A Study of English Mobile Learning Applications at National Chengchi University

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ABSTRACT

The pervasive popularity of the Internet in the past decade has changed the way many students live and learn, in part, because modern technology has made it possible for learners to access Real-Time Multimedia information on the Internet, or research any topic of interest to them from virtually any computer anywhere in the world. Students can also receive immediate feedback from their peers and/or their teachers when involved in collaborative projects. As a result, teachers of all disciplines need to incorporate the Internet and the concept of mobile learning into today’s classrooms to take advantage of this technology. This research investigated the response of English majors to a mobile learning platform (NCCU-MLP) developed at National Chengchi University (NCCU) in which they were involved as participants. The goal of the NCCU-MLP is to improve the students’ English ability as well as to update the teachers’ understanding of how to use the technology. The purpose of this research was to investigate the responses of students to a mobile learning environment. The research involved 18 participants in a pilot study and 37 participants in a follow-up study who participated in a group activity involving mobile learning activities. The students were asked to complete the activity following which they completed a brief survey of their response to the mobile learning activity. The findings indicate a positive response from the participants regarding the content and procedures involved in the activity. Technical support for the project was found to need enhancement for future projects of this nature.

Keywords: Collaborative Learning, Digital Natives, Language Learning, Mobile Learning, Wifi Multimedia System

BACKGROUND

The pervasive popularity of the Internet in the past decade has changed the way people process information. It has also changed the way many students live and learn (Prensky, 2001; Wagner, E. D. & Wilson, P. (2005). Learning has evolved from the traditional teacher-centered classroom to a more collaborative student-centered classroom, and to mobile learning wherein students

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have direct interaction with the teachers, their peers, and even the world via the Internet. Technology has taken learning to the next level of innovation. With the installment of WiFi (Wireless Fidelity) or IEEE 802.11 WLAN (Wireless Local Area Network), it is possible for learners to access Real-Time Multimedia information on the Internet. Students with a mobile device such as a PDA, or a notebook computer, can access the information they wish to know and learn from virtually any location in the world at anytime of the day or night. In that sense, learning has become mobile. Facing a group of students who grew up with the Internet, “digital natives” as researchers have called these students, teachers of all disciplines need to incorporate the Internet and the concept of mobile learning into today’s classrooms (Prensky, 2001). In addition, since more than 70% of the information on the Internet is in English, English has become the most commonly used language for people around the world to access information and to communicate. As a result of these circumstances, how to improve the students’ English ability is another challenge that teachers face today.

Being one of the campuses that celebrates a WiFi environment, National Chengchi University provides its teachers and students with a “mobile learning” context. However, how to encourage students to take advantages of this environment to improve their English is a question that has remained unanswered. After a series of discussions, a proposal was made by the authors to combine the traditional approaches to learning and the latest technology to the English learning activities where students participate in groups to test the feasibility of incorporating mobile learning into a college level English class. NCCU, being the top rated internationalized university in Taiwan, postulated that both local students and international students on campus should be able to take advantage of this “mobile learning” context.

This article is divided into three main parts. The review of the evolution of learning in the past decades, the theory of mobile learning, and the significance of its application in learning is discussed first. In this section, the gap found in the literature review will also be discussed. In the second section, the design of the group activity and the technical support will be described in detail. The last section will focus on the discussion of the results of the study, its limitations, and future possibilities.

LITERATURE REVIEW

To receive an education, schools are no longer the only option for students. In fact, a student can take courses tailored to one’s needs at any time and any place today. Such is the nature of distance learning (d-learning), where students and the instructors are separated by time and/or distance (Georgiev, T., Georgieva, E. & Smrikarow, A., 2004). D-learning offers numerous advantages, especially for those who need flexibility in their life, such as learners with restricted mobility, an irregular work schedule, or family responsibilities. In addition to having freedom in time and location, d-learning is also student-centered. Not only do learners choose their materials in some cases, they also proceed at their own pace and intensity in some cases (USJournal.com, LLC). Students are not the only beneficiary of distance learning: institutions also increase revenue by delivering education to distance learning students since the class size increases while overhead stays the same in some cases (Valentine, 2002).

Though distance learning is often thought to be a new form of education, it actually has a history of over 100 years. As early as the 19th century, efforts were made to promote adult education beyond university campuses using correspondence type courses where interaction takes place through the postal system. With technological improvements, more and more mediums have become available to serve as educational tools. During the World Wars, the concept of serving education through radio was developed when broadcasting licenses were granted to many higher educational institutions by the U.S. government. Though the concept never matured, it prompted research in other
possible mediums, such as educational television in the mid 20th century. A few decades later, in the 1970s and 1980s, cable and satellite television and videotapes were used as delivery tool for distance learning courses (Nasseh, B., 1997; Valentine, D., 2002).

With the advancements of technology in the 1980s, the electronic learning (e-learning) era reigned. It compensated for a major defect in distance learning, the lack of face-to-face learning. It became possible for teachers to instruct a class in another country, and have real-time discussions with their students. By using the three major didactic uses of technology, satellites, video conferencing, and the World Wide Web, learners were able to interact with their instructors and other learners. However, in the e-learning environment, the equipment decided where learning would take place. The cables and wires restricted the movement of the students as seen in Figure 1.

As technology advanced to its wireless phase at the end of the 20th century, devices such as cell phones and laptop computers were incorporated with wireless communications (e.g. Wi-Fi) and technologies (e.g., 3G), allowing learning to become interactive, taking place at anytime and anywhere (Georgiev, T., Georgieva, E. & Smirikov, A., 2004). Nevertheless, the term “mobile learning” (m-learning) has different definitions depending on the viewpoint one takes. From a more technological perspective, Quian (2000) views m-learning as learning made possible through mobile devices. In line with that definition is O’Malley, et al (2003), where m-learning is seen as “[a]ny sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies.” Sharples (2005), on the other hand, takes a more constructivist view of m-learning; he believes that mobile technology increases the amount of communication and interaction in learning. This research project will adopt the m-learning definition by Sharples, Taylor, & Vavoula (2005), which is “the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies.” (Figure 2)

M-learning significantly improves the education environment in e-learning, as seen

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Figure 1. The e-learning environment (Keegan, D., 2000)

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in Table 1 (Laouris & Eteokieous, 2005). From the pedagogical perspective, m-learning allows more types of instruction and gives student flexibility in their environment. When learners communicate with the teacher and other fellow students, m-learning is instantaneous, spontaneous, and not restricted by time or geographical locations.

Today's students are different from their predecessors; these students are the first generation growing up in a ubiquitous computer environment. Prensky (2001) labels them as digital natives who are born in the digital era and fluent with the use of technology. Digital natives carry out many daily activities online, such as chatting with their friends via instant messaging, meeting new people on virtual communities, and doing their shopping online. With wireless technology combined with portable gadgets, students can conduct these activities anytime and anywhere. Students nowadays are characterized as those who are accustomed

<table>
<thead>
<tr>
<th>Pedagogical differences</th>
<th>e-learning</th>
<th>m-learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture in classrooms, home, or in Internet labs</td>
<td>Learning occurring in the field or while mobile (Anywhere)</td>
<td></td>
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<tr>
<td>Lecture at restricted time</td>
<td>Learning occurring at non-restricted time (Anytime)</td>
<td></td>
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<table>
<thead>
<tr>
<th>Communication differences</th>
<th>Teacher vs. Student</th>
<th>Student vs. Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-shifted (delayed checking of e-mails or web)</td>
<td>Instant delivery and check of e-mail or Instant Messages</td>
<td>Spontaneous</td>
</tr>
<tr>
<td>Scheduled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted location</td>
<td>No geographic boundaries</td>
<td></td>
</tr>
<tr>
<td>Travel time to reach to Internet site</td>
<td>No travel time to access WLAN</td>
<td></td>
</tr>
<tr>
<td>Poor voice communication due to public courtesy</td>
<td>Rich voice communication due to reduced inhibitions in open field</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Differences between e- and m-learning (Modified from Laouris & Eteokieous, 2005)
to on-demand information, multi-tasking, preferring visuals to texts, and constantly networking (Prensky, 2001; Valentine, 2002). As most instructors are born before the digital era, they never experienced what their students went through. The instructors will encounter problems applying conventional methods that worked for them in the past to this new breed of students. Prensky (2001) urges instructors to communicate in the style of the students to bridge the gap between them.

Mobile learning is the answer to the students' needs because of its numerous advantages. First, learning for students is no longer restricted in terms of physical space or time; rather, they are able to engage in nomadic learning. At any time or place, students can easily access learning materials of their choice. Teachers are able to conduct lessons outside of the classroom into the students' surroundings. The learning then becomes more contextual, and personal, rather than hierarchical and lecture-recited (Naismith, Lonsdale, Vavoula, & Sharples (2005). Furthermore, students make better use of their time because of mobile learning. They receive formal learning experiences (e.g., taking a class, attending a workshop) with informal learning experiences (e.g., on a school bus). Students could be using their time more efficiently.

Secondly, the ubiquity of wireless devices and services allows mobile learning to be easily integrated into peoples' lives. By the end of first quarter of 2006 in Taiwan, there were 22.51 million cell phone numbers in use, and about 1.91 million people who subscribed to mobile Internet services, allowing them to be connected to the web using their cell phones. Moreover, the popularity of WiFi in Taiwan has increased annually (see Figure 3). Lastly, the prices of personal digital gadgets continue to decrease as time passes, making them more affordable to the public. Hence, they provide more opportunity for people to have access to mobile learning (Wagner & Wilson, 2005).

Taiwan has a large population of Internet users. The nation's population totaled 22.75 million as of October, 2005 and more than 65% use Internet services as seen in Figure 3. The number of Internet users has steadily grown over the last 4 years, as shown in the July, 2006 Taiwan Network Information Center (TWNIC)

![Figure 3: Growth of Internet users in Taiwan from 2003-2006](image)

**Figure 3: Growth of Internet users in Taiwan from 2003-2006**

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (in million)</th>
</tr>
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<tbody>
<tr>
<td>2003</td>
<td>10.95</td>
</tr>
<tr>
<td>Mar</td>
<td>11.75</td>
</tr>
<tr>
<td>Jul</td>
<td>12.66</td>
</tr>
<tr>
<td>Jan</td>
<td>12.73</td>
</tr>
<tr>
<td>Jul</td>
<td>13.46</td>
</tr>
<tr>
<td>Jan</td>
<td>14.40</td>
</tr>
<tr>
<td>Jul</td>
<td>14.77</td>
</tr>
<tr>
<td>Jan</td>
<td>15.38</td>
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summary report of Internet broadband usage. In just a few years, a growth of 60%, or 6 million users, used Internet services. More impressively, approximately one out of five Internet users used wireless Internet services as of 2006, and the number of wireless customers continues to climb annually (see Figure 4). The number of wireless Internet users has doubled, from 1.5 million to 3 million people in just two years, from July 2003 to July 2005. An additional half a million used the service in the next year, from July 2005 to July 2006. We can expect the number of wireless Internet users to continue to increase as the government of Taiwan actively promotes the wireless services.

THEORETICAL UNDERPINNINGS

Learning with mobile technology can be examined using an adapted version of Engeström’s (1987) expansive activity model, which originated from activity theory. The theory was developed from sociocultural theory, founded by Vygotsky, Leont’ev, and Luria in the 1920s and 1930s, but was only internationalized half a century later, in the 1980s and 1990s (Engeström, 1999). The basic tenet of sociocultural theory is that the human mind is mediated and relies on tools and labor activity to establish indirect relationship among themselves and the world (Lantolf, 2000). The tools may be symbolic, such as language, or physical, like computers. Activity theory is an extended theory developed from sociocultural theory, focusing on Vygotsky’s claim that “human behaviors results from the integration of socially and culturally constructed forms of mediation into human activity” (As quoted in Jin, Wu, Liao, & Liao, 2003, p. 8).

Engeström (1999) illustrates how activity theory applies to education in his expansive activity model (see Figure 5). To achieve the final outcome of learning, may it be one’s well being, or success, the premise is to produce objects, in this case, knowledge. The subject, or the learner, engages in activity in order to obtain the object (knowledge). During the process, the learner uses artifacts, or mediating instruments, which includes both tools and signs (e.g., language, learning resources), to conduct the activity. Another element that mediates activity is the community, which is composed of individuals or the group involved. The subjects may share responsibility of achieving the objective with
the community, realized through the division of labor. Finally, the community may establish rules referring to the regulations and norms that restrict actions and interactions of the subjects (Engeström, 1987).

A modified Sharples et al. (2005) model of mobile learning explained that using the activity theory will serve as the framework for this study. The mediating artifacts refer to the mobile learning technology, which the subjects, in this case the students, mediate in their learning activity. Control refers to issues regarding human-computer interaction, such as rules indicating acceptable behaviors (e.g., network etiquette) in operating mobile devices students must adhere to during learning. The students will conduct the activities in various buildings on campus, the context they will be exploring. During the activity, students will communicate with their peers, and also interact with their laptops to gather information. Finally, students' knowledge and skills should be improved and revised upon completion of these activities. By integrating mobile technology with learning, an optimal learning environment that caters to needs of today's students is provided. Figure 6 is an illustration of this modified model.

**RELEVANT MOBILE LEARNING STUDIES**

**Tate Modern Multimedia Tour**

In 2002, the Tate Modern Museum in the UK launched a multimedia guide for visitors to learn more about the art of its galleries (Tate Modern and Antenna Audio Ltd.). A 3-month pilot project studied how visitors evaluated the guide. Visitors used PDAs that provided them with more contextual information of the artwork on display via different media, such as still images, audio clips, and videos. Visitors could use the interactive screen to select the media desired, and play games and quizzes about the work. The wireless network in the project is location sensitive, meaning correct information is sent to the visitors at the right time and place. As a central server stores all the information, the content sent to the PDA is limitless in continent and easily updated. Some 825 visitors participated in the pilot study, and questionnaires and focus groups were used to gather feedback.

The results showed that the visitors enjoyed the tour, spending an average of 55 minutes on the tour, and 70% of the participants commented that they had spent longer in the museum than

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*Figure 5. Engeström's expansive activity model (Engeström, 1987)*
expected, and a similar percentage said the tour had improved the quality of their visit. Multi-tasking and multi-tracking of different media (e.g. looking between screen and artwork) was not a problem for the users. However, they did not tolerate long messages and blank screens. Using PDAs to enhance learning is demonstrated in Tate Modern Museum’s media guide. The photos in Figure 7 are from Tate Modern, 2002.

A mobile butterfly-watching learning system (Chen, Kao, Yu, & Sheu, 2004) was developed for 4th-grade Taiwanese elementary students to learn about local butterfly species.

The experimental group was divided into teams of two, and each team received a PDA with a LAN card and a digital camera. The teacher used a notebook with a wireless LAN card system that acts as the server, containing a database of the butterflies in Taiwan. The students visited a butterfly farm six times. The first step of the procedure is self-selection, where students take pictures of butterflies. Second, in the self-determination step, students transfer the photo to the database to find possible matches. Next, in the self-modification step, students modify their previous search to arrive at the final decision. The last step is for students to record their find-
ings and their learning process in their journals, and then the teacher sends her comments to the students on their PDAs. The experimental group was compared with a control group, who used a butterfly textbook instead of a mobile system. To evaluate the learning effects of mobile system implemented, multiple-choice questions on butterflies' key features were administered before and after the trial. Results showed that the experimental group did better than the control group in identifying key features. The following photos of the mobile system are taken from Chen, Kao, Yu, & Sheu (2004). (Figure 8)

A study was conducted by Thornton & Houser (2004) in Japan to see how university students' acquired English vocabulary using SMS. Forty-four students received 100-word text messages three times a day, for a period of two weeks. Each week the students studied five vocabulary words used in context and reviewed them periodically. The medium of learning vocabulary through the cell phone was then compared with Internet and paper-based materials. In the first experiment, a within-in subject, counter-balance design was used. One group of students received a 10 word vocabulary set from their cell phones while the second group logged onto the instructor's website to retrieve the same material. After two weeks, the groups switched the media and the experiment ran for another two weeks. The results from pretests and posttests revealed that mobile text messaging showed an improvement over using the Internet method. In the second experiment, one group of students learned vocabulary via SMS while the other received vocabulary on paper. The same tests were run, and the results revealed that students who studied by mobile text messaging did significantly better than the other groups.

**Gap Found in the Literature Review**

In the domain of mobile learning, most studies are conducted in science education with few studies conducted related to language learning and teaching. In Taiwan, the studies focused mainly on elementary education. Numerous studies implement mobile gadgets such as tablet PCs and PDAs in elementary schools to see how effective these devices are for students' motivation and learning. Content of the studies included aquatic life (Kao, 2006; Tsai, 2004, & Wu, 2006), botany (Ling, 2004) and birdwatching (Su, 2003). The results from these studies indicate positive results for motivation, though in some cases, the effectiveness is not more significant than conventional methods. There are a lack of studies in the area of integrating foreign language education and mobile learning, especially in higher education. Hence,

**Figure 8. Short message service (SMS)**

| Interface of the PDA | Test sheet for evaluation |

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the purpose of this study was to address the issue with the hope to explore the students’ response to mobile learning with the future possibility of incorporating mobile learning in university classrooms.

**Technical Support and Activity Design**

Before designing an English learning activity that could be used by NCCU students on campus, the first question to be answered was “What should or can students learn on campus using mobile devices?” The answer, after discussion, was the history and the stories of some old buildings on campus. By adopting the activity model proposed by Sharples et al. (2003), students learned the knowledge in a context with a group of peers using English and a mobile device as the tool when participating in this activity. Unlike the Japanese study discussed above, English in this activity was not just the goal of learning, but also a tool to learn new knowledge, and a tool for communication with peers. Also unlike the Japanese study, students did not passively receive information but actively participated in a group activity sharing and exchanging the information they received with their peers in order to learn new knowledge.

However, before such a group mobile learning activity could be designed, the establishment of the audio, video and text files of these buildings, and the confirmation of technical support are vital. As a result, a field investigation of the buildings and the study of their histories were conducted by the authors. Photos were taken and the content of the introduction were recorded in digital files. A series of experiments were conducted as well to ensure the “friendliness” of the campus. In the following sections, the experiments conducted and the decisions made on the technology side and the detailed design of the group activity are discussed.

**TECHNICAL SUPPORT**

**NCCU-Mobile Learning Platform (NCCU-MLP)**

In order to investigate the feasibility of mobile learning on campus, the activity designed needed to be able to foster group work, peer communication, and Internet access while subjects walked around campus. Thus, a NCCU-mobile learning platform (NCCU-MLP) was implemented to meet these needs. This platform consisted of three main subsystems which included an Instant Communication subsystem, a Positioning subsystem, and a WiFi Multimedia subsystem as shown in Figure 9.

The Instant Communication subsystem had an Instant Message and Push-to-Talk to exchange text messages and voice message among a group of participants. The Positioning subsystem was used to determine the locations of the users through surrounding WiFi access points (APs). NCCU-MLP has to dynamically detect the user location first then access the right learning materials. The WiFi Multimedia subsystem has WiFi TV to play IPTV programs, WiFi Radio to listen to radio stations, WiFi Theater to support movies on demand, WiFi Music Station to play local music, and WiFi Monitor to support on site real-time video monitoring. The WiFi Multimedia subsystem was programmed by Microsoft Embedded Visual C++ 4.0 and Java JMF (Java Media Framework API). Both the Instant Communication subsystem and Positioning subsystem were integrated under a Java programming environment.

In the following sections, a brief description of the three subsystems is presented.

**INSTANT COMMUNICATION SUBSYSTEM**

**Characteristics of Group Communication**

As stated earlier, in order to test the feasibility of mobile learning on campus, the activity designed must be able to foster group work...
and peer communication on the move. In other words, a wireless instant group communication system becomes a very important part of a mobile learning environment. Generally speaking, a mobile group communication system must be inexpensive in cost, convenient in use, and comprehensible in quality.

Before discussing what might be the most appropriate system to be adopted for this study, it is important to understand the demands of an instant group communication. The demands are as follows:

- The system must be able to manage the group membership, including adding, removing, and authorizing group members;
- A user must be able to initiate a “talk” to all members in one touch (it is not desirable to have callers to call all members one by one);
- A user must be able to broadcast his/her “talk” to all other members;
- The communications must be able to proceed in full or half duplex conversation mode. (In full duplex mode, any user can talk to all others at any time, while in half duplex mode, only one user can talk to all others at a time);
- The communication delay time MED (the time latency from the speaker’s mouth to the listeners’ ears) must be controlled within a reasonable limit. (The maximum allowable MED is yet to be determined);
- The consumed network bandwidth must be kept as low as possible;
- And users must be able to communicate with others in writing or drawing.

Though the last characteristic is essential in a mobile learning system, as the participants in this study may need to communicate to each other by writing or drawing to assist voice communications, it is not the priority of this section to discuss the use of “White Board” in this study. Voice communication will be the main focus here.
Selection of Communication Technology

With inexpensive cost, convenient use, and comprehensible quality in mind, researchers in this study evaluated several possible means to be used in this subsystem. The evaluation consisted of two steps. The first step was to choose to use either the public cellular phone system or an Internet-Based VoIP (Voice over IP network) system. With its high quality and stability, public cellular phone system is an ideal communication system to meet this study’s need. However, it is simply too expensive to use. Thus, the VoIP over WLAN was chosen for this study, although it has a lower reliability and quality (long MED delay, large jitter, and high packet loss rate).

The second step was to choose to use either half-duplex or full-duplex conversation mode. Full-duplex conversation mode, also named “Conference Call,” is a better conversation mode in a high bandwidth and high quality communication system. On the other hand, VoIP over WLAN has a limited network bandwidth and a lower quality in delivering voice streams. Thus, it can only support a very limited number of simultaneous users with what is called “double talk” problem. However, half-duplex conversation mode, which has a popular name, “Push-to-Talk” (PTT), consumes less network bandwidth such that it can support more simultaneous users. Furthermore, it allows only one user to talk at a time such that it can tolerate much longer MED delay to avoid the double-talk problem. Therefore, PTT was chosen to be implemented on the NCCU-MLP system.

Subsystem Design and Implementation

As a result, the PTT was implemented in Java programming language and was an integral part of the NCCU-MLP System. A group management system was deployed in a server located in the Mobile Communication Lab. The server also performed the re-broadcast function. Participants in this study pushed a button on the NCCU-MLP system to acquire the right to talk. The server granted the right to only one participant at a time. The one that obtains the right can talk to the group. The system used G.711 Codec to convert the voice into packets and send them to the server. These voice packets were then broadcast to all other subjects. (Since G.711 consumes 64k bps bandwidth, it was replaced by either iLBC or G.729a Codec to reduce bandwidth consumption.)

Positioning Subsystem

The most popular positioning systems are GPS (Global Positioning System), infrared, ultrasonic, and RF (Radio Frequency). Among them, RF suited this study for the following reasons. First, since the activity was conducted indoors, GPS failed to meet the need. Second, infrared or ultrasonic positioning usually needs more receivers installed for good coverage, and thus is not cost-effective. Third, PDAs or small laptops equipped with mobile users are embedded with WiFi which uses RF to connect to AP (Access Point) to access Internet, and can penetrate walls and thus have better coverage than infrared systems. As a result, using a RF-based positioning system was the most promising and convenient for this study.

RADAR and its Limitations

Among all RF-based works, RADAR and its variations are probably the most famous and popular ones (Bahl, & Padmanabhan, 2000; Krumm, & Platt, 2003). RADAR refers to a positioning system which requires a construction of a RM (Radio Map) by measuring RF SS (Signal Strength) for every grid point of any given space before it can be used. The biggest disadvantage of the process of constructing RM, known as calibration, is that it is time consuming because in order to achieve accuracy, more calibration data in the RM is required to be measured manually to fight the otherwise fading channel.

With this limitation in mind, RADAR would not be ideal for this study. In the following
section, a modified RF-based positioning subsystem was proposed to maintain the accuracy while reducing calibration efforts.

**Modified RF-Based Positioning Subsystem Design and Implementation**

In order to achieve acceptable accuracy while reducing the time and man-power investment in the positioning subsystem, the following measures were taken. First, instead of measuring SS for many points manually, a few points, one, three or five, in any given space was measured in the offline calibration phase. After these points were measured, researchers, then, carried the WiFi device to walk around this space and pause 3-5 seconds at random spots for the system to collect data. Third, after this process, the system automatically “learned” or traced the best possible path using HMM (Hidden Markov Model) and the wireless channel propagation model in order to complete the RM necessary for the positioning system to function.

In this study, a space with a dimension of 11X52 meters was used for testing. With one, three, and five calibration points measured prior random trace points were learned. Figure 10 below demonstrates how our modified positioning subsystem increased accuracy with the increase of “learned” trace points.

Compared with RADAR and its modification Microsoft positioning system, the proposed modified positioning subsystem adopted in this study performs the best with the least time investment as shown in Table 2 below.

**WIFI MULTIMEDIA SUBSYSTEM**

**System Architecture**

The NCCU-MLP was implemented as a client-server model. The WiFi Multimedia subsystem (except WiFi Monitor) was based on a VLC (VideoLAN) media player framework as shown in Figure 11. A VLC media player is a highly portable multimedia player for various audio

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**Figure 10. Accuracy of reducing calibration effort**

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**Table 2. Comparison of different positioning systems**

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<tbody>
<tr>
<td>Mean error distance (m)</td>
<td>2.89</td>
<td>1.92</td>
<td>9.19</td>
</tr>
<tr>
<td>Reduced calibration effort percentage</td>
<td>99%</td>
<td>0%</td>
<td>90%</td>
</tr>
</tbody>
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and video formats (MPEG-1, MPEG-2, MPEG-4, DivX, mp3, ogg, etc.) as well as DVDs, VCDs, and various streaming protocols. It can also be used as a server to stream in unicast or multicast in IPv4 or IPv6 on a high-bandwidth network.

**Server Side**

At the server side, video is captured by a Video Capture Filter. The capture filter will then select an appropriate Video Compress Filter to compress the video according to the bandwidth of information flow and hardware equipment. All those processes for the audio are done in a similar way. Both the compressed video and audio were mixed by a Video and Audio Mixed Filter. Finally, video and audio streaming was sent through a Network Transfer Filter. Figure 12 illustrates the process.

**Client Side**

The client retrieves the information flow through WiFi, and separates this flow into video and audio through the Splitter Filter. Both the split video and audio are sent to the Video Decompress Filter and Audio Decompress Filter, respectively. The decompressed video is received by Video Receiver Filter, and audio by the Audio Receiver Filter. Output devices can be any kind of monitors and speakers. Figure 13 illustrates this process.

Figure 14 and Figure 15 show the main page of the NCCU-MLP. On the left side, there are “Talk to Others,” “Video,” “Media,” and “Questions” buttons. The logo of our system displays on the right side. When pressing the “Talk to Others” button, the participants of this study will be prompted a small window of two parts to the left side of the original window. The window above is for Push to Talk, the window below is for Instant Message. Before the participants talk or write to others, they should select a group of persons from the contact list. The “Push to Talk” button and the “Stop to Talk” button are used to start and end the talk session, respectively. Once the button of “Push to Talk” is pressed, the participant’s voice will be sent to each person in the group. When using Instant Message, the participants only need to type messages and press the “Send” button. When pressing the “Video” button, the participants will be prompted with a tour navigation video. One of the videos will be intelligently selected according to the locations the participants are on campus. As long as the mobile learning

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![Diagram](http://www.videolan.org/vlc)

**Figure 11. VLC media player framework (http://www.videolan.org/vlc)**

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device is on, the participants’ locations will be dynamically tracked by the Positioning Subsystem. When they press the “Media” button, the participants can access all multimedia services, such as WiFi TV, WiFi Radio, WiFi Theater, WiFi Music Station and WiFi Monitor. Pressing the “Questions” button will bring subjects to the learning assessment system.

**ACTIVITY DESIGN**

With the above technical support, the mobile learning activity was designed as follows:

**Sample**

A total of 18 students from one English Honors Program freshman class were chosen as the participants of the pilot study. Another group of 37 students from two English Honors Program classes were chosen as the participants of the main study. The students’ average English proficiency is high as their Joint College Entrance Exam English score ranked them as the top 1% among all freshman students. In the pilot study, students were divided into 5 groups of 4 or 5; while in the main study, due to the limited amount of mobile devices, two sessions of the main study were conducted. Again, students in each session were divided into 5 groups of 4 or 5. Each group was assigned to one of the five buildings on campus to fulfill several tasks designed by the research team.

**Activity Development**

The activity was a timed activity. Subjects were given 50 minutes to finish answering five questions regarding the campus historical buildings. At the end of the 50 minutes, the participants were required to submit answers to these questions online to the researchers. With the technical support, Tablet PC was chosen as the mobile learning device.
In accordance with the features of these five buildings, researchers designed five questions for each building. In order to foster group and peer communication on the move, the questions were categorized into three types. They were “compare and contrast,” “current events,” “on-site interviews,” and “important dates, numbers or figures.” Compare and contrast questions required the participants to compare and contrast information with other groups. For example, subjects needed to exchange information in order to answer which building is the oldest on campus. Current event or on-site interviews emphasized the mobility in this activity. For example, the participants were required to find out one professor’s teaching schedule for the semester. Important dates, numbers or figures, on the other hand, expected participants to...
collect information from different floors in the building to answer questions like the total amount of labs in that building.

Most importantly of all, among the five questions that were given the participants who were assigned to a certain building, only one question was related to that building. The rest of the four questions were questions for the other buildings. With this design, subjects were forced to do constant communication using the mobile device while walking up and down the building they are assigned.

Additionally, an online questionnaire in relation to content, procedure, technical support and mechanism was designed and used to verify the effectiveness of the group activity and students’ motivation.

Procedure

With the consent of the participants, the pilot study was conducted on June 8, 2007 and the main study on December 13 and 14, 2007. After the participants were divided into 4 or 5-person groups and assigned to five different buildings on campus with Tablet PCs at hand, a 20-minute orientation concerning the steps, tools and equipments used was given. Participants were asked to learn the history of the building they were assigned using the NCCU-MLP presented on their Tablet PCs. Then, within the following 50 minutes, each group was asked to communicate with other group members using Push-To-Talk, whiteboard, and other technology supported by the PC. In the meantime, through learning and sharing information concerning the building, the participants were asked to download a worksheet containing questions related to different buildings, give answers to the questions and then submit them via the mobile device to the server. At the end of the activity, the participants were asked to fill out an online questionnaire to verify the content, feasibility, user-friendliness, and mobility of the developed materials. The participants every communication during the activity was recorded and transcribed for evaluation and study. A quantitative analysis was applied to the online questionnaires.

A brief of the study result and its limitations will be discussed in the last section below.

RESULTS, LIMITATIONS AND FUTURE POSSIBILITIES

To assess the effectiveness of this group activity, improve students’ motivation for language learning and assist in developing a model for m-learning in universities, an online questionnaire in relation to content, technical support, procedure and mechanism was designed. The participants in both the pilot and the main study completed this questionnaire. Many technological flaws were improved and debugged after the pilot study and the analysis of questionnaire result.

Results

In this section, only the results of the main study are discussed. In this survey, 30 respondents from two classes out of 37 participants ranked their degree of satisfaction concerning the criteria mentioned and further provided additional information for this learning experience by responding to 4 open-ended questions. The followings are the four charts illustrating the outcome of the online questionnaire.

Figure 16 shows an overall evaluation in terms of 3 criteria concerning content, technical support, and procedure. The chart indicates that the results of these 2 classes are consistent with each other. They had a close rapport with the use of content and the implementation of the procedure, but ranked technical support lower than the other 2 criteria.

Figure 17, Figure 18, and Figure 19 show the analyses of these 3 criteria respectively. Figure 17, focusing on content indicates the participants considered the material design and interaction among groups rich and English subtitles essential. Over half of students agreed that the questions designed in the activity can enrich communication in teams and enrich the
collaboration through discussions with others at a distance. Furthermore, 21 students would like to consult English subtitles when replaying the video clips, while 4 students did not consider it essential. However, they had different views on if the video clips were explained clearly. Twenty-three students agreed the oral descriptions of the video clips were of such clarity, while 4 students remained neutral, and 3 disagreed with this item.

Figure 18 illustrates that students needed more technical support from some improvements in the mobile devices themselves, the interface, the use of whiteboard, and mobile network connection. The limitations of technical support will be further discussed.

Figure 19 indicates that the participants were satisfied with the procedure of this group activity in relation to the inclusion of some technical instructors and a comprehensive orientation, except for the inconvenience and a certain lack of mobile device effective performance caused by the unpredictable weather condition. Approximately 26 students indicated that technical assistants played an important role in implementing this activity. Also, approximately 21 respondents were pleased with the comprehensive orientation given at the beginning of the activity.

In general, these 4 figures illustrate that students showed great interest in using this innovative learning method; however, they felt a bit frustrated and overwhelmed when the technology was not so supportive and helpful.

In the following section, weaknesses in the activity and future possibilities for such activities are discussed in more detail.

**Weaknesses**

Mobile computing and communication systems are in general more vulnerable than those on
fixed networks, such as a PC. The followings are the limitations found in the experiments:

- Battery life is limited so that it is difficult for NCCU-MLP to support any long activity over two hours.
- The transmission quality of a wireless radio signal is highly dependent on the weather conditions, especially on rainy days. As a consequence, the stability of a mobile network connection is lower than fixed networks. The design of a mobile learning environment must take this into consideration.
- The software system in a mobile computing environment is much more complicated than that on fixed networks. Thus, it needs more effort to make the software system robust.
- Compared with whiteboard, the pen-based word recognition system supported by the Windows XP operating system is less ideal for group communication because of time concern. A pen-based word recognition system consists the time of carefully typing the character, character recognition, and character correction due to wrong recognition. On the other
hand, whiteboard reflects input to all the other subjects in terms of image. There is no time wasted in both recognition and correction.

- Compared with a voice communication tool, like PTT, a whiteboard is even less ideal for group communication. First, people are used to talking rather than writing. Second, voice communication is much faster than that of hand-writing. Third, whiteboard is a groupware. Images from different ends can easily be mixed up and then reflected to each end. In other words, whiteboard fails to transmit images correctly and clearly.

- In some special environment such as a library, the use of voice communication will be limited. This may hurt the efficiency of collaborative learning. A simple earphone, wired, or wireless, will easily solve the problem.

- Users prefer full-duplex conversation mode to half-duplex mode. However, it remains a great technical challenge to offer group voice communication in full-duplex conversation mode under limited bandwidth.

- In order to achieve high accuracy in a positioning system, the more AP in any given space are better.

With regards to the activity design and content, the followings are some weaknesses that were found:

- In this activity, whether during video-watching or group discussion, any enclosed quiet learning environment such as a library, embarrassed our students. Consequently, the limited use of voice communication was not encouraging and the interaction among groups in collaborative learning was inefficient.

- As for the video content, the researchers were restricted by the authenticity and accessibility of the materials. In other words, the researchers had to make great effort to find motivating, informative authentic material on campus. They also had to help students apply new knowledge and skills, and integrate these into the learner's world to make learning effective. As a result, students complained about the content of these video clips as not exciting and intriguing enough.

- The students relied on their technical assistants mainly because there was considerable anxiety among them about high-tech use. It may prove that students need a certain amount of related prior learning and training.

**Future Possibilities**

The followings are the future plans for the development of a better (or more powerful) group communication system:

- Making both the group communication and positioning systems more robust;
- Porting the system to the newer WiMAX wireless communication system;
- Porting the system to light-weighted, small-size, powerful UMPC (Ultra Mobile PC) platform
- Installing formative evaluation to track learner’s improvement over time.

Again, with regards to the activity design and content, the followings are some future possibilities:

- Improving and enriching the quality and quantity of the content to enhance learning and motivation as some students suggested the creative use of interesting anecdotes about the buildings to add interest and liveliness to the group activity, while others showed interest in learning more about other buildings and areas on campus.
- Redesigning a competition game like “Treasure Hunting” to elevate learning interest.
CONCLUSION

In conclusion, the participants found the m-learning environments enjoyable and creative. In addition, m-learning provides flexibilities, practicality, and usability for various learning styles. However, as the questionnaire illustrated, students depend heavily on technical assistants to execute the activity. In other words, even many students are digital natives, prior learning and training seem necessary for m-learning activity implementation. Last, for teachers and researchers, the challenge remains in how to design and develop relevant and interesting learning environments based on sound pedagogical principles to foster the use of mobile learning devices.

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