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RESEARCH ARTICLE

Socioeconomic strata, mobile technology, and education: a comparative analysis

Paul Kim · Teresita Hagashi · Laura Carillo · Irina Gonzales · Tamas Makany · Bommi Lee · Alberto Gàrate

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Abstract Mobile devices are highly portable, easily distributable, substantially affordable, and have the potential to be pedagogically complementary resources in education. This study, incorporating mixed method analyses, discusses the implications of a mobile learning technology-based learning model in two public primary schools near the Mexico-USA border in the state of Baja California, Mexico. One school was located in an urban slum and the other in a rural village community. Empirical and ethnographic data were collected through a series of achievement tests, observations, surveys, and interviews involving 160 s grade school children recruited by convenience sampling. The general technology infrastructure, distinctive features of mobile learning to supplement literacy development, profound contextual phenomena arising from the two uniquely underserved communities, and social factors possibly influencing the educational experiences are discussed. The findings suggest that students in the rural village, seriously lacking educational resources and technology exposure, may have benefited substantially more from mobile technologies than urban school students possibly due to their relatively higher socio-economic status and higher parental involvement and interest in education. In contrast, there was no evidence of interaction with parental education levels, the experience of teachers or school principals, or the teacher's perception or preparation of the technology. Overall, the mobile learning technology adoption was rapid, seamless, and actively driven by the students rather than the teacher. The challenges of the phenomenal migratory nature of most families in this unique geographical region are also discussed to benefit future studies.

Keywords Mobile learning · Rural · Urban · Mexico · Literacy development

P. Kim (✉) · I. Gonzales · T. Makany · B. Lee
Stanford University, 520 Galvez Mall #3084, Stanford, CA 94305, USA
e-mail: phkim@stanford.edu

T. Hagashi · L. Carillo · A. Gàrate
CETYS Universidad, Calz. CETYS s/n, 22159 Col. Rivera Mexicali, BC, Mexico

Introduction

Technology can be a powerful means to increase access to learning opportunities and to a broader information society (Cummins and Sayers 1995). With proper design and planning, technology can become capable of delivering education to the students even in the smallest towns in the world (Carnoy and Rhoten 2002). Mobile technology, in particular, with its low cost and accessibility, has great potential to provide access to or supplement education in rural areas (Zurita and Nussbaum 2004). Unlike desktop computers, mobile devices require substantially less infrastructure and electricity, which makes mobile devices more widely distributable and easily deployable than desktop computers especially in underserved and geologically remote areas. Several studies have shown that mobile learning devices could be effective supplementary education resources not only for schools that lack educational resources or places traditional learning cannot take place (See Attewell 2005; Sharples et al. 2005; Stead et al. 2006), but also for underperforming students (Shin et al. 2006). Also, mobile learning technology solutions have been specifically examined as a tool to support literacy exposure and development (Kim et al. 2008) and also personal enrichment (Sharples et al. 2005).

Given that mobile learning devices could be effective in supplementing education particularly in a community with a poor educational infrastructure; there is a lack of studies examining mobile learning at an eco-systematic level especially in developing regions. Thus, this study selected one school in an urban slum area and another in a rural village of Baja California, Mexico. Both schools seriously lack educational and technology resources and the general socio-economic status of the students is low (i.e., considering the nation's GDP per capita - purchasing power parity and also ranking in the world). Nonetheless, the actual learning environment in the two schools differs somewhat from one another. With the given context, we examined whether mobile learning devices could have a differential effect in supporting students' learning (i.e., potentially through self-directed literacy exposure and technology-supported personal enrichment) in the two schools with their unique socio-economic disparity.

The present study employed a series of pre/post-test, surveys, interviews and class observations to measure the effect of the mobile learning technology intervention on literacy education and analyze contextual factors that might be related to the overall student learning experiences and outcomes.

Background

General social context

Baja California is in the northwestern part of Mexico and it borders the State of California of the United States. According to a census in 2005, the state has a population of 2,844,469, ranking the state the 14th most populated state in Mexico. Currently, over 75% of the state population is currently living in the capital city, Mexicali, or in Tijuana (SINIEG 2009). The population is increasing due to a growing number of migrants from other Mexican states and from South America, who come to settle in the state or plan to cross the border to the United States, but mostly fail to do so and end up migrating within Baja California. The increase of the state population in recent decades led to increasing demand for schools, hospitals, and social services, which resulted in lowering the overall quality of services. Typical social problems in the border cities such as poor infrastructure, health issues, increasing water shortages, violence and a coinciding lack of public security, and ever increasing drug trafficking (Pineiro 2009) are serious concerns in Baja California. Such social problems have a negative impact on the school community.

Education

Over the last few decades, Mexico has focused on expanding access to basic education. Currently public schools serve 87% of children officially residing in the country (Santibanez et al. 2005). Although Mexico has achieved 97.2% of elementary school attendance (INEE 2007), inequalities in access to education are persistent between urban and rural regions. Table 1 shows the percentage of students achieving various levels of proficiency in the National Literacy Test Results between 2005 and 2007. It illustrates that students in public urban schools generally perform better than students in public rural schools. Our study re-examined whether this was indeed the case in the schools we have selected and observed the patterns of discrepancy between urban slum and rural school students' learning after the mobile learning intervention.

Technology infrastructure in schools of Baja California

The overall technology infrastructure in Mexico is poor. According to the OECD, the percentage of 15-year olds with Internet connections at home is less than 20%, while in other OECD countries this number is more than 40% (OECD 2006a. Nevertheless, more than 80% of the students in Mexico have access to computers either at home or school (OECD 2006a. These data are, however, somewhat deceptive as for example, it includes schools with one merely functional computer.

Compared to the national average, the lower primary education in Baja California also lags behind in terms of access to technological resources and infrastructure. Only 13.2% of elementary schools in this region have received computers for educational purposes, compared to the national average of 22.9% (INEE 2007).

Mobile technology as an educational resource

A wealth of recent research has emphasized that mobile technologies have great potential to contribute in education. Roschelle and Pea (2002) described that mobile technology is easy to access, promotes autonomous learning, motivates students to learn, encourages student collaboration and communication, and supports inquiry based instructional activities. In addition, Shuler (2009) explained that the increasing functionality of mobile

Table 1 Percentage of students achieving proficiency in the National Test Results in Literacy: 2005–2007

Level	Below basic		Basic		Medium		Advanced	
Year	2005 % (SE)	2007 % (SE)	2005 % (SE)	2007 % (SE)	2005 % (SE)	2007 % (SE)	2005 % (SE)	2007 % (SE)
School stratum national	18.0 (0.5)	13.8 (0.6)	50.8 (0.6)	49.2 (0.9)	24.6 (0.5)	28.5 (0.8)	6.6 (0.3)	8.5 (0.5)
Public rural	25.8 (1.0)	20.5 (1.2)	56.0 (0.9)	56.2 (1.4)	16.1 (0.8)	19.9 (1.3)	2.2 (0.3)	3.4 (0.5)
Public urban	13.2 (0.7)	10.6 (0.9)	51.9 (0.8)	49.9 (1.3)	28.4 (0.7)	31.3(1.2)	6.6 (0.4)	8.3 (0.7)

Source: National Institute for Education Evaluation (INEE), 2008 technology has created "pockets of educational potential" as mobile learning technologies can break down barriers by allowing access to and processing of information 'anywhere anytime.' Even in isolated geographical locations or areas with little or no access to educational infrastructure (i.e., lack of qualified teachers, materials, learning resources), the individual learner equipped with mobile technologies can be situated in a meaningful context that enables active learning. Such activity is the precursor of successful learning (Jonassen and Rohrer-Murphy 1999; Uden 2007). Although there are some potential usability limitations in mobile devices due to display size, input mechanisms and other contextual constraints, these can be overcome by user-focused design sensitive to human needs, capabilities and interactions (Jones and Marsden 2006). Finally, from an economical perspective, Soloway et al. (2001) and Zurita and Nussbaum (2004) have underlined the low cost of mobile learning technology as one of its major advantages. They asserted that the lower cost may ease the access issue and allow children to have a 'sense of belonging.'

Mobile learning and games

The literature also shows that mobile learning devices can be effective tools for low-performing students and students who also may lack educational resources outside school. Shin et al. (2006) conducted a study to investigate the effect of mobile math games on student learning. Their study showed that a mobile learning device coupled with a game activity in the classroom was beneficial for students overall, but had a greater effect for low achieving students. In regards to games, an earlier study by Schwartz (1988), who conducted a study on primary students with games designed to improve reading comprehension, showed that poor performing students had significantly higher score gains than average performing students. Herselman's (1999) study also found that those South African students who lacked educational resources benefited the most from computer games.

Mobile learning, literacy development, and language learning

The development of mobile technologies has also opened up possibilities for the literacy development and language learning (Joseph and Uther 2006). For example, in an attempt to provide literacy exposure for children who do not have access to schools or books, Kim (2009) conducted an action research with mobile short story books and observed how children responded to the mobile learning model. Brown (2001) developed one of the earliest projects using mobile phones in language learning. He developed Spanish study programs utilizing both voice and email with mobile phones and reported that mobile phones were effective for vocabulary lessons and quizzes. Cavus and Ibrahim (2009) conducted a study that tested the use of wireless technologies for learning new technical English language words with SMS text messaging. They developed what was called a mobile learning tool (MOLT) and tested 45 first-year undergraduate students. The result of this study showed that mobile phones were helpful for students' learning of new English words.

Mobile learning in the social contextual view

As most human activities, learning and technology use are both mediated and distributed in a dynamic social context (Lea and Nicholl 2002). Nyíri (2002) reminds us that in a social environment mobile communication by itself becomes learning. Modern learning theories, such as social constructivism (Crook 2002) or cognitivism (Dror and Harnad 2008) also emphasize the importance of the socio-cultural environment by describing learning as an active, engaging and dynamic interaction between people that has a fundamental influence on educational development (Driscoll 2000). Consequently, it is not enough to examine the technological artifacts and instruments operating behind mobile learning, but researchers should also pay attention to the underlying socio-cultural values that add to the formation of these learning activities (Jonassen and Rohrer-Murphy 1999). For example, Straub et al. (2001) and Anandarajan et al. (2002) demonstrated that cultural factors play an important role in information technology transfer in the Arab and in the West African context, respectively. Also, Goldenberg et al. (2005) noted that influences on children's development are embedded in family life, which is again embedded in a larger cultural context. Acknowledging this, Kim (2009) reported numerous distinctive social factors that may influence a mobile learning model especially for children living in areas of low socioeconomic status.

Research question

In short, mobile learning appears to have the potential to influence educational development (e.g., literacy exposure and development, personal enrichment, etc.) in a social context and may effectively supplement school programs, especially for communities where general technology infrastructure and educational resources may be seriously lacking.

Provided that social strata (i.e., urban slum and rural village) and economic hierarchy play a role in differentiating effects of mobile learning the following research question arises: "*How do socio-economic variations interact with learning outcomes and what specific social factors or latent agents, if any, may be identified?*"

The similar economic status combined with unique social localities between the urban slums and rural village communities in Baja California provided an ideal setting for our research on mobile learning.

Methods

Participants

A total of 160 students from two elementary schools (80 from a rural and 80 from an urban location) were selected, one in an urban slum location in a major city near the US-Mexico border, and another in a rural area of Baja California, 40 miles South of the border city. About 15% of the students in both schools were migrant indigenous children who followed their parents throughout the southern part of Mexico (i.e., Oaxaca mountain regions). The parents of migrant indigenous children often move from one place to another to seek jobs (e.g., farm workers in rural villages or manual laborers in cities) and in many cases, they do not speak the mainstream Spanish language. Due to their migrations, many of these children never attend a school long enough to complete a grade.

Both schools were state elementary schools and had morning and afternoon programs (i.e., 8 a.m–12 p.m and 1 p.m.–5 p.m.). The teaching staffs were permanent at both locations, although double-shifts are common practice in underserved communities due to economic and financial reasons.

Both schools at each location had one experimental group (integrating mobile learning devices) and one control group (without the mobile devices) with 40 students in each subgroup. Second grade students (7–8 years old) were selected because preliminary tests showed that first grade students (6–7 years old) had not reached the level ready for the first grade curriculum standards adopted for the mobile devices.

As additional measures, a total of 33 parents (19 from the urban location & 14 from the rural location) of participating students were interviewed, using self-report surveys. In addition, the participating teachers and school principals from each school were also interviewed a total of four times (30 min each).

In order to minimize disruption of the schools' overall curriculum plans and on-going scheduled activities while taking advantage of the unique existing structure where one teacher teaches the two same grade classes, a nonrandomized control-group pretest–posttest design (Campbell and Stanley 1966) was employed. Although a random assignment was considered initially, it turned out that a random assignment at both schools with only two classes for the second grade would require not only rescheduling of classes, but also pick-up times for parents who may not accommodate such major changes due to their existing work or family commitments. Therefore, the present study design was based on practical feasibility with convenient sampling, falling short on minimizing threats to internal validity. However, there was no apparent indication that students in the two respective subgroups would perform or behave differently and the pretest showed that all participating groups were statistically homogeneous in terms of their literacy achievement.

Setting

The urban school

The socio-economic status of the students in the urban school was lower than that of the rural school (See parent income disparity in the results). The urban school, like other schools in the low-income area in the border city, had very poor infrastructure that consisted of a half-classroom size library facility. Additionally, only a single room in the entire school was equipped with one computer, projector and access to the Internet. The parents of the students worked mostly for factories or were unemployed.

The rural school

In contrast to the urban school, the overall socio-economic status of the students in the rural school was slightly higher. Although the rural school had a computer lab, the computers were stacked up under dust, not arranged to be used and there was no Internet access at the school, leaving the school without single functioning computer and Internet access. The teacher in the rural school had 2 years, while the school principal had 4 years less working experience than their respective colleagues in the urban school. Both schools reported an extremely high (over 50%) student dropout rates.

Mobile learning device

Students in the experimental groups were equipped with a mobile learning device called TeacherMate (see Fig. 1). The device featured a color screen (11 cm × 7.5 cm), four direction arrow buttons, three control buttons, one execution button, a built-in microphone,

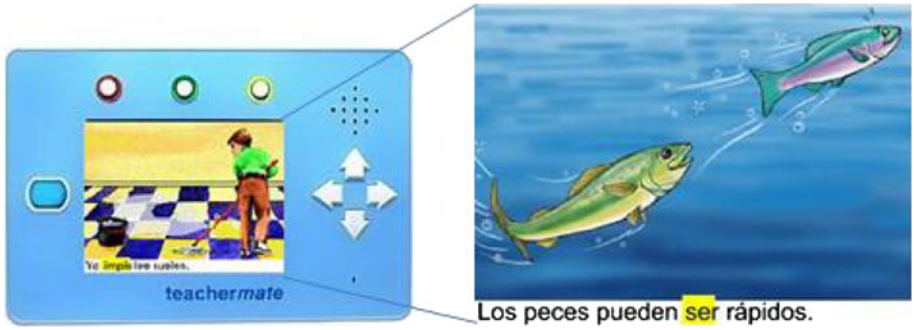

Fig. 1 TeacherMate mobile device and a screenshot of the e-book sample

an integrated speaker, USB data port, and a headphone output jack. The manufacturing cost of a single device was $50 USD. The device uses the same ARM processor (i.e., Advanced 32-bit RSIC, reduced instruction set computer, Machine) that conventional smartphones use and its architecture can allow an 802.11 wireless module (i.e., $\sim$ $60) to be integrated. Technically, it could also host other Linux kernel variants and various sensor modules (e.g., accelerometer, GPS, temperature, humidity, IR, sonar, etc.) to create advanced mobile interaction opportunities if required. Currently, it uses a USB communication port to exchange, download, or upload contents and student performance data for various academic activities and analyses.

Each TeacherMate was labeled with each student's name, creating and promoting the sense of ownership and personalization. Small plastic cases, specifically designed for storage, charging, student data download, were placed in the classroom for students to quickly access and put away the devices.

For this study, each device was pre-loaded with 18 short story e-books (mobile e-books) aligned with the first grade Spanish reading curriculum. The mobile e-books were coupled with a text-to-audio feature in Spanish (i.e., enabling the student to look at the images associated with the stories, hear corresponding narrations, and read the text of the stories by following each word as it was highlighted and narrated with either a male or female voice). The device also allowed the student to record their own narration as the student was prompted to read the text on screen and replay their own recordings. This feature enabled the student to compare the programmed narration with the personal reading. The reading program was developed in open Flash (GNASH) under Linux operating system, allowing open-access and easy development for further interactive learning contents with little knowledge of Flash programming.

With the series of reading materials on the device, those individuals who wanted to advance were able to freely advance while those who were falling behind were able to repeat and reread stories at will. Overall, the configuration of the device for this particular study focused more on individualized remedial and self-directed personal literacy enrichment opportunities.

Literacy achievement test and surveys

A 40-items, standard, Spanish literacy assessment instrument (i.e., achievement test) developed by the school district was adopted to measure the individual student's level of literacy. The achievement test was not modified or tested for its reliability. The questions were such as matching questions (e.g., action verb—action image, vocabulary—object, vocabulary—color, vocabulary—size or direction description) or fill-in-blank questions.

Surveys for teachers and principals, consisted of both open-ended and multiple choice questions, measured their perception and attitude towards technology for education in general, the mobile learning model, informal learning options, educational resources, school planning, previous and current educational technology projects, etc. The surveys for parents inquired about their combined family income, education level, parental support for their children's learning, ownership of a computer with Internet access, learning resources at home or in their neighborhood, their perception and attitude towards technology in school, etc.

Procedure

One week prior to the experiment, teachers at both locations were trained to use the mobile device for 1 h. The teachers followed the instruction given by the researcher and explored contents on the device without much difficulty. At the beginning of the experiment, the mobile device was introduced to the students by the researcher. The students quickly adopted to use the device in less than 20 min at both schools and even some cases, (i.e., as shown in Fig. 2) students volunteered to help each other on how to navigate contents on the device.

However, there was still a 40-min orientation session for the students to freely explore the device in which period the teacher and researchers were roaming in the classroom to provide any support to any student who might struggle to use the device. In the orientation period, there was no special activity other than simply learning to use the device and exploring different short story contents on the device. Following the orientation, teachers used the device as a supplement to regular classroom activities. The participating teachers freely decided the mobile learning time amount and frequency as needed. They indicated that they had the students use the devices mostly twice a week for an average of 20 min each, amounting to at least 640 min of individual mobile learning time in class for the span of 16 weeks.

Fig. 2 Students helping each other with the mobile learning device

Unlike the orientation period when students were free to interact and help each other learn about the device, during the period of learning with the device, students were interacting with own devices individually. This enrichment activity (i.e., consists of reading with visual effects, listening narrations and own recorded voices, and reflecting, etc.) was personal and at the individual level because each student freely selected own materials and interacted at own pace.

The teachers did not allow the student to take the devices home although it was specifically requested by the researcher. The teachers at both schools emphasized that there is usually a high drop out rate at the school. The researcher followed the teacher's advice and the devices were used only in school.

Data collection

A literacy achievement pretest was administered in September 2008 with two intervention groups (experimental & control) at both Locations (urban & rural), creating four subgroups in total (i.e., Urban-Control; Urban-Experimental; Rural-Control; Rural-Experimental). This pretest was 2 weeks after the initial introduction of the mobile devices. The interviews with principals, teachers, and parents at both locations were conducted at the same time of the pretest.

A follow-up literacy achievement posttest was administered in December, 2008, exactly 16 weeks after the initial orientation. All interviews and test were conducted in Spanish by a native researcher from a regional university.

Results

A 2 (Location) × 2 (Technology) × 2 (Time) mixed-model Analysis of Variance (ANOVA) with Location and Technology as between subjects factors and Time as within subjects factor revealed a significant main effect of Location, $F(1, 88) = 7.88$, $p = .006$, partial $\eta^2 = .08$; a significant main effect of Technology, $F(1, 88) = 8.66$, $p = .004$, partial $\eta^2 = .09$; and a significant main effect of Time, $F(1, 88) = 7.67$, $p = .007$, partial $\eta^2 = .08$ on the literacy achievement test scores. The main effect of Location revealed that the literacy scores were higher in the Rural school ($M = .68$, SE = .02) than in the Urban school ($M = .56$, SE = .02). The main effect of Technology revealed that the literacy scores were higher in the Experimental group ($M = .64$, SE = .02) than in the Control group ($M = .60$, SE = .02). Thus the use of mobile learning devices significantly contributed to higher literacy achievement levels in contrast to the control situation where only existing educational materials were used for literacy development and enrichment. The final omnibus test of Time showing a main effect revealed that compared to the average initial scores ($M = .45$, SE = .02), students improved their literacy levels over the course of 16 weeks of learning ($M = .62$, SE = .02).

To further examine the between subjects main effects (Location & Technology), four independent post-hoc *t*-tests with Bonferroni correction were calculated. These post hoc tests compared subgroup effects separately at the pretest and posttest. At the pretest, there was no statistically significant difference between Technology, $t(78) = .46$, *n.s.* in neither the urban, nor in the rural population, $t(78) = 1.37$, *n.s.* Equally, there was no statistically significant difference between Location, $t(78) = 1.24$, *n.s.* in neither the experimental, nor in the control group, $t(78) = .28$, *n.s.* Thus at the pretest, all four subgroups were homogeneous in terms of their literacy achievement (see Table 2 for details).

Table 2 Pretest descriptive statistics on literacy achievement shows four homogenous subgroups

PreTest		Technology									
		Experimental					Control				
		N	Mean	SD	Min	Max	*N*	Mean	SD	Min	Max
Location	Rural	40	.47	.21	.00	.88	40	.45	.26	.00	.91
	Urban	40	.46	.24	.00	.78	40	.43	.26	.00	.89

Note: Literacy Achievement Score range is 1.00

As the teachers warned prior to the study, about 50% of the students from both rural and urban schools dropped out and migrated to a different region by December 2008 at the time of the posttest data collection. Table 3 shows the means, standard deviations, minimum, and maximum literacy achievement scores of the remaining students.

During the posttest, there was no significant difference between Experimental and Control participants analyzed separately in the urban, $t(46) = .45$, *n.s.,* nor in the rural subgroups, $t(42) = 1.40$, *n.s*. The lack of significant differences in these post hoc comparisons was somewhat surprising given the significant main effect of Technology. However, this suggests that any mobile device in itself is seldom sufficient to improve learning performance and additional factors (e.g., socio-economic factors, parental involvement, etc.) need to be considered. These factors are analyzed and discussed in the following section.

The next post hoc comparisons with Cohen's *d* effect-size (see Cohen 1988) found a significant difference of Locations as the literacy achievement scores of those students using the mobile learning devices (i.e., Experimental group) were significantly higher in the Rural school ($M = .70$, SD = .11) than in the Urban school ($M = .57$, SD = .23), $t(46) = 2.80$, $p = .007$, $d = .72$ (see Fig. 3). Taken together this finding about Locations with the significant main effect of Technology and the lack of post hoc differences in Technology intervention suggest an interaction between Location and Technology. In fact, a difference between Rural and Urban locations was only found when the mobile learning technology was used by the students.

To verify such moderating interaction of Technology on Location differences, a fourth posttest comparison of literacy achievement scores was conducted between the Control subgroups. This revealed that there was no significant difference between the Rural and Urban students in the Control group, who did not use the mobile devices, $t(42) = 1.79$, *n.s.* This confirms that the higher literacy achievement scores in the Rural Experimental group is indeed moderated by the use of the mobile learning technology and it is not simply a consequence of different Locations.

Table 3 Posttest descriptive statistics on literacy achievement shows higher scores in the Rural Location and with students in the Experimental groups

PostTest		Technology									
		Experimental					Control				
		N	Mean	SD	Min	Max	*N*	Mean	SD	Min	Max
Location	Rural	18	.70	.11	.30	.85	20	.66	.17	.15	.93
	Urban	24	.57	.23	.05	.85	24	.54	.25	.03	.95

Note: Literacy Achievement Score range is 1.00

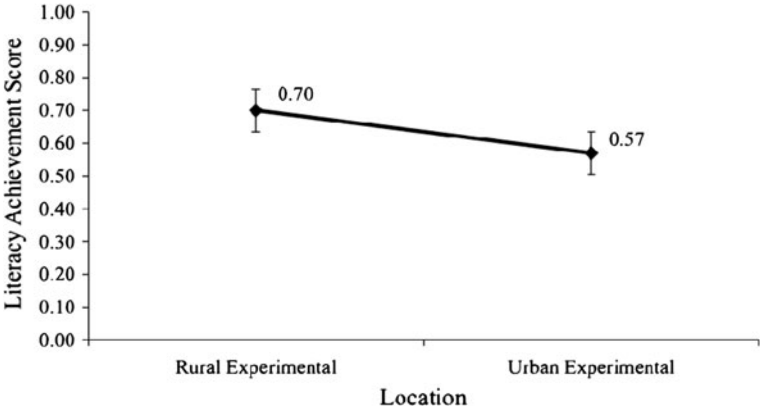

Fig. 3 Significant difference between the Experimental posttest subgroups at the two Locations demonstrating that students with the TeacherMate mobile learning device in the Rural school (*Rural Experimental*) had higher literacy achievement scores than Urban school children also using the mobile learning technology (*Urban Experimental*)

Thus, we can conclude that the use of TeacherMate as a supplementary learning tool had a fundamentally different effect in the rural school compared to the urban location. The students from the rural village benefitted more from the technology than their respective peers in the urban slums.

Finally, to examine in depth the significant main effect of Time, another set of four post-hoc independent *t*-tests with Bonferroni correction were calculated (see Fig. 4 for an overview).

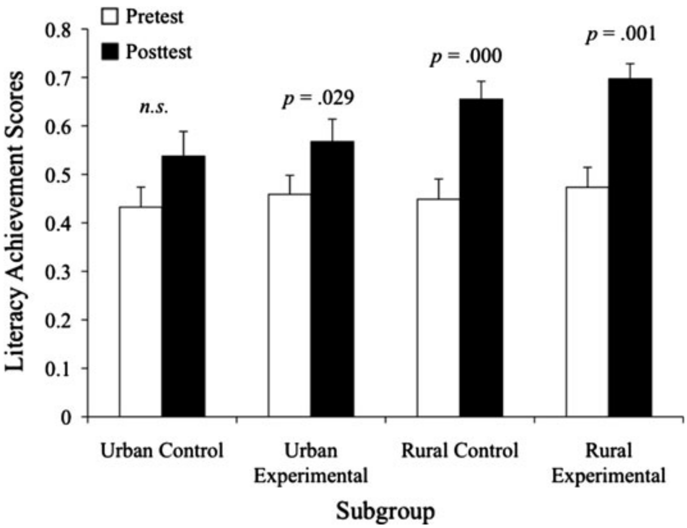

Fig. 4 Overview of the differences between pretest and posttest literacy achievement levels showing a more beneficial effect of the 16 weeks learning period in the rural group and in students with mobile learning technologies

The Urban Control pretest ($M = .43$; SD = .26) and posttest ($M = .54$; SD = .25) groups did not differ from each other, $t(86) = 1.97$, *n.s.* Due to the Bonferroni correction, the otherwise significant mean difference of 0.11 points between the Urban Experimental pretest ($M = .46$; SD = .24) and posttest ($M = .57$; SD = .23) subgroups was only considered here as a strong tendency, $t(86) = 2.22$, $p = .029$, $d = .46$. A significant mean difference of 0.21 points was found between the pretest ($M = .45$; SD = .26) and posttest ($M = .66$; SD = .17) of the Control group in the Rural school, $t(78) = 4.25$, p = .000, $d = .96$. Finally, the Rural Experimental pretest ($M = .47$; SD = .21) and posttest ($M = .70$; SD = .11) groups had a significant 0.23 points mean difference with the highest effect size, $t(74) = 3.55$, $p = .001$, $d = 1.4$.

Overall, students from the rural Mexican village benefitted differently from the 16-week learning experience than school children in the urban slums. All subgroups, with the exception of the Urban-Control, improved somewhat in their literacy performance during this period. The post hoc tests suggest that the learning (Time) was stronger in the rural setting and especially in those students, who supplemented their studies with the mobile learning device. The use of mobile learning technology appears to have a moderating interaction with other variables, such as geographical location, on literacy achievement. In the next section, we evaluate further socio-economic and external factors to better understand these results.

Parent background and support

The survey and interview data indicated further differences between the two schools in terms of the parental attitudes toward the children's education. Based on the interviews, parents from the rural school appeared to be more involved in their children's education with 90% of them being aware of the mobile learning project in the school. This was in sharp contrast to the mere 13% of the parents in the urban school, who were aware of the project. The rural school parents also spent more time helping their children with their schoolwork at home. More specifically, 94% of rural school parents spent more than 5 h a week helping their children. In contrast, 74% of urban school parents spent less than 2 h a week working with their children.

The survey result also indicated that, generally, parents from both rural and urban schools wanted their children to finish college. There was not a single parent who hoped for a below tertiary level of education. A few parents ($n = 3$) in the rural school even hoped their children would complete a doctoral degree. Overall, parents in the rural village had a slightly higher educational expectation for their children than the urban parents.

Additional survey results provided information about students' family backgrounds. The level of parents' education in general was extremely low in both rural and urban schools as shown in Fig. 5. Although a few parents in the rural village had taken at least one course at a college, the overall education experience of the rural parents was lower than that of the urban slum school parents.

The level of income, on average, was greater in the rural area, where most of the parents made an average $720 monthly, whereas in the urban slum area the majority of parents made an average $410 in a month.

Survey results also informed us about the level of exposure to technology in both areas. The awareness of technology in the urban area was generally higher than the rural area. 50% of the parents from the urban school replied that they had access to computers in their

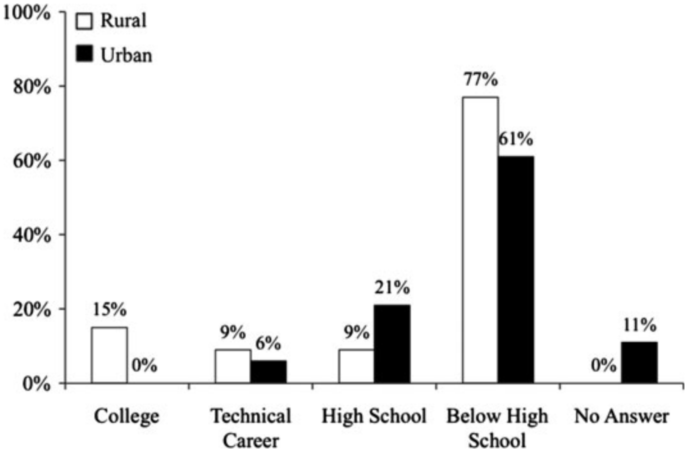

Fig. 5 Parents' level of education

community (i.e., through Internet Cafe). In sharp contrast, most respondents in the rural area (85%) replied that they did not have access to computers.

Teacher interview

Although the study result was not shared with the teachers or principals, the interviews indicated that the teachers from both rural and urban schools believed that the mobile learning devices brought about positive changes in their students' learning. The teachers also agreed that the learning process with the mobile devices was easy for both teachers and students. In addition, they indicated that the mobile devices helped the teacher manage the class more flexibly. For example, when the teacher needed to separate the class into teams for alternative group activities, the teacher was able to have a group work with the mobile learning device independently while working with another group with other activities. The teacher at both schools indicated that children's average attention span using the mobile learning device independently throughout the experiment period could be over 30 min, while the average attention span for other activities was normally less than 20 min.

Teachers at both schools also mentioned several problems with the mobile learning device. The accent of the narration of the preloaded set of stories was different from the Mexican native speakers; children found it highly entertaining when they heard the narration and were somewhat distracted them from focusing on the story content. Also, teachers reported that the learning contents of the mobile devices did not completely align with the curriculum and lesson they were teaching; teachers used the mobile learning content for mostly supplementary enrichment activities. Teachers also indicated that more training with the devices would have helped the teachers plan their daily activities better. However, the teachers agreed that their children knew more about the devices than the teachers.

Interestingly, there was a drastic difference between the rural and urban school teachers in their attitudes toward technology in classrooms. The teachers from the urban school, in comparison to the rural teachers, were more open to the use of technology in classrooms, appreciated the potential of technology, and spent more time learning and planning with the mobile learning technology in their everyday classroom activities.

Principal interview

Overall, principals from both the rural and urban school indicated that they found the use of the mobile learning device to be highly useful in the development of their students' literacy and technology competencies. They also saw the mobile learning technology as an innovative learning tool because their children seemed to be very interested in playing and learning with it.

A difference between the two principals was in their perception of teachers in the way they were embracing new technologies in the classrooms. The principal from the urban school indicated that his teacher was quite open to technology and training was somewhat easy. On the other hand, the principal from the rural school mentioned that his teacher did not embrace technology in the classrooms. He also noted that teacher training was always found to be invariably difficult in the rural school. The principal did not specify what so-called "technology" was introduced in the past.

Discussion

This study investigated the potential implication of a mobile learning technology-based learning model in two Mexican public primary schools. The quantitative analysis found a strong positive effect of supplementing regular classroom education with such technology. In addition, the pretest–posttest comparison revealed that students from rural villages benefitted more from the mobile devices than their peers from urban slums. The work of Bainbridge and Lasley (2002) helps explain these findings. They assert that the achievement gap is likely a result of an interaction of social, familial, and economic factors. In the present study, the interviews and surveys reveal convincing explanations confirming this assertion.

First, the rural school parents indicated in the survey that they pay more attention to their children's education. The number of answers reflected that 9 in 10 of the rural school parents were aware of the mobile learning project taking place at school, whereas only slightly more than 1 in 10 of the urban school parents knew about the project.

Second, the rural school parental involvement in education is much higher with 5 h a week spent with the children compared to the urban school average weakly less than 2 h. There is a substantial body of research supporting that parental involvement is one of the most significant predictors in children's achievement (See Henderson 1987; Mercy and Steelman 1982; Sammons et al. 2004).

Third, the average combined income of the rural school is slightly higher (i.e., average $720/month) than that of the urban school (i.e., average $410/month). Children in less economically advantageous schools often achieve at lower levels than children in schools that are more economically resourceful (Bainbridge and Lasley 2002; McNaughton et al. 2003). A higher income might give the rural school parent more leveraging power in providing necessary educational resources or opportunities to their children with less financial stress and greater peace of mind. Generally, a correlation between socio-economic status and children's academic achievement has been reported to exist across many countries including Mexico and the United States (OECD 2006b.

As a fourth and somewhat speculatively point, the condition of the rural community with less access to technology might have created a greater novelty effect for the rural children to engage in the mobile learning activities, leading to more attention, interest, engagement, and eventually higher achievement. The novelty effect may possibly be a plausible explanation because there was no functioning computer nor access to Internet at the rural school while there was a functioning computer and also Internet access at the urban school. Accessing electronic appliances, advanced mobile technology, or children game devices such as Nintendo is much easier for the children living in the urban setting, creating a smaller or no novelty effect for the urban school children to engage in the activity with the mobile learning devices.

According to the posttest post-hoc comparisons, rural students outperformed urban school children when their regular classroom education was supplemented with the mobile learning technology. We can find a few plausible explanations to account for this result. The use of mobile learning devices loaded with the interactive story series might have contributed to the development in the literacy achievement scores since the experimental group of the rural school used the device as individualized remedial and self-directed personal literacy enrichment tool in class. Considering the fact that the availability of educational resources at the rural school was even less than at the urban slum school (i.e., books, computer, Internet access, etc.), the extra educational resources and learning opportunities that the mobile learning devices provided may have served the children effectively. Research has documented that children living in impoverished communities have a limited exposure to vocabularies that puts them at risk for literacy development (Hart and Risley 1995). The stories on the mobile devices covered topics such as fish, birthday cake, circus, cat and dog, playground, etc., providing an expanded literacy exposure and enrichment opportunities that the children may not otherwise have. In addition, each story was accompanied by animated highlighted text, graphics, story narration, own voice recording and replaying sessions. The mobile devices highlighted sentences, word by word, slowly and synchronously as the recorded voice narrated each sentence in the story. This reading support design (i.e., helping children develop a higher level phonemic awareness skill) was discussed earlier by Kim et al. (2008) in their discussion on mobile learning. Such phonemic awareness skill enables children to use letter-sound correspondences to read and spell words correctly (Griffith and Olson 1992) and it is the ability to allocate conscious attention to the relationship between sounds in words (Adams 1990). Juel (1988) refers such ability as the best predictor of reading achievement and a prerequisite for the proceduralized identification of words as children become capable of reading effortlessly (Juel 1991).

The recording and playing feature of the mobile devices prompted the children to listen, record own reading, and replay it to compare own reading with the original narration for each story sentence by sentence. This repeated exercise might have provided the experimental group children with an increased opportunity to practice reading and correct any discrepancies (i.e., in phonemic correspondences) that the children observed when they were interacting with the mobile devices. Ultimately, reading fluency requires the automatic recognition of words, a feat that can be achieved only by repeated readings and recurrent practices. Predictable texts and repeated readings of sentence structures previously memorized also foster fluency (Kuhn and Stahl 2000).

During Q&A sessions after the experiment, the children indicated that the story topics were interesting and the overall activity was entertaining. Interesting stories coupled with entertaining activities seem to be realistic needs for children who do not have easy access to other means of entertainment such as cartoon channels on television, multi-user games on Internet, amusement parks, or movie theaters. Children will embrace mobile learning only if it meets their individual needs (Parsons and Ryu 2006) and stimulates their particular intellectual curiosities.

Without much difficulty, the children adopted the mobile learning activity quickly and engaged in the activity as the teacher presented it as a routine activity over the 16 weeks period. According to the teacher, the children with the mobile learning device completed all 18 stories and repeated the stories as they continued to play the recording and replaying feature. It is noteworthy to mention that the control group used the existing school materials for remedial and enrichment activities and the existing materials were more aligned with the assessment content used in this study.

In short, based on the overall findings, it is reasonable to conjecture that the interesting and entertaining mobile learning technology coupled with individual reading support and personal enrichment opportunities positively influenced the experimental group's literacy development and ultimately led to the higher achievement observed in this study. Also, the findings align quite well with previous studies (i.e., Herselman 1999; Schwartz 1988; Shin et al. 2006).

Alternative explanation

A compelling alternative explanation also exists to interpret the main findings of our study. In the pretest, the four groups performed equal in their literacy tests and thus were considered as statistically homogeneous (See Table 2). However, it is possible that the small initial, non-significant achievement gap (i.e., by selection threat in the design) might have increased over time as earlier performance often serves as one of stronger predictors for later achievements. Bainbridge and Lasley (2002) note that prior learning influences later achievements and also a substantial body of research demonstrates that students who experience difficulty learning to read early in their academic path continue to struggle in later stages (Juel 1988; Vellutino and Scanlon 2002). In addition, a lack of comprehension leads to negative attitudes and a loss of motivation over time; therefore avoid engaging in further reading opportunities (Graves et al. 2003). Based on the insights from previous studies, it is reasonable to consider that the higher achieving students in the pretest stage might have continued to develop their literacy at a perhaps faster rate while the poorer achieving students simply were slower, leading to an increased achievement gap after all.

Another possible area to look at is the experimental mortality as a threat to internal validity. Unfortunately, almost half of the students in each school dropped out by the time the posttest was conducted. This is due to the migratory nature of the population. It is unlikely, but still possible that the Rural Experimental group ended up having only higher achievers after other lower achievers left the school. As shown in Table 3, the attrition rate is much higher in the rural school than the urban slum school. Also, more students dropped out of the experimental group (e.g., 55%) than the control group (e.g., 50%) in the rural school. Nevertheless, the facts of this study hold: (1) overall, the rural school students performed better than urban school students, (2) the advantage of the rural group was due to the supplementary use of the mobile learning technology, (3) in addition to technology, socio-economic and parental factors also mediated the effect of improved learning. Considering the uniformity in student achievement scores, experimental mortality may be less plausible.

Lastly, it is also conceivable that the higher achievement demonstrated by the Rural Experimental group might have been simply from a short-lived novelty effect. There is a classic debate over novelty effect particularly with studies involving educational technology interventions. For example, Clark (1985) argued that a novelty effect with newer media tends to disappear quickly over time and further noted a significant reduction of effect size of media intervention (e.g., an effect size of over 0.5 within 4 weeks becoming

0.2 after 8 weeks of intervention). To back up his argument, he re-examined meta-analyses conducted earlier by Kulik et al. (1983). However, the average effect size of the present study (e.g., 0.93) is much higher than what Kulik found in traditional media related studies (e.g., average 0.32). Therefore, the argument for a short-term novelty effect seems less convincing for this study.

Discrepancies between the findings and the literature

Interestingly, there are several discrepancies between the two localities that must not have played any role influencing the achievement gap because they are somewhat counterintuitive at least at the surface level.

First, according to the survey result, the overall education experience of the rural parents was less than that of the urban slum school parents. Halle et al. (1997) found that parents with higher education had higher expectations for their children's academic attainment and that their higher expectations were related to their children's achievement. Also, Klebanov et al. (1994) found that mothers' education was one of important predictors of the physical environment and learning experiences in the home, leading to children's achievement in school. Therefore, the findings of the present study are not consistent with the existing body of literature regarding parental education level and its positive correlation with children's achievement. It seems that the interest of the parents in their children's school experience and support at home is important, but parent's education level may have played little or no role in the present case.

Second, the teacher from the urban school was more open to the use of technology in classrooms, appreciated the potential of technology, and spent more time learning and planning with the mobile learning technology in everyday classroom activities. However, none of the extra interest and effort led to a more positive outcome for the urban school children. More interestingly, the principal from the rural school mentioned that his teacher did not embrace technology in the classroom. As a result, training was always quite difficult with any educational technology project at the rural school.

In an earlier study, Zhao and Cziko (2001) have identified conditions for adoption and integration of technology: "(1) The teacher must believe that technology can more effectively maintain a higher-level goal than what has been used. (2) The teacher must believe that using technology will not cause disturbances to other higher-level goals that he or she thinks are more important than the one being maintained. (3) The teacher must believe that he or she has or will have the ability and resources to use technology" (p. 6).

The urban school teacher closely met all three conditions Zhao and Cziko (2001) described. In addition, the rural school principal had 4 years less working experience compared to the principal in the urban school and the teacher in the rural school also had 2 years less teaching experiences than the teacher of the urban school. Thus, the present finding suggests that what teachers or principals believed or tried or their prior experiences virtually had little or no influence on the substantial achievement gap.

Although it is somewhat inconclusive and thus require more rigorous research, the overall circumstance that explains the higher achievement of the rural school children seems to be more linked with parent's interest in children's school experience, more time with the parent at home, and parent's higher income (i.e., $310 more income per month), but less with parent's education level, teacher's perception on technology, teacher's years of teaching, or principal's years of service. The inconsistency with previous studies particularly regarding the teacher's perception may be due to the fact that the technology intervention in this study was mobile learning technology (i.e., it requires less teacher intervention and gives more control to the learners).

Evidently, it would have been preferable if there were a way to run a multiple regression analysis to pinpoint what predictors may best explain the children's achievement. Unfortunately, the data were not collected in a way to uniformly link all elements in pre/posttest, parent surveys, and interviews with a unique identifier for each child case. The absence of a multiple regression analysis is a major shortcoming of this study and should be part of future follow-up studies.

Conclusion

As pointed out by Zurita and Nussbaum (2004), mobile learning technology, in particular, with its low cost and higher accessibility, has great potential to provide access to or supplement education in underserved areas and particularly the rural village schools. As discussed in our study, the mobile learning technology has demonstrated its capability in providing expanded literacy exposure to children living in a rural village. In addition, it appears to be less susceptible to teacher perception or prior experience or even school infrastructure. At the same time, the technology deployment process was quite seamless, short, and driven more by the student than the teacher or administrator.

More importantly, the programmable open design of our mobile learning technology enables the development of other mobile learning activities to increase phonemic awareness skills of children at multiple levels and offer opportunities to practice reading through interesting content and entertaining activities.

However, this study presents several shortcomings and some of them are due to the unique conditions of the populations and communities. In future iterations of this study, some of the weaknesses of the present version will need to be addressed (e.g., better research design to cope with the high attrition rate, multiple regression to better explain the intervention effects, larger sample through more schools in similar context, randomized assignment to minimize threat to internal validity, longer and closer observation on what's happening in classrooms, other subjects such as math and science, pedagogies more fully integrating mobile devices, etc.). In addition, future studies should attempt to identify and control potential extraneous variables and effects that could be introduced by a mobile learning technology intervention. Even with a rigorous research design, an intervention involving today's mobile technology could not be simply controlled to induce a treatment with a single effect in a complex learning scenario. In other words, involving mobile technology intervention is not similar to prescribing a Tylenol; it is probably somewhat close to involving a whole pharmacy on a mobile trailer. With mobile learning technology, exploring, identifying, practicing, building new ideas, acquiring new skills, making mistakes, reflecting, recording, documenting, etc. can take place in a non-linear and non-discrete fashion. That is one of the reasons why we attempted to look at more than just what the technology might do to the student in the classroom, but also how they might view and interact with such technology given their context (e.g., socioeconomic, locality, parenting, etc.). Overall, this study may inevitably fall short on identifying and separately tracking possible mobile learning technology effects.

Furthermore, the original intent with the devices was to let students take them home. Since the devices automatically log what buttons are pushed and when, what problems are solved or failed, and how long the students used the devices. In addition, it is possible to require the students to sign in with their logins so teachers or researchers can track who used the devices to do what, if the devices were shared at home. With such information, the present study could have discussed more in-depth phenomena that may arise in unique social contexts. However, the devices in most cases, stayed in the classrooms. Therefore, the mobile learning devices never realized their full potential as ubiquitous learning companions. It was clear from the observation that the teachers were more concerned than the researchers about the devices (i.e., possible loss, storage, maintenance, continuous and future class use, etc.). Although they were assured that they will be replenished with many more devices if they are all lost, they were highly protective of the existing devices as if they would never be given another opportunity to receive any kind of technology in the future.

In future iterations of the study, even with a high attrition rate, we plan to devise a strategy to collect the additional layer of information that was not captured in the current version of the study. Furthermore, future mobile device designs may incorporate a geo-tagging component coupled with a cellular communication feature. With such setup, the researcher will be able to conduct a longitudinal study and monitor device usage behaviors, learning activities, and academic achievements on various contents regardless of their locations (i.e., whether they are on the go or in school or migrating to a different geographical region). Such data can be collected and shared with participating school districts for better analyses of social contexts and learning patterns. More importantly, with such mobile networking feature, students should be able to exchange learning contents as they complete multiple series of learning modules, help each other as peers may seek help, and connect to the global open source education resources.

ITU (2009) reported that by the end of 2008, 4.1 billion mobile subscribers out of 6.7 billion world population took advantage of mobile communication technology. As more mobile technology is becoming available, there should be more research investigating the potential impact of such technology to alleviate inequalities and link children situated in extremely underserved communities with better educational opportunities. The mobile learning device employed in the current study was $50 (i.e., more affordable than many cellular phones in most regions). The mobile device is capable of carrying over 600 textbooks or 300 textbooks with 200 5 min educational videos in a mobile video format. For extremely underserved localities whose inhabitants often lack learning materials altogether, the significance of the content these devices can deliver is vast.

The United Nations World Food Program (2009) started to use mobile technologies to help Iraqi refugees with food and resource distribution processes. It will be absurd if educators do not take advantage of mobile innovations in equalizing educational access for disadvantaged children. If UN could do it, could educators also distribute educational contents to refugee children or nomadic children while tracking and assessing their learning progress on a daily basis?

It is our hope that a study such as this can (1) generate constructive discussion on relevant topics; (2) challenge educators to think of innovative ways to address inequalities; and ultimately (3) help develop a robust, scalable, sustainable, and contextualized education models for the marginalized.

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References

Adams, M. (1990). *Beginning to read: Thinking and learning about print*. Cambridge, MA: MIT Press.

Anandarajan, M., Igbaria, M., & Anakwe, U. P. (2002). IT acceptance in a less-developed country: A motivation factor perspective. *International Journal of Information Management*, *22*(1), 47–65.

Attewell, J. (2005). *From research and development to mobile learning: Tools for education and training providers and their learners*. Paper presented at the 4th World Conference on mLearning.

Bainbridge, W. L., & Lasley, T. (2002). Demographics, diversity, and K-12 accountability: The challenge of closing the achievement gap. *Education and Urban Society, 34*, 422–437.

Brown, E. (Ed.). (2001). *Mobile learning explorations at the Stanford Learning lab. speaking of computers, 55*. Stanford, CA: Board of Trustees of the Leland Stanford Junior University.

Campbell, D. T., & Stanley, J. C. (1966). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally.

Carnoy, M., & Rhoten, D. (2002). What does globalization mean for educational change? A comparative approach. *Comparative Education Review, 46*(1), 1–6.

Cavus, N., & Ibrahim, D. (2009). M-learning: An experiment in using SMS to support learning new English language words. *British Journal of Educational Technology, 40*(1), 78–91.

Clark, R. E. (1985). Evidence for confounding in computer-based instruction studies: Analyzing the meta analyses. *Educational Communication and Technology Journal, 33*(4), 249–262.

Cohen, J. (1988). *Statistical power for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Crook, C. (2002). Learning as cultural practice. In M. R. Lea & K. Nicholl (Eds.), *Distributed learning: Social and cultural approaches to practice* (pp. 152–169). London: RoutledgeFalmer.

Cummins, J., & Sayers, D. (1995). *Brave new schools: Challenging cultural illiteracy through global learning networks*. New York: St. Martin's Press.

Driscoll, M. (2000). *Psychology of learning for instruction* (2nd ed.). Needham Heights, MA: Allyn & Bacon.

Dror, I. E., & Harnad, S. (Eds.). (2008). *Cognition distributed: How cognitive technology extends our minds*. Amsterdam: John Benjamins Publishing.

Goldenberg, C., Gallimore, R. G., & Reese, L. (2005). Using mixed methods to explore Latino children's literacy development. In T. S. Weisner (Ed.), *Discovering successful pathways in children's development: Mixed methods in the study of childhood and family life*. Chicago: University of Chicago Press.

Graves, F., Juel, C., & Graves, B. (2003). *Teaching reading in the 21st century* (3rd ed.). Boston: Allyn & Bacon.

Griffith, P. L., & Olson, M. W. (1992). Phonemic awareness helps beginning readers break the code. *The Reading Teacher, 45*, 516–523.

Halle, T., Kurtz-Costes, B., & Mahoney, J. (1997). Family influences on school achievement in low-income, African-American children. *Journal of Educational Psychology, 89*, 527–537.

Hart, B., & Risley, R. T. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: Paul H. Brookes.

Henderson, A. T. (Ed.). (1987). *The evidence continues to grow: Parent involvement improves student achievement*. Columbia, MD: National Committee for Citizens in Education. (ERIC Document Reproduction Service No. PS 018 600).

Herselman, M. E. (1999). South African resource-deprived learners benefit from CALL through the medium of computer games. *Computer Assisted Language Learning, 12*(3), 197–218.

Instituto Nacional para la Evaluación de la Educación (INEE). (2007). *Estimates from Census lifted by ILCE Technology Resources*. Banco de Indicadores Educativos.

International Telecommunication Union. (2009). *Measuring the Information Society: The ICT Development Index*. Retrieved September 23, 2009, from http://www.itu.int/ITU-D/ict/publications/idi/2009/material/IDI2009_w5.pdf

Jonassen, D. H., & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Techonology Research & Development, 47*, 61–79.

Jones, M., & Marsden, G. (2006). *Mobile interaction design*. Chichester, UK: Wiley.

Joseph, S., & Uther, M. (2006). Mobile language learning with multimedia and multi-model interfaces. In *Proceedings of the fourth IEEE international workshop on wireless, mobile and ubiquitous technology in education (ICHIT '06).*

Juel, C. (1988). Learning to read and write: A longitudinal study of fifty-four children from first through fourth grades. *Journal of Educational Psychology, 80*(4), 437–447.

Juel, C. (1991). Beginning reading. In R. Barr, M. L. Kamil, P. D. Pearson, & P. Mosenthal (Eds.), *Handbook of reading research* (Vol. 2, pp. 759–788). New York: Longman.

Kim, P. (2009). Action research approach on mobile learning design for the underserved. *Educational Technology Research & Development*, *57*, 415–435.
Kim, P., Miranda, T., & Olaciregui, C. (2008). Pocket school: Exploring mobile technology as a sustainable literacy education option for underserved indigenous children in Latin America. *International Journal of Educational Development*, *28*(4), 435–445.
Klebanov, P. K., Brooks-Gunn, J., & Duncan, G. J. (1994). Does neighborhood and family poverty affect mothers' parenting, mental health, and social support? *Journal of Marriage and the Family, 56*, 441–455.
Kuhn, M., & Stahl, S. (2000). *Fluency: A review of developmental and remedial practices*. Ann Arbor, MI: Center for the Improvement of Early Reading Acquisition, University of Michigan.
Kulik, J., Bangert, R., & Williams, G. (1983). Effects of computer-based teaching on secondary school students. *Journal of Educational Psychology, 75*, 19–26.
Lea, M. R., & Nicholl, K. (Eds.). (2002). *Distributed learning: Social and cultural approaches to practice*. London: RoutledgeFalmer.
McNaughton, S., Phillips, G., & MacDonald, S. (2003). Profiling teaching and learning needs in beginning literacy instruction: The case of children in "low decile" schools in New Zealand. *Journal of Literacy Research, 35*, 703–770.
Mercy, J. A., & Steelman, L. C. (1982). Familial influence on the intellectual attainment of children. *American Sociological Review, 47*, 532–542.
Nyíri, K. (2002). Towards a philosophy of M-learning. In: *Proceedings IEEE international workshop on wireless and mobile technologies in education* (pp. 121–124), August 29–30, 2002.
OECD. (2006a). *Are Students Ready for a Technology-Rich World? What PISA Studies Tell Us.* OECD.
OECD. (2006b). *Starting Strong II. Early childhood education and care*. OECD.
Parsons, D., & Ryu, H. (2006, April). A framework for ssessing the quality of mobile learning. In: R. Dawson, E. Georgiadou, P. Lincar, M. Ross, & G. Staples (Eds.), *Learning and teaching issues in software quality*. Proceedings of the 11th international conference for process improvement, research and education (INSPIRE), Southampton Solent University, UK, pp. 17–27.
Pineiro, R. C. (2009). *Developing the U.S.-Mexico border region for a prosperous and secure relationship: Mexican border cities and migration flows*. Rice University: Baker Institute for Public Policy.
Roschelle, J., & Pea, R. (2002, January). A walk on the WILD side: How wireless handhelds may change CSCL. *Proceedings of CSCL 2002*, Boulder, CO, pp. 51–60.
Sammons, P., Elliot, K., Sylva, K., Melhuish, E., Siraj-Blatchford, I., & Taggart, B. (2004). The impact of pre-school on young children's cognitive attainments at entry to reception. *British Educational Research Journal, 30*, 691–712.
Santibanez, L., Vernez, G., & Razquin, P. (2005). *Education in Mexico: Challenges and Opportunities.* RAND Education.
Schwartz, S. (1988). A comparison of componential and traditional approaches to training reading skills. *Applied Cognitive Psychology, 2*(3), 189–201.
Sharples, M., Taylor, J., & Vavoula, G. (2005). Towards a theory of mobile learning. In: *Proceedings of mLearn 2005 conference*, Cape Town.
Shin, N., Norris, C., & Soloway, E. (2006). Effects of handheld games on students learning in mathematics. In *Proceedings of the 7th international conference on learning sciences*, pp. 702–708.
Shuler, C. (2009). *Pockets of potential: Using mobile technologies to promote children's learning*. New York: The Joan Ganz Center at Sesame Workshop.
SINIEG. (2009). *National institute of statistics, geography, and data processing*. Retrieved on 14 April 2009 from http://www.inegi.org.mx/inegi/default.aspx
Soloway, E., Norris, C., Blumenfeld, P., Fishman, B. J. K., & Marx, R. (2001). Devices are ready-at-hand. *Communications of the ACM, 44*(6), 15–20.
Stead, G., Sharpe, B., Anderson, P., Cych, L., & Philpott, M. (2006). *Emerging technologies for learning*. Coventry, UK: Becta.
Straub, D. W., Loch, K. D., & Hill, C. E. (2001). Transfer of information technology to the Arab world: A test of cultural influence modeling. *Journal of Global Information Management, 9*(4), 6–28.
Uden, L. (2007). Activity theory for designing mobile learning. *International Journal of Mobile Learning and Organisation, 1*, 81–102.
Vellutino, F. R., & Scanlon, D. M. (2002). Research for the future: The interactive strategies approach to reading intervention. *Contemporary Educational Psychology, 27*, 573–635.
World Food Programme. (2009). *WFP launches mobile phone-based food voucher pilot for iraqi refugees in Syria.* Retrieved on 28 October 2009 from http://www.wfp.org/news/news-release/wfp-launches-mobile-phone-based-food-voucher-pilot-iraqi-refugees-syria

Zhao, Y., & Cziko, G. A. (2001). Teacher adoption of technology: A perceptual control theory perspective. *Journal of Technology and Teacher Education, 9*(1), 5–30.
Zurita, G., & Nussbaum, M. (2004). A constructivist mobile learning environment supported by a wireless handheld network. *Journal of Computer Assisted Learning, 20*, 235–243.

Paul Kim is the Assistant Dean and also Chief Technology Officer at Stanford University School of Education. He is one of senior researchers for Programmable Open Mobile Internet (POMI)-http://cleanslate.stanford.edu. He has been conducting research with multidisciplinary approaches and teaching graduate courses on technology-enabled empowerment and entrepreneurship.

Teresita Hagashi is a lecturer at CETYS Universidad Escuela de Ciencias Sociales y Humanidades. She received her B.A. degree in Psychology from Universidad Autónoma de Guadalajara and M.S. degree in Networking and Information Technology from CETYS Universidad. She is currently a candidate for Doctor of Education and Values at CETYS Universidad and interested in the studies of teaching critical thinking with technology and assessing values & ethics in education.

Laura Carillo is the Director of Special Projects at CETYS Universidad. She is interested in international collaborative research projects focused on organizational effectiveness, institution-wide electronic portfolios, and performance-based assessment strategies.

Irina Gonzales is a research assistant at Stanford University School of Education in the POMI team. She earned her M.A. degree in International Comparative Education from Harvard University, M.A. degree in Learning, Design, and Technology from Stanford University, and B.S. degree in Electronic Systems Engineering from Tecnológico de Monterrey, Mexico.

Tamas Makany is a visiting scholar at Stanford University School of Education in the POMI team. He received his Ph.D. degree in Cognitive Psychology from University of Southampton, England and also M.A. degree in Psychology from University of Pecs, Hungary. His primary research interests are in human spatial memory & cognition and digital learning environment optimization.

Bommi Lee is a research assistant at Stanford University School of Education in the POMI team. She earned her M.A. degree in International Comparative Education from Stanford University and B.A. degree in English Literature from Sogang University, Korea.

Alberto Gàrate is a professor at CETYS Universidad Escuela de Ciencias Sociales y Humanidades and currently teaching graduate courses such as "Education and Values." He received his Ph.D. degree in Educational Sciences from the Universidad Iberoamericana and authored multiple books including, "The values to the social fragility of Education" and "The Telesecundarias as Institutions of Learning for the State Educational System."