

Using Mobile Phones in Education

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Abstract

We present three projects in mobile learning.

First, we polled 333 Japanese university students regarding their use of mobile devices. 100% reported owning a mobile phone. 99% send email on their mobile phones, exchanging some 200 email messages each week. 66% email peers about classes; 44% email for studying. In contrast, only 43% email on PCs, exchanging an average of only 2 messages per week. Only 20% had used a PDA.

Second, we emailed 100-word English vocabulary lessons at timed intervals to the mobile phones of 44 Japanese university students, hoping to promote regular study. Compared with students urged to regularly study identical materials on paper or web, students receiving mobile email learned more ($p < 0.05$). 71% of the subjects preferred receiving these lessons on mobile phones rather than PCs. 93% felt this a valuable teaching method.

Third, we created a web site explaining English idioms. Student-produced animation shows each idiom's literal meaning; a video shows the idiomatic meaning. Textual materials include an explanation, script, and quiz. 31 college sophomores evaluated the site using video-capable mobile phones, finding few technical difficulties, and rating highly its educational effectiveness.

1. Introduction

If you walk onto any university campus in Japan, you will find a majority of students carrying mobile phones. Many will be silently tapping away, composing or reading email, as they walk between classes. Others will be having quick conversations, letting other students know about missed classes or evening plans. According to Taylor (2001), 95% of the 15-24 year old population in Japan own web-enabled mobile phones. In Japanese society as a whole, mobile phones outnumber PCs 5 to 1 (Cohen, 2002). Japanese young people have been quick to adopt a mobile technology that allows them to email their friends and access the web as they move through their daily schedule. Given their popularity, we wanted to know to what extent mobile phones were being utilized for educational purposes among university students, and to measure students' reactions to educational materials for foreign language learning developed specifically for

mobile phones.

Learning a foreign language involves memorization and practice of a large number of vocabulary words and grammatical structures. For students of English as a foreign Language (EFL), 5,000 base words are considered a minimal requirement for understanding non-specialized English texts (Laufer 1997; Nation 1990). Recent research concerning the brain and learning indicates that learning a new word or concept requires multiple experiences, giving repeated practice and exposure, so that the neural network for that word can be developed and strengthened. Over time, with enough exposure, activation and recognition become relatively automatic (Genessee, 2000) which is one of the goals of foreign language learners. Yet, in many educational institutions around the world, the amount of class time is very limited. In Japanese universities, for example, a typical class meets once a week for 90 minutes. Teachers must make difficult choices about how to use that limited time to promote language learning. Since foreign language students usually have opportunities to speak and hear the target language only in the classroom, it makes sense to use as much class time as possible in communicative activities. This means that other kinds of practice and exposure must be provided in other ways. We believe that mobile technology can help extend learner opportunities in meaningful ways.

With that in mind, we surveyed students at the university to determine patterns of usage of mobile devices, mobile phone functions they use, and the types of educational activities they consider useful for mobile phones. In this paper, we first present the results of that poll. Then we introduce two types of materials developed for studying English as a Foreign Language on mobile devices for learners in Japan, and present students' reactions to these types of learning activities on mobile phones. The first, *Learning on the Move* (LOTM), sent English vocabulary materials to students at timed intervals, in order to promote regular interval study (Thornton & Houser 2001; Houser, et al. 2001). LOTM uses the inexpensive SMS (short messages service, or mobile email) capabilities of common 'second generation' (2G) mobile phones. The second, *Vidioms*, uses the multimedia capabilities of 'third generation' (3G) mobile phones and PDAs to display short, web-based videos and 3D animations and to give visual explanations of English idioms (Thornton et al. 2003).

2. A Survey of Japanese students' use of mobile devices

We polled 333 female Japanese university students regarding their use of mobile devices. Students' ages ranged from 18 to 21, and fields of study included EFL, modern culture, computers, design, and home economics. The questionnaire was divided into 7 sections: personal data (name, class, etc.); types of mobile phone owned; frequency of use of various mobile phone features; use of other electronic devices; the frequency of various categories of email sent or received via mobile phone; categories of web pages accessed via mobile phone; and a ranking of the desirability of possible educational activities via mobile phone.

First, we found that every student who participated in our poll owned a mobile phone. Most Japanese mobile phones have many features besides making voice calls, but we found that the types and models of our students' mobile phones varied, with some having more multimedia capabilities than others.

Our poll showed that email was the most utilized mobile phone feature. Students reported making relatively few voice calls (a mean of 7 calls per week). In contrast, students reported exchanging on their mobile phones an average of almost 200 email messages each week (with an average length of about 200 characters each).

Next, we compared mobile phone email with PC email. Where 99% of our subjects reported sending email on their mobile phones, only 43% send email from PCs. Subjects reported exchanging an average of only 2 email messages on PCs per week. We see that mobile email is used much more frequently than both PC email and mobile voice calls.

Regarding other features, many students made occasional use of the appointment calendars and digital cameras built into their mobile phones. Newer features, such as todo lists, bilingual dictionaries, games, and video cameras, were seldom used. (Our instrument failed to distinguish between phones not offering the feature, students not using the feature, and students being unaware they had the feature.)

We asked students to estimate the number of times they used these features each week. Inspired by a similar poll of Norwegian college students (Divitini, 2002), we partitioned student responses into four categories: *never* (used 0 times per week), *seldom* (at most once a week), *occasionally* (between 2 and 5 times per week), and *often* (at least six times per week). Figure 1 shows the average frequency of each of these four categories. Darker colors indicate greater frequency of usage.

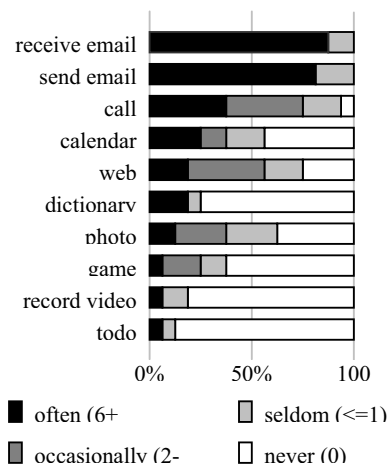


Figure 1. Frequency of use of cellphone features

Subjects also reported using another type of mobile device: the electronic bilingual dictionary (with half-size keyboards). All students at our university are required to take two years of EFL, and many use these small devices. In our poll we found that more than half the subjects report using them, either occasionally or often. On the other hand, about 20% of students reported ever using a PDA. (See Figure 2.)

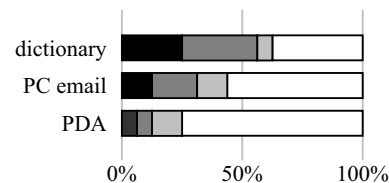


Figure 2. Frequency of use of PC email, electronic dictionaries, and PDAs

Since students were using mobile email extensively, we wanted to find out if they were already using their mobile phones for educational purposes. A majority (83%) reported using mobile email often for chatting with friends and family. 66% reported using it (occasionally or often) to ask other students about classes or lectures. A smaller number, 44%, used it (occasionally or often) for studying. Other educational purposes such as contacting a teacher or finding out about events at the university were seldom or never used by most students. Only a few students occasionally or often used their phone for finding out about part-time jobs or reading email magazines.

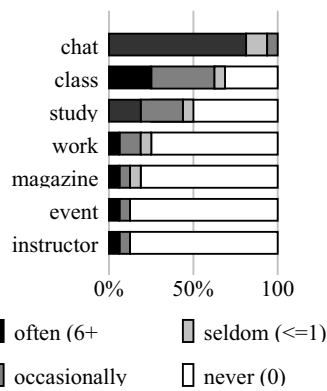


Figure 3. Purpose of email messages

Although 61% of subjects reported using the web function of their mobile phones at least occasionally, a majority of students reported never using their mobile web for the purposes we asked about. 27% reported using the mobile web for chatting with friends. 22% used it for studying. 18% used it for finding out about classes and lectures. 12% read web-based magazines. Only a very few used it for contacting teachers or finding out about campus events and part-time jobs. (See Figure 4.)

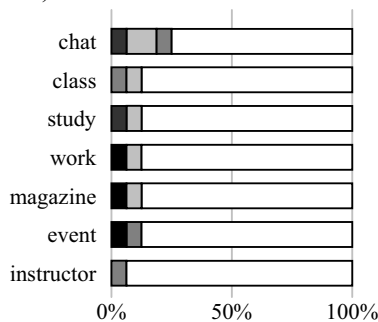


Figure 4. Purpose of web usage

Subjects were then asked to rate the desirability of several types of educational functions they would like to have with mobile phones, using a scale of 1-6, with 1 being the most important and 6 being the least important. A majority of students gave the following rankings:

1. (62%) Receiving notification about class cancellations, room changes, and other administrative details
2. (53%) Receiving and submitting assignments
3. (31%) Receiving notification of quiz and test grades
4. (27%) Taking lecture notes
5. (37%) Answering questions in class
6. (70%) Consulting with other students

Administrative tasks such as receiving notification of cancellations, receiving and submitting assignments, and notification of grades were ranked highest. These were followed by in-class tasks such as taking notes and answering questions. Subjects rated consulting with other students as the least important educational use for mobile technology. Figure 5 shows the frequency of each ranking; dark areas were rated more important.

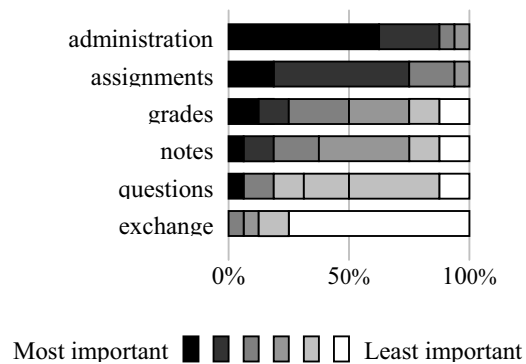


Figure 5. Student rankings of importance of mobile educational uses

Discussion. The results of our poll indicate that a majority of Japanese students own and frequently use mobile phones. Students are very practiced at using the email functions of their phones but are less experienced at using the web and other newer features such as cameras and todo lists. In terms of educational use, more than half of students are already using their mobile email to get information about classes and lectures. They would like to receive administrative information about classes on their mobile phones.

Concerning the mobile web, to a large degree, students are not yet using mobile web for educational purposes. We believe that this may be related to the small number of university teachers in Japan that offer information via the web or online segments of their courses. Ring (2001) posits that web-based course materials should be decomposed into small pages that can be easily read on small mobile screens, and in his experiments students applauded a hierarchical structure of such small pages. So, even for courses that offer web-based materials, redesigning is necessary if they are to be accessed by mobile devices.

In order to find out how students felt about

materials designed specifically for mobile phones, we developed sets of English vocabulary lessons that utilized the email or SMS function of mobile phones, and another set of multimedia lessons teaching English idioms that could be accessed via the web function of mobile phones. The next two sections introduce these materials and present students' evaluations.

3. Text Materials via Mobile Phone Email: Learning on the Move

Research on memory and learning suggests that for an item to be stored in long-term memory, distributed practice is superior to massed practice (Bjork 1979; Dempster 1996; Wozniak 1995). Studies have examined spacing effects in the learning of foreign language vocabulary without technology (Dempster 1987; Bahrick & Phelps 1987). These show that the number of recalled words was greater under spaced conditions. Other studies have also shown that the type of rehearsal is important: Elaborative rehearsal that causes deeper mental processing is more effective (Craik & Lockhart 1972). This suggests that students of a foreign language should review words at spaced intervals, and in a variety of contexts, to facilitate long-term memory storage.

Research has shown that both intentional learning through explicit instruction (Coady 1997; Nation 1990) and incidental learning through reading (Nagy, Anderson, & Hermann 1987) can lead to vocabulary acquisition in non-native language learners. A combination of these methods is recommended by most experts (Wood 2001), but existing teaching materials provide inadequate exposure for learning many of the 5000 essential words (Groot 2000). Thus, students need a structured program in which unknown words are identified and then taught in a way that supports long-term memory storage. We thought that a *push* media like email or SMS would provide such a program.

Mobile technology and email. We chose mobile phones as the medium for delivery because of their popularity in Japan. At the time this project began in 2000, nearly 60 million Japanese (half the population) constantly carried mobile phones (Mobile Media 2001). In contrast, only 20% had occasional access to desktop PCs. Regarding university students, in April 2000 in an undergraduate course on computers and language learning, we surveyed 48 students to determine how many had computers at home. Eight of the 48 (17%) indicated home access to a computer. Of those same 48 students, 100% had mobile phones.

The cost of mobile phone SMS in Japan is very low. A student would typically be charged about US\$0.002 to receive each message; a two-week set of 30 messages would cost around US\$0.06.

Experiment. Three times a day, at 9:00, 12:30, and

17:00, we emailed short mini-lessons (less than 100 words of text or 365 bytes each) to 44 female Japanese university students in two EFL classes. Lessons defined five words per week, used each word in multiple contexts, reviewed previously introduced vocabulary, and incorporated target words in story episodes. Lessons were discrete chunks readable on the tiny screens of mobile phones. Pre- and post-tests determined the number of words learned during each two-week cycle.

Students evaluated this push learning by responding to a questionnaire. 71% preferred receiving these lessons on mobile phones rather than PCs. 93% responded positively when asked, 'Is this a valuable teaching method?' And 89% wished to continue learning via mobile phone email. 69% indicated the small screen size was not a problem. Although most students read lessons at least once per day (Fig 6) the varied frequency indicated limited success in promoting carefully timed interval study.

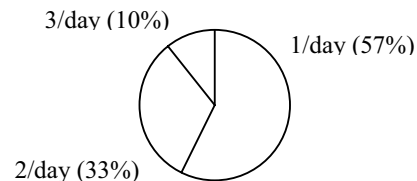
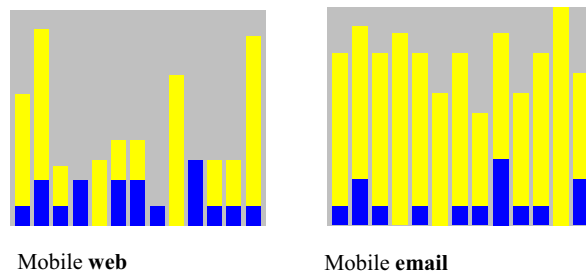


Figure 6. Students reading LOTM messages once, twice, and three times each day.

When identical lessons were given to crossover groups via Web (pull media) and SMS (push media), we found an average of 3 words learned via Web compared with 6.5 via SMS. In Fig 7 below, for each student, dark bars show pre-test score, light bars show post-test score after studying via mobile web (left) and mobile email (right). Mobile push media was significantly more effective than mobile pull media ($p < 0.05$).



Comparing lessons delivered via paper (pull media) and SMS, only 48% of students using paper-based lessons improved their score on the post-test while 88% improved via SMS.

Emailed lessons promoted learning even without

outside motivation for study (i.e., grades). In one class students learned averages of 3 and 4 words on earlier non-graded cycles, then learned 7 words when a post-test was counted as a graded quiz. We suspect external motivation will increase the effectiveness of any study method, including SMS review.

In summary, this first stage of the LOTM project found that delivery of foreign language vocabulary lessons via mobile phone email is effective and received positively by Japanese university students. This method takes advantage of the push aspect of mobile technology, and promotes regular study.

However, student feedback indicated that many students postponed reading their LOTM messages until they had time during their commute home to concentrate in a foreign language. They were often unable to concentrate on the task during the day when they had only a small chunk of time. In the third phase of our experiment, we compared long and short versions of the same vocabulary lessons. We hoped shorter versions would be easier to read, but feared the shortened context would hinder language learning. Here are examples introducing the word *vision*:

Long version:

Hi. I hope everyone had a nice summer vacation. Today's word is VISION (視覚). VISION is the same as eyesight. Do you have good VISION or do you have to wear glasses? Today, people with bad VISION can have eye surgery to improve their eyesight. Then they have good VISION and can throw away their glasses or contact lenses.

Short version:

Today's word, VISION (視覚), is the same as eyesight. Do you have good VISION or do you have to wear glasses?

In our two-week crossover study, half the students received short messages for one week and half received long messages. In the second week, students received messages of the opposite length. The test results showed there was no significant difference ($t=0.08$, $n=29$) in learning between the short and long messages.

4. Video and Web Materials via Mobile Phones and PDAs: Vidioms

Idioms are highly contextualized phrases that are often difficult for foreign language learners to master. Many idioms are comprised of language that lends itself to visualization through animation and video. To help students understand the meaning and context in which various idioms are used, we created a series of web pages. Each page presents one idiom (e.g., 'He has a big mouth.') first explaining the idiom's meaning in the students' first-language (L1; Japanese, in our case), then showing a computer animation illustrating the

literal meaning (e.g., a character with an unusually large mouth), and presenting a second-language (L2; English) script and live-action video showing the idiomatic meaning (e.g., a person who talks too much, giving away secrets). A final quiz checks students' understanding.

Background. Current research in computer-aided instruction points to the effectiveness of multimedia materials for some fields of study. In a report summarizing leading research on the effectiveness of technology in education from the late 1980s through 2000 (Software and Information Industry Association, 2000), video was shown to have a significant positive effect on achievement in the following cases:

1. when video anchors instruction to real-world problems. (It is used to show or demonstrate a real world problem for discussion and review in the classroom.)
2. when the skills and concepts to be learned have a visual component.
3. for providing multi-modal foreign language materials (captioned video, and access to native language resources while viewing video presentations)

Our website of idioms meets all three criteria.

We also considered current research involving educational materials delivered via mobile devices. We identified four educational studies using mobile phones. Ring (2001) accessed distance learning materials on web phones. Regan, et al. (2000) used mobile phone email, web, and voice to study Spanish. Thornton & Houser (2001) emailed English vocabulary lessons to mobile phones. The Telenor m-learning Project (Ericsson, 2001) reviewed training materials on mobile phones outside of face-to-face training sessions. In all of the studies, participants highly rated the convenience of learning with mobile phones. All reported that text size was not a problem, but that a different organization of materials was required: Text needed to be decomposed into chunks that could be displayed on small screens and learned in small fragments of time (e.g., while awaiting a bus). None of the studies used video or multimedia web materials.

We also found studies using PDAs for education. Interactive K-12 learning materials were tested in elementary schools in the U.S. (Soloway et al., 2001), Chile (Rodriguez et al., 2001), and the U.K. (Sharples, 2000). Gustavsson, et al. (2001) developed interactive business training materials. Most of these prototype applications downloaded web materials and communicated through infrared 'beaming' and cables to desktop computers. Most projects used older generation PDAs that could display images, but video and real time communication capabilities were found only in the HandLer Project (Sharples, 2000).



Figure 8. Example web pages and videos from Vidiom web site, viewed on a PDA.

All these studies assert the convenience and usability of mobile devices as instructional delivery tools for text and images. We wanted to investigate their usability for multimedia including animation, video, and sound.

Mobile technology and the Web. Japanese university students have constant access to the Web through their mobile phones. Table 1 shows that most young adults in Japan own a web-enabled phone. However, only a little more than half that number have access to the Web via a desktop PC at home. So, in order to make language learning materials that were accessible to a majority of students, we chose to make pages that could be read on mobile phones. This required 15 second videos and animations. Currently the cost of accessing video via mobile phones is prohibitive for students, US\$8/minute. Although none of our students own PDAs, we wanted to compare students' reactions to the website on different devices.

Table 1. Penetration of web devices in Japan (per cent of population owning device)

Penetration	Device
2%	PDA (pocket computer) (JETRO 2002)
58%	PC in the household (Japan Ministry of Public Management 2002)
95%	web-enabled mobile phone (subscribers aged 15-24) (Taylor 2001)

Experiment. First instructors and then teams of 3rd and 4th year college students wrote L1 explanations (in Japanese) of English idioms and L2 scripts demonstrating idiomatic meanings, and then created videos and animations to illustrate them. Instructors wrote multiple-choice quizzes to evaluate students' understanding of the idioms, and constructed a mobile phone-sized website to present the materials. 'Hit the ceiling' can be seen in Fig 8.

Next, students used and evaluated these materials. As part of a class on the evaluation of language-learning technology, 31 college sophomores spent 10 minutes looking through the vidiom web site on mobile phones and PDAs. Students immediately started exploring the website and were unwilling to stop. We hypothesize a strong novelty effect coupled with the visual appeal of brightly-colored animations and lively skits. Students then answered 21 questions using 10-point Likert scales, evaluating various aspects of the hardware, web pages, videos, sounds, educational effectiveness, and overall reaction. All scores were quite positive, averaging 6.7 on a scale from 0 to 9. All

scores were similar between users of cell phones and PDAs, except for *video quality*. Students rated PDA video superior to mobile phone video ($p < .01$; PDA mean 7.4, mobile phone 5.9). The PDA has a larger, brighter screen, with four times the number of pixels, and five times the video bitrate (The PDA showed 264 kbps mpeg1; the mobile phone displayed 50 kbps mpeg4). No other scores differed significantly between the devices.

Students finished their evaluations by writing their positive and negative impressions in separate blanks. Tables 2 and 3 overview these comments.

Table 2. Positive comments about Vidioms web site.

frequency	category	example comments
38%	helpful for study	Easily understood and remembered. The video depiction of the two meanings was very clear. Videos are more evocative than text. Watching videos makes the meaning transparent.
25%	fun	Videos were very interesting. I like watching videos. It was fun.
19%	specific animation	Kick the bucket. Money talks. [Coins greeting each other.]
16%	attractive	The videos are very colorful and cute. The video was surprisingly clear.
9%	ubiquity	With this I can study everywhere.
3%	legible	Words are easily read.

Many students found the site enjoyable, and felt it an effective study aid. Several students applauded specific animations.

Table 3. Negative comments about Vidioms web site.

frequency	category	example comments
29%	audio poor	Difficult to hear clearly. Animations are too loud; conversations too quiet.
16%	screen too small	Screen is small, so I am tired to see. It's difficult to watch screen.
12%	specific idioms	Animation is obscure to me. Bite the dust.
6%	download slow	It takes time. I don't like waiting.
6%	awkward	Mobile phone buttons are very small. Difficult to use.
3%	video poor	Video quality was rather poor.

Students reported difficulty hearing the audio on both PDAs and cell phones; some suggested headphones might help. Students reduced volume to avoid disturbing neighboring students, and felt headphones would be required when studying in trains and other public places. The sound quality, compression technology, and bitrate on the mobile phone are similar to normal wireless voice calls, and seem inadequate for listening to a second language.

These complaints about the sound, as well as others concerning the opacity of some videos, are probably at least partially due to the fact that some of the script writers and actors were not native speakers, and semester time constraints did not allow for adequate editing and revision. The Achilles heel of video and 3D animation is the time they require to prepare.

But overall we see few serious technical limitations to widespread use of mobile video technology in education. We heard few complaints about the mobile phone's tiny screen, the 5-to-10 second video download, and the tiny controls. PDA users reported none of these problems. One student summarized, saying 'I can see how the large screen, superior audio, and efficient stylus interface make the PDA a better learning tool in the classroom. But the small size and one-handed operation of a mobile phone will probably make it the better choice when walking around outside the classroom.'

5. Conclusion

Our poll shows that Japanese university students use mobile phones often for sending and receiving email, sometimes concerning their classes. They less frequently access the web from their mobile phone but when they do, it sometimes relates to their university studies. However, they think that receiving information about their classes via mobile phones is a important potential use.

When actually using educational materials designed for mobile phones, students evaluated them positively, and test results showed that they were able to learn via this medium. The two projects described in this paper show that mobile devices such as phones and PDAs can be effective tools for delivering foreign language learning materials to students. The two studies show that Japanese university students are not bothered by reading text on small screens. Rich multimedia can capture their interest, and pushing study opportunities at students via mobile email is effective in helping them acquire new vocabulary.

6. Future Work

In the future we plan to add interactivity to Learning on the Move materials to provide productive as well as receptive language practice. Providing more variety in the types of activities will promote further development of the neural network for new vocabulary. We are also currently developing Flash movies to present foreign language materials on mobile devices.

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