- Shawn Gross, Project Director, Project K-Nect
- Mimi Ito, Research Scientist, University of California, Irvine
- Eric Klopfer, Associate Professor and Director, MIT Scheller Teacher Education Program
- Liz Kolb, Adjunct Assistant Professor, Madonna University
- Okhwa Lee, Professor, Chungbuk National University (South Korea)
- Chee-Kit Looi, Associate Professor, National Institute of Education, Nanyang Technological University (Singapore); Head, Centre of Excellence in Learning Innovation
- Mark Nieker, President and Executive Director, Pearson Foundation
- Roy D. Pea, Professor, Stanford University; Co-Director, Stanford Center for Innovations in Learning
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About the author:
Carly Shuler is a researcher, developer, and author in the children's media and toy industry. Currently, she is a Fellow focused on industry initiatives and research at the Joan Ganz Cooney Center at Sesame Workshop. Throughout her career, Carly has worked with a host of children's media and entertainment groups, including Sesame Workshop, Spin Master Toys, the Michael Cohen Group, and WGBH. She holds a master's degree in Technology, Innovation, and Education from the Harvard Graduate School of Education, where she studied how media and technology can be used to educate children effectively. Carly is passionate about the magic that happens when fun, research, and education converge, and is dedicated to working on quality children's products that inspire thought and creativity. Carly can be contacted at carly.shuler@sesameworkshop.org.

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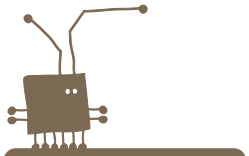

the Joan Ganz Cooney Center
at Sesame Workshop

One Lincoln Plaza
New York, NY 10023
p: (212) 595-3456 f: (212) 875-7308
cooney.center@sesameworkshop.org
www.joanganzcooneycenter.org

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