

Chapter 18

K-12 Mobile Learning

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Abstract

Mobile devices have been the focus of a push in many nations and internationally as part of efforts to achieve greater literacy and numeracy among students. Research has shown a strong link between Internet usage, the spread of broadband in a country, and its GDP. Those countries that are the highest performing educationally already integrate mobile devices in their education. This paper synthesizes empirical research on mobile devices from 2010 to 2013 in K-12 schools by focusing on studies that demonstrate emerging themes in this area. It is also clear that the pedagogy needed to be successful in creating positive outcomes in the use of technology has to be student-centered with the aim of personalizing the learning experience. Research found that students could become collaborators in designing their own learning process. As students become independent learners, they become more prepared in the skills needed for college and in their careers.

Introduction

Maximizing school learning to best benefit individuals and communities requires individualizing educational experiences and resources for each learner. The key roles of technology in

individualizing learning include providing anytime anywhere access to education tools and content, and guiding the use of the tools and content with flexible and responsive path, pace, and pedagogy according to learner needs, interests, and choices. Ubiquitous access to these learning environments is intended to enhance engagement, thereby amplifying knowledge acquisition, skill development, and application of learning in comprehensive tasks. Personalized learning is a promising way to differentiate pedagogy for all students and prepare them for college, career, and community (Weber, Biswell, & Behrens, 2014). Effective personalized learning environments provide tools and learning resources that students use in self-directed and self-paced learning. Because learning is deepest with guidance and interaction, the content and tools should be collaborative (Jonassen, 2012).

This chapter explores anytime anywhere learning by synthesizing recent research in K-12 mobile learning. Operationally defined here, mobile learning or m-learning includes school learning experiences and environments that are accessible to students in and out of school with devices and services that go with students when and where they learn, including in blended and online programs. These environments may include laptop computers; however, they increasingly include tablet devices and mobile phones. We review relevant research across mobile devices, specifying the form when possible.

School age children experience a wide range of physical and cognitive development stages from entry to school leaving. Thus, these stages have implications for learning environments, tools and resources, the roles of teachers, and educator professional development, and these differences should be considered when applying the research findings that follow. Table 1 briefly outlines the differences between categories and implications as they pertain to mobile learning.

Table 1. Learner stages that influence design of mobile learning approaches.

Category of difference	Early years (age 5-10)	Later years (age 11-18)
Cognitive development (Piaget, 1973)	Concrete thinking is strengthened as the foundation for abstract reasoning.	Abstract reasoning develops and is refined.
Optimizing learning (Papert, 1996)	Cognitive development depends on manipulation of physical and virtual objects. Logo, Turtle, Scratch are examples that bridge physical and virtual.	Conceptual development depends on exploration and manipulations of ideas and principles. Coding and cognitive mapping are examples.
Learning environments (Vygotsky, 1978)	Schooling emphasizes limited social development, real world experiences, and exploration of things and situations. Learning is guided by teacher feedback.	Schooling emphasizes broad social development, pre-professional experiences, and exploration of roles and identity. Learning is guided by peer and expert feedback.
Pedagogical content knowledge (Shulman, 1986)	Teachers emphasize content through alternative forms of representation.	Teachers combine the two domains of knowledge into pedagogical-content knowledge.
Roles of teachers (Mishra & Koehler, 2006)	Teachers guide psychomotor and cognitive skills, and development of close social ties.	Teachers guide conceptual and reasoning skills, and development of social ties.
Educator professional development (Laurillard, 2012)	Professional development focuses on media to present content, tools to create media in application of content, concrete skill development, personalization.	Professional development focuses on data and abstract representations, tools to visualize and explore concepts, systems for collaboration and integration into communities and professions.
Technology affordances (Jonassen, 2012)	Technology must be media-rich with power for knowledge acquisition and demonstration of learning, embedded in story; technology must be an interface with the physical world.	Technology must be data-and collaboration-rich, with powerful tools that connect to the world of ideas, embedded in relationships; technology must be an interface with communities.

In the following section we review learning affordances and limitations of mobile technology for primary and secondary students from empirical studies, national and academic perspectives. Then we offer some implications and recommendations for policy, practice, leadership, and research in order to guide adoption and advancement of K-12 mobile learning.

Research guided policy and practice on Mobile Learning

The design and implementation of a mobile learning program depends on the vision and needs of a school or government. Documented purposes include influencing student achievement (Martin & Ertzberger, 2013; Wu, et al., 2012), increasing student-centered teaching practices (Cochrane, Narayan, & Oldfield, 2013), closing the digital divide (Traxler, 2010), and improving family involvement in education (Kim, Hagashi, Carillo, Gonzales, Makany, Lee, & Garate, 2011). Personalization of learning (Sattler et al., 2011; Melhuish & Falloon, 2010; Peng et al., 2009) is a recent addition to the goals for mobile programs in schools. Past rationales have focused on improving the conditions that influence learning, such as student engagement, motivation, attitude and confidence, and student organization, study skills, and study habits (Gardner, Morrison, & Jarman, 1993; Warschauer, 2006; Benton, 2012). Reasons related to teaching practice now cite collaboration (Park, 2011; Sattler et al., 2011; Pettit & Kukulska-Hulme, 2007; Motiwalla, 2007, Maor, 2008) more commonly than previous goals that included student-centered practices (Fairman, 2004; Cavanaugh, Dawson & Ritzhaupt, 2011), inquiry-based practices (Fisher & Stolarchuk, 1998), cooperative learning and project-based instruction (Warschauer & Sahl, 2002; Fairman, 2004), and differentiated instruction (Fairman, 2004). Academically, with the added emphasis worldwide in measures such as PISA, mobile devices have been associated with student acquisition of 21st century skills (Wakefield & Smith, 2012) and general academic skills (Shin, Norris & Soloway, 2007).

The collaborative capacity of mobile devices and learning environments are very well suited to cognitive development. It is accepted in learning sciences that multiple forms of conversation, interaction, and collaboration amplify learning. Research in mobile learning environments (Ekanayake & Wishart, 2011; Zurita & Nussbaum, 2004) shows significant learning gains with mobile collaboration. Language, mathematics, and academic skills are complex cognitive processes requiring immersion and practice over time. Success can be magnified by mobile learning because learning time and the learning environment can extend far beyond the classroom and class period. Mobile devices, digital resources, and collaborative learning tools give each student continual access to the types of self-directed, personalized learning that expands learning as needed throughout the duration of a course with the teacher's support (Graham,

2006). Among the highly effective learning approaches (Hattie, 2013) that are well-supported by mobile learning are vocabulary programs (language practice, games), creativity programs (drawing, writing, video), meta-cognitive strategies (mind mapping, brainstorming), reflection (journals, portfolios, note taking), feedback on performance, especially formative evaluation (annotation of student work, peer review, polling), spaced practice (flashcards and formative assessment apps), and mastery learning (adaptive lessons and games). In the sciences and social studies, much mobile learning research at K-12 levels applies augmented reality in ways that increases meaningful learning of complex concepts and systems due to authentic opportunities to explore time and space (Cavanaugh, 2011).

Learning language and mathematics with technology is most effective by far when the use of the technology tools are controlled by students and when the technology is flexible and open-ended, such as through the use of mind tools including word processors, digital notebooks, and spreadsheets (Hattie, 2013; Jonassen, 2012). Further, learning with technology is far more effective when peer learning and interaction are optimized, such as with collaborative tools (Hattie, 2013) or assistive technology tools (Maor, Currie, & Drewry, 2011).

The World Bank and Brookings Institute research (Yuki & Kamayama, 2013) indicates that school mathematics results correspond to increased GDP and income. Effective math education must engage and inspire, and equip students with cognitive skills by using compelling mind tools and valuing open-ended explorations (Jonassen, 2012). Mobile learning approaches teach mathematical skills and strategic thinking in primary and secondary level students, as well as expanding learning time in mathematics (van't Hooft, 2013).

Regarding language learning, the strongest impact on reading skills comes from attention to spatial and auditory perception, skills that are well-supported using technology (Hattie, 2013). Writing skills are best developed through strategies and practice in planning and revising, especially in peer groups, activities that are effective in shared text and journal apps (Hattie, 2013). It is through this type of “comprehensible input” that seems to be the most direct path to acquiring the grammar and vocabulary of a language, and to applying the language in real communicative situations (Krashen, 2003; Watson, 2009). Mobile learning environments support classroom and out-of-class comprehensible input through engagement in a receptive stage of reading and listening followed by a productive stage of speaking and writing because all of the tools are easily accessed and learned. A large study involving 10 schools in two US states examining mobile learning and literacy suggests that mobile devices have contributed to students gaining broad skills, knowledge, and abilities that support learning and literacy de-

velopment (Warschauer, 2006). The study documents shifts toward interdisciplinary, iterative, public, collaborative, purposeful, and authentic writing tasks along with increased range in writing. The study also suggests mobile computing leads to higher quality student work, more autonomy in the writing process, more individualized learning, and development of multimedia literacy that integrates 21st century skills (Warschauer, 2006). Overall writing ability increased significantly, with the largest increases noted in groups who used mobile devices in all stages of the writing process (Warschauer, 2009). Mobile language learning systems were found to be effective and engaging for vocabulary development through spaced practice (Thornton & Houser, 2004). Research showed that reluctant readers were more motivated to read eBooks on mobile devices (Maynard, 2010). In language application, students appear to analyze and synthesize text better with graphic organizer apps than when they use non-technology tools (Garcia, 2011). Language learning has benefited from the anytime capabilities of mobile technology (van't Hooft, 2013).

Assessment of student learning in the mobile environment should be a seamless, developmental, and integrated part of the learning process (Marzano, 2002) using forms such as portfolio, project-based, and other performance assessment aligned with development of academic and 21st century knowledge, skills, and dispositions. Marking rubrics aligned to each assessment approach can be embedded in the collaborative environment shared production tools. Assessment that centers on formative feedback is among the most effective practices (Hattie, 2013). Mobile technology enables frequent feedback, as well as reflection on learning that develops metacognition supported by research in persistence (Dweck, 2006). Shared note taking and journaling apps have been shown to improve student exam performance when they are used to prepare and to reflect on learning (Michaelsen & Mohr, 2010), and to improve note taking quantity and efficiency in students with learning disabilities such as dyslexia (Garbo, Mangiatordi & Negri, 2012).

The following section presents an overview of recent research to ascertain what empirical studies say about K-12 mobile learning environments.

Research Synthesis

What does the research say about m-learning?

Our analysis began with an electronic based search of a number of educational databases of Proquest; Educational Resources Information Centre (ERIC) and A+ Education Informit. The initial search was limited to peer-reviewed documents over the last five years using the key

terms “m-learning” and “mobile learning” and yielded 3807 articles. The search was further refined by including more keywords, “peer learning” and “K-12” that yielded 46 studies, and another set of technological terms such as “mobile learning”; “tablet computing” and “school” and “personalized learning” which resulted in 23 studies. In the final cull, abstracts and papers were reviewed, and those papers which were based on empirical research and within a K-12 setting were kept for further consideration. Finally, we selected ten studies from 2010-2013 to identify the major themes in mobile learning research.

The ten-selected research articles illustrate a very interesting scenario about pedagogical models and the teacher’s role in personalizing learning. M-learning in these research studies allowed for flexibility, customization, collaboration, and co-creation. The use of a Mobile Adaptive Learning System in high school (Hus, et al. 2013) or a tailor-made eBook in elementary schools (Yueh-Min Huang, et al. 2012) enhanced personalized learning and enabled students to practice language study anywhere and anytime. An investigation (Huang et al., 2012) into how students’ personalized learning using smartphones in primary science classrooms found that a goal-based approach supported the students in personalizing their learning. Students using mobile phones in a middle school who worked as mathematicians to explore authentic problems (Daher, 2010) resulted in the construction of useful knowledge in mathematics.

When using text-messaging in a secondary school on personal mobile phones (Faure & Orthobr, 2011), the asynchronous nature of texting enabled the students to reflect more although some teachers were reluctant to use mobile phones. Others (Riconscente, 2013; Lan, et al, 2010) explored the use of a fractions game application on iPads to examine students’ fractions knowledge and attitude or the use of tablet PC to learn computational estimation skills. In both cases the use of mobile technologies helped elementary school students develop their mathematical skills.

In a study that involved a cloud-based adaptive learning system that incorporated mobile devices in a year eight science classroom, Nedungadi and Raman (2012) found that through formative assessment the system provided teachers with real-time feedback about individual and group learning. The framework also included pedagogical recommendations to the teachers that were based on the users’ knowledge levels and preferences.

However, the results of using mobile tools were not always positive. According to Fitzsimmons (2011) when the iPad was used as a teaching tool, teachers were required to invest considerably more time in talk related to classroom control and resource management and students’ engage-

ment was lower than for comparable tasks when the iPads were not used. In an empirical study (Kim, et al., 2010) that involved 160 students in urban slum and rural village communities in Mexico, students in the rural village benefitted more from the mobile technologies, but there was no evidence about the teachers' perceptions or preparation of the technology. In this rural community the rapid adoption of mobile learning technology was driven by the students rather than the teachers.

These exemplary studies found that students' personalized and cooperative learning was facilitated through the use of mobile devices. These empirical research studies were conducted mainly in elementary and middle school, and therefore more research is needed at the secondary level to help teachers develop appropriate pedagogies and to create greater understanding on the m-learning potential and its impact on students learning.

National Perspectives for Mobile Learning

Governments and education institutions are under increasing pressure to rationalize new programs financially and educationally (Warschauer, 2009; Perkins & Saltsman, 2010). In many countries, mobile learning is embedded in a broader digital inclusion agenda that is promoted to enable all citizens to fully participate in their communities, benefit from online services, and access learning opportunities that will prepare them for the future workforce. "Some 125 million school children around the world remain illiterate, even after four years of attendance – a waste of \$129 billion a year" (United Nations, 2014, np). Worldwide, countries are committed to universal access to quality education as a foundation for vibrant economies and societies. Technology access for students, teachers, and families empowers anyone, anywhere with the opportunity to have a top quality education, in part because its reach and scalability exceed the capacity of many countries to provide universal traditional schooling. For all citizens, access to the global digital society means economic, employment, and social opportunities. For governments, increasing digital inclusion accelerates employment by bringing training in reach of all citizens. Education is the most significant factor correlated with entrepreneurial growth (McKay, Williams, Atkinson & Levin, 2014). Digital access is used to bring young children learning opportunities that speed school readiness, reduce holiday learning slides, and close achievement gaps among groups of students. Access to digital tools and content affords expanded learning time beyond the school day (Cavanaugh, 2009), which increases school engagement and completion.

In addition to the economic benefits, digital inclusion makes possible an array of social benefits. Digitally-empowered teachers and students are being leveraged around the world to allevi-

ate numerous educational problems, including crowded schools, shortages of secondary courses needed by remedial or accelerated students, lack of access to qualified teachers in a local school, students who need to learn at a pace or in a place different from a school classroom (Ferdig & Cavanaugh, 2011; Ferdig, Cavanaugh & Freidhoff, 2012), and students in remote areas such as the outback of Australia (Barbour, 2011). Where a national vision of social and economic benefits from mobile technology aims for a knowledge-intensive economy, a greater premium is placed on cognitive skills and on lifelong learning, adapting, and innovating. Knowledge-intensive activity generates growth and expands exports, and thus may be crucial to national prosperity. Knowledge-intensive activities require application of significant intellectual effort, idea generating, and problem solving of the type that require extensive time with the mind-tools of technology (Mares, et al., 2013). These benefits result in many positive contributions to society. An OECD report (2010) links home computer use to academic success.

Further, the longer a child has an Internet-connected device at home, the stronger are the academic benefits, even stronger than school computer use: according to the Broadband Commission, a joint body of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Telecommunication Union (ITU), every 10 percent increase in broadband penetration results in additional growth of 1.3 percent in national gross domestic product (GDP) (Broadband Commission, 2010).

Education Policy Perspectives on Mobile Learning

As digital inclusion is approached, academic gains are expected. Lessons may be learned from international high performing schools that are benchmarking based on international measures such as PISA as well as UNESCO measures like child well-being and economic competitiveness. This approach was used in an analysis that identified noteworthy examples of educational transformation (Hargreaves & Shirley, 2012). Factors contributing to these successes are summarized in Table 2. Many of these high-performing education systems have already integrated mobile learning into their visions for transformation.

Table 2. Policies and practices of high-performing education systems

Schools	Policies and practices
Finland	Investment in teacher quality, teachers as curriculum developers, communities of educators, autonomy of schools, community participation in education
Singapore	Teaching with technology, school autonomy, learning-centered teaching, iterative innovation, collaboration within and among schools as well as with policy and research agencies, alignment of education strategy with national economic needs, mobile learning days
Alberta, Canada	School innovation and teacher inquiry focused on learning, networks of schools, long term vision and planning, education culture of risk and trust
Ontario, Canada	Education for all policy with differentiation and strategies for learning of all students, professional learning communities, inclusive pedagogy, assistive technology, local authority with integrated strategy and shared accountability
California, USA	Leadership focused on equity, Innovation of school structures to increase engagement and differentiation, inquiry at school level, professionals as intellectuals.

In addition to countries already identified as high-performing, several countries are adopting mobile learning as one of the reform strategies in their focused drives to become high-performing. These countries include the United Arab Emirates, Qatar, Malaysia, Mexico, Thailand, Slovakia, and Japan.

Parents and government leaders understandably focus attention and resources on schooling that will prepare students with core cognitive skills needed for college, higher education, career, and civic participation. Thus, educational initiatives including mobile learning are expected to develop thinking and communication with literacy and numeracy. To answer the question, “In what ways have school mobile learning programs related to improved literacy and mathematics achievement?”, we can begin with the most recent Programme for International Student Assessment (PISA) results and map the most-improved countries to their national mobile technology programs (OECD, 2013). Between 2000 and 2012, the countries that have recorded the highest increases in math and reading scores are shown in Table 3, although starting points varied, so growth potential was relative.

Table 3. 2000-2012 PISA improvements

Rank in improvement 2000-2012	Mathematics	Increase in points	Reading	Increase in points
1	Peru	76	Peru	57
2	Brazil	57	Luxembourg	47
3	Poland	48	Albania	45
4	Luxembourg	44	Poland	39
5	Chile	39	Israel	34
6	Israel	33	Liechtenstein	33
7	Portugal	33	Chile	31
8	Italy	28	Latvia	31
9	Latvia	28	Indonesia	25
10	Mexico	26	Germany	24

Among the five countries with the greatest overall academic improvement over the past decade in both Mathematics and Reading, [the] four that instituted national or large-scale mobile learning programs and key policy changes, are shown in Table 4.

Table 4. Mobile learning and policy change in most-improved PISA countries

Country	Mobile learning program	Policy changes
Chile	Eduinnova	Integrated professional development to transform pedagogy
Peru	OLC-Peru, PCs for all students in 500 schools	Focus on rural schools, emphasis on collaboration in teaching and learning
Poland	European Schoolnet, ePoland	National reform integrates ICT
Portugal	Magellan, public private partnership	Math Action plan and Technology Action plan

Policies that high-performing and improving countries have in common support student-centered learning with the affordance of mobile environments, showing the need for holistic planning (OECD, 2013). The key policies included highly qualified teachers, longer school

days, technology for all students, and expanding preschool/primary education. Specific policy changes enacted between 2000 and 2013 by the most improved countries included the improvement of data and information on learning accessible to schools, increased student-computer ratios, and increased teacher qualifications and professional development.

Professional Development for Mobile Learning

Time spent in professional development, especially collaborative professional development, is one of the most effective differentiators of high performing schools (Jensen, Hunter, Sonne-
mann & Cooper, 2014). Internationally and in the US, student academic achievement is linked directly to the time their teachers spend in professional learning, especially collaborative learning. Countries with high PISA results tend to be countries with more time in the teaching day for professional learning (OECD, 2011; Darling-Hammond, Wei & Andree, 2010). A holistic ecosystem of curriculum and content, pedagogical and leadership approaches, and technology-empowered learning environments can bring the vision to life, and points to quality criteria. The following holistic framework (Table 5) has been found to be effective in large-scale mobile learning programs (Cavanaugh, Hargis, Soto & Kamali, 2013).

Table 5. Framework for holistic professional development

Vision for holistic education transformation (Why)		
Pillar 1. Where	Pillar 2. What	Pillar 3. How
What are the elements of the learning environments that will transform education?	What curriculum and content will transform education?	What pedagogical and leadership approaches transform education?
Levels of technology adoption: SAMR model (2012) <ul style="list-style-type: none"> • Substitution • Augmentation • Modification • Redefinition 	21st Century Learning Foundational Knowledge Meta-Knowledge Humanistic Knowledge (Mishra & Kereluik, 2011)	Technology, Pedagogy, and Content Knowledge (TPACK) (Koehler & Mishra, 2009) framework for technology integration
Quality indicators and measures for education transformation		

Research in professional development for mobile learning indicates that educators most value

having their individual needs considered, attention to time demands for learning, acknowledgment of their anxieties, and ways to get information on their fundamental questions (Psiropoulos, et al., 2014). These results suggest that ongoing, job-embedded, peer-facilitated approaches to professional development are needed, in keeping with the 4Cs model that follows.

1. **Champions.** The foundation of sustainable professional development for school transformation is local champions who are already innovative teachers, who engage in training on adopted changes and engage in interactive discussions, small group work, and the creation of samples of effective teaching, and who facilitate learning among colleagues.
2. **Create.** Educators and support professionals should identify exemplary student work, media assets, lessons, and assessments to share and refine as "creative commons" property in the learning community.
3. **Communicate.** Using virtual environments along with onground approaches, champions, and leaders facilitate sharing of pedagogical success so it builds quickly and efficiently. These communities connect every teacher to high-impact, personalized, and collaborative, job-embedded learning in iterative cycles of lesson study, looking at student work, creating content, and inquiry into practice (Dawson, Cavanaugh, & Ritzhaupt, 2012).
4. **Celebrate.** A teacher peer-sharing event is an occasion for faculty to share their experiences about using the innovations in teaching and learning. Celebrations should be regular events designed to move the culture of innovation and transformation forward (Cavanaugh, Hargis, Munns, & Kamali, 2013).

Implications for Policy and Practice

To increase the likelihood of education benefits for mobile learning, the following recommendations for implementation are offered. Innovative and effective schools with the attributes needed to envision and enact a successful mobile learning program are associated with a clear and specific vision for education and the role of the school (Jensen & Sonnemann, 2014). These schools recognize the importance of getting buy-in for change from across the system and throughout the school. These schools view technology as one of the tools needed to accomplish their goals, employed to enhance teaching and student learning (Cavanaugh, Dawson, & Ritzhaupt, 2011).

Schools leaders should consider classroom, school, district, and home factors, including pol-

icies and conditions that may enable or inhibit program success. These may relate to physical space, security of information and equipment, availability of digital curricula and library materials, and teacher latitude in forms of learning assessments.

They should also include families in planning so they have opportunities to experience technology-empowered learning, understand how children will be protected, know that the teacher is central to facilitating mobile learning, and become advocates for the richness that technology brings to the classroom. Providing as much access to the technology as possible for students and teachers increases the level of control of the learning process and to expand learning time, especially for students at risk of not completing school (Cavanaugh, Repetto, Wayer, 2013). Teachers are encouraged to place instructional focus on interactive and collaborative uses of the technology, such as interactive books for literature circles, student design projects involving capturing and working with media, and engaging apps for practicing skills for mastery as well as deep learning. Integrating technology with curriculum and assessment helps to achieve clear, measurable educational objectives. These collaborations can be increasingly global with new on-the-fly voice and text language translation technology, prompting research opportunities to examine development of authentic 21st century skills. Using technology in ways to show students the process of problem solving and have opportunities to use technology in problem solving develops higher order thinking skills (Ritzhaupt, Dawson, Cavanaugh, 2012).

Implications for Research

With the advance of technology, there has also been an increase in discovering aspects of learning that can be challenged by the technology and in particular there is concern of whether the digital pedagogies enable the teachers to maximize learning using the emerging technologies. Some of the following questions are major foci for future research and educational practitioners: What are the gaps in m-learning research? How affordable is the introduction of mobile technologies in the current classroom environment? How sustainable is the impact of technology on learning? What is the best practice for Professional Development? and To what extent do teachers and students as end-users take a role in planning and implementing this new emerging field? Other questions related to PD include: What is the role of digital pedagogies in helping with PD, and what is the role of the PD in enhancing the use of mobile technologies in the K-12 curriculum? These questions require continuous research in the K-12 m-learning environment.

To address this concern, detailed knowledge is needed for leaders, policymakers, educators,

instructional designers, and professional development providers.

- Communities can benefit from research-based models for bridging education divides in places where schooling is not available, not practical for all children, and not enough for adults needing new skills.
- Educators, content developers, and mobile learning product developers can apply refined, research-based guidance on the specific device configurations, features, instructional design approaches, and pedagogical practices that can be expected to be effective for specific learners and learning environments.
- Teacher educators and providers of educator professional learning should have access to evidence-based recommendations on how teachers can best develop their mobile teaching skills. For example, will they lead students better in mobile learning environments if they have had successful learning in these environments? Can pre-service teacher programs embed students in K-12 mobile learning programs in support of this goal? In what ways can mobile learning propel new education approaches, such as collaborative assessment, competency-based learning, and new pedagogies for deep learning?
- Educators and leaders can benefit from research showing how mobile learning can serve student outcomes.

At the macro level, larger scale studies are needed at elementary and high school levels to identify the gaps in our knowledge about mobile learning. In particular, there is a need to identify challenges, limitations, and to document the success stories in schools and in the community. To do this, more authentic research methods that involve teachers in the data collection and analysis processes should yield more sustainable results for the future. This may involve research from different paradigms, such as design-based research, participatory action research, or virtual ethnography. On a micro level, some research showed (Israel et al., 2013) that students collaboratively informed the design process, which enhanced their learning. Therefore, students can engage not only as learners but also as collaborators and designers of the learning process in particular where elements of gamification can be introduced in ways that align K-12 learning environments with professional contexts.

Conclusion

There appears to be a slight shift towards personalized learning and more collaboration among students in the pedagogy used with mobile devices. It would be interesting to discover if this was a result of studies such as PISA that emphasize personal achievements that are then trans-

lated into national scores. Mobile tools are uniquely suited to increase collaboration thereby empowering students to personalize each others' learning experiences.

One of the conclusions from the emerging research is that the design of pedagogical models is essential for better adaptation of the mobile devices to maximize learning and to make the environments flexible and accessible anytime anywhere. In particular, these pedagogical models should be based on the needs that teachers and students have expressed regarding personalized and collaborative learning styles. Continuous improvement of professional development for teachers based on rigorous research as well as teachers' lived experiences will contribute to the design of digital pedagogical models.

In the future the aim will be to develop apps that enable teachers and students to move seamlessly from personalized environments to collaborative environments. Another goal will be to design features of assessment activities with the ability to consult with the teacher and to share the results with the students. These apps on mobile devices should provide mobility, flexibility, and creativity in learning.

In this chapter we demonstrated the multidimensional use of mobile devices to enable m-learning environments to challenge students in their learning. Students who use m-learning as their learning hub are prepared to be independent learners who are accomplished in the 21st century skills needed in higher education and workplaces where they adopted them (Beheshti, Jambhekar & Deloney, 2010; Barber, Haque & Gardner, 2009; Scott, 2011; Penciu, Abel & Van den Abele, 2012). These tools support knowledge sharing in distributed teams of the type students will join in college and later in their careers (Sharp, Giuffrida & Melnick, 2012). With a diversity of involvement in m-learning from teachers, policy makers, researchers, technologists, and end users; the students for whom this learning experience is aimed, there should be a greater chance that their achievements will result in a successful and sustainable story.

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