Mobile Learning: Major Challenges for Engineering Education

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Abstract - There is a high demand for engineers to design, produce and develop mobile learning (mLearning) technology. However, there are only a limited number of courses which fully present the correct pathway to develop and construct mLearning courseware. This paper is a report based on documentary research and a needs assessment survey of mLearning, the whole concept being, in many ways, a work in progress, pending general adoption. The survey aims to explore how university students consider mLearning and how mLearning would be suited to their needs. The outcome of the survey reveals many crucial elements that should be applied to create a new curriculum in the engineering area. The participants of the survey were 296 university students in Thailand. The majority of respondents were Thai (91.2%). Almost all (97.4%) of the participants who would pay for mLearning courses believed that mLearning would enhance their present learning capabilities. mLearning will assuredly be accepted in the future, since 96.6 per cent of university students stated they wanted to use mLearning if they can access the material with no charge. The proposed mLearning sciences and technology program can be structured into three main areas: wireless technology, mobile education and application management.

Index Terms - engineering education, mobile learning, scholar teaching, university students.

1. Research Background

Mobile campus and wireless universities have been forecasted to be ubiquitous by 2015 [1]-[2]. The demand for mobile content is continually growing [3]-[4] since the exponential growth of computer network technology emphasizes that people can access the Internet from any appropriate device. To quote the familiar catchphrase: anyone, from any place, at anytime [5]. Wireless network technology like Wi-Fi, WiMax, and Radio Frequency Identification (RFID) already operates on the Internet with portability [6]. The Internet potential in this far-reaching computing era of widespread eLearning will expand to include mLearning. The growth of the mobile age becomes obvious with world mobile telephone subscribers already reaching 3.3 billion in 2007 [7], which will mushroom to more than three times that number (1 billion) of personal computers (PCs) by the end of 2008 [8] and more than double the number (1.3 billion) of world Internet users [9]. In third world countries, the leapfrog effect of numbers of mobile devices has quadrupled from 1997-2007 [10]. mLearning will expand educational opportunities and narrow digital divides, especially for rural youth in many developing countries such as India, Pakistan and Thailand, due to the affordable cost of devices [1], [5]. Moreover, in developed countries such as the UK, mLearning has become an outstanding option to assist hard-to-reach learners in off-campus learning situations [11]-[12]. In another example, the mobile phone penetration of students is over 100 per cent in countries such as Japan, Korea, Europe and the Philippines, because so many people own and use several devices [13].

The availability of mLearning content and applications on wireless networks is a key factor to a complete mLearning process [4], otherwise there might be no education, only communication [14]-[15]. Designing an appropriate application of mLearning is a priority for mLearning software development [1], [4]. Concurrently, students’ expectations for delivering mobile services for mLearning include an increasing demand for both content and media [3]. As eLearning was a “critical” component of the long-term planning strategies in American institutes, [16] the mLearning production plan must be ready prior to the surge of wireless campuses coming in the 21st century.

Scholars teaching in engineering education should take this opportunity to create hybrid programs intertwining education sciences and engineering technology. These new programs will be valuable to educate society about why mLearning will be highly in demand since students who graduate from these programs can be experts in both mLearning sciences and technology. Based on these facts, it becomes apparent that the production procedures of mLearning will always need staff who have knowledge of both mobile application and instructional design. In other words, producers of mLearning are involved in computer engineering [15] as well as in education theories and principles. A high demand for engineering courses in mLearning production was reflected from the fact that all organizations and institutions are faced with significant shifts, resulting from the impact of emerging technologies and global economy [17]. Therefore, it is critical to construct the curricula for mLearning sciences and technology in both degree programs and short courses.
This study, therefore, aims to explore mLearning situations in higher education in order to formulate and develop engineering education curricula for mLearning. The result of this study should help to improve the conduit to mLearning, and hopefully to help establish a professional eLearning approach which could be systematically implemented worldwide, since the potential of mobile devices in the 21st century is not only to connect people but also to extend education options for all.

2. LITERATURE REVIEW

mLearning has been used significantly among different projects which aimed to train people in both formal education, such as supplements to courses, and informal education, i.e. visits to museums, tourist sites, and geographical locations around the world [18]. In order to build curricula for mLearning, developing appropriate projects through research must be implemented. This section will analyze and synthesize information to aid in the construction of appropriate topics for mLearning programs. The overview of developing mLearning projects consists of five stages [14] (see Figure 1).

Figure 1: The processes of mLearning can be described in 5 steps. Step 1: students own portable devices and are ready to learn. Step 2: students connect to a wireless network to search for available content. Step 3: students search and keep searching until they find the desired material. Step 4: students perform learning activities. Step 5: students achieve learning objectives. Based on the processes of mLearning, the involved elements are the students, mobile devices, wireless technology, mLearning content, and learning performance [14].

The study to evaluate the development of wearable devices in higher education institutions is organized into three main parts [19]. First: technological and technical evaluation of current wearable mobile devices which explores the characteristics of these devices. Second: three scenarios for further and higher education which review several projects: A) Web lectures. B) Campuses without walls. C) Field trips. Third: consideration of the uses and purposes for wearable and mobile devices in tertiary education. The elements of mLearning, then are mainly technology, creative projects for solutions in mLearning, and education [19].

mLearning was claimed to be a prospective distance education approach since it can deliver “ANYTHING, if we design it right” [13]. Possible learning activities of mLearning included “listening, observing, imitating, questioning, reflecting, trying, estimating, predicting, “what-if-ing and practicing” [13]. mLearning has delivered knowledge in English, Mathematics, and has accessed live and archived university lectures for millions of students in China and Japan, the Philippines, and Germany [13]. CTAD in the UK owns voice-only mLearning projects for school dropouts with language needs [18]. Short English Lessons that Japanese students can easily dial up are being implemented [18]. Cell-phone-based English Language Training by the BBC et al has already been offered in China [18]. Game-based courses which offer passing grades when users complete the games such as crossword and mathematics have already been launched [18]. Electronic learning is utilized in many companies and institutes such as the American College of Physicians, UCLA School of Medicine and Harvard Medical School, Minnesota State University, the University of North Carolina, Wharton, BBC Bitesize Learning Content and the Norwegian Telemedicine Center at the University of Tromso [18]. mLearning projects are therefore involved not only in technology and in many educational areas, but also in business model management, creativity and game-based learning.

There are some negatives, however. Above these noticeable applications of mLearning, there are also the obvious issues occurring from many aspects of the mobile devices themselves, such as a) miniature screen sizes [4] [19]; b) the limitations of and different styles of buttons on handheld devices affecting interactivity design; c) limited battery life of wearable devices [4]. Moreover, the operating systems of mobile devices differ from computers in general [19]. And research design effective mLearning applications necessitates production content that is sharable in a wide range of devices [4]. These many divergences cause limitations of eLearning application adaptabilities into mLearning. Therefore, characteristics of mLearning applications are unique, not only in an educational media format, but also presenting formidable challenges for information communication technology [15].

In practice, very few existing programs and workshops educate and produce experts in mLearning techniques. The majority of courses focus on general mobile applications and games. Therefore, to produce competence in mLearning, the curriculum should be structured into three main areas: wireless technology, mobile education and application management. This aggressive curriculum should include many subjects, such as mobile technology, distance

978-1-4244-1970-8/08/$25.00 ©2008 IEEE

October 22 – 25, 2008, Saratoga Springs, NY

38th ASEE/IEEE Frontiers in Education Conference

T4F-12
education principles and theories, mLearning project management, mLearning application creativity, instructional mobile interactivity design and game-based mLearning.

3. METHODOLOGY

The curriculum for mLearning sciences and technology for engineer education has been drafted from documentary research results in the previous section. The online survey to examine the needs and characteristics of mLearning also has been constructed to explore original information that might influence educational instruction in mLearning for university students. The Internet-based survey was carefully designed in three versions: English, Thai and bilingual in order to limit the problem of comprehension. The survey was on-line for one month in July 2007 and advertisements of the survey were posted at many universities’ home pages. The on-line questionnaire included 22 items, which are grouped into two main parts: demographic information, and experiences with mLearning. Question type used in this study were dichotomous questions, filter questions, multi-option questions and open-ended questions.

4. RESEARCH QUESTIONS

The survey part of this study aimed to 1) explore university students’ experiences with mLearning and 2) identify demands of mLearning characteristics to form the appropriate courses to produce mLearning experts. The eight sub-research questions were set to cover all objectives, which included; 1) were university students ready for mLearning? 2) Did university students need mLearning? 3) Were university students interested in buying mLearning courses and what factors influenced them to buy mLearning courses? 4) What types of mobile devices would be used for mLearning? 5) What types of learning styles were preferred for mLearning? 6) What were the most preferred activities of mLearning? 7) What were the main purposes of using mLearning? And 8) what were the obstacles in using mLearning?

Participants

The samples of this survey were derived from university students at both international and national universities in Thailand who were mainly a target group for mLearning. Most of the participants were Thai – 91.2 per cent or 270 from 296 people. Only 8.8 per cent were non-Thai. The gender of the participants was quite different – male 51.4 per cent to female 48.6 per cent. The participants of this survey were a random sampling of good university students in Thailand. This included not only students from Bangkok but also from outside Bangkok as well as from National Universities where teaching is in Thai, but also students from an International University where teaching is in English. Approximately two fifths (41.2 %) of the respondents were students at the International University, three fifths (58.8 %) of respondents were students at the National Universities, 31.8 per cent of all participants were students in the National Universities outside Bangkok and the last group (27 %) of participants were students at the National Universities in Bangkok. The respondents of this survey covered all university levels, the majority of respondents (60.1%) were studying for Bachelors Degrees, the second group (23.6%) were studying for Masters Degrees and the smallest group (16.2%) were studying for Doctoral Degrees. The majority of students who participated were unemployed (56.8 %) and the rest (43.2 %) were employed.

The areas of study of the participants was varied, the majority of respondents (27.4%) were students who selected “others” from 16 offered majors. The percentages of students based on majors were Management and Commerce (20.3%), Education (15.5%), Information Technology (11.8%) and Engineering (8.8 %). Other majors included Law, Political Science, Health, Accounting, Creative Arts, Society and Culture, Mixed Field Programs, Architecture and Building, Natural and Physical Sciences, Food, Hospitality and Personal Services, Agriculture and Environmental, and numbered fewer than five percentage points in each major.

5. RESEARCH RESULTS AND DISCUSSIONS

The majority of participants (70.9%) had never used mLearning before, and only 29.1 per cent indicated they had some experience in mLearning. Another related result: the majority of respondents (66.2%) already had mobile devices that could be used for mLearning, and only one third of the respondents did not own an advanced type of mobile device. Based on this information, mLearning was new to these university students, who were obviously in need of more familiarization. Significantly, mLearning will eventually be adopted primarily for university students since more than half of them already own mobile devices that are suitable for this purpose.

These students had a high demand for using mLearning. Approximately four fifths of participants (78 %) indicated they wanted to use mLearning, 18.6 per cent were not sure, and only 3.4 per cent indicated that they did not want to use mLearning. mLearning will eventually be accepted and widely used in universities since more than half of the participants (54.7%) who had no experience with it still indicated they wanted to learn to use it. Similarly, approximately four fifths of participants (76.4 %) indicated that they believed mLearning would enhance their learning. Bachelor’s degree students, the youngest students within these groups, were the largest group of participants (44.3%) who believed in using mLearning, compared to master’s degree students and doctoral students (18.6 % and 13.5 % respectively). Approximately one fifth of the respondents indicated ‘not sure’ and only 2.7 per cent stated they didn’t believe in the potential of mLearning. This poll reflected that mLearning courses, particularly for the bachelor’s degree, should be produced, since the respondents had positive attitudes towards these new learning approaches.

Referring to Figure 2; almost all (97.4%) the participants who would pay for mLearning courses believed...
that mLearning would enhance their learning. mLearning definitely will be accepted in the future, since 96.6 per cent of university students stated they wanted to use mLearning if they can access the material with no fee attached. Importantly, this research found that only one per cent of participants indicated ‘did not want’ and ‘did not believe’ in the capability of mLearning. A survey of experts, in companies from the educational sector who were involved in the design and production of educational materials in Germany, found that 43 per cent of those surveyed would use the mLearning approach [20]. Moreover, the same research in Germany found that more than half of the subjects were confident about using mLearning, and 44.7 per cent of the experts also consider mLearning to be most suited for higher education [20]. Drawn from this result, mLearning sciences should extend coverage to business models and proper project management, since the demand for acquiring mLearning courses was high. Not only were students confident about learning to use the system, but also design and manufacturing experts were committed to their production.

![Usage of mLearning courses](image)

**FIGURE 2**
**USAGE OF mLEARNING COURSES**

In the event that mLearning is not free, the cost of mLearning courses was one main issue that students considered (43.9 %) and demand was another. (30.4%). It was no surprise that the percentages of students who indicated ‘use’ and ‘not use’ mLearning with a personal cost were equal (12.8 % each). Based on the fact that price became the first considered issue followed by demand, the well-business model of mLearning courses needs to be implemented to reduce these obstacles to mLearning availability.

Notebook computer (43.6 %) was the preferred device followed by mobile phone (18.9%), PDAs (7.8%), MP3 (4.7%), TabletPC (3%) and iPod (3%) respectively, because the participants already owned them in those percentages. 80.8 per cent of participants who did not own a mobile device that can be used for mLearning indicated that they could afford to buy a device for this specific purpose. More than half of participants who would buy a device for mLearning indicated their interest in having notebook computers (57.1%). PDAs and Mobile phones were in the second group, 16.8 and 14.3 respectively. Tablet PC, MP3 and iPod were in the third group with less than 10 per cent in total (6.7, 2.5 and 2.5%). More than half (54.7 %) of participants who did not own devices for mLearning intended to buy a mobile device by 2007. The budget that students indicated as affordable for a mobile device was about US$788. The average budget of Thai National University students was slightly higher than the average budget of Thai International University students (US$830 and US$770 respectively). This concluded that Notebook computers and Laptop computers might be more popular for mLearning in Thailand. As well, it might imply that university students preferred to have portable computers which are able to work on multi-purposes tasks rather than smaller palm-size devices.

The most preferred learning style for mLearning discovered from this research was that of an individual approach (39.1%). Similar to the research result of Attewell (2005), those users preferred working independently due to the freedom of personal time management and less pressure [20]. Moreover, the research results in Germany stated that nine tenths of participants indicated advantages of mLearning for time and location independence, and four fifths of these mLearning experts stated that mLearning provided more opportunities to students because of individual learning speed, flexibility and availability [21]. This research also found that university students preferred using mLearning to collaborate with friends after class, to collaborate with teachers after classes, teachers during classes, and friends during class (21.4, 15.7, 12.3 and 11.4 % respectively). This was similar to survey results in the UK, where over nine tenths of students indicated that discussing and questioning opened an opportunity for effective learning [12]. The result gleaned from the preferred styles of mLearning survey showed that education principles and theory would play important roles in improving mLearning quality.

The participants were asked to select any preferred activity of mLearning. These results revealed that most preferred activities were the Internet for education on mobile devices (21.9%), watching videos (18.6%), reading ebooks (17.1%), and listening to MP3s (15.5%). University students also used mobile devices for transferring data (12.6%). Surprisingly, less than ten per cent preferred to use Short Messaging Service (SMS) and Multimedia Messaging Service (MMS) (7.3 and 7 % respectively). Similar to another research, more than half (58 %) stated that text materials were viewed as inappropriate for mLearning [21]. The Internet for education would be used more on mobile devices because of the availability of educational multimedia material. In addition, the growth of social software was able to facilitate developing collaborative learning communities [22]. Therefore, mLearning technology needs to be added as a subject to educate mLearning experts to work with these new activities.

The survey also asked university students to select any preferred purposes of mLearning. Approximately one fourth of participants (24.5%) selected ‘self administered’ as the...
most preferred purposes of using the courseware through mLearning. This was similar to another research that problem solving in groups using mLearning was considered inappropriate (52.4%) [21]. This survey also revealed that other learning purposes shared important roles in mLearning: delivering class supplements (22.4%), course summary (21.2%), education media (17.4%) and drill & practice (14.5%). These findings were similar to mLearning perspectives in Germany stating that true-false questions were the most appropriate for mLearning application [21]. Based on this survey of preferred mLearning purposes, either instructional mobile interactivity design or Game-based mLearning should be utilized by mLearning experts in their designs for effective mLearning courseware.

Again, some negative factors. Participants had been asked to indicate any obstacles that surfaced in using mLearning. Cost of services (24.3%) was the greatest issue from university students, followed by quality of courseware (22%), size of screen (17.5%), prices of devices (16.1%), subjects of courseware (11.6%) and usability (8.6%). The issues of mLearning would have probable solutions, but only if a section regarding mLearning project management were to be implemented. This is because the business plan needed to guide the price of learning services also needed to include other obstacles which were influenced by technology.

The last question on this survey was open-ended. The interpretation can be grouped into various positive opinions and some fears: 1) ‘We need mLearning as quickly as we can get it’. 2) ‘I wish mLearning could be implemented very soon.’ 3) ‘mLearning should have been produced a long time ago.’ 4) ‘I wish to have all lecture scripts in MP3.’ 5) ‘Where can I get mLearning now?’ 6) ‘I want to download learning material to my portable devices.’ 7) ‘I hope that the university will produce all courses for mLearning since it can assist me to have a better understanding.’ 8) ‘Please make it real as soon as possible.’ 9) ‘Hope it happens soon.’ 10) ‘I do agree that mLearning is able to reduce restrictions of study and extend educational opportunity where students can learn at any time, in any place, based on their demand.’

The second category of opinion once again focused on the negatives: 1) ‘mLearning must not be expensive.’ 2) ‘I wish to have an affordable device for mLearning.’ 3) ‘The devices are still expensive for students.’ 4) ‘More flexible prices.’ 5) ‘More usage of mLearning courseware.’ Based on these opinions, mLearning projects were highly desired to be available for university students because of their flexibility. On the negative side, the price of both devices and courseware is of significant concern.

In conclusion, the needs assessment mLearning survey presented answers based on the foregoing research questions. 1) University students were ready to participate in mLearning because of the majority of them already owned mobile devices which can be used for mLearning, and because they believe that mLearning would enhance their study. 2) All university degree programs need mLearning, especially bachelors degree students. 3) The mLearning courses should be presented in varied approaches, e.g., either free of charge or affordably priced based on demand of courses, since the most important factor influencing the purchase of mLearning courses was price. 4) Notebooks or other similar mobile devices are preferred for mLearning rather than wearable devices. 5) The most preferred learning styles indicated that mLearning should be used individually. 6) The most preferred activity for mLearning was to use the internet for education. 7) The main purpose of using mLearning was for self-administered learning. 8) The price of services was the biggest concern of university students in using mLearning.

6. mLearning Curriculum

The above survey results clearly support the implementation of an mLearning sciences and technology program. Referring to the literature review conclusion, mLearning curriculum should include: 1) mobile technology, 2) distance education principles and theories, 3) mLearning project management, 4) mLearning application creativity, 5) instructional mobile interactivity design, 6) game-based mLearning. The guidelines for each subject area include the following:

- **Mobile technology**: standardization of wireless networks and the various types of mobile and wearable devices, pros and cons of mLearning, and especially the capabilities and limitations of transferring data using mobile technology. Positive and negative effects concerning mLearning and issues concerning network security.

- **Distance education principles and theories**: comprehension of principles and theories through which educational technology and psychology combine together in Distance Education and how this can be applied to the use of mobile devices.

- **mLearning project management**: how to manage projects to be profitable and sustainable in our information society. The content also needs to delineate how to encourage people to make better use of business plans, when and how to use mLearning, prices, types of services, intellectual rights and copyright.

- **mLearning application creativity**: consisting of two main parts: first, mobile application authoring programs which include knowledge of computer engineering; second, emphasize the creativity of mLearning applications to increase the value of the course and make it suitable as education media for a self-administered learning style.

- **Instructional mobile interactivity design**: a system approach to guarantee the quality of mLearning courseware with emphasis on mobile circumstances, learning objectives, interactivity design and accessibility and usability of mLearning.

- **Game-based mLearning**: design and development of game-based mLearning which includes inherent limitations. However, this might be the most enjoyable component from the users’ sites since the main target group of mLearning is young people just past 16.
Moreover, the market share of computer games on mobile devices is increasing remarkably.

Education theory is the best element to control teaching and learning innovations [22]. Thus, this paper proposes six courses to educate a competent mLearning staff, integrating not only scholarly teaching in the engineering field but also in both the education and management arenas. The usage of mLearning in the future is predictably worldwide. The programs of mLearning science and technology will also offer opportunities in engineering education, able to deliver either in a traditional mode of teaching or in an eLearning mode. This is an obvious rationale, for those who are interested in this type of program tend to be skilled in technology. Thus, eLearning will be an opportunity rather than a barrier. The advent of mLearning science and technology also should be considered as part of a first or second degree program. Workshops or short courses on this subject should be implemented. The productivity of mLearning – not only, always on [23], just-in-time [4], [12], [21], on-the-spot [4], but also disruptive technologies [22] – all of these affect the future of mLearning and make it exponentially more interesting.

7. CONCLUSION AND FUTURE STUDY

mLearning will be more extensively used due to the increase in the number of mobile devices. mLearning science and technology is a unique plus innovative program that should be implemented through engineering education. Both documentary research and mLearning should have assessment surveys conducted to enhance the sound future of mLearning. The proposed six subjects cover the comprehensive background needed for mLearning experts. To increase the value of the proposed program, criticism by local educators should be solicited. The proposed program needs to be put into practice, monitored and evaluated systematically, subsequently to improve the quality of both learning and teaching on the variety of mobile devices.


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