Ubiquitous Learning Opportunities: Learning via Web Video on Mobile Phones

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Introduction

Many in the field of education have been excited about the possibilities of Web-based learning. They see the internet as a way of extending the classroom beyond the physical space of a building or institution. Learning with ubiquitous mobile devices, such as pocket computers and cell phones, promises to bring us even closer to this goal. Unconstrained by even a cable, mobile devices have real potential for “anywhere, anytime” learning. Mobile devices enable the study of rich multimedia educational materials not only in computer-equipped classrooms, but also at home, in public transportation, and coffee shops, freeing students to study whenever and wherever they please. This exciting new development is the focus of our research.

In this project we investigated some educational uses of multimedia cell phones. We analyzed mobile hardware (cell phones and pocket computers, often called Personal Digital Assistants or PDAs). Then we created animations, videos, web sites, and computer programs for mobile web phones. Finally we measured student reactions and collected student opinions of our mobile web learning materials. We chose web-based video as an appropriate instructional medium for demonstrating a highly visual component of English language: idioms.

Background: Ubiquitous 2G Mobile Phones Today

We consider mobile phones to be an ideal platform for ubiquitous learning for three reasons. First, mobile phones are truly ubiquitous: Almost all Japanese university students constantly carry mobile phones, making them available anytime and anywhere. In Table 1, statistics for December 2002 show that, in Japan, mobile phones are much more ubiquitous than other web devices:
<table>
<thead>
<tr>
<th>Penetration</th>
<th>Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>PDA (JETRO 2002)</td>
</tr>
<tr>
<td>58%</td>
<td>PC in the household (Japan Ministry of Public Management 2002)</td>
</tr>
<tr>
<td>95%</td>
<td>web-enabled mobile phone (subscribers aged 15-24) (Taylor 2001)</td>
</tr>
</tbody>
</table>

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

Second, students purchase, set-up, charge, and constantly carry their mobile phones, relieving the educational institution and instructors of the cost and effort required to buy and maintain these devices. Third, Japanese mobile phones are powerful web-based multimedia machines. They are actually miniature computers with wireless networking, providing ubiquitous access to miniature web pages and email. Today most students carry ‘second generation’ (2G) mobile phones, which connect to the internet at 9 to 64 kbps, speeds similar to analog computer modems.

Japanese mobile-phone carriers provide these networking functions at a low cost. Most carriers charge by the amount of data transferred, rather than the connect time. This makes textual web pages and email messages inexpensive. Most carriers charge 0.0020yen/byte (US$0.000020/byte). So a typical tiny email costs a fraction of a yen. Even extensive educational use of mobile web and email is economical: An entire year of study via mobile email or web costs less than a typical textbook.

**Vision: Web Video on 3G Mobile Phones Tomorrow**

Today most students carry 2G mobile phones, which offer limited multimedia capabilities: They can exchange short email messages, and view small web pages including tiny graphic images and students quickly upgrade their phones to the latest models. ‘Third generation’ (3G) models being sold today support even richer media, including video and Java programs. How can educators use these new multimedia phones?

We investigated prototype 3G phones running on NTT DoCoMo’s FOMA network. The main feature of these 3G models was the ability to download and view tiny videos. These machines offered color video with sound in the palm of ones hand. But video on these prototype models has some severe limitations. We found the 50 kbps postage-stamp-sized video to be fuzzy for scenes with motion, but clear enough for mostly static ‘talking head’ shots. The 8 kbps audio
distorted music, but was clear and loud enough to understand speech. (The sound and video quality reminds us of the earliest web video, Real Video over analog modems.) In contrast to mostly-textual email and web pages, these videos are expensive, costing about 200 yen per video (US$2). But the strictest limitation is the maximum 15-second length of video. This permits short sound bites but precludes much story development. It may be argued that, with these limitations, these phones are not yet ready for educational use, but we decided to investigate what kind of educational web videos could be produced under these constraints, and to actually try using them to see how students could benefit from them.

**Previous Work**

Related research can be found in the use of mobile devices in education and in the development of web-based learning materials. Table 2 lists research and development projects using mobile phones and pocket computers, highlighting the target population and main conclusions.

Four of the research studies used mobile phones. Ring (2001) reports on a study in which subjects used phones as one mode of accessing textual distance learning materials on the web. The Stanford Project (Regan et al., 2000) performed informal trials of Spanish language learning via mobile phone including the use of voice, email, and web. Thornton & Houser (2001) conducted experiments using the 2G textual email capabilities of mobile phones for English language vocabulary instruction. The Telenor m-learning WAP Project (Ericsson, 2001) used mobile phones to review training materials outside of a face-to-face training session. None of these studies used video or multimedia web materials. In all of the studies, participants highly rated the convenience of learning with mobile phones. All found that the small screens and texts were not problems, but that a different organization of the teaching materials was required for the small screen. Text needed to be decomposed into chunks that could be learned in small blocks of space and time due to the limitations of the hardware and the distraction-filled environments in which mobile devices are often used (e.g., waiting for or riding a bus).

Another paper by Kluge (2002) proposes a variety of language learning
activities that can be conducted on mobile phones, and enumerates their technical requirements.

The researchers in the studies in Table 2 using pocket computers either produced interactive learning materials for K-12 students, such as those seen at the HiCE lab at the University of Michigan (Soloway et al, 2001), or produced interactive training materials for business, such as those being developed by Mobilearn (Gustavsson et al, 2001). These projects prototyped applications that communicate with desktop computers through cables or infrared ‘beaming’. Web materials were available only through download via a desktop computer. Images were included in many of the listed projects, but video and real time communication capabilities were found only in the HandLer Project (Sharples, 2000). Most of these projects were limited by their use of older generation pocket computers that could neither connect wirelessly nor display multimedia.

These studies do assert the convenience and usability of mobile devices as instructional delivery tools when using text and simple images. However, we wanted to investigate their usability for multimedia including rich text, sound, music, animation, and video.

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:

- 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.)
- when the skills and concepts to be learned have a visual component.
- for providing multi-modal foreign language materials (captioned video, and access to native language resources while viewing video presentations)

This led us to our choice of making animated representations and videos of English idioms because they are an area of foreign language study that has a strong visual component. We also linked our native language videos to web pages with first language (Japanese) explanations.
<table>
<thead>
<tr>
<th>Learning Environment</th>
<th>Mobile devices used</th>
<th>Country, Context Purpose</th>
<th>Mobile Learning Activities</th>
<th>Title (Citation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F2F (face to face classroom) + mobile</td>
<td>Japanese mobile phones; NTT DoCoMo iMode; J-Phone models</td>
<td>Japan, University English (EFL) Class Regular, spaced practice of foreign language vocabulary</td>
<td>Vocabulary lessons via cell phone/email</td>
<td>Learning on the Move (Thornton &amp; House, 2001)</td>
</tr>
<tr>
<td>F2F + mobile</td>
<td>Various PDAs</td>
<td>United States, K–12 Education Prototype K-12 learning activities</td>
<td>Simulations for science; Concept mapping; Productivity applications</td>
<td>Learning in the Palm of Your Hand (Soloway et al., 2001)</td>
</tr>
<tr>
<td>F2F + mobile</td>
<td>• Ericsson R380 WAP Phones</td>
<td>Norway, Company Training Course Use WAP (mobile internet) applications as add-ons to a course</td>
<td>Content review; Quiz; Course evaluation and idea box</td>
<td>Telekom M–learning WAP Project (Ericsson, 2001)</td>
</tr>
<tr>
<td>F2F + mobile</td>
<td>• Nintendo Pocket GameBoy</td>
<td>Chile, K–12 Education Provide inexpensive substitute for PCs</td>
<td>Quiz; Collaborative work via ‘beaming’</td>
<td>PDAs in the Classroom (Rodrigues et al., 2001)</td>
</tr>
<tr>
<td>Web + mobile</td>
<td>• Palm Pilot III; • Nokia 8210 WAP phone</td>
<td>Singapore, Business Course Distance course delivery via Web and WAP</td>
<td>Text-only content; Interactive quizzes; Reminders and prompts from coaches</td>
<td>eBusiness on the Move (Ring, 2001)</td>
</tr>
<tr>
<td>Mobile</td>
<td>Mobile phones</td>
<td>United States, Stanford University Volunteers, Foreign Language – Spanish Informal test of prototypes for distance learning via mobile only</td>
<td>Coaching by tutors; Interactive quizzes; Textual content; Vocabulary notebook; Interactive and automated audio</td>
<td>Stanford Learning Lab Project (Regan et al., 2000)</td>
</tr>
<tr>
<td>Mobile</td>
<td>Various inexpensive portable technologies</td>
<td>European Union, Young Adults Outside Traditional Educational Institutions Prototype products to provide information and learning modules</td>
<td>Prototype multi-agent &quot;intelligent&quot; tutoring system for needs analysis of learners; Prototype multimedia modules, incorporating speech technology.</td>
<td>m-learning IST Project (Ultrasound, 2000)</td>
</tr>
<tr>
<td>Mobile (User studies and prototype development)</td>
<td>• Compaq PAQ Pocket PC; • Sony VAIO C1 laptop</td>
<td>Sweden, Business Training Understand the competence development needs of mobile workers, and support these needs with 3G or other wireless solutions.</td>
<td>Multimedia, problem-based learning modules; Video conferencing - collaborative projects</td>
<td>MobileLearn (Ongoing) (Gustavsson, et al., 2001)</td>
</tr>
<tr>
<td>Mobile (prototype development)</td>
<td>• Fujitsu Stylistic tablet PC; • Nokia GSM card phone</td>
<td>U.K., K–12 Education; Lifelong Learning University of Birmingham Develop mobile technologies for learning</td>
<td>Video conferencing - collaborative projects</td>
<td>MobileLearn (Ongoing) (Gustavsson, et al., 2001)</td>
</tr>
<tr>
<td>F2F + mobile</td>
<td>FOMA mobile phones</td>
<td>Japan, University Language activities for foreign language classes</td>
<td>Speaking, listening, reading, &amp; writing activities for language learning</td>
<td>Tomorrow’s CALL: The Future in Our Hands (Kluge, 2002)</td>
</tr>
</tbody>
</table>

Table 2: Previous work in mobile education
Materials: Web Video and Animation

In our Ubiquitous Learning Opportunities (ULO) project, we created a series of web pages to introduce English idioms to Japanese students. For each idiom (e.g., has a ‘big mouth’), we produced a small website with a Japanese explanation of the idiom’s meaning, a quiz, a 15-second 3D computer animation showing the literal meaning (e.g., a person with an unusually large mouth), and a live-action video showing the idiomatic meaning (e.g., a person who talks too much, giving away secrets). In detail, for each idiom:

◊ We used the DOGA 3D animation system on Windows XP to prepare the animation showing the literal meaning. We created 3D models of characters, background scenery, title text, and props such as cars and furniture. We then animated and rendered these, and finally added background music.

◊ We shot live-action video using a consumer-grade digital video camera in our school’s TV studio. We edited this video down to 15 seconds, and added titles using iMovie 2 and QuickTime Pro 5 on Macintosh computers.

◊ We then encoded both the animation and live-action video. We encoded in 200+56 kbps MPEG-1 using the free TMPEG for playback on desktop PC and Macintosh computers, and on the iPaq pocket computer. We encoded in 50+8 kbps MPEG-4 ASF using the proprietary Spot-XDE for playback on the FOMA mobile phones. We also used Quick Time Pro 5 to create thumbnails (tiny static images) for each video and animation, and then used Microsoft Photo Editor to shrink the thumbnails to one size for computers and a smaller size for mobile phones.

◊ We wrote Japanese explanations of the idioms’ literal and idiomatic meanings, and multiple-choice quizzes to check student comprehension.

◊ We built a program, using the Tcl language, to automatically generate two web sites, one for the FOMA phones, and one for the desktops and pocket computer. Each website contained an explanation, quiz, two thumbnails linking to the videos, iconic navigation, and an index listing all the idioms.

First the researchers (college professors) produced materials for two sample idioms, gathering the required software and knowledge and debugging the creative procedures. Next, in an effort to delegate some of the creative work, we
assigned 2-4 member teams of third and fourth year college students to prepare materials for 12 more idioms. Students created 3D animations, scripted and acted their videos, and prepared L1 explanations (in Japanese). The researchers wrote quizzes and edited, encoded, and titled the videos, then created and uploaded the web sites.

Figure 1 shows example pages from these web sites. These can be viewed on the web at vidioms.houser.vze.com.

![Example web pages and videos from ULO web site, viewed on a mobile device](image)

**Evaluation**

Finally, these materials were used and evaluated by students. As part of a class on the evaluation of language learning technology, 31 college sophomores spent 10 minutes looking through the idiom website on mobile devices (phones and PDAs), and then filled out a questionnaire.

Students viewed our web site using the free PocketTV program running on an iPaq pocket computer, as well as on several 3G FOMA phones. (We received the phones from RBEC as part of an NTT DoCoMo development contest, and received a grant from Kinjo Gakuin University Humanities Research Institute.
to cover their communications costs.)

We observed that students were drawn to the web site: They immediately started exploring, and were unwilling to stop. We hypothesize a strong novelty effect coupled with the visual appeal of brightly-colored animations and interesting skits. Students spontaneously formed small groups, typically pairs, and excitedly shared their discoveries.

The questionnaire (Appendix 1) contained 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 of PDAs, except for video quality. Students rated PDA video superior to mobile phone video (p<.01; PDA users evaluated the video quality at an average of 7.4, where mobile phone users rated it only 5.9). This is hardly surprising: The PDA has a much larger, brighter screen, with four times the number of pixels, and five times the video bitrate. (The iPaq pocket computer actually has the power of a typical PC circa 1997: 200 MHz CPU with 32 megabytes of RAM.) No other scores differed significantly between the devices (p=0.87).

Students finished their evaluations by writing their positive impressions and negative impressions in separate blanks. Tables 3 and 4 give an overview of these comments.

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

Table 3. Positive comments about idioms web site.
Many students found the site enjoyable, and felt it was an effective study aid. Several students applauded specific animations.

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

Table 4. Negative comments about Vidioms web site.

Students reported difficulty hearing the audio on both PDAs and cell phones; some suggested headphones might help. We observed students reducing volume when the videos became loud enough to disturb neighboring students. Students also felt headphones would be required when studying in trains and other public places. The sound quality, and indeed the compression technology and bitrate, on the mobile phone is very similar to a normal wireless voice call, but that seems inadequate for listening in a second language.

These complaints about the sound, as well as others concerning the semantic 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 sufficient practice and editing. The Achilles heel of video and 3D animation is certainly the time it takes to prepare; this experiment was only partially successful in having students create peer-teaching materials.

But overall we see few serious technical limitations to widespread use of mobile video technology in education. We were surprised to see how few complaints students offered on the mobile phone’s tiny screen, the 5-to-10 second wait during 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.’
Conclusion
This project investigated the production, use, and evaluation of educational web videos delivered on mobile devices. These ubiquitous pocket computers and mobile phones allow a student to interact with rich multimedia educational materials anytime and anywhere. Our materials explained idioms, a highly visual component of the English language. Students rated our materials highly, and we enjoyed some success in asking students to actually create the materials.

These materials were prepared as part of RBEC’s promotional campaign, and our presentation of these materials earned us the ‘best contents’ prize at DoCoMo’s contest.

In the future we plan to develop and evaluate more mobile language activities to further the progress of ubiquitous language learning.

References


Appendix 1: Form for student evaluation of Vidioms

<table>
<thead>
<tr>
<th>Evaluation of Idiom Videos</th>
<th>Date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name: Student</td>
<td>Number:</td>
</tr>
</tbody>
</table>

Circle the appropriate response for each item below.

Type of device: cell phone (model:_______) or PDA
How many idioms did you study? Please write a number between 1 and 15.

Overall reaction to Vidioms:
1. terrible 0 1 2 3 4 5 6 7 8 9 wonderful
2. difficult 0 1 2 3 4 5 6 7 8 9 easy
3. frustrating 0 1 2 3 4 5 6 7 8 9 satisfying
4. boring 0 1 2 3 4 5 6 7 8 9 interesting

Screen
5. Reading words on the screen
   hard 0 1 2 3 4 5 6 7 8 9 easy
6. Watching videos on the screen
   can’t see them 0 1 2 3 4 5 6 7 8 9 very clear
7. Choosing new pages or moving between pages
   difficult 0 1 2 3 4 5 6 7 8 9 easy
8. Organization of information
   confusing 0 1 2 3 4 5 6 7 8 9 very clear
9. Sequence of screens
   confusing 0 1 2 3 4 5 6 7 8 9 very clear
10. The use of color on the page (does it make it clearer or more difficult to read?)
    terrible 0 1 2 3 4 5 6 7 8 9 perfect

Sound
11. couldn’t hear 0 1 2 3 4 5 6 7 8 9 very clear
Instructions

12. Knowing what to do
    couldn’t understand 0 1 2 3 4 5 6 7 8 9 very clear

Learning

13. Using this software will help me learn English idioms.
    not helpful 0 1 2 3 4 5 6 7 8 9 very helpful
14. After using this software, I can remember English idioms.
    none 0 1 2 3 4 5 6 7 8 9 all
15. Overall, do you think this software is good for studying English idioms?
    not good 0 1 2 3 4 5 6 7 8 9 very good
16. Mobile phones are good for studying vocabulary.
    not good 0 1 2 3 4 5 6 7 8 9 very good
17. Mobile phones are good for practicing listening.
    not good 0 1 2 3 4 5 6 7 8 9 very good
18. Mobile phones are good for watching videos in English.
    not good 0 1 2 3 4 5 6 7 8 9 very good
19. PDAs are good for studying vocabulary.
    not good 0 1 2 3 4 5 6 7 8 9 very good
20. PDAs are good for practicing listening.
    not good 0 1 2 3 4 5 6 7 8 9 very good
21. PDAs are good for watching videos in English.
    not good 0 1 2 3 4 5 6 7 8 9 very good

Comments:

Please write anything you especially liked about the Video Idioms.

Please write anything you especially disliked about the Video Idioms.