MOBILE LEARNING IN LOW-RESOURCE COUNTRIES

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Abstract

Twenty years ago, the newly released always-connected Blackberry and the lightweight iBook launched a "wi-fi revolution" that promised to deliver—at last—cable-free internet access across the globe.[1] Educators and international development professionals were captivated by the prospect of mobile devices helping hundreds of millions of children in low-resource countries to gain access to basic literacy skills. Innumerable initiatives followed, all greeted with great fanfare. After decades of investment and hype, where do we stand? What have we learned? What has worked? What hasn't? Why? Many studies of technology interventions in schools have shown pockets of success and clear signs of *potential*, but few studies are definitive, large, or rigorous enough to show which, if any, technology interventions are transferrable, effective at improving learning, and appropriate for scale. This paper summarizes knowledge to date, reviews trends, identifies gaps, and suggests priorities for the coming decade.

Introduction

Reading is the foundation of education. Still, literacy eludes too many. Two hundred fifty million children globally lack the basic literacy skills they need to build a healthy, economically secure life.[2] Numerous studies have shown that literate mothers take better care of their own health and their children's, and enroll their children in school and make positive decisions for their health, yet 60 percent of women worldwide are illiterate, a rate that has not changed in decades.

In low-resource countries, up to one-fifth of primary school students don't have a textbook or even shared access to one.[3] For more than 30 years, textbook donation programs such as those run by the International Book Bank, Books for Africa, and Books for Asia have sought to address this need across Asia and sub-Saharan Africa.[4] Providing just one textbook to every student in sub-Saharan Africa would increase literacy scores by 5-20 percent, according to UNESCO.[5] With the development of smartphones and tablets, organizations and governments have directed their attention toward digital materials. Portable, continually decreasing in cost, ever more available, and content-rich—mobile devices are bound to infiltrate every aspect of education. From software pilots to countrywide laptop distributions, the past 20 years have seen thousands of initiatives, largely targeting young and middle-grade levels, all greeted with great fanfare and high expectations.

After all the investment and hype, where do we stand? What have we learned? What has worked? What hasn't? Why?

On the whole, the research on use of mobile technology for education is inconclusive. Hundreds, maybe thousands, of studies of technology interventions in schools have shown pockets of success and clear signs of *potential*, but few studies are definitive, large, or rigorous enough to show which, if any, technology interventions are transferrable, effective at improving learning, and appropriate for scale.

Methods and measures typically are ill-defined, and evaluations are thin. The terminology—e-learning, m-learning, edtech, computer-assisted instruction, online learning, learning software, and more—is used differently and sometimes interchangeably. Some findings are compromised because comparison schools are often lower quality to begin with and are staffed by less-motivated teachers.[6] The

prospect—even inevitability—of classrooms becoming mobile-dependent mandates a better understanding of what impact mobile devices are having on learning. This paper summarizes knowledge to date, provides examples that illustrate trends, identifies gaps, and suggests future directions for investment.

From Books to Digital: By the Numbers

Delivery of education via mobile devices builds on the experiences and results of textbook donation programs, which have been popular for more than 30 years. Together, the major donors have delivered tens of millions of books. Studies have shown positive correlations between achievement test scores and the possession of textbooks.[7] Even as many move toward mobile devices, book-based initiatives will continue to be important, since internet access is available to only 54 percent of the world's population (with notable geographic disparities).[8] In Africa, only 35 percent of the population uses the internet. In 11 African countries, use is less than 10 percent.[9] While 72 percent of the U.S. population owns smartphones, ownership is dramatically lower in low-resource countries: 4 percent in Ethiopia and Uganda; Pakistan, 11 percent; India, 17 percent; Kenya, 26 percent; and Brazil, 41 percent.[10] Experts predict that 6 billion people will be cell phone subscribers by the end of 2025, with about half of them internet-connected.[11] By 2018, experts predicted that nearly 1.3 billion people worldwide would be using tablets.[12]

Bird's Eye View: Five Notable Trends

Programs have been tool-driven, not learning-driven. For nearly 20 years, millions of computers, laptops, and tablets have been delivered to schools in something of a vacuum.[13] In their enthusiasm for doing good, educators, international development agencies, and donors frequently have neglected to address the complexities of the school setting when introducing new elements or programs. Few if any education reforms—technological or not—can succeed without consideration of student learning needs and styles, teacher capacity, school culture and climate, and administrative practices. Nevertheless, too many programs have bypassed the essential steps of helping teachers understand how to maximize use of mobile devices, teaching students about their capabilities, adapting materials to the local context, and engaging families and communities.

Some reports show that technology can be a benefit, but not in and of itself. A 2016 review of 216 programs reaching 16 million children across 52 low- and middle-income countries noted that technology hardware "may be necessary but not always sufficient for improving learning outcomes."[14]

A 2015 review by the Commonwealth of Learning, a Vancouver-based NGO, analyzed 11 large-scale government-sponsored tablet initiatives. Its conclusion: The majority of these initiatives have been driven by the tablet hype rather than by educational frameworks or research-based evidence.[15]

An earlier (2012) landscape review noted that little of the writing on the topic discusses impact: "Much of the documentation from the developing world is from implementation reports, conference sites, and blogs and is descriptive and promotional, rather than analytic and evaluative; or, they are reports of university-led pilot projects that focus on implementation considerations, feasibility, and attitudes toward m-learning, but not learning outcomes."[16]

The lessons of the highly hyped, expensive "One Laptop per Child" (OLPC) initiative from 2005 still resonate. Its delivery of 2 million laptops to 36 low-resource countries at a cost of almost half a billion dollars produced no discernible learning impact.[17] As Great Britain's Department for International Development (DFID) report notes, "If new technologies are introduced without changing any of the other aspects, *nothing different is happening*."[18] OLPC left lingering distaste around the world, with some perceiving the effort as "inappropriate technological colonialism" that ignored local stakeholders.[19] Still, similar large-scale efforts continue to be launched. For example, the Kenyan government has spent almost $300 million to provide a tablet to every public school student. Roundly criticized, the program is suffering from many of the weaknesses of OLPC and similar initiatives: inadequate teacher training, lackluster content, and chronic repair problems.[20]

While UNESCO reports that mobile phone use alone cannot advance literacy and learning, many experts believe that first the basic premise must change—from simply providing *tools* to identifying *learners' needs* and then deciding which strategies should be enlisted. As Michael Trucano, a World Bank blogger who has followed mobile learning for decades, puts it, "All too often, the . . . question being asked is not *'what challenges are we trying to solve, and what approaches and tools might best help us solve them?*', but rather, *'we know what our technology "solution" is, can you please help us direct it at the right problems?*'"[21]

Technology author Kentaro Toyama makes a similarly pointed observation: "If a private company is failing to make a profit, no one expects that new laptops will turn things around. Yet, that is exactly the logic of so many attempts to fix education with technology."[22]

Infrastructure is inadequate. Governments, mobile manufacturers, and utility corporations continually make improvements in hardware, software, and the power infrastructure, but basic issues of electricity supply, connectivity, battery life, charging, and usability remain significant obstacles. About 1.2 billion people globally are without reliable electricity. More than 95 percent of those living without electricity are in sub-Saharan Africa and developing Asia, where education needs are the most acute, according to the International Energy Agency. Less than 10 percent of the population of Burundi, Chad, Liberia, Malawi, and South Sudan has electricity.[23]

Continued use of mobiles in school is assured. Even with partial, lukewarm, or inconclusive research results, enthusiasm for technology as a tool to improve education only grows. The potential is undeniable. Mobile devices have innate characteristics that seem to make them ideal learning tools. For math, devices offer computational sophistication; for literacy, devices offer access to libraries of content, updateability, and capacity to integrate local content. When the devices are present, they seem to jumpstart a more interactive classroom dynamic, with small groups using the same device and producing more student-to-student and student-to-teacher interactions.

The International Federation of Library Associations and Institutions vouches for the "motivational influence" of technology-delivered content and encourages educators to see it as a positive in promoting reading.[24]

Signs abound that young people are hungry for education and see mobiles as a desirable entry point. A multi-country study from Uganda, Morocco, Ghana, and Maharashtra in India reveals that only family and health are considered more important than education. And 63 percent of the young people surveyed believe they could learn using even the most basic of mobile devices. Fifty—two percent of

youth in India said that they could envision learning via their phones. Interestingly, 69 percent of Indian youth said the reason they do not have a phone is “no need,” though just 10 percent of Moroccans felt the same. For many, mobile learning is understood to be a way to get a new or better job (56 percent in Ghana and Uganda), learn a language (50 percent in India), and to read material or books (19 percent overall). [25]

But still, opposition persists. Many parents, teachers, and some students tend to view mobile technology as out of place in education and potentially harmful to students, or at best a distraction.[26] This is especially true in the Middle East and Africa, and particularly regarding girls. In Uganda, UNESCO reports that family disapproval is the reason more than a quarter (28 percent) of youth give for not owning a phone (27 percent in Morocco and 25 percent in India). Researchers studying mobile phone use in Ghana, Malawi, and South Africa in 2015 pointed out the downsides of mobiles in education. “Negative impacts included academic performance affected by disrupted classes, due not only to pupil practice, but also to teachers’ calls; disruptions in adolescent sleep patterns associated with cheap night calls; time lost through prolonged sessions on social network sites; harassment and bullying; and increasingly widespread access to pornography.”[27]

Devices are catalysts for reading. In 2014 Nokia, UNESCO, and Worldreader joined forces to survey 4,000 mobile phone users in Ethiopia, India, Kenya, Nigeria, Pakistan, and Zimbabwe about the use of their devices for reading. They found that people read more when they read on mobile devices, and that young people like reading books on mobiles, both those with negative and positive pre-existing attitudes toward reading. With the low cost and portability of mobile devices, adults report increased reading of books and stories to children from their devices.

Noting that “deriving meaning from text is a deeply complex act that does not happen through exposure alone,” UNESCO observes, “It is a skill that needs to be taught and practiced, again and again and again. It is UNESCO’s hope that mobile reading will be integrated into broader educational systems that teach people how to use text productively—from access to comprehension, and all the stages in between.”[28]

Worldreader, founded in 2010 to use technology to deliver books and other content, works with a variety of governments, nonprofits, local agencies, and corporations, notably Amazon, the Kindle creator. Worldreader has distributed about 25,000 preloaded Kindles to 160,000 people in 12 sub-Saharan African countries. "It really is the best way to get books into people's hands where the physical infrastructure isn't very good, the roads are bad, gas costs too much,” says David Risher, founder of Worldreader. “But you can beam books through the cellphone network just like you can make a phone call—and that's really the thing that changes kids' lives."[29]

Worldreader’s efforts, using e-readers containing culturally and age appropriate reading materials in local language and English, are showing some impact on learning. In its first test at six schools in Ghana starting in 2010, the organization found that grade 2 students who used Kindles (at a cost of 50 cents each) increased their performance on standardized reading tests from about 13 percent to 16 percent.[30] In a follow-on program, Worldreader conducted a randomized evaluation that showed students in the e-reader program more than doubled their comprehension score and improved in oral reading.

Africa Storybook, a nonprofit that provides open-license, age appropriate, local-language picture books to the youngest students, has begun experimenting with projecting books on screens and with mobile delivery. It has already succeeded in delivering volume and scope—more than 1,000 storybooks with

content in both English and 173 local languages. Books are available via a tablet or website and can be printed. According to implementing agency Saide, the pilot program has collaborated with 30 partner organizations to implement in schools and libraries; integrate teacher education; and use websites, story donation, and story republishing.[31]

Mobile devices can be essential tools amid political and social disruption. Most low-resource countries are reckoning with some combination of political insecurity, economic instability, natural disaster, poverty, or war. The average length of time a refugee is displaced is 20 years, making education loss a significant concern. In addition to being lifelines for displaced people facing emergencies, mobiles have the potential to deliver educational resources. The UN estimates that 93 percent of refugees are covered by 2G and 3G networks, and that 39 percent of refugee households own at least one phone with internet capability.[32] Of the 56 million refugees in low-resource countries, more than half are children, who are increasingly using mobiles for information sharing, education, and training. Currently, little research exists on use of mobile technology for education in refugee communities, but numerous examples indicate that text messaging, blended learning, and teacher training programs are gaining some traction.

A Closer Look at the Research: What Does(n't) It Tell Us?

Research about the benefits and challenges of using mobile devices to bolster basic skills is voluminous, but limited in value, producing a mosaic of results with myriad qualifiers. As the Mobiles for Education Alliance (a consortium of USAID, World Bank, Inter-American Development Bank, UNICEF, and 15 others) reported in 2015, "a paucity of rigorous evaluations forces funding organizations and the public to rely on a general sense that technology may enhance learning, rather than solid evidence, when making decisions."[33] What passes as "research" is often embellished common sense rather than data-informed evidence.

A major shortcoming in the research is failure to identify exactly what factors the technological intervention was meant to address, in what way, and how its contribution could be precisely assessed. A 2015 study that identified 11 countries with large-scale national tablet initiatives noted that "none of the identified initiatives was supported by a rationale or evidence for why tablets in general would help achieve the articulated objectives, let alone be supported by the reasons for selecting a particular brand or type of tablet."[34]

In many studies, little distinction is made between what literacy experts call "learning to read" and "reading to learn." A major transition from the former to the latter ideally comes by grade 4. Thus, if the reading materials and teacher support are designed for young children, we can assume that these are "learning to read" efforts and support decoding through letter recognition, linguistic awareness, vocabulary development, and basic comprehension. If, however, the materials are to build content knowledge in science, social studies, or literature or to support workforce development, we can assume that these are "reading to learn" efforts. Further, distinctions must be made between delivering *content* via technology and delivering *learning*.

We know little about the comparable utility of the various devices (e.g., smartphones, tablets, laptops), as reports rarely distinguish between materials accessed from a cell phone, a community computer, or efforts tied to the school.

Signs of success. Taking the broadest view, we know that mobile devices show the greatest signs of success when schools have the following:

- Some infrastructure, both physical and logistical
- Relevant, language-appropriate content at the right knowledge level
- Teachers skilled in use of these tools in the classroom
- Use of interactive learning/teaching/child-centered methods
- Customization for each student

A handful of programs showcase some of those key levers for success.

Eneza Education, based in Kenya and operating also in Ghana, distributes content to more than 4 million subscribers via text message. Local teams develop local-language lessons that are based on the national curriculum, and users have access to an ask-a-teacher service. Eneza also vets and trains the teachers.[35] The founder reports that test scores improve as much as 20 percent within nine months when the service is used for just two hours per week. [36]

Mindspark, a computer-assisted math and Hindi learning program in India, offers customized learning (i.e., lessons adapted for each student based on achievement status and updated according to patterns of error). A 2017 evaluation showed that, combined with teacher-supported group instruction, Mindspark produced significant improvement for scores in math and Hindi. The results were strong for both boys and girls, with the most gains among the weakest students. While cautioning that the program was small-scale (619 middle-grade students), short-term (90 days), and deployed in an after-school setting, the researchers see potential. "Our results suggest that well-designed, technology-aided instructional programs can sharply improve productivity in delivering education," the researchers write. In addition, they highlight Mindspark's ability to engage students who are significantly far behind.[37]

Uruguay has used its OLPC laptops to improve learning. With primary students' (grades 4–6) laptops connected to the internet, schools offered video-based English-language lessons for both teachers and students. They added teacher training, inclusion with community members and agencies, and a monitoring and evaluation plan. The program produced a 72 percent gain in achievement test scores. The British Council, a primary sponsor, and others suggest that remote lessons have identical outcomes to face-to-face learning and that the methodology shows promise for other subjects.[38],[39]

Another powerful sign of the potential of technology in education is the eagerness of major corporations to invest. Google reports that over the last five years, it has committed more than $160 million toward using technology to improve education in underserved communities.[40]

Two notable innovations supported by Google warrant a closer look. Targeted toward older children who already can read, the Rumie educational tablet is essentially a "library on a chip" that is delivered in-country by NGOs. The device is low-cost, lightweight, updatable, trackable, and does not depend on an internet connection. Curated content can be adapted to age and learning level, tailored to local context, and continually updated. A seven-country evaluation in 2016 shows that students who used the tablets had improved math and reading abilities, and teachers experienced increased efficiency and ability.[41] Based on those successes, Rumi has plans to install its software on smartphones.[42]

Since 2013 Google has been funding Pratham Books to encourage reading. Through the Storyweaver initiative, which began in 2015, students have access to an open-source platform where they can share

and translate books. Launched in India, it now offers books in 104 languages. The platform integrates Google Translate and transliteration tools, which Google volunteers continually improve. The goal is to provide 200,000 titles for 500,000 users.

Some studies effectively demonstrate the potential of digital technology but are limited in scope. For example, Education Development Center, Inc., a global NGO, launched "Time to Learn" in Zambia, a suite of technology-enhanced training, coaching, and assessment tools for primary teachers to improve reading instruction. It produced significant increases in reading ability among both boys and girls, with strongest results in the areas where teachers were applying the tools and practices from their training. It also connected communities with services to counter the impact of poverty and HIV/AIDS on children's learning.[43]

A cautionary tale comes from the tablet-focused, private Bridge International Academies. Bridge, which engaged 470 schools in five low-resource countries, was launched with funds from Mark Zuckerberg and Bill Gates, among others. Bridge schools provide teachers with tablets to guide them through scripted lessons and track their own and their students' progress, adapting instruction accordingly. A 2017 interim study covering a four-month period shows that Bridge K-2 students in Liberia are performing better across all literacy and numeracy metrics, reading faster and better, and solving basic math problems more quickly. The successes also are attributed to longer school days, teacher training and monitoring, standards aligned with learning, and the technology-enabled teacher program, as well as significantly higher expenditures per child. Unfortunately, those positive findings have been dramatically overshadowed by the findings of a 2017 independent study that asserts that Bridge's work in 23 schools in Liberia was marred by unethical practices and policies, including manipulation of evaluation results by reducing class size, unwarranted teacher dismissals, and inequitable contributions of supplemental funding.[44],[45]

Devices alone cannot guarantee progress. The inputs to a child's education are myriad and part of a complex and dynamic context. To be successful, any reform must engage the whole system.[46]

Technology doesn't drive progress; it simply amplifies and responds to existing affordances. As Kentaro Toyama writes in *The Atlantic*, "Technology's primary effect is to amplify human forces, so in education, technologies amplify whatever pedagogical capacity is already there."[47]

A 2014 report on 83 studies, funded by DFID, concludes, "Edtech programmes should focus on enabling educational change, not delivering technology."[48] Findings from the 36-country OLPC delivery captured the same message. "The absence of effect could be explained by the fact that the program did not involve compulsory teacher training and that laptops in class were mainly used to search for information on the internet," note Uruguay researchers.[49]

Others note that first we need an improved understanding of how people learn, with *and* without technology.[50]

The use of radio in schools may be instructive. Decades ago, when educators brought "interactive radio instruction" (broadcast lessons enhanced by teacher inputs) into schools, the radio was understood to be the conveyor, not the focus, of the intervention. Programs were in local language. The focus was on

content and teacher training in interactive approaches. Radios were embedded in community life. These programs have consistently been shown to increase learning over time.[51]

The context can pave the way for success or failure. Research consistently indicates that mobile learning is most effective when embedded in ongoing technology-oriented activities, such as mixing sports information with educational information. This might mean embedding short informational sections during half-time breaks in a football game listened to on a mobile.[52] Notably, in the United States, interventions that are imbedded in a comprehensive, sequenced plan are more likely to succeed.[53] In the critically stressed climate of schools in low-resource countries, high staff turnover, low budgets, poor attendance, and absent or unreliable electricity seriously handicap mobile learning.

Teachers matter. Strong content and skilled teachers lead to improved learning, whether technology is in play or not. But teachers' circumstances and needs are too often neglected. Delivering mobile devices is only the first step. For [information and communications technology] to become a tool for improving teaching and learning . . . they need to be supplemented by teacher professional development," asserts DFID, the United Kingdom's international development agency. [54] A Michigan State University study further recommends that teacher training programs both use and teach with technologies, that teachers be supported by a pedagogical foundation for e-learning, and that schools provide ongoing support for teachers and ways for them to join a community of practice.[55]

Across the Philippines, the Text2Teach program combines improved pedagogy and instructional materials with a teacher training program. Supported by Nokia, Pearson, International Youth Foundation, UN Development Programme, and Globe Telecom, the program has shown significant impact in improving the achievement rate (up 30-50 percent) and decreasing the dropout rate (down about 98 percent). "Key to the success of the program has been extensive teacher training for the use of the mobile technology to effectively and efficiently integrate the tool into their classroom practice."[56]

As Thomas Arnett of the Christensen Institute, a health and education think tank, writes, "The most powerful innovations for education in the developing world will likely come from blended-learning models that expand the reach and augment the effectiveness of the teaching force."[57]

That said, Sugata Mitra's "hole in the wall" experiments (starting in 1999) in India's rural slums raise provocative questions about the fundamental role of the teacher. His experiment embedded computers in kiosks, invited children to figure out how they work, and then posed complex questions to be answered without any supervision. Children quickly mastered the devices, (which they had never seen before), discovered internet browsing, and answered all questions the experiment posed. (Interestingly, the experiment found that youngsters' successes emerged from interactive group work, not solo use.)[58] Mitra has gone on to experiment with "schools in the cloud," which gather a group of about 20 students together in a learning lab and provide Skype assistance from retired teachers.

Funding models work against long-term impact. The typical funding model for mobile technology in schools is sporadic, short-term, and externally sourced, which makes it nearly impossible to achieve sustained impact. As UNESCO notes, "The majority of mobile learning projects in AME [Africa and the Middle East] were initiated by individuals or organizations backed by private corporations or donor agencies. These supply-side initiatives generally follow a predictable trajectory: an initial injection of funds and resources enables the project to be launched in a pilot phase; partnerships are established with additional stakeholders; monitoring and evaluation is occasionally included; project reports are

produced, sometimes with recommendations for scaling up; promotional materials are distributed that suggest the pilot was successful; and after the pilot phase ends, resources are usually not available to sustain the project."[59] As the National Academy of Sciences notes, it often takes a while to get the "recipe" right, and the cook needs to taste the meal and tweak it.[60] This requires time, pilots, repeated iterations, and ongoing measurement—and the funding to do it.[61]

Additionally, many studies identify a "novelty" effect at play. "Some critics will warn that it is only the novelty of the technology that has an impact on motivation and time on task, and thus learning gains cannot be attributed to the software or instructional approach. In such a situation, the novelty effect can be expected to wear off quickly, leaving students and teachers in the same instructional situation they were in earlier."[62]

In early programs such as OLPC, teachers often saw themselves, rather than the pupils, as the primary laptop users. We've seen recently that interventions that "focused on touch screen tablet technology used directly by pupils" show more promising results, particularly in math, notes one research team

One India study in 2002-2004 showed that having computers in class produced improvements in math knowledge and performance, but results dropped off after the study.[63] Research from the United States similarly notes the frustration of irregular improvements. "Although overall effects seem to be positive, no single technology program produced consistent results."[64]

Content matters. Content, whether delivered via multimedia, print, lecture, radio, or other means, forms the heart of education. "Effective programs have clear curriculum focus, use of relevant curriculum materials, a focus on teacher development and pedagogy, and evaluation mechanisms that go beyond outputs," notes a DFID report.[65] Locally developed local-language content that is age appropriate and aligned with education goals is the gold standard. With their potential to be continually updated and refreshed, mobiles show great potential as we gain the ability to provide personalized content to meet students' specific needs.

National policies for integrating technology into education will improve outcomes. Policies that support the use of mobile learning have not yet become commonplace, and without them programs come and go without connecting to the larger education infrastructure or strategy. In its Education Strategy 2014–2021, UNESCO prioritizes this point, noting that, "in most countries, policy challenges with regard to teaching quality, learning outcomes, school dropout, gender equality, socio-economic inequality and transition from school to work are inadequately addressed."[66]

Policy improvements, however, are not quick fixes—they usually depend on an interlocked set of improvements.[67] In a five-country (Jordan, Namibia, Rwanda, Singapore, and Uruguay) analysis of what constitutes a successful national information, communications, and technology (ICT) policy, UNESCO identified the essential ingredients: alignment with national goals, alignment with other education goals, use of ICT as a lever for changing other components of the education system, incremental implementation over the long term, monitoring and evaluation components, professional development for teachers, financial support, and connection to the private sector.[68] For example, policies that eliminated school fees across Malawi produced enrollment surges, but no concurrent plan existed to hire more teachers, build more facilities, or provide next-level education, diminishing the impact of the fee change.[69] Similarly, national policies to decentralize education, like the ones Argentina imposed at

the secondary level, had varying results depending on the quality of management at the district level. In well-managed districts, decentralization improved education; in poorly managed districts, the opposite was true.[70]

Gender matters. Many researchers have unearthed differences between men's and women's access to and use of mobile devices. In its 2018 study *Connected Women,* GSMA, a mobile phone industry association, concludes, "unequal access to mobile technology threatens to exacerbate the inequalities women already experience." [71]

The GSMA study found that in 86 percent of all low- and middle-income countries, more men than women own mobiles; to be specific, 184 million fewer women than men own mobile phones. Even when women do own a mobile phone, they are generally less likely to use it to connect with the internet. A total of 327 million fewer women than men use mobile internet. The gender gap is wider in rural areas.

While male users of mobiles for reading greatly outnumber women, there are signs that once women start reading on their phones, they are more engaged, read more, and read to their children. [72] In fact, UNESCO's seven-country study found that as use of mobile devices increases, "the gender balance tilts to a female majority for the most active readers across countries. Among the top 2,000 active readers, over 59 per cent are female; among the top 1,000 active readers, 72 per cent are female; and among the top 100 active readers, 80 per cent are female."[73] In South Asia, 72 percent of women are without a mobile phone; in sub-Saharan Africa, 64 percent; and in East Asia and Pacific, 54 percent.[74] A seven-country study (Ethiopia, Ghana, India, Kenya, Nigeria, Pakistan, and Zimbabwe) of reading on mobiles showed that male readers outnumber females, largely a function of phone ownership. Looking more closely, when women do read on mobiles, they read significantly more than men—207 minutes a month versus 33 minutes.[75]

A "complex set of socio-economic and cultural factors" negatively affects women's ownership of phones, notes the GSMA. "Without targeted intervention from the mobile industry, policy makers and other stakeholders, the gender gap in ownership and usage is unlikely to close naturally on its own."[76] Noting that the industry stands to gain $170 billion in the next five years with increased female ownership, the association also notes that "substantial socio-economic benefits" to women, families, and communities would also accrue.

Affordability matters. Phones are still out of reach for many, with cost the major barrier to use in low-resource countries. Even where phones are donated, service fees are too much for many. As the GSMA noted in its 2018 study, "impediments to ownership vary significantly between regions and between countries within regions, highlighting the importance of understanding the local context when tackling the gender gap in mobile ownership."[77] After cost, the main barriers to mobile ownership generally are lack of literacy and difficulty using handsets.

Now What? Seven Priorities

No doubt the enthusiasm for mobile technology in low-resource countries will remain high. Drawing on what we've learned so far, seven areas warrant investments of time and money.

Increase private sector investment. Development aid for education has been declining over the past several years and may continue to do so.[78] Yet the desire and need persist. In addition to local government support and foreign aid, new investments are needed. The Brookings Institution calls upon

the private sector to step up in low-resource countries: "The private sector, [which has the] most to gain (or lose) from weak education systems compounded by demographic shifts, should engage more fully in solving this education crisis through a combination of funding and capability." Brookings further notes that "corporate giving to global health is 16 times what it is to global education."[79]

Private sector investment in education totals about $700 million a year, the equivalent of only 5 percent of all aid to education in developing countries, according to Education for All's *Global Education Monitoring Report*.[80] Further, those investments tend to be small, short-term, and uncoordinated.[81]

Conduct more sophisticated research. To improve education in low-resource countries, innovators and their supporters need a more sophisticated understanding of how people learn with and without technology, as well as knowledge about what has and has not been achieved already, to avoid repetition of mistakes or duplication of effort. Many experts and organizations are joining the movement to get serious about research. USAID and its partners in the Mobiles for Education Alliance issued a call in 2016 for increased funding for "research concerning the use of education technology in the developing world to support learning gains in schools," noting that "ministries of education are faced with a lack of evidence about which innovations actually yield education outcomes."[82]

Surrounding issues must be examined as well. "Research is needed that focuses not only on pupil learning outcomes, but also on critical aspects of implementation, such as teachers' use of and attitudes toward tablet technology and the embedding of tablet technology within the country's education system," according to the 2016 Mobiles for Education Alliance report.[83]

Continual analysis and sharing of best and most promising practices will advance our understanding of how/when technology is relevant for teaching and learning. Many observers bemoan the loss of intelligence when reports are not published, translated, or shared among interested professionals. We may accelerate progress if we explore the experiences of the higher-resource countries to develop a more sophisticated understanding of which if any of those lessons might apply to low-resource countries.[84]

Improve infrastructure. As many as 600 million people in sub-Saharan Africa lack access to energy—the lifeblood of economies, social progress, and improved health and education. As the professional association Africa Oil and Power says, "The issues surrounding Africa's electricity shortages are multifaceted and include decades of neglect in building up country-wide infrastructure, a lack of international investment, poor regulatory frameworks and the difficulty surrounding bankability of power projects."[85]

Significant progress has been made in broadening the availability of electricity and internet. Hundreds of millions have gained electricity in the last 20 years, especially in China and India, largely in urban areas. In Kenya, the electricity rate in 2012 was just 25 percent; today it stands at 73 percent. The major investments underway by electricity companies, donors, lenders, and governments must continue, such as the 2018 opening of Africa's largest windfarm at Lake Turkana and the 2016 operationalization of the world's largest solar plant in Morocco.

Develop more high-quality, diversified content. Mobile devices' versatility, storage capacity, and ease of updating make them ideal containers for content. Continued growth in locally developed, relevant content in local languages is a necessity. Interestingly, GSMA, the mobile operators' industry

association, calls upon its members to take the lead here. In a report on the importance of local content, GSMA notes, "For emerging markets in particular, mobile operators are well placed to effect change given their network assets, local presence and increasing involvement with entrepreneurial hubs, and trusted relationship with consumers."[86] While the report was not discussing educational content, the point applies.

Enhance teacher training. As EdTech innovator Wayan Vota notes, "Tablets are good, content is better, and teachers are the best educational ICT investment."[87] Far too many schools have too few and/or underprepared teachers, and low teacher pay and attendance plague many low-resource countries. Not only are more teachers needed, but better-trained teachers. The presence of technology often serves to jumpstart more interactive approaches in classrooms, and the more engaged and skilled a teacher is, the more he or she can contribute to the success of mobile innovations. "Teacher training and continued, on-going, relevant professional development for teachers are essential if benefits from investments in ICTs are to be maximized," writes World Bank's Trucano. Without it, he adds, technology can potentially improve the performance of highly skilled teachers while overwhelming less-skilled teachers.

Teachers are on the frontlines of the infusion of technology into schools. "The mass introduction of devices directly into the hands of students can be very disruptive—and teachers will need to be supported as they manage their way through," adds Trucano.[88]

Bring promising programs to scale. The role of donors is not only to supply financial support. Well-informed donors "can help policy makers answer some basic questions before they choose to adopt new gadgets," notes Devex, a media platform for global development. Donors can help policy makers clarify their objectives, identify content and technology already in place, and determine how impact will be measured.[89] With donors insisting on applying lessons learned, scale becomes more possible.

The Mobiles for Education Alliance, which coordinates and connects players in the private, government, foundation, research, and donor realms, could play a transformative role.

Use technology in all aspects of school. This paper has focused on the use of technology among students and teachers for learning. But the entire school ecosystem is primed for technological enhancements in governance and management, training, storage of materials, curriculum reform, and record keeping.[90]

Conclusion

Thirty years ago, in 1989, "futurist" educators wrote on a then-esoteric question: What impact will the introduction of instructional technologies—still far off in the future—make on education? Their conclusion was prescient: "Advances occur only insofar as they are accepted, understood, and used by teachers."[91] That truth is at the heart of all subsequent findings about the use of technology in schools. Technology isn't a substitute for teaching, and it isn't an asset in itself. It is instead a supplement and complement to what educators worldwide know works: a holistic approach to teaching and learning that positions teachers to engage with the right tool at the right time with the student who needs it. With that, mobile learning can succeed anywhere.

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