A new trend of mobile and ubiquitous learning research: towards enhancing ubiquitous learning experiences

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Abstract: This paper overviews features and approaches of technology-driven researches on educational system development, describes research trends on mobile and ubiquitous learning, and explicates two cutting-edge mobile and ubiquitous research projects called LORAMS and SCROLL as a new trend of ubiquitous learning research.

Keywords: m-learning; mobile learning; u-Learning; ubiquitous learning.

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1 Introduction

We have witnessed that the emergence of new technology accelerated the dramatic change of teaching/learning methodology over the decades. Pervasion of the internet, for instance, has enabled us to conduct distant-learning as well as e-learning. More recently high-efficiency mobile phones or smartphones have raised the potential to generate
new learning environments using this cutting-edge technology. This paper overviews the research tendencies of technology-driven researches on educational technology. One of our foci is mobile language learning, undoubtedly one of the most active research areas.

The main characteristics of mobile and ubiquitous learning are shown as follows (Ogata and Yano, 2004):

1. **Permanency**: Learners never lose their work unless it is purposefully deleted. In addition, all the learning processes are recorded continuously every day.

2. **Accessibility**: Learners have access to their documents, data, or videos from anywhere. That information is provided based on their requests. Therefore, the learning involved is self-directed.

3. **Immediacy**: Wherever learners are, they can get any information immediately. Thus, learners can solve problems quickly. Otherwise, the learner can record the questions and look for the answer later.

4. **Interactivity**: Learners can interact with experts, teachers, or peers in the form of synchronous or asynchronous communication. Hence, the experts are more reachable and the knowledge becomes more available.

5. **Situatedness**: The learning could be embedded in our daily life. The problems encountered as well as the knowledge required are all presented in their natural and authentic forms. This helps learners notice the features of problem situations that make particular actions relevant.

Recently, mobile phone network enables accessibility, immediacy, interactivity and situatedness. However, permanency still needs further research. The next section will give examples to tackle this issue. Mobile and ubiquitous learning takes place in variety of learning spaces, e.g. classroom, home and museum. The fundamental issues of mobile and ubiquitous learning are: how to record learning experiences that happen at anytime and anyplace in our daily life, and how to share and reuse them in future learning. To tackle these issues, LORAMS (Linking of RFID and Movie System) (Ogata et al., 2008) for linking a video and physical objects, and SCROLL (System for Capturing and Reminding of Learning Log) (Ogata et al., 2010, 2010b) for reminding past learning log were developed.

### 2 Historical overview

This section provides the historical overview of the trends of learning technology researches that were led by the technologies. Figure 1 shows the correlation between emerging technologies and users’ social interaction in terms of e-learning technology paradigms. The graph indicates that the development of ICT (Information and Communication Technology) has generated new learning environments from CAI/ITS to u-learning (ubiquitous learning) and has enhanced social interaction among learners more deeply, widely, easily and effectively from individual base to global base.
2.1 Personal computers

The first emergence of computers dated back in 1940s. It naturally affected teaching methodology of any learning fields. First ‘Teaching machines’, realisation of programmed instruction based on operant conditioning theory propounded by Skinner (1957) were developed, then followed by more sophisticated branched-structured teaching machines which were aimed to provide each learner with different contents according to his/her learning level. But at that moment, the technology needed to realise the customised instructions was not available yet. Appearance of the truly personalised or intelligent learning system was yet to come. We needed to wait until the emergence of personal computers.

The development of a personal computer, which began in the early 1970s with the Dynabook project from the Learning Research Group at the Xerox Palo Alto Research Center (Kay and Goldberg, 1977), led to a drastic change in learning and teaching environments. The research of CAI (Computer Assisted Instruction) was started, which comprises any forms of computer supported learning and teaching using fixed PC, not mobile and networked at that moment. Also ITS (Intelligent Tutoring System) has been investigated by the emergence of AI (Artificial intelligence), which provides personalised instructions to learners. Along with the development of multimedia and internet technology, the emergence of personal computers eventually led to shift the educational paradigm from traditional behaviourism-based programmed learning to supporting each learner’s autonomous learning.

2.2 Multimedia technology

In 1980s, data digitisation technology enabled us to make originally separated data such as sounds, texts, images, videos into one integrated data. The media which deals with
such multiple forms of media and contents together at a time is called multimedia. Being able to be provided with multimedia-based, or game-based learning contents such as CD-ROM, DVD course materials using various kinds of platforms or devices, learners could gain significant benefits from the integration between multimedia and intelligent educational systems. Multimedia technology made more adaptive, personalised learning systems possible. In such systems, however, interaction was still limited between individual learners and the system.

2.3 Internet technology

The prototype of internet, APRAnet which contained the concepts of packet switched networks, time-sharing system (TSS) started in 1960s, but we had to wait for the birth of present-type of internet until early 1980s when Internet Protocol Suite (TCP/IP) was standardised and the concept of a world-wide network called the Internet was introduced. The emergence of the internet provoked new learning concepts such as CSCL (Computer Supported Collaborative Learning) and WBL (Web Based Learning). Prevalence of the internet enabled us to go beyond the interaction between individual learners and the system, and it realised collaborative learning that can occur simultaneously with group of learners connected each other (CSCL). Various kinds of learning supports were made into a reality by accessing resources of websites, and linking learners and numbers of learning objects.

2.4 Mobile and ubiquitous technology

Mobile technology is, as the name implies, technology that is portable. New communication technology such as Wi-Fi (wireless fidelity), 3G (third generation), Bluetooth has enabled various kinds of devices which are portable (e.g. laptop or netbook computers, palmtop computers or PDA, mobile phones, smart phones, GPS devices, MP3 players, handheld electronic game devices). These technologies allow users to access information that match their needs on an ‘anytime, anywhere’ basis, so then it came to be called ubiquitous.

Researches on practical uses of mobile technology, which have been very active since early 2000s, cover a wide range of approaches and designs from providing learning contents by mobile phone SMS and e-mails, podcasting on demand, linking people of the same interest, creating learning communities, to supporting lifetime learning.

The new generation smartphones as represented by iPhone and the open sourced mobile OS Android provide users with such advanced functions as the multi-touch interface, full browser, GPS, and millions of applications. One of the key features of smartphones is that they are equipped with a range of sensors such as the accelerometer, ambient light sensor, GPS, microphone, camera, compass and so on (Li et al., 2011). Aggregation of mobile devices with such multi-sensor systems would enable users to benefit from information gathered via other surrounded devices and users, which will significantly impact the future of education, providing new environment called surround learning or seamless learning and inducing more social interaction and collaborative learning among learners.
3 Mobile and ubiquitous learning

Mobile and ubiquitous learning (often abbreviated as m-learning or u-learning) has generally been defined as learning with its use of mobile and wireless technologies. However, more recently, its notion tends to include the mobility of the learner (Sharples, 2006). The concept for mobile learning was foreseen as early as 1970s with the Xerox Dynabook project which proposed a ‘self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook’ (Sharples et al., 2009). It has been recognised as one of the natural directions toward which CALL (Computer Assisted Language Learning) is heading (Chinnery, 2006; Stockwell, 2007). Thornton and Houser’s (2005) study, which indicated that the learners preferred mobile platform rather than PCs, endorsed this trend. Especially, mobile and ubiquitous technologies have been expected to foster shifting from classroom based learning to the one that is free from time and space boundaries. However, we should not overlook the fact that all evaluations regarding mobile device uses generate favourable results: small screen, and keypad, unstable wireless LAN etc. (Carlson, 2002; Uosaki and Ogata, 2009).

Up to now, mobile and ubiquitous technology has been applied to a wide range of learning fields such as science, history, sports (cf. Table 1), and most often language learning which we will supply details later in Section 3.2.

Table 1  Researches categorised by the target learning field

<table>
<thead>
<tr>
<th>Field</th>
<th>Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science</td>
<td>Rogers et al. (2004), Chen et al. (2004), Milrad et al. (2005), Seow et al. (2009), Hwang et al. (2010), Maldonado and Pea (2010)</td>
</tr>
<tr>
<td>History</td>
<td>So et al. (2008)</td>
</tr>
<tr>
<td>Zoo/Museum</td>
<td>Kusunoki et al. (2002), Hlavacs et al. (2005), Suzuki et al. (2009)</td>
</tr>
<tr>
<td>Sports</td>
<td>Gotoda et al. (2009)</td>
</tr>
<tr>
<td>Communication</td>
<td>Scornavacca et al. (2007), So (2009)</td>
</tr>
</tbody>
</table>

3.1 Seamless learning

The progress of mobile and wireless technologies offers us a new learning environment, namely ‘seamless learning’ and it has been gaining quite a few researchers’ attention as a new learning environment (Seow et al., 2009; Boticki and So, 2010; Chen et al., 2010; Hsieh et al., 2010; Ye and Hung, 2010).

As early as 1994, American College Personnel Association used the term ‘seamless learning’, stressing the importance of linking students’ in-class and out-of-class experiences to create seamless learning and academic success (Wong and Looi, 2011). However, in technology-driven research attempts, ‘seamless learning’ is usually used to describe the situations where students can learn whenever they want to in a variety of scenarios and that they can switch from one scenario to another easily and quickly using one device or more per student (‘one-to-one’) as a mediator (Chan et al., 2006).

According to So et al. (2008), seamless learning can be depicted in a two-dimensional way: (a) in-class and out-class learning and (b) planned and unplanned learning. Thus there are four types of learning accordingly: in-class planned learning, in-class unplanned learning, out-class planned learning and out-class unplanned learning (cf. Figure 2). And
A new trend of mobile and ubiquitous learning research

if the technology could help these four types of learning interact with one another and help them to be incorporated into one continuous learning beyond time and space, learning will be very successful.

Figure 2  Incorporation of four types of learning (adapted from So et al., 2008) (see online version for colours)

3.2 Mobile and ubiquitous language learning

Mobile language learning has always been among top research topics in mobile (ubiquitous) learning since early 2000s (the epoch of mobile learning). In the earlier days, it often focused on the simple use of SMS and mobile e-mails as a means of delivering learning contents, most often for the vocabulary learning or facilitating interactions between learners.

Kiernan and Aizawa (2004) examined the use of cell phone text messages in the task-based L2 learning. Thornton and Houser (2005) proposed a mobile e-mail based vocabulary learning system for Japanese university students. Levy and Kennedy (2005) introduced a mobile SMS-based Italian language learning system in Australian university focusing the timing and the number of repeated messages. Along with the use of SMS and e-mails, there appeared quite a few studies exploring L2 learners’ listening skill using iPods or podcasting (cf. Table 2).

Then, there followed researches into developing more sophisticated systems such as context-aware, user-customised systems using PDA, then subsequently smartphones. Ogata and Yano (2008) proposed TANGO system which employed the physical objects using RFID tags for language learning. Stockwell (2007) developed a prototype of mobile-based intelligent vocabulary learning system called Vocab Tutor. Chen and Chung (2008) developed personalised mobile English vocabulary learning system based on Item Response Theory and learning memory cycle. (Li et al., 2010) evolved an adaptive Kanji learning system using mobile phones. Underwood et al. (2010) developed a mobile-based self-initiated vocabulary learning application called m-iLexicon. As mentioned earlier, mobile technologies will possibly play a critical role in the future CALL activities.
Table 2  Researches classified by the target language skill

<table>
<thead>
<tr>
<th>Target language skill</th>
<th>Citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grammar</td>
<td>Sung et al. (2006)</td>
</tr>
<tr>
<td>Reading</td>
<td>Soloway et al. (2001), Zurita and Nussbaum (2004), Lan et al. (2007), Sung et al. (2008), Chen et al. (2008)</td>
</tr>
<tr>
<td>Listening</td>
<td>Gromik (2008), Nah et al. (2008), Sze (2006)</td>
</tr>
<tr>
<td>Speaking</td>
<td>Kukulska-Hulme (2005), Sze (2006), Uosaki and Ogata (2009)</td>
</tr>
<tr>
<td>Writing</td>
<td>Bennui (2008), Lan et al. (2008)</td>
</tr>
<tr>
<td>Integrated</td>
<td>Paredes et al. (2005), Pemberton et al. (2009)</td>
</tr>
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</table>

4 The next step of ubiquitous learning

4.1 LORAMS

The characteristics of LORAMS are as follows:

1. Learner’s experience is recorded on a video and the video is automatically linked to the real objects in the scene by scanning their RFID tags. Therefore, it does not need to add keywords or annotations into a video and is easy to make an index of the video to be shared with other learners.

2. Learners can find suitable videos by scanning RFID tags around them without entering keywords of real objects.

3. Based on the ratings of the learners and the system, the results are listed.

There are three phases for LORAMS as follows:

1. Video recording phase
2. Video search phase
3. Video replay phase

Video recording process requires PDA, RFID tag reader, video camera and wireless access to the internet. First, a user has to start recording video at the beginning of the task. Before using objects, the user scans RFID tags and the system automatically sends the data and its time stamp to the server. After completing the task, the user uploads the video file to the server and the server automatically generates SMIL (Synchronised Multimedia Integration Language) file to link the video to the RFID tags.
On the other hand, video search and reply processes require PDA, RFID tag reader, and RealPlayer software. The user scans RFID tags around him/her and/or enters keywords of the objects, and then the system sends them to the server and shows a list of videos that match the objects and keywords. Moreover, the system extracts a part of the video that matches with these objects. The video is replayed.

As shown in Figure 3, by scanning RFID tags of physical objects and/or entering keywords in (A), the video search will be started. LORAMS searches for videos and lists them in an appropriate order. The list in (C) shows the videos that have been registered recently.

Figure 3 Interface of LORAMS for video search (see online version for colours)

By selecting a video from the list (B), the video playback window will appear. The video title, the author’s name, and the recorded date are shown in (D), all the objects are listed in (E) in order of time. By clicking an item in the list, the system will jump to the video segment that includes the selected item. Pictures of the items are shown in (F). By clicking once on the pictures, the system will playback the video segments that include the selected item. By pushing a button in (G), the user can rate the video by the scale from 1 to 5. The playback can be adjusted using the tool bar in (H) such as fast-forward. The similar videos to the current video are listed in (I).

User can compare two different videos in the window as shown in Figure 4. For example, the left is a video of an expert, and the right is a video of the user after watching the expert’s video. The tile of the video is shown in (A) and the video is replayed in (B). The timeline of the left video is shown in (D) and that one of the right video is (E). In Figure 4, the user can find that the timeline (E) took longer time than (D) and the performance of the user is not that good. On the timeline, a coloured rectangle shows an object that the user used at a certain time. If the mouse cursor is over the coloured rectangle, the system will show the picture of the corresponding object in (F). Since the same object has the same colour, the user can easily recognise when the object was used in the two videos.
4.2 SCROLL

How do we learn from past learning logs? Taking notes is a usually way we do, e.g., when we learn foreign language we may record new vocabularies, idioms, sentences. Whereas, the notes will not remind us of what we have learned, or the situation where the knowledge was used. We think this process can be enhanced by using mobile devices. SCROLL interface that supports the learners to record, share and reuse ubiquitous learning logs (ULLOs) with Android mobile devices are as follows:

1. **ULL recorder**: This component provides an easy way for the learners to upload their ULLOs to the server whenever and wherever they learn. In order to add a UULL, the learners can take its photo, ask questions about it and attach different kinds of meta-data with it, such as its meanings in different languages, e.g., English, Japanese and Chinese, comments, tags and location information. Also the learner can select whether the new UULL can be shared or not. Figure 5a is the android interface of adding a UULL. Figure 5b shows an example of UULL. Besides, it is possible to look through others’ shared learning objects and to re-log them that mean the learner can take others’ UULLs as his/her own. In other words, the learner can obtain a lot of knowledge from the other learners even though he has not experienced that knowledge by himself. By sharing UULLs with the other learners and re-logging the other learners’ UULLs, the acquisition of the knowledge is enhanced.
A new trend of mobile and ubiquitous learning research

2 **ULL finder**: If learner registers a new ULLO, the system checks whether the same object has been already stored or not by comparing the name fields of each object using a thesaurus dictionary. Also, as shown in Figure 5c the learner can search ULLOs by name, location, text tag and time. Using this function, learners can understand what, where and when they learned before. In the future works, the visualisation of the ULLOs will be developed.

3 **ULL reminder**: Quiz function is designed to help the learners remind what they have learned. Figure 5d show two types of multiple-choice quizzes generated based on the meta-data of ULLOs by the system. The system classifies the ULLOs for each learner into five types: this learner’s own new ULLOs, the ULLOs whose quizzes has been answered correctly, the ULLOs whose quizzes has been mistaken, the ULLOs that he or she looked through frequently and the ULLOs that are in the learner’s preferred category. Different type of ULLOs has different reminder interval. For example, the new logs will be reminded after stored 1 day and the right quizzes will be shown in 5 days firstly and then a month, a year. Quizzes cannot only be practiced by learners themselves but also could be notified by setting receiving time on the server or be recommended by the context-aware function.

4 **ULL navigator**: LL navigator provides mobile augmented reality that allows the learner to navigate through the ULLOs. It provides the learner with a live direct view of the physical real-world environment augmented by a real time contextual awareness of the surrounding objects. While a learner is moving with his mobile phone, the system sends an alert on the phone as soon as entering the region of ULLOs according to the GPS data. This view is augmented, associated with a visual compass, and overlapped by the nearest objects in the four cardinal directions (Figure 6, left). Also, it provides the learners with a list of all surrounding objects. When the learner selects one or more of these objects, the Google map will be retrieved, and marked with the learner’s current location and the selected objects. Moreover, the system shows a path (route) for the learner to reach to the objects locations (Figure 6, middle). This assists the learner to acquire new knowledge by discovering the existed ULLOs and to recall his ULLOs. Figure 6 (right) is the web interface of the ULL Time Map. Time map function is designed to help the learners to reflect what they have learned. To review all past ULLOs, user can scroll the timeline above and then the map below will display the ULLOS recorded during learners’ selected period. With the time and location contextual data, it is helpful for the learners to remind their learning history.

Regarding related works, life-log is a notion that can be traced back at least 60 years (Bush, 1945). The idea is to capture everything that ever happened to us, to record every event we have experienced and to save every bit of information we have ever touched. For example, SenseCam (Hodges et al., 2006) is a sensor augmented wearable stills camera; it is proposed to capture a log of the wearer’s day by recording a series of images and capturing a log of sensor data. MyLifeBits (Gemmell et al., 2006) stores scanned material (e.g. articles, books) as well as digital data (e.g. emails, web pages, phone calls, and digital photos taken by SenseCam). Ubiquitous Memory system (Kawamura et al., 2007) is a life-log system using a video and RFID tags. The most common idea of those projects is to use life-log data for memory aid, however, SCROLL aims to utilise life-log data for the learning process.
Originally, the term ‘learning log’ was used for personalised learning resources for children. The logs were usually visually written notes of learning journals, which could become an integral part of the teaching and learning programme and had a major impact on their drive to develop a more independent learner. Research findings indicated that journals were likely to increase meta-cognition and reflective thinking skills through students who become more aware of their own thought processes (Suwan and White, 1994; Daudelin, 1996; Stockwell, 2007). Also the term ‘electronic portfolio (e-portfolio) or digital portfolio’ is used for a collection of electronic evidences maintained by a learner. Our approach focuses on how to enrich learning log or e-portfolio, and to promote retention and meta-cognition by using mobile, ubiquitous and context-aware technologies.

5 Conclusions

This paper described the research trends of mobile and ubiquitous learning environments. First, we presented the historical view of educational technology research in the view from technologies and users. Second, this paper described the overview of mobile and
A new trend of mobile and ubiquitous learning research. Especially, we focused on mobile language learning and seamless learning. Furthermore, this paper gave two research projects, LORAMS and SCROLL, for enhancing the permanency attribute of ubiquitous learning.

Recently, smart phones have become popular and multi-languages and global network-connection can be supported. Thus, we can use it globally. Also software development toolkits for smartphones are available for free. In this situation, users at any age and gender in the world can easily implement their idea into applications for smartphones and publish them on the app market. The users can also download and test them from the app market. Then, we can share learning experiences globally by using apps. Therefore, we hope that teachers and students will collaboratively develop, improve or select appropriate apps for education and learning.

References


A new trend of mobile and ubiquitous learning research


