The 8 Essentials for Mobile Learning Success in Education

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Introduction

All across the globe, students from elementary school through high school are increasingly engaging with advanced wireless devices to collaborate with peers, access rich digital content, and personalize their learning experiences. Always-on, always-connected, smartphones and tablets provide today's students with a ubiquitous gateway to a new ecosystem of information, experts, and experiences, regardless of the physical assets and resources (or lack thereof) in their own communities.

Many education leaders are intrigued with the opportunity to use smartphones and tablets as learning tools within schools and want to understand the power of these devices to transform teaching and learning. According to the latest Speak Up report on digital learning, school principals believe that the use of mobile devices and mobile-enabled content in the classroom have the potential to significantly impact student achievement (Project Tomorrow, 2014). The principals link enhanced student outcomes afforded by the mobile devices to a new classroom paradigm in which the students are more engaged in learning, the learning process is highly personalized and extends beyond the school day, and students develop college and career readiness skills such as critical thinking and teamwork using real world tools and resources.

While this new learning vision is appealing to students, parents, teachers, and administrators, realization of this educational model remains elusive for many schools. In some cases, teachers and school leaders have tried using different kinds of mobile devices in the classroom, but efforts focusing only on adding devices have not resulted in better student outcomes or teacher productivity, and these innovators are unsure how to improve those results. Other school leaders are eager to endorse mobile learning, but are hesitant to implement an initiative at their school because they lack knowledge on how to get started and what pitfalls to avoid. At the same time, communities and policymakers are increasingly interested in how mobile learning can be the long sought after catalyst for reforming education, so that every child is well prepared to compete and thrive in the global economy and society.

For the past seven years, the Qualcomm® Wireless Reach™ initiative has developed an in-depth understanding of this complex situation through investments in school and community projects. Qualcomm has also sponsored thought leadership events and published reports that address the opportunities and challenges of mobile learning. This paper presents a synthesis of insights from these investments to support education leaders worldwide in their quest to improve educational opportunities for their students through the effective use of mobile and wireless technologies.

QUALCOMM'S COMMITMENT TO ADVANCING MOBILE LEARNING

Qualcomm is a world leader in next-generation mobile technologies. For nearly 30 years, Qualcomm ideas and inventions have driven the evolution of wireless communications, connecting people more closely to information, entertainment, and one another. Today, Qualcomm technologies are powering the convergence of mobile communications and consumer electronics, making wireless devices and services more personal, affordable, and accessible to people everywhere. At the heart of Qualcomm's culture is the belief that mobile technology presents an opportunity to create value, extend its reach, and make a genuine impact. The company believes that building lasting value to realize this vision requires more than a focus on shareholders — it involves a significant commitment to the global community.

Wireless Reach as a strategic initiative

Through Wireless Reach, a strategic initiative that brings advanced wireless technologies to underserved communities globally, Qualcomm works with partners to invest in projects that foster entrepreneurship, aid in public safety, enhance the delivery of health care, enrich teaching and learning, and improve environmental sustainability. To date, Wireless Reach has funded more than 100 projects in 40 countries, with 40 of those projects focusing on education. These projects are designed specifically to address the barriers to adoption of wireless technology in the classroom, including needs for digital content and assessment, infrastructure, privacy and security, and professional development for teachers.

Qualcomm believes that always-on, always-connected advanced wireless devices and ubiquitous tools have the potential to transform teaching and learning in K-20 schooling. When this potential is realized, students will benefit from 24/7 access to digital curriculum that is highly personalized with respect to level, pace, and learning style.

To date, Wireless Reach has funded more than 100 projects in 40 countries, with 40 of those projects focusing on education.

Teachers will benefit from digital participation in communities of practice with global reach and from dashboards that actively display real-time data about their students' progress. As wireless education technologies allow learning to expand beyond the four walls of the classroom and the hours of the school day, teachers will gain flexibility in how they can use precious classroom minutes. In this vision, researchers too will benefit from a platform that allows the distribution and evaluation of innovations in Internet time.

Education is a key driver for growth, economic prosperity, and the advancement of both developed and developing countries. Mobile devices can bring high-quality education to all communities, regardless of their income status or location. For the millions of children in emerging countries who lack access to formal education, the proliferation of mobile devices could provide a new opportunity, perhaps their only means, for accessing learning resources. Within the United States, only 60 percent of high school students in low-income communities report having broadband access to the Internet outside of school (Project Tomorrow, 2014). In some cities, like Detroit, 70 percent of students lack Internet access when they leave school grounds (Kajeet Case Study, 2014).

Wireless Reach is exploring how these devices, so common in our pockets, can be used in education so that all students have the opportunity to learn, prepare for good jobs, and participate in our global economy.

Substantial barriers and challenges remain in effectively utilizing these new technologies in school and in implementing the types of best practices that have been proven to overcome these obstacles. Based upon a comprehensive examination of the effective implementation strategies and resulting successful outcomes derived from the global projects within the Wireless Reach education portfolio, the authors have identified 8 essential components of a successful mobile learning initiative in primary and secondary education. While no single project or initiative must incorporate all of the essential components, an understanding of these 8 essentials for project success and their inter-relationships can help education leaders be more informed and prepared to implement a successful mobile learning project.

8 ESSENTIALS FOR A SUCCESSFUL MOBILE LEARNING INTIATIVE IN PRIMARY & SECONDARY EDUCATION

The 40 Wireless Reach funded education projects across the globe have produced many insights about how to design, deliver, and evaluate highly successful mobile learning projects. These include in-school or after-school learning environments in which each student has access to a personalized mobile device, such as a smartphone or tablet, from which they can access Internet resources and tools. A hallmark of the Wireless Reach initiative is a recognition that, to have emerging mobile solutions impact more students and teachers, the K-20 educational sector needs best practices, proven solutions, and evidence-based exemplars that address commonly held challenges and concerns about mobile learning. This research-informed collection of 8 essential components addresses that vital need and provides valuable input to inform local plans and initiatives:

- Purposeful planning for mobile device usage
- Leveraging content and curriculum that is mobile-empowered
- Understanding the power of Internet access
- Preparing educators effectively
- Securing leadership buy-in
- Building personal learner efficacy and capacity for self-directed learning
- Measuring project results with meaningful metrics
- Creating an ecosystem that is sustainable and scalable

Results from the Wireless Reach projects indicate that the thoughtful application of these strategies in combinations that meet local context substantially increases the probability of a successful implementation of a mobile learning initiative. Below, we provide an explanation of its value for each of the 8 essential components, and we demonstrate how a particular Wireless Reach project leveraged several essentials to build capacity and deliver outcomes that transformed teaching and learning environments.

Purposeful planning for mobile device usage

The first step in designing a mobile learning experience is understanding that its power for improving student outcomes does not magically come simply from using a mobile device. Smartphones and tablets are not like fire, a technology from which one gets a benefit simply by standing near it. Instead, learning technologies serve as catalysts: their power for effective education stems from enabling deeper content, more active forms of pedagogy, more authentic and diagnostic assessments, and more links between classroom experiences and life. Usage of mobile devices without empowering at least one of these dimensions — or some other evidence-based mechanism for deeper learning — is a waste of time, effort, and resources, because phones and tablets don't intrinsically create learning any more than does a pencil.

Yet many mobile initiatives begin with just this mistake: the project consists of only device acquisition and distribution. So what types of planning are needed? First, just as with any other form of educational innovation (technology based or not), it's important to consider some fundamental questions:

- *What are the learning goals to be accomplished?* These can include not only cognitive dimensions, but also intrapersonal and interpersonal skills, including motivation.

- *Who are the learners, and what prior knowledge and skills do they bring to the experience?* Students are not empty vessels to be filled with information, but instead bring many skills, ideas, and misconceptions — as well as developmental levels and individual motivations — that must be considered in designing effective learning experiences.

- *Who are the teachers, coaches, guides, and mentors serving to enhance learning, and what prior knowledge and skills do they bring — and need?* Part of the power of mobile devices is their ability to involve human resources "life-wide" for students, not just in classroom settings.

Too often, educational innovations are developed in a way that requires a continuous infusion of outside resources to keep them going.

- ***What instructional and curricular materials are available — or need to be developed — and how will these materials be delivered via mobile devices?*** The Internet can supply vast resources, but these are of variable quality and frequently require integration and alignment to be effective for learning. In addition, there are a variety of learning platforms available to deliver course materials. When making decisions about content delivery solutions, built-for-mobile platforms have advantages using native features of the device such as the camera. Other features might include online collaboration tools using video, the ability to cache large content on the device so a student can review it anywhere and anytime, video grading capabilities for teachers, push notifications from teacher to student, student to student, and analytics.

- ***What will be measured to determine and enhance educational effectiveness, and how?*** Embedded, diagnostic measures of student learning formative for instruction are crucial for success; and summative assessments of student learning, along with other evaluative measures, are very important in determining the effectiveness of the initiative.

- ***What are the contextual "conditions for success" that must be met for the initiative, and what leaders in each setting will ensure these conditions are developed and sustained?*** Just as taking a medication must be done in certain ways to ensure its effectiveness (e.g., right dosage, proper timing, sufficient duration), educational innovations also require contextual conditions (e.g., prepared teachers, quality curriculum) in order to succeed — and will fail unless these conditions are met by leaders in the setting of innovation.

- ***How will the initiative be sustained and scaled when special start-up resources are gone?*** Too often, educational innovations are developed in a way that requires a continuous infusion of outside resources to keep them going. This limits both how many sites can use the innovation and how long the improvements will last, because the initiative disappears as soon as external funding is discontinued.

- ***Are the views of students, parents and the greater community included in the planning process for the mobile initiative?*** By virtue of already using these devices to support self-directed learning outside of school, students are a treasure trove of ideas for effective in-school implementations. Per the recent Speak Up Survey results, the majority of parents are already supportive of mobile learning with 6 out of 10 parents of school aged children wanting their child in a class that includes mobile devices (Project Tomorrow, 2014). And community members who are part of the planning process can help to articulate the benefits to a larger audience, and provide value-added insights into how to build sustainable funding to support proven programs.

In summary, thoughtful planning with a focus on determining the foundational objectives of the mobile learning initiative combined with the active involvement of the education stakeholders, including your students, are primary requisites for a successful mobile learning initiative. The ***Onslow County Schools' Mobile Learning Initiative*** provides a good example of how to structure a mobile learning project around specific learning objectives.

ONSLOW COUNTY

Onslow County Schools' Mobile Learning Initiative

During the 2006/07 school year, the leadership within Onslow County Schools in North Carolina came to an important conclusion regarding their longstanding struggle to improve student math outcomes. Despite a strong curriculum, highly effective teachers, and committed administrators, too many students were not adequately prepared for future college or career success because of a lack of math proficiency, even with basic Algebra. This was not acceptable to the leadership of the district; the schools had to do something different.

A strategic partnership between Wireless Reach and Onslow County Schools created an opportunity to implement a landmark mobile learning project within high school math classrooms. This relationship, which began in 2007 with smartphones in the hands of underperforming Algebra students, ultimately grew over the next seven years to serve over 1,000 high school students, supporting math instruction from Algebra through AP Calculus with tablets at seven district high schools. In addition to the school access, students were provided with 24/7 Internet connectivity through 3G/4G transmission, closing at least a portion of the digital divide so common in rural districts. The students placed a high premium on the value of having access to the tablet as part of their education: 90 percent of the students rated access to the tablet as valuable, with 44 percent calling it "very valuable." Almost two-thirds of the students took additional math courses as a byproduct of their experience with mobile-enabled math instruction, and over 50 percent considered a career in the math field because of having a mobile device to use within their math classes. At the heart of the impact of mobile devices is the change in teacher practice and the transformation of the math classroom. The ubiquity of the student access with every student having access to online remediation videos, digital textbooks and social media tools to support peer mentoring, required that the teachers re-engineer their approach to math instruction; the teachers took full advantage of the features and functionality of the devices to create a more personalized learning environment for every student.

Leveraging content and curriculum that is mobile-empowered

Curriculum that supports the learning goals for a mobile initiative is essential for its success. These materials provide resources for both students and teachers to guide their activities. It is crucial that the curriculum provides a balance of activities between passive forms of assimilation (e.g., reading, watching videos) and active forms of learning (e.g., writing, designing, gathering data, collaborating). Also, the curriculum must be tailored to fit particular student characteristics. For example, having materials in a student's primary language is important, as is using vocabulary at their reading level. To help students with special needs or learning preferences, providing alternate modalities (e.g., reading text, listening to audio, viewing a video) is good.

This range of options is important because learning is a human activity quite diverse in its manifestations from person to person (Dede, 2008). Consider three activities in which all humans engage: sleeping, eating, and bonding. One can arrange these on a continuum from simple to complex, with sleeping towards the simple end of the continuum, eating in the middle, and bonding on the complex side of this scale. People sleep in roughly similar ways; if one is designing hotel rooms as settings for sleep, while styles of décor and artifacts vary somewhat, everyone needs more or less the same conditions to foster slumber. Eating is more diverse in nature. Individuals like to eat different foods and often seek out a range of quite disparate cuisines. People also vary considerably in the conditions under which they prefer to dine, as the broad spectrum of restaurant types attests. Bonding as a human activity is more complex still. People bond to pets, to sports teams, to individuals of the same gender and of the other gender. They bond to others similar

or opposite in nature, for short or long periods of time, to a single partner or to large groups. Educational research strongly suggests that individual learning is as diverse and as complex as bonding, or certainly as eating. Yet theories of learning and philosophies about how to use technology for instruction tend to treat learning like sleeping, as a simple activity relatively invariant across people, subject areas, and educational objectives. Current, widely used instructional technology applications have less variety in approach than a low-end fast-food restaurant.

Mobile learning can do much better than that, because today's phones and tablets are powerful enough to support a wide range of options, and their capabilities keep expanding over time. That said, the form-factor of mobile devices (small screen, varied network speeds on wireless connections, difficulty typing text) means that some types of educational materials and activities are best done on larger computers or via non-digital media. In instructional design for mobile initiatives, understanding which materials to deliver via various means is important.

In summary, for all types of technology-based learning, it is important to build on existing digital resources, but recognize that adaptation and integration are necessary. Curricula developed for large-screen devices may need alteration for small-screens. Isolated "learning objects" may need modification and synthesis to form a coherent, aligned, cumulative set of learning experiences. Budgeting resources for the kinds of development discussed above is important for mobile learning initiatives. The good news is, developers are continuing to build "mobile first" content that goes beyond a flat PDF. The ***Power of mLearning*** project in Kenya demonstrates the criticality of mobile-enabled content for project success.

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KENYA

Kenya Power of mLearning Project

In Kenya, Wireless Reach has been working with eLimu, an e-learning social enterprise, to curate existing content. The goal isn't to dump content from another medium into mobile; rather, the objective is to redesign content to leverage the strengths of mobile. *The Power of mLearning* project utilizes the eLimu model by repurposing Kenyan curriculum from textbooks, adding interactive, engaging, and locally designed content in the form of songs, games, quizzes and animations. This mobile-empowered curriculum is then delivered through 3G enabled tablet computers to make learning more interactive, interesting, fun, and locally relevant. Via this strategy, eLimu has developed a platform and educational content that seeks to achieve quality lessons for Kenyan upper primary school students preparing to take national examinations (Kenya Certificate of Primary School Education – KCPE) by focusing on interactive engagement in the learning process through the use of mobile technology.

Understanding the power of Internet access

Equity of access to educational resources is increasingly becoming the next high profile civil rights issue of our global society. At the heart of this issue worldwide is access to the Internet as one gateway to a plethora of rich educational content and tools that could be accessed by students for learning purposes. The Internet access discussion however includes a wide spectrum of types of equity. For many students in Kenya, for example, equity starts with whether Internet connectivity is even available in their community, and then, what types of devices can be provided to those students to facilitate that access, at school or at home. In the United States, the discussion revolves around school policies that prohibit student usage of their own mobile devices or limit student access to the Internet while at school. While addressing radically different conditions, the resulting experience is similar. Limited or non-existent access equates to diminished educational opportunities.

Internet access anyplace, anytime, is a powerful tool for learning that is uniquely provided by mobile devices. In addition to all the web-based resources this enables, the combination of the Internet and Global Positioning Satellite (GPS) capabilities opens up new forms of learning, such as augmented reality (AR). AR enables students carrying mobile wireless devices through real-world contexts to interact with virtual information, visualizations, and simulations superimposed on physical landscapes. For example, via AR a tree might describe its botanical characteristics, a historic photograph might offer a contrast with the present scene, or a cloaked alien spaceship might appear, visible only through the mobile device. This type of immersion infuses digital resources throughout the real world, augmenting students' experiences and interactions (Klopfer, 2008). A more detailed review of how AR enables student learning is provided later in this paper. In addressing key factors in the power of Internet access, the Wireless Reach project on *Personalized Learning via 3G in Jordanian Schools* is illustrative.

JORDAN

Personalized Learning via 3G in Jordanian Schools

In 2010 the Jordan Education Initiative and Wireless Reach worked together to develop a 1:1 mobile learning project that was piloted during the 2011-2012 academic year at two public schools in Amman, Jordan. The project, *Personalized Learning via 3G in Jordanian Schools: Anytime, Anywhere Access to Educational Resources*, provided 35 teachers and more than 200 students in grades 7-10 at two all-girl public schools with mobile devices at a ratio of one device per student. The project promoted the use of mobile learning and provided specialized training to teachers, students, and parents on netbook maintenance, computer software, online educational resources, Internet safety, and how to access the Ministry of Education's (MoE) Eduwave portal with e-learning content for students.

Students in grades 7-9 at Balqees School and grades 8-10 at Um Abhara School received 3G-enabled netbooks and 3G Internet connectivity to use in and out of school for accessing online learning
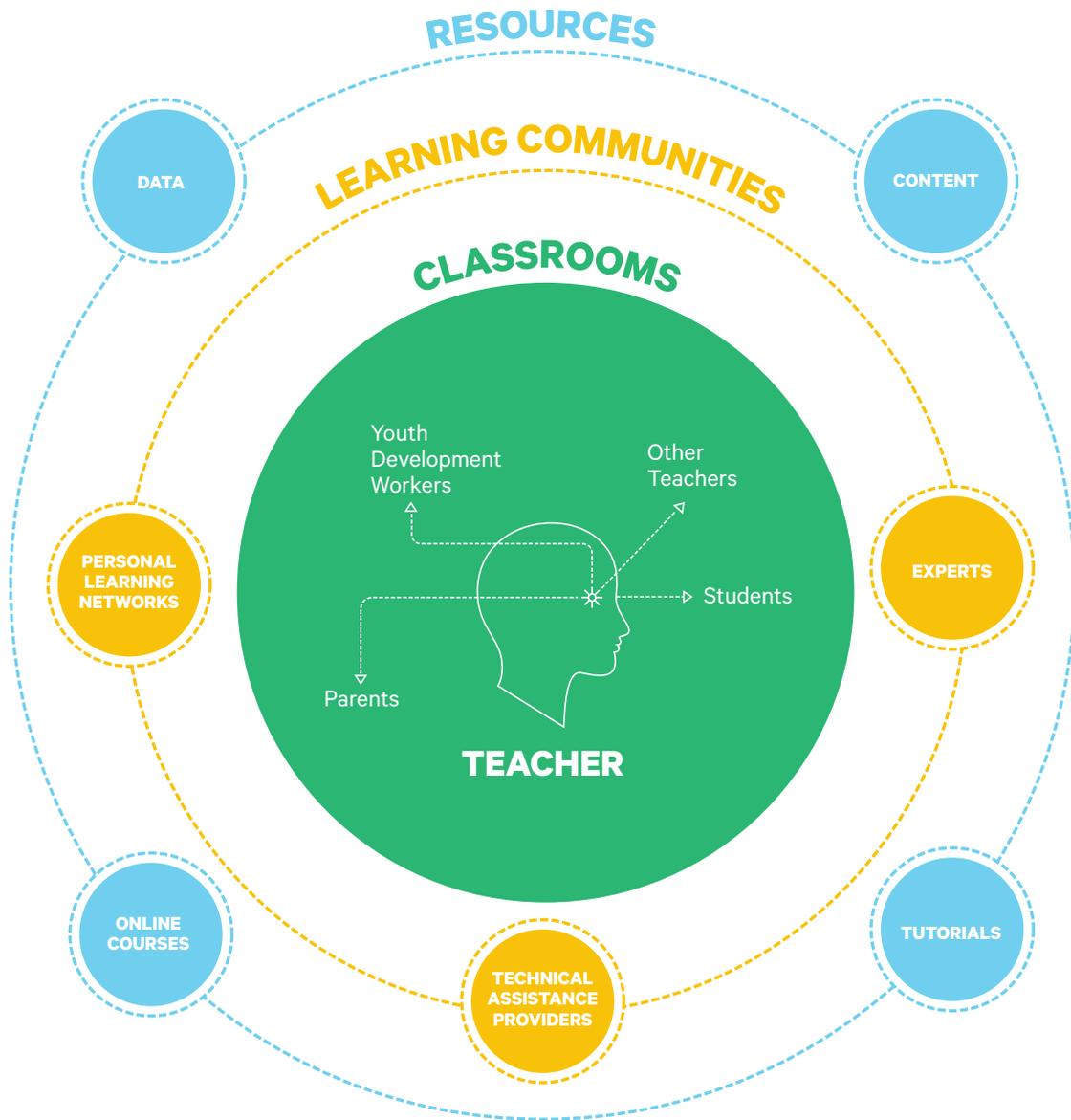
materials, creating multimedia presentations, collaborating with their peers and teachers, and participating in project-based learning assignments - all of which helped them to develop 21st century skills. This 1:1 mobile learning model empowered students to extend their learning beyond the classroom and enabled teachers to personalize their students' learning experiences.

Taking the netbooks home to have Internet access everywhere helped students to do their homework effectively and to share these tools with their parents and siblings. The technology enhanced the communication skills of students and parents by enabling them to use e-mail and social media channels such as Facebook. Having access to online educational resources at all times nurtured and maximized each student's opportunity for learning. It also made school work more engaging by encouraging personalized, self-initiated learning.

Preparing educators effectively

The U.S. National Education Technology Plan (US Department of Education, 2010) discusses how enabling the life-wide learning described above requires that mobile initiatives prepare educators for connected teaching (Figure 1).

Potentially, parents trained and licensed as tutors, informal educators (e.g., museum staff, librarians) certified as coaches, and community members prepared and licensed as mentors can supplement what teachers do in school settings.

Ultimately, the effectiveness of a mobile learning initiative depends on the quality of the educators involved. As discussed earlier, the innovation is not technology, but instead the empowerment of human performance through changing the ways education is structured and delivered. This type of professional development is very challenging because participants must not only learn new skills, but also "unlearn" almost unconscious beliefs, assumptions, and values about the nature of teaching, learning, and schooling. Professional development that requires unlearning necessitates high levels of emotional/social support in addition to mastering the intellectual/technical dimensions involved. The ideal form for this type of professional development is distributed learning communities, so that the learning process is consistent with the knowledge and culture to be acquired. In other words, teachers must experience technology-based learning as the medium of their professional development as well as its message.

The need for professional development that is tailored to teachers' busy schedules, that draws on valuable resources not available locally, and that provides work-embedded support has stimulated the creation of online and blended teacher professional development programs. Generally, these programs are available to teachers at their convenience and provide assistance. In addition, they often give schools access to experts and archival resources that fiscal and logistical constraints would otherwise limit. A range of objectives for educational improvement underlie these online teacher professional development ventures, such as introducing new curricula, altering beliefs and instructional and assessment practices, changing school organization and culture, and enhancing relationships between school and community.

In summary, to succeed, mobile learning initiatives must include professional development that meets these criteria and fosters educators' capacity for connected teaching. With the *Making Learning Mobile* project in Chicago, the impetus for enhanced professional development on mobile strategies originated with the teachers. This project provides additional insights on the value of addressing each teacher's needs when designing a professional development plan.

Securing leadership buy-in

Every innovation has conditions for success without which it cannot succeed. The effective use of antibiotics illustrates this concept: Antibiotics are a powerful innovation, but worshiping the vial that holds them, rubbing the ground-up pills all over one's body, or taking all the pills at once are ineffective strategies for usage — only administering pills at specified intervals works as an implementation strategy. A huge challenge educators face, and one of the reasons this field makes slower progress, is the complexity of conditions for success — and the sophistication of the processes necessary to achieve these conditions — required in effective interventions.

A crucial challenge for leadership in mobile learning initiatives is ensuring that their conditions for success are met at each implementation site. The concept of leadership is fraught with misconceptions. People often see leadership as a combination of meticulous management, adept political maneuvering, and responsive facilitation of others' activities. While each of these is important in advancing the field of educational technology, the true nature of leadership is exemplified by four attributes (Dede, 1993).

- *Leadership Requires Envisioning Opportunities.* One of the most important attributes that distinguishes leaders from managers is "vision": the ability to communicate desirable, achievable futures is quite different from where the present is drifting. Leaders create and convey compelling images of how our reach is much less than our potential grasp; they redefine people's paradigms about what is possible.

- *Leadership Requires Displacing Cherished Misconceptions.* An important attribute of leaders is their ability to displace deeply held, cherished misconceptions with alternative visions that more accurately depict reality. Mistaken beliefs most people hold about teaching and learning form a barrier that blocks improving American education, particularly for new models like mobile learning. Leadership requires packaging alternative assumptions and paradigms as part of a larger vision that inspires new roles for educational stakeholders.

- *Leadership Requires Inspiring Others to Act on Faith.* Inspiring a group to work toward a shared vision necessitates building trust: faith that this team of people

CHICAGO

Making Learning Mobile in Chicago

The *Making Learning Mobile* project is a collaboration between Wireless Reach, Kajeet for Education, and the Chicago Public Schools. 136 low income 5th grade students with limited to no Internet access at home and their four classroom teachers were provided with ubiquitously connected 3G mobile devices to use at school and at home to extend learning. For the teachers, this was a new experience, as none of them had taught in a mobile-enabled classroom. The learning curve in year one was naturally steep. One of the results of the project evaluation from year one was that the teachers wanted more hands on training on teaching strategies, mobile applications, and project-based learning. The teaching cohort is a strong team who regularly plans their class activities together.

In recognition of that support structure, the 2013/14 project plan provided dedicated professional development for the four teachers. A Chicago-based education technology consultant with deep expertise in mobile learning introduced the teachers to various educational apps, provided consultation on classroom strategies for effective use, and was a consistent resource for informal coaching and mentoring on instructional tools and methods. The teaching team also attended two education technology conferences during the school year and applied what they learned from those professional development opportunities in the classroom. These teachers' strong commitment to professional development and their willingness to incorporate new strategies and resources into their classroom is a hallmark of a successful and maturing mobile learning project.

can overcome all the obstacles that block the creation of a future quite different from the present. We often speak of visions as "dreams" because we do not believe they are possible; we doubt that they can be made real. Actualizing a plan for the future involves harnessing people's emotions as well as their minds, developing both understanding and belief. Leaders build on the enthusiasm that mobile devices induce to encourage an affective climate that rewards risk-taking and accepts occasional failures as an inevitable byproduct of developing new approaches.

- *Leadership Requires Discouraging Followers.* A destructive myth about leadership is that a visionary person gives directions to followers who execute this plan. Real leaders discourage followers, instead encouraging use of their visions as a foundation for other, better insights. True solutions to problems are always based on ideas from multiple perspectives; no individual, however capable, can incorporate the full range of knowledge and experience needed to invent an educational system that fulfills the needs of a diverse community. A leader in educational technology should inculcate others' visions, knowledge, and commitment to the point that all are jointly leading. This requires moving beyond the role of team facilitator or coordinator, acting as an exemplar by deliberately following others instead of always leading.

In summary, using these characteristics of leadership to meet the conditions for success required at each implementation site of a mobile learning initiative is crucial for its effectiveness. To achieve that goal, school and district administrators need to learn how to provide leadership support and guidance for their teachers. The Education Development Center provided a cohort of school principals with a unique opportunity to use a tablet for their own professional development, and thus build up personal capacity for mobile learning leadership.

Building personal learner efficacy and capacity for self-directed learning

As discussed earlier, two important characteristics of 21st century education are (1) personalized learning for each student in classroom settings and (2) life-wide learning outside the school place and school day, involving families, informal educators, and communities in every child's education. The Software Information and Industry Association (SIIA) describes personalized learning as (Wolf, 2010, pg 6):

> *...ensuring that a student's educational path, curriculum, instruction, and schedule be personalized to meet her unique needs, inside and outside of school... through a wide range of resources and strategies appropriate for her learning style, abilities, and interests, as well as social, emotional, and physical situation.*

The knowledge and skills students acquire from a mobile learning initiative should have intrapersonal and interpersonal dimensions, not just cognitive attributes. For example, mobile learning can foster academic engagement: sustained voluntary participation in pursuits related to learning academic knowledge (content, skills, culture), both in and out of school (Lepper & Henderlong, 2000). This would not only encompass excitement about learning in science classes and in the after-school robotics club, but also hobbies such as computer programming for fun (computational thinking), making clothing that is a mixture of textiles and electronics (engineering), or adeptly selecting players in fantasy sports leagues (statistical reasoning). Engagement is a mixture of states (e.g., using social media on a mobile device to collaborate with friends) and traits (e.g., approaching all new situations with intense curiosity about their causes).

BOSTON

EDC Mobile Online Professional Development for Educators

School principals face two central problems relative to their own professional development — a lack of time and a lack of familiarity with online collaboration tools and mobile devices for professional learning. In this online course which was developed by the Education Development Center for implementation with 15 Boston public school principals in summer 2013, the participants collaborated on what it would take to maximize the value and minimize the challenges of using mobile devices to implement web 2.0 technology within their school communities of practice. In order to effectively use mobile devices to implement web 2.0 technology, school leaders agreed they must rethink what it means for teachers to teach and for students to learn. The leaders indicated that schools need to "embrace the [mobile] technology that [students] are coming with," "embed the technology goals with the content goals," and "provide new teacher training [because] teachers cannot introduce students to web 2.0 technology unless they understand it themselves." The course participants concluded that "the school leader is the catalyst for change" when it comes to using mobile devices to implement web 2.0 technology. School leaders must "become familiar with using new technologies," "set the expectations and lead by example," and "work with school staff to create the three-to-five year plan and blueprint" for implementing policies on mobile devices and utilizing this technology in their schools.

An individual's traits related to engagement are difficult to change, but can alter slowly based on experiencing a series of states that push in a particular direction (e.g., many children enter schooling curious about academic issues, but become disengaged after years of boredom).

Mobile learning can also help to build academic tenacity, another important capability for student success (US Department of Education, 2013). Pushing onward with learning even when not engaged in the moment is important because through persistent practice learners can reach proficiency levels sufficient to "unlock" experiences that further increase engagement. For example, at a certain stage of sustained learning, foreign language students gain the proficiency of spontaneous conversation in the new language, which promotes a virtuous cycle of increased motivation (based on autonomy, flow, relevance…). Many types of academic engagement are characterized by this type of threshold, where attaining a level of fluency enables new forms of motivating experiences.

Sports are a good analogy: Practice is not fun, but succeeding in a competition is. Casual golfers may have fun in an intriguing hobby, but are unlikely to improve over time.

In contrast, professional golfers put up with the rigors of training because they are motivated by competition, pursuit of excellence, fame, and fortune. Self-regulation includes strategies such as setting specific proximal goals, adopting powerful strategies for attaining the goals, monitoring one's performance selectively for signs of progress, restructuring one's physical and social context to make it compatible with one's goals, managing one's time use efficiently, and self-evaluating one's methods. Teenage gymnasts succeed through self-regulation to progress by endless grueling practice that is certainly not fun; sometimes coaches overdo the drills and the gymnast drops out because the rewards do not seem worth the struggle.

In summary, the relationship between momentary engagement, learning, and continued involvement through tenacity is complex, not simply reciprocal reinforcement. Mobile learning initiatives should be designed with an understanding of these motivational dimensions and issues. The success of the *WE Learn* project in leveraging mobile devices and specific content to help students' self-efficacy as learners is a good demonstration of this essential component.

SINGAPORE

Singapore WE Learn Project

In Singapore, the *WE Learn* project provides 3G-enabled Nokia Lumia 710 smartphones, mobile broadband connectivity, a mobile learning platform called MyDesk, and educational applications to third and fourth grade students and their teachers at Nan Chiau Primary School. All of the smartphones are equipped with MyDesk, a next-generation mobile learning platform tailored to leverage the capabilities of Microsoft's Windows Phone operating system.

MyDesk is an application that contains a broad range of education-specific tools that support the Nan Chiau teachers as they enact an inquiry-based pedagogy. Concept mapping, drawing and animating, writing, etc. can all be done in MyDesk and at an individual's own pace and schedule. Teachers can easily send assignments to their students from the cloud-based classroom portal; when a student finishes an assignment, the student submits it back into the portal for the teacher to review. This can be done from the classroom, the bus, or at home — truly anywhere. And, as MyDesk is running on a smartphone that is connected to the Internet, students can access websites outside of class as easily as they can inside of class, and they can collaborate and share documents with each other from home using the portal. This allows for collaboration with peers even when outside of school, and continued interaction and engagement with classmates 24/7. MyDesk enables each student to access his or her assignments at any time; they can search relevant websites that contain podcasts, textual material and video clips. Students also use educational applications, such as concept mapping, drawing, and animating, to practice both self-directed and collaborative learning.

Measuring project results with meaningful metrics

In mobile initiatives, embedded, diagnostic measures of student learning formative for instruction are crucial for success; and summative assessments of student learning, along with other evaluative measures, are very important in determining the effectiveness of the initiative. Dede and Richards delineate the central role of technology in empowering these types of assessment in their 2012 book, *Digital teaching platforms: Customizing classroom learning for each student,* (DTPs).

DTPs are a new kind of learning platform enabled by advances in theory, research and 1:1 computing infrastructures in school settings. This type of learning platform is designed to operate in a teacher-led classroom as the major carrier of the curriculum content and the primary instructional environment. A full-fledged DTP enables personalization through three major aspects of classrooms that have 1-1 student/computer ratios:

- First, a DTP is a networked digital portal that includes interactive interfaces for both teachers and students. To use a DTP, each student and the teacher have a mobile device connected to the network. Teachers use the administrative tools of the DTP to create lessons and assignments for students, and to manage and evaluate the work the students return. These capabilities include specific tools for assessment: for creating tests and other types of measures, assigning them to students, and reviewing the results. The teacher tools also provide timely reports on student progress and on their remedial needs. The administrative tools for students allow them to complete assignments and assessments. More important, these tools allow for both individual and group work: some students can work independently on individualized assignments, while others work collaboratively on shared assignments.

- Second, a DTP provides the content of the curriculum and assessments for teaching and learning in digital form. This content includes the material in the curriculum, the instructional strategies, the exercises, and the assessments. The content includes interactive elements, manipulative activities, special-purpose applications, and multimedia materials. If developed in a format suitable for the DTP, teachers can add additional content and assessments.

- Third, a DTP supports real-time, teacher-directed interaction in the classroom. The system includes special tools for managing classroom activity; monitoring progress on assignments; displaying student work to the entire class, displaying demonstrations and challenges on an interactive whiteboard or similar device; managing group discussions; and coordinating large-group and small-group activities. The DTP is an assistant for all the types of instructional activities a teacher might wish to implement. All of these features of a DTP are designed to function effectively in the give-and-take atmosphere of a classroom. The teacher can shift quickly from large-group demonstrations, to small-group activities, to individualized practice and assessment. Students move seamlessly from using their devices for these activities to ignoring their laptops and participating in discussions. The teacher is fully in control of student activities by giving assignments, mentoring individuals, and leading discussions.

Through this suite of capabilities, the system provides support for a shift in teaching and learning away from one-size-fits-all presentational/assimilative instruction and high stakes assessment to instead personalized active learning with embedded assessments that provide continuous diagnostic feedback tailored to each student. Although mobile devices do not at present support all of these functions, they can be an important aspect of a DTP and provide a stepping-stone towards this vision of integrated instruction and assessment. In planning mobile learning initiatives, it is important to see today's mobile devices, which will rapidly become more powerful, as a transitional step towards strategic goals.

Beyond the use of mobile devices to enable more sophisticated forms of assessment, the evaluation of mobile learning projects is critical for understanding first, if the project met the learning goals that were established as the foundation for the implementation, and second, what can be done to improve outcomes in the next iteration of the project. Too often within schools, an evaluation of the mobile learning project is an afterthought or something that is valued only for its role in funding compliance. Due to the twin issues of complexity and potential associated with mobile learning projects, it is imperative that a mobile project evaluation plan meet the following specific criteria to collect and report on meaningful metrics:

1. The evaluation plan should be an *inherent part of the overall project planning* from the first discussions about the project goals to implementation strategies.

2. The identification of the project goals should be a *shared exercise with key stakeholders* so that the buy-in is evident not only for the implementation efforts but also for the data collection processes as well.

3. The types of evaluation data or metrics that are used to evaluate project impact should be *contextualized to the local environment* of the school or community. One size definitely does not fit all with mobile learning projects. Since the transformative potential of mobile is within the personalization of the learning environment, the evaluation processes should reflect that ethos as well.

4. Evaluation results should not be based solely upon an examination of student achievement data. A successful mobile implementation should be seamlessly integrated within the classroom environment. Therefore, the evaluation process should take into account the *overall lived experiences of the students and the teachers* in that classroom. As evident by many recent mobile learning evaluations, a meaningful measure of the impact of a mobile learning project focuses on how the features and functionality of the mobile devices create an environment for increased teacher effectiveness, a proven foundation for increased student achievement.

5. The evaluation plan should report on a *variety of outcomes and the lessons learned*. While there is public benefit in reporting on quantitative results of a project

it is within the lessons learned from the experience that the school or district can build capacity and sustainability for the benefits realized through the mobile project implementation.

In summary, in contrast to other technologies being used in the classroom, the discussion of meaningful metrics involves both the use of mobile devices as data collection tools, as well as the focus of evaluating project goals around student learning outcomes and teacher effectiveness.

Creating an ecosystem that is sustainable and scalable

As an overarching goal, Wireless Reach selects which projects to fund in part on their potential for scalability and sustainability. Research has documented that in education, unlike other sectors of society, the scaling of successful instructional programs from a few settings to widespread use across a range of contexts is very difficult, even for innovations that are economically and logistically practical (Dede, Honan, & Peters, 2005). In fact, research findings typically show substantial influence of contextual variables (e.g., the teacher's content preparation, students' self-efficacy, and prior academic achievement) in shaping the desirability, practicality, and effectiveness of educational interventions. Therefore, achieving scale in education requires designs that can flexibly adapt to effective use in a wide variety of contexts across a spectrum of learners and teachers. Clarke and Dede (2009) document the application of a five-dimensional framework for scaling up to the implementation of the River City multi-user virtual environment for middle school science:

- *Depth:* evaluation and design-based research to understand and enhance causes of effectiveness
- *Sustainability:* "robust design" to enable adapting to inhospitable contexts
- *Spread:* modifying to retain effectiveness while reducing resources and expertise required
- *Shift:* moving beyond "brand" to support users as co-evaluators and co-designers
- *Evolution:* learning from users' adaptations to rethink the innovation's design model

THE 8 ESSENTIALS IN ACTION: THE EcoMOBILE AUGMENTED REALITY PROJECT

The 8 Essentials in Action: the EcoMOBILE Augmented Reality Project

As illustrated above, the Wireless Reach education portfolio of mobile learning projects has many examples of the 8 essentials in action, where school and community leaders have integrated these key components within their projects for enhanced success. To illustrate the value of these essentials within project planning, and how these components work together to heighten the benefits derived by students and teachers with mobile learning, the authors identified one of the Wireless Reach projects for closer study. In this examination, the following three essentials are key components within the project plan, implementation, and outcomes and are illustrated in the following project description:

- Leveraging content and curriculum that is mobile-empowered
- Understanding the power of Internet access
- Building personal learner efficacy and capacity for self-directed learning

Funded by Qualcomm's Wireless Reach Initiative and the National Science Foundation, the **EcoMOBILE** project (http://ecomobile.gse.harvard.edu) is exploring the unique affordances of augmented reality, as well as the capabilities of data collection probeware, to support setting-enhanced learning in environmental science education (Kamarainen et al., in press). As an illustration of an **EcoMOBILE** learning experience, during a field trip to a pond students focused on understanding the relationship between biotic and abiotic factors, data collection and interpretation skills, and the functional roles (producer, consumer, decomposer) of organisms in an ecosystem. This learning experience included one class period before the field trip, the field trip itself, and one class period after the field trip (Kamarainen et al, 2013). Prior to the field trip, the students had access to learning quests, which are online modules providing a 5–10 minute activity that introduces the students to the ideas behind dissolved oxygen, turbidity, and pH.

At hotspots, students experienced visualizations overlaid on the real environment, as well as interactive media including text, images, audio, video, 3D models, and multiple-choice or open-ended questions. Students collected water measurements using Texas Instruments (TI) NSpire devices with Vernier environmental probes. The TI NSpire enables graphing calculator capabilities along with a Data Quest data collection mode that allows display of multiple probe readings on a single interface. Probes were provided to measure four variables: dissolved oxygen concentration, turbidity (Figure 2), pH, and water temperature.

The augmented reality devices supported students' use of the probes by helping them navigate to a location to collect a sample, providing step-by-step instructions for use of the probes, entering the reading in response to a multiple-choice question, and delivering immediate feedback related to the student-collected measurement (Figure 3).

On the next school day after the field trip, back in the classroom, students compiled all of the measurements of temperature, dissolved oxygen, pH, and turbidity that had been taken during the field trip. They looked at the range, mean, and variations in the measurements and discussed the implications for whether the pond was healthy for fish and other organisms. They talked about potential reasons why variation may have occurred, how these measurements may have been affected by environmental conditions, and how to explain outliers in the data.
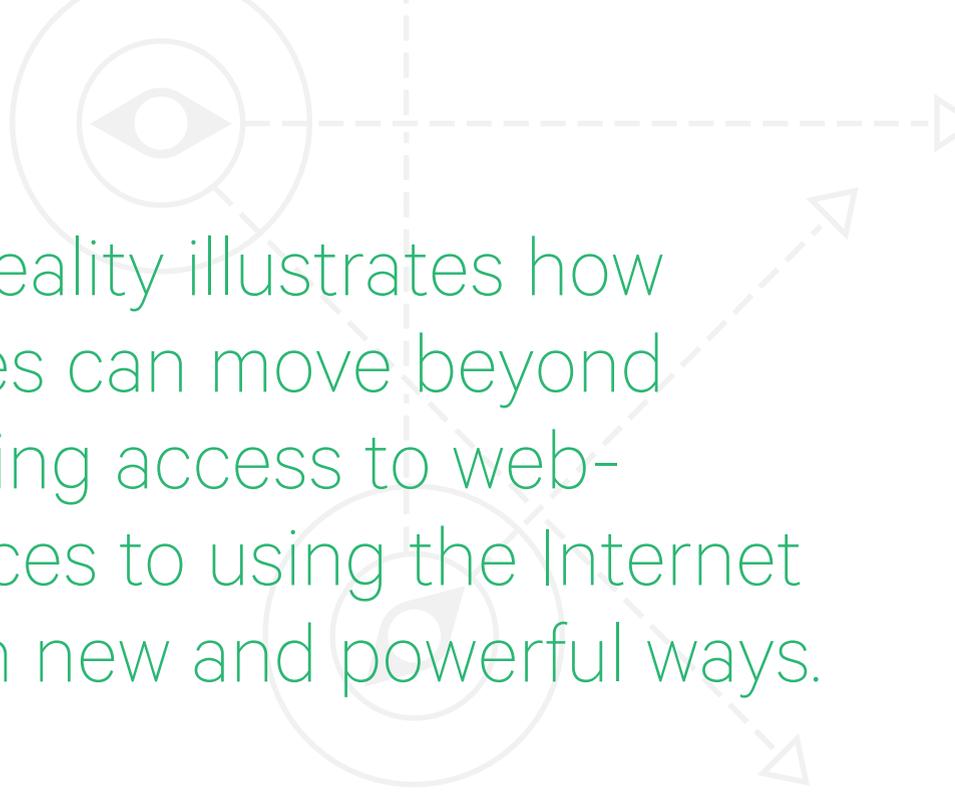
Figure 2: Collecting water quality data

Figure 3: Handheld device delivering information.

Augmented reality illustrates how mobile devices can move beyond simply providing access to web-based resources to using the Internet everywhere in new and powerful ways.

Research (Kamarainen et al, 2013) showed that students were highly engaged with the *EcoMOBILE* technology and also with science. Teachers were able to use pedagogical approaches that might otherwise be difficult in an outdoor learning environment. Student learning gains on the content survey were significant both from a statistical perspective and from the viewpoint of the teachers, who compared these gains to memories of prior field trips without technological support. These results suggest that combining augmented reality with virtual worlds holds potential for helping students to draw connections between what they are learning in the classroom and new situations.

Augmented reality illustrates how mobile devices can move beyond simply providing access to web-based resources to using the Internet everywhere in new and powerful ways. Mobile technologies potentially provide learners with a device that knows about how they like to learn, what around them

is augmented for learning, and how through social media to access communities of peers and experts that can help them interpret what they are experiencing. Exploring these new dimensions of Internet use is important to take advantage of what these technologies can offer.

In addition to illustrating the power of mobile learning to support student engagement and an enhanced learning environment, the *EcoMOBILE* project is also an excellent exemplar for understanding the transformative nature of this type of learning. While putting a device in the hands of a student may have a compelling value proposition, it is the combination of the devices and specific, mobile enabled educational content empowered by ubiquitous wireless access that changes the educational experience for both student and teacher.

ENDING THOUGHTS – LESSONS LEARNED FOR EDUCATION LEADERS

As the case studies in this paper document, always-on, always-connected, smartphones and tablets have the power to transform teaching and learning in many ways, across the world. Students, parents, teachers, and school leaders want to implement mobile learning; but providing the devices is only a first step in enabling learning anyplace, anytime for every student. Reaching the full potential of mobile learning requires going beyond the school place and school time to provide 24/7 access to digital curriculum that is highly personalized with respect to level, pace, and students' strengths and preferences. This is essential as a driver for growth, economic prosperity, and the advancement of both developed and developing countries, giving all students the opportunity to learn, prepare for good jobs, and participate in our global economy.

Through its Wireless Reach initiative, Qualcomm has developed eight essential strategies that can help innovators achieve success in their mobile learning initiatives. Not every project need implement all eight strategies to succeed; rather, each initiative should use combinations of strategies that meet the needs of its local context. The descriptions and case studies in this paper are designed to help innovators understand each strategy and its role in an overall model for innovation in mobile learning. That such a wide range of educators worldwide have succeeded in their Wireless Reach projects using these strategies shows that any group can benefit from this approach.
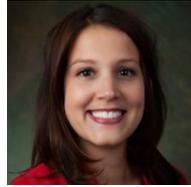
We hope that you will be empowered by this paper to move forward with your mobile learning initiative, realizing the full potential of smartphones, tablets, and mobile broadband. We look forward to hearing about your successes and adding to the casebook of illustrations that show how mobile learning can benefit all students, helping transform education for the 21st century.

...providing the devices is only a first step in enabling learning anyplace, anytime for every student.

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