Context-awareness and Personalization Using Ubiquitous Learning Logs

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Contents

List of Papers

Main Papers

[1] "Context-aware and Personalization Method in Ubiquitous Learning Log System", Mengmeng Li, Hiroaki Ogata, Bin Hou and Noriko Uosaki, Journal of Educational Technology & Society (Accepted)

Secondary Papers

[1] "Adaptive Kanji Learning Using Mobile-based Email", Mengmeng Li, Hiroaki O gata, Satoshi Hashimoto, Yoneo Yano, Proc. of The 17th International Conferenc e on Computers in Education ICCE 2009, pp.520-526, Hong Kong, Nov,30-Dec. 4, 2009.

[2] "Development of Adaptive Kanji Learning System for Mobile Phone", Mengmen g Li, Hiroaki Ogata, Bin Hou, Satoshi Hashimoto, Noriko Uosaki, Yuqin Liu, Yo neo Yano, International Journal of Distance Education Technologies, Vol. 8, No. 4, pp.29-41, 2010.

[3] "Ubiquitous Learning Log: What if we can log our ubiquitous learning?" Hiroak i OGATA, Mengmeng LI, Bin HOU, Noriko UOSAKI, Moushir M. EL-BISHO

UTY, Yoneo YANO. Proc. of The 18th International Conference on Computers in Education ICCE 2010, pp.360-367, Putrajaya, Malaysia, 29,Nov.–03,Dec.2010.

[4] "Personalization and Context-awareness Supporting Ubiquitous Learning Log System", Mengmeng Li, Hiroaki Ogata, Bin Hou, Noriko Uosaki, Yoneo Yano, Proc. of The 19th International Conference on Computers in Education ICCE 2011, pp.391-395, Chiang Mai, Thailand, Nov,28-Dec.2, 2011.

[5] "Personalization in Context-aware Ubiquitous Learning-Log System", Mengmeng Li, Hiroaki Ogata, Bin Hou, Noriko Uosaki, Yoneo Yano, Proceedings. Of the 7th IEEE WMUTE 2012, pp.41–48, Takamatsu, Japan, March 2012.

List of Figures

List of Tables

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Chapter 1

Introduction

1.1 Background

Mobile technology has been believed holding out great promise for learning (Houser, Thornton, & Kluge, 2002). However, some of its limitations such as the small screen size, the high cost of 3G network and so on stopped the technology from growing as fast as we expected. Until the last few years, a real great revolution is occurring in the mobile device world with the release of the new generation smartphones represented by iPhone launched by Apple Inc. and the open sourced Mobile OS Android released by Google. Since the new generation smartphones accommodate users with many advanced functions such as the multi-touch interface, full browser, GPS, millions of applications and so on, the number of smartphone users is increasing very sharply in recent years. According to IDC (International Data Corporation) report, the Japan smartphone market recorded 42.1% year-over-year shipment growth in 2012 (International Data Corporation, 2013). Another key feature 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. Several years ago, researchers forecasted that the mass of mobile smartphones equipped with sensors could be turned into a giant distributed sensing system, allowing users to benefit from information gathered via other phones and users (Padmanabhan, 2008). The evolution of the mobile technology, especially the sensor technology in mobile devices provides more possibilities for ubiquitous learning.

According to Ogata & Yano, The main characteristics of mobile and ubiquitous learning are shown as follows (H. Ogata & Yano, 2004):

(1) Permanency: Learners never lose their work unless it is intentionally deleted. In addition, all the learning processes can be recorded seamlessly and sequentially.

(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.

Among the five features, the advantage of situatedness of ubiquitous learning can be enhanced with the evolution of the sensor technology. And based on Ogata, even though it is easy to capture the learning data ubiquitously because of the evolution of the technology, how to make use of the learning data is still a problem (Hiroaki Ogata, Li, Hou, et al., 2010). In this research, we will explore the value of the learning data in a ubiquitous learning environment. Here the learning data includes both the knowledge data and the meta-data of learning such as the geographic location, time and so on, which is acquired by the sensors.

1.2 Motivation

As far as we concern, the capabilities of the sensors equipped on the smartphones can be used in context-aware and personalization mobile learning, because the sensors can play at least two important roles in our daily learning. On one hand, it can monitor learners' current context including their activities involving whether they are running, walking, listening to the music or surfing on the Internet and so on, and the environmental information including the location, time, temperature, and humidity and so on. According to the studies about context-aware learning and the basic research on human learning and memory, the learners can benefit from the learning context on several aspects. For example, the learning contexts can be used to help learners to recall what they have learned in the past. And the system can also introduce new knowledge for the learners by taking into account of the learners' needs and their current learning contexts. On the other hand, learners' contextual data can be tracked as context history when learners study using smartphones. And by analyzing the context history, the system can catch individual's personal learning habits, which can also be used to assist learners' learning (M. Li, Ogata, Hou, Uosaki, & Yano, 2012). Therefore, this paper will mainly discuss about how to use both learners' learning context and learning habits acquired by using the sensors to support individual learners' learning.

Consequently, we propose a context-aware and personalized learning model in our study. This model is built on a life-log system called SCROLL (System for Capturing and Reminding of Learning Log). SCROLL allows learners to save their learning experiences with photos, audios, videos, location, QR-code (Quick Response code), RFID (Radio-frequency identification) tag, and sensor data and so on, and share and reuse them with others (Hiroaki Ogata, Li, Hou, et al., 2010). The goals of SCROLL are lying in helping users to easily record and remember what they have learned effectively by making use of learning contexts to help learners recall, recommending other learners' learning experiences for them, finding out individuals' learning habits and supporting their learning in accordance with personal learning habits. To reach these goals, the sensor data is proposed to make use of. The details about SCROLL are introduced in chapter 3.

1.3 Thesis Outline

The thesis is organized in 7 chapters. The rest part is constructed as follows.

Chapter 2 overviews the related work in the literature. The studies about the context-aware learning and personalized learning are introduced. By reviewing these works, we propose to apply their advantages in our study and then create new values by combing them in our case. In addition, since our system is designed on the basis of several theories on human memory, we describe them at the end of this chapter as well.

Chapter 3 introduces a ubiquitous learning log system called SCROLL. We will present its backgrounds and objectives firstly. Then its main functions are described, such as how to log what you learn and recall them in quizzes, how to navigate you to reach them and guide you to do learning task.

In chapter 4, the context-aware and personalization mechanism is presented. The mechanism contains four issues which are to remind learners what they have learned using learning context, to recommend other learners' knowledge to the learner, to find learners' learning habits and to provide appropriate knowledge for specified learner. The technological process and the details of its recommendation process are talked about as well.

Chapter 5 introduces the implementation details of the system. The architecture of SCROLL is firstly introduced. Then we talk about how to implement SCROLL in both server and client sides respectively. How the to support the context-aware function and how to synchronize data between different devices are also described.

In chapter 6, three experiments are introduced, which evaluated the system and our context-aware and personalized learning model. Both the design and results of the experiments are talked about. With the results of the experiments, a discussion about this study is given at the end of this chapter.

In the last chapter, we summarize this doctoral dissertation briefly. Both conclusions and future work are given out.

Chapter 2

Related Work

As mentioned in chapter 1, how to make use of the learner's learning context and how to adapt the appropriate learning contents to individual learner are the two main issues to explore in this research. Therefore, this chapter firstly reviews the previous work in these two fields. In addition, since this study is designed on the basis of several theories on human memory, they are introduced in this chapter as well.

2.1 Context-aware learning

2.1.1 Definitions of learning context

The term context-aware computing was firstly introduced by Schilit et al. in 1994 (Schilit, Adams, & Want, 1994). Schilit gave his definition about context by enumerating context elements like, location, nearby people, hosts, time and accessible devices. According to Schilit, context consists of three important aspects which are:

where you are, who you are with, and what resources are nearby. After Schilit, many other authors also defined the context by examples in their studies, such as (Gross & Specht, 2001; Ryan, Pascoe, & Morse, 1998). In these studies, more elements of context are proposed, such as temperature, noise level, motion as well as the beliefs, desires, commitments, and intentions of the human (H. Chen, Finin, & Joshi, 2003). However, these types of definitions that define context by example are difficult to apply. This is because it is not clear to determine whether a type of information not listed in the definition is context or not (Dey, 2001). Therefore, Dey provided his definition on context which is accepted widely by other researchers. In (Dey, 2001), Dev wrote "context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." Even though many researchers accept Dev's definition, in Zimmermann's opinion, the definition is still general because the expressions such as "any information" and "characterize the situation" is indefinite (Zimmermann, Lorenz, & Oppermann, 2007). Therefore, some other definitions which organize the elements of context in structure or categories to adapt different studies can be found in the literature (G. Chen & Kotz, 2000; Derntl & Hummel, 2005; L. Li, Zheng, Ogata, & Yano, 2004; Verbert et al., 2012; Wang, 2004). Here some of them are picked up to highlight. For instance, Schmidt presents a structure for the characterization of context by describing context in three dimensions which are self, activity and environment. Self dimension stands for what context is related to, such as device, user and application (Schmidt, 2003). Zimmermann divides the elements of context into five categories which are Individuality, activity, location, time, and relations (Zimmermann et al., 2007).

By referring to these previous works and considering the capability of the smartphones, we divide the learning context in this study into three categories. They are learners, device and environment. Each category contains different elements as follows:

(1) Learner: This aspect mainly includes a learner's activity which means what the learner is doing now, such as sleeping, playing, running, walking and so on. Among the various activities, it is possible to detect two kinds of learners' activities with the current technology, which are their motion state (e.g. walking, running, travelling on the train or bus or keeping stationary) and what they are doing with the devices (e.g. listening to the music through earphone, surfing on the internet, or doing learning with our system).

(2) Device: Because the status of device determines whether the learning system can serve learner or not, this aspect also plays important role. The device aspect mainly includes the left battery percentage, the Internet connection (3G, Wi-Fi or no connection), the status of the ringtone (vibrate status or ringtone) and the screen lock status and so on.

(3) Environment: The environmental elements consist of location, time, temperature, weather, and noise level and so on.

About how to capture and make use of the learning context will be talked about in chapter 4.

2.1.2 How to make use of learning context

With the evolution of mobile technology, there is a growing interest about context-aware learning by many researchers over the last decade. For example, Hwang and his team have done a lot of research in this field. Their studies covers learning activities based context-ware learning and learning tools supported context-aware learning. For instance, the former type can be represented by learning in museum (Chiou, Tseng, Hwang, & Heller, 2010) and nature science observation activities (Hwang, Chu, Shih, Huang, & Tsai, 2010). The latter one includes mindtools (Hwang, Chu, Lin, & Tsai, 2011), concept map (Hwang, Shi, & Chu, 2011; Hwang, Wu, & Ke, 2011) and an algorithm used for planning personalized learning paths (Hwang, Kuo, Yin, & Chuang, 2010) and so on. Besides hwang, there are also many previous works fond in the literature (C.-C. Chen & Huang, 2012; Lee, 2012; P.-H. Wu, Hwang, Su, & Huang, 2012).

Because this research focuses on MALL (mobile assisted language learning), we prefer to review how the researchers employ the learning contexts to support language learning. There are many context-aware mobile learning systems found in the literature and some of them are picked up as follows:

- CAMCLL (Context-aware Mobile Chinese Language Learning) provides the foreign students who learn Chinese in China with service guide when they are out of campus (for instance;hospital, bank, railway station, airport,etc.) (Al-Mekhlafi, Hu, & Zheng, 2009). The system can provide suitable learning contents to the learner by considering his location, time, activity and ability level.

- CAMLES (Context-aware Mobile Learning English System): (Viet Anh Nguyen & Ho, 2010) adapts English topics and test questions to individual English learner by taking into account of the learner's context including location, time, manner and learner's knowledge.

- TenseITS is a language learning environment that adapts the interaction to the individual learner's understanding, as represented in a learner model constructed during the interaction. It also adapts according to the learner7s location, time and so on (Cui & Bull, 2005).
- JAMIOLAS utilizes sensors to catch the environmental data such as temperature and light and recommend learners with the appropriate Japanese mimetic words and onomatopoeia which are related to the environment (Ogata, Miyata, Hou, & Yano, 2010).

Besides the studies introduced above, some other studies utilizing location and time (or schedule) to recommend appropriate contents for learners can also be found in the literature (T. Chen & Yap, 2013; Clough, 2010; V. A. Nguyen, Hanoi, & Van Cong, 2012; Yau & Joy, 2010). From these studies, we find that most of the researchers mainly put their attention on how to provide the learners with the learning materials that are related to the learning context especially the location. However, besides this use direction, the learning contexts can also be used to help learners to recall what they learned. This is because based on the encoding theory, the learning context may be encoded when learners memorize knowledge and the encoded context can be used as retrieval cues for learners to recall what they have learned effectively. In this research, we do not only employ the learning context to recommend related knowledge, but also help learners to recall their learned knowledge with the help of the learning contexts.

2.2 Personalized learning

2.2.1 Personalized and Adaptive learning

Over the last decades, researchers did a lot of studies on adaptive and personalized learning in technology enhanced learning field. For example, Wu & Yang developed a reading-based English learning system which provides personalized reading suggestions for increasing learning performance according to the assessment of defined dynamic parameters (T.-T. Wu, Sung, Huang, Yang, & Yang, 2011). More studies can be found in the literature (Peter Brusilovsky & Peylo, 2003; Hsu, Hwang, & Chang, 2012; Martins, Faria, de Carvalho, & Carrapatoso, 2008; Mulwa, Lawless, Sharp, Arnedillo-Sanchez, & Wade, 2010).

ATP (Advanced Technology Program) clarify that adaptive learning systems can tailor knowledge to the requirements of the learners to help them learn (Advanced Technology Program (ATP), 1998). Furthermore, according to Sampson & Kinshuk, the personalisation in technology enhanced learning means that the training programmes are customised to individual learners, based on an analysis of the learners' objectives, current status of skills/knowledge, learning style preferences, as well as constant monitoring of progress (D. Sampson, Karagiannidis, & Kinshuk, 2010). That is, one objective of the adaptive and personalized learning is to provide specified learner with suitable learning contents and services by considering his learning needs and learning preferences. Paramythis & Loidl-Reisinger listed the measures adopted in the major adaptive learning systems: monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and preferences out of the interpreted activities, appropriately representing these in associated models and acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process (Paramythis & Loidl-Reisinger, 2004).

From these previous works, we find that most of the researchers mainly focus on two aspects: learner and learning contents and some of them build a user model and a learning content model in their studies. For example, Jane & Mike focus on learners' learning preferences including location of study, noise/distraction level in location and time of day (Yau & Joy, 2011). Hsieh & Lee employ learners' memory cycle, ability level and other learning preferences to support their English learning (Hsieh, Wang, Su, & Lee, 2012). Mengmeng lays more attention on both learner's interests, ability and the difficulty of the learning objects (M. Li et al., 2010). Zhao & Okamoto emphasis on the delivery of the learning contents (X. Zhao & Okamoto, 2011). By reviewing these studies, we learn that the user model usually consists of learners' goals, preferences, knowledge, attitudes, interests and the devices they used while the learning object model includes the difficulty, the length and the hypermedia included and so on (P. Brusilovsky & Maybury, 2002; C. M. Chen, Lee, & Chen, 2005; Riding & Sadler-Smith, 1997). In this study, such parameters are also taken into account.

However, we find that few user models considers about learning habits which is very personal but important for assisting learner's learning. As far as we concern, compared with e-learning one big advantage of Mobile Learning is to enable learners to study anytime and anywhere. And because the mobile devices are always with the learners and they are equipped with sensors such as GPS, it is possible for the systems to understand when and where the learning happened. So the mobile device knows that when and where the learner usually studies. These learning habits also have an effect on learners' learning. Consequently, the learning habits will be investigated in this study.

2.2.2 Differences between personalized learning and context-aware learning

Through the literature review, we can see that more and more researchers investigate in context-aware learning and personalized learning at the same time (C.-M. Chen & Li, 2010; D. G. Sampson & Zervas, 2013). For instance, some adaptive personalized learning studies also adapt learning contents to suit learner's contexts. Meanwhile, besides the external contexts such as the temperature, sound, air pressure, time and so on, the internal contexts such as learners' cognitive activities are also addressed by a few researchers (Hong, Suh, & Kim, 2009). Actually, as shown in Figure 2.1 with the evolution of mobile technologies, the boundary between the two fields is becoming close.

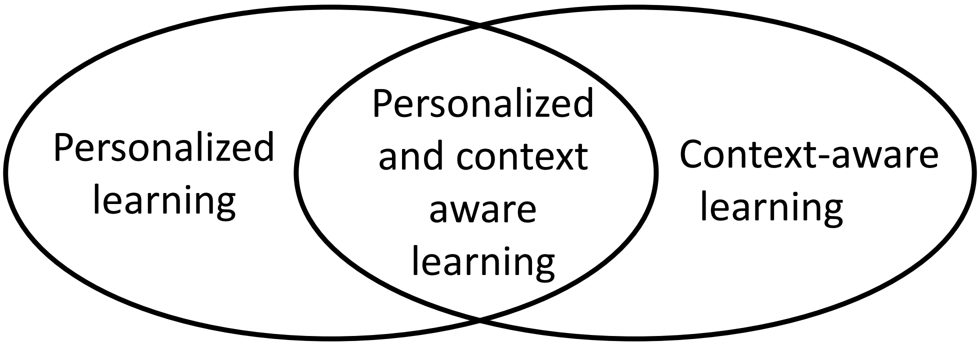

Figure 2.1 The scope of personalized learning and context-aware learning

2.3 Learning Theories

One target of this study is to help learners to master and remember what they have learned effectively. To realize this goal, the system in this study is designed on the basis of the theories and studies on the human memory. This section presents several such theories.

Accoring to Tulving (Endel Tulving, 1972), there are two memory systems: episodic memory and semantic memory. Episodic memory is concerned with storage and retrieval of temporally dated, spatially located, and personally experienced events or episodes, and temporal-spatial relations among such events. Semantic memory is the system concerned with storage and utilization of knowledge about words and concepts, their properties, and interrelations (E. Tulving & Thomson, 1973). This study focuses on helping learners to remember what they have learned in daily lives. Therefore, we lay my emphasis on how to support episodic memory. Memory is often considered to be a process that has main stages, including encoding, storage and recall (retrieval).

According to Tulving and his colleagues' research, for episodic memory, specific retrieval cues facilitate recall if and only if the information about them and about their relation to the TBR (to-be-remembered) knowledge is stored at the same time as the TBR knowledge is stored (E. Tulving & Thomson, 1973; Endel Tulving & Osler, 1968; Endel Tulving, 1983). It means that if the input coincidental information, which is encoded when remembering, is efficient for learners to recall remembered knowledge. To help learners to recall what they have learned, there are three theories found in the literature:

- Environmental Context Effects

Several experiments have proved that environmental context can facilitates recall(Fernandez & Alonso García, 2001; Smith, Glenberg, & Bjork, 1978; Smith, 1982). The elements of environmental context include such things as the time of day, the building and room in which to-be-remembered items are presented and so on (Smith et al., 1978). It means that the location, time and other environmental context data can be used for learners to recall what they learned effectively. This provides an effective retrieval strategy.

- Picture Superiority Effect

A number of experiments have proved that pictures are more efficient for People to remember than words (Defeyter, Russo, & McPartlin, 2009; Paivio & Csapo, 1973). This phenomenon is called picture superiority effect which is found by Nelson and his colleagues (Nelson, Reed, & Walling, 1976). According to Paivio's dual coding theory

(Paivio, 1991), pictures hold an advantage over words because they are amenable to semantic encoding through two different routes. Whereas words are processed only through a verbal pathway, Paivio claims that pictures are processed through both “imaginal” pathway and verbal pathway. The dual coding of pictorial information facilitates access to the semantic store and hence increases the strength of encoding (Whitehouse, Maybery, & Durkin, 2006).

- Testing Effect

If students are tested on material and successfully recall or recognize it, they can remember the knowledge better in the future than if they had not been tested (Roediger & Karpicke, 2006). This phenomenon is called the testing effect. The studies on the testing effect have been done over a long period of time (Gates, 1922). According to McDaniel and his colleagues (McDaniel & Fisher, 1991; McDaniel, Kowitz, & Dunay, 1989; McDaniel & Masson, 1985), testing enhances learning by producing elaboration of existing memory traces and their cue-target relationships. Bjork argues that testing operates by multiplying the number of ‘‘retrieval routes’’ to stored events (Bjork, 1975, 1988). Roediger and his colleagues find that testing can also improve long-term retention and the strategy of repeated testing enhances learning more than repeated reading (Butler & Roediger III, 2007; Karpicke, Butler, Roediger, & others, 2009).

- Memory Strategy

As time passes, People will forget what he has remembered if no repeat learning process is performed (C. M. Chen & Chung, 2008). However, the results of the research on forgetting find that memory strategies can help People to overcome forgetting. As this study focuses on language learning, some strategies proposed in this field are found. For example, Nemati categories the memory strategies on vocabulary into four sets: creating mental linkages; applying images and sounds; reviewing; and, employing actions (Nemati, 2009). In addition, Pimsleur proposes a memory schedule which defines the length of recall interval is 5 times of the previous interval's length (Pimsleur, 1967).

With the above theories, we can find that when a learner learns something that is related to the physical environment (such as objects, location, time) and if he can save such information with pictures or sensors, they can be assisted to recall what they learned later. And if the retrieval cues are presented in quizzes and the recall strategy is appropriate, it may be more efficient. Our system is implemented on the basis of this idea.

Chapter 3

Ubiquitous Learning Log System

3.1 Note-taking based on smartphones

Note taking is a common habit for foreign language learners when they learn new vocabularies, idioms or sentences (shown in Figure 3.1). However, because such notes are usually written down on the papers, some problems with the paper-based notes are found. The first one is that these notes cannot be shared with other learners easily and such information cannot be reused widely. For example, most of the oversea students who learn Japanese in Japan have their own Japanese notes. But if they go back to their countries, the data of the notes will be lost and cannot be used for the other learners. The second problem is that if the notes are accumulated too many, it is difficult for them to find what they want quickly. Besides, the paper notes are just used for reminder and reference. They plays little role on help learners to remember what they have learned. In fact, most of the notes do not work after they are taken. What's more, compared with the notes taken by the mobile devices, the paper-based notes usually do not contain the context information such as the location where the knowledge learned and the time when the notes are taken. But such information is useful for learner to recall what they learned. In order to make the best use of the notes and to help learners search and remember their notes easily, taking notes with smartphones is proposed in this study.

Figure 3.1 Notes for language learning

With the evolution of the mobile devices, our lives are changing gradually. For example, more and more people prefer to record memos or notes (such as schedules, planners or task lists) with cell phones. And for many people it is a simpler way, since the information can be contained in much more ways like texts, photos, audios, videos and so on. Researches have focused on facilitating this kind of note taking (Dai, Lutters, & Bower, 2005; Lin, Lutters, & Kim, 2004). However, the notes like the schedules, task lists are only called the informal notes. This is because these notes only contain information not knowledge. Different from the informal notes, the notes like the foreign language notes are defined as formal notes. The contents of formal notes are knowledge. As mentioned above, the paper based formal notes have several problems. This paper focuses on assisting formal notes taking and reusing problem. The system called SCORLL is designed to improve the disadvantages of the formal note taking described above. Its aims are to help learners to share knowledge with other learners and to remind learners what they have learned via the learning context.

3.2 What is SCROLL

Before introducing SCROLL (System for Capturing and Reusing Ubiquitous Learning Log), the definition of ubiquitous learning log is given firstly. In this study, learning log is defined as a recorded form of knowledge or learning experience acquired in our daily lives. It serves as memory storage for notable or important knowledge to review, to remind and to reflect. For example, a learning log can be a Japanese word or a piece of English sentence taken down by a language learner. SCROLL is a system to aid these users to simply capture, review and reflect their learning logs, reuse the knowledge when in need, be reminded at right time at right place and be recommended others' learning logs properly. It adopts an approach of sharing user created contents among users. It means that a learner's learning log cannot merely available for him, but also can be shared with other learners who have the same learning needs. In our study, a learner's own and others' learning logs are his main learning objects.

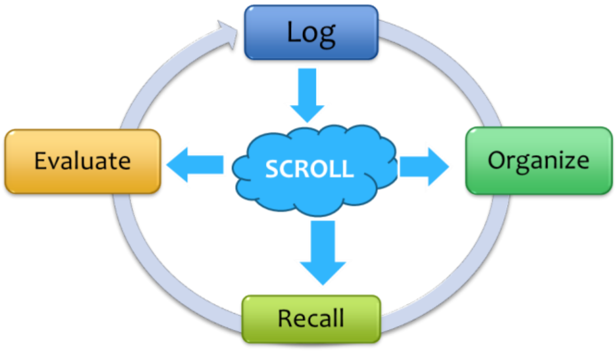

Figure 3.2 Learning process using SCROLL.

In the terms of the learner's activity, the learning process is defined in a model called LORE (Shown in Figure 3.2):

(1) Log what the learner has learned: When a learner learns something in the daily lives, he can capture the knowledge or learning experience by using SCROLL. Besides, when the learner faces a problem in the daily life, he can ask questions through the system. If the questions are answered, the questions are treated as ubiquitous learning log as well. The form of ubiquitous learning log is defined previously. It will be introduced later.

(2) Organize: Learners can organize their ubiquitous learning logs using tags and categories. This is to help learners to find what they want quickly after they accumulate too many learning logs. What's more, the system can recommend the similar ubiquitous learning logs and the near ubiquitous learning logs to the learner after they added a new learning log. It can help learners to learn the related knowledge uploaded by the other learner.

(3) Recall: As mentioned before, the paper based notes are mainly used for reminder and reference. To improve this, SCROLL aims to help learners to remember what

they have learned. The context data of ubiquitous learning log is proposed to be used. Quiz function which makes use of the photos of learning log and the location based learning log reminder function play important role on help learners to recall what they have learned.

(4) Evaluate: It is important for learners to check how much they have mastered the knowledge. Quiz function plays this role as well. However, it is also very important for learners to know whether they can use what they learned in the real world. Therefore, task function is proposed, which can guide learners to use their knowledge to reach a goal.

Based on the LORE model, the functions of SCROLL are designed and developed. The next part of this section describes them in details and. At the end of this section, the usage scenario of SCROLL is also talked about.

3.3 Log what you have learned

To simplify the process of capturing the learning experience, the system provides a pre-defined form to illustrate a ubiquitous learning log. It includes four basic elements, which are the time when the learning occurred (when), the knowledge (what), the sequence recorded in texts, photos, audios or videos that the learning should comply (how), and the location where the learning happened (where). Besides, the logs can be organized by tag and category. Figure 3.3 is the interface of adding a new learning log and Figure 3.4 is an example of learning log.

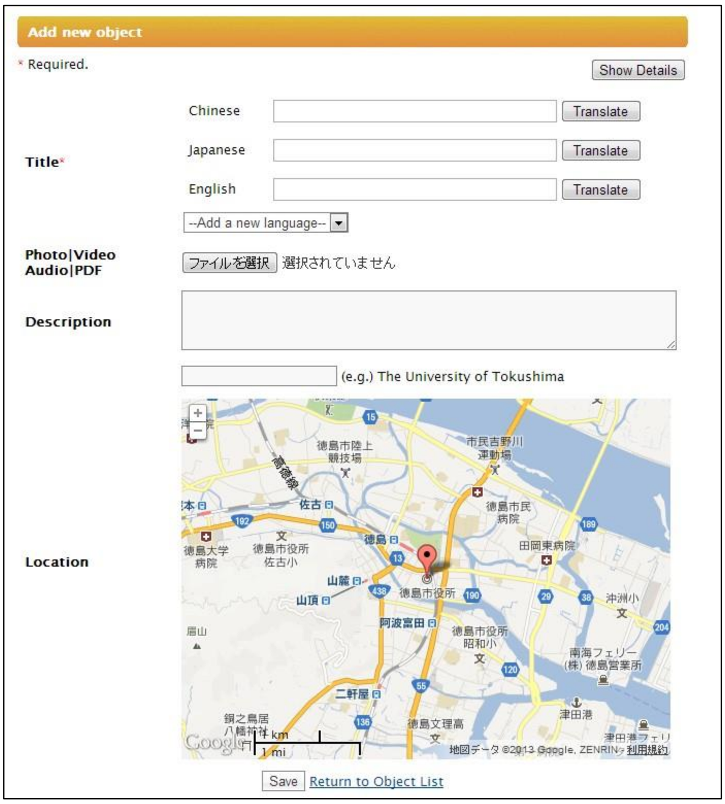

Figure 3.3 Interface of adding new learning log

There is a special type of learning log called location based learning log in this study. This type of learning log is regarded as the knowledge that can be recalled by the location or place as a retrieval cue. Its purpose is to remind learners of what they have learned when they come to the place where the learning happened. According to the theory of encoding specificity, the place where we learned can be encoded as a retrieval cue initially and it is effective to activate a stored memory (E. Tulving & Thomson, 1973). For example, if we learned the Japanese names of vegetables in a supermarket, when we enter the supermarket next time some of what we have learned may come into our mind again.

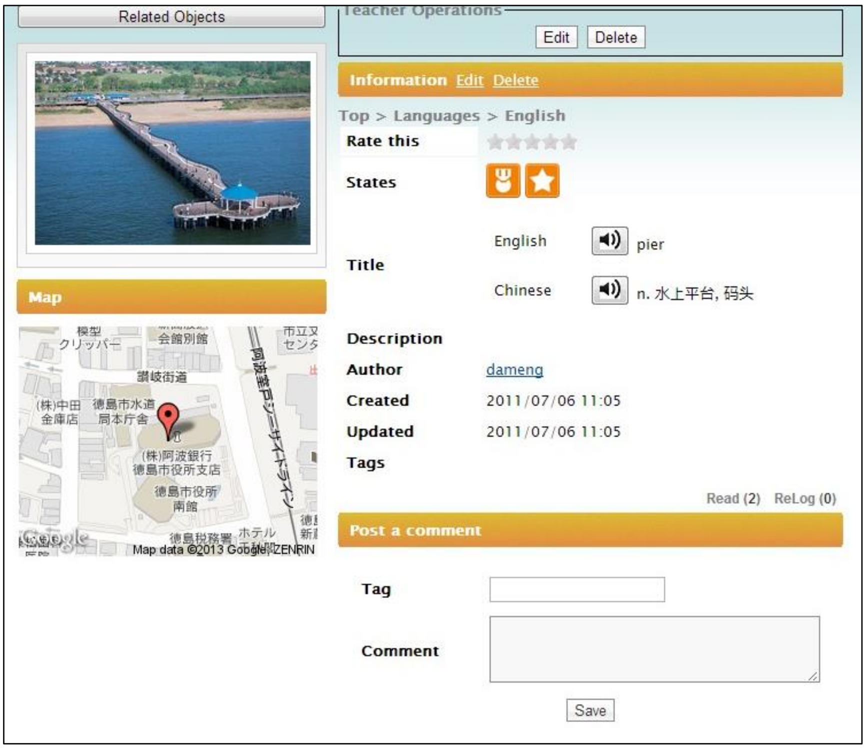

Figure 3.4 An example of learning log

3.4 Recall what you have learned using quizzes

An important goal of SCROLL system is to help learners recall what they have learned after they archived their learning logs. Quiz function is designed to play this role. This is supported by two theories. Firstly, according to the basic research on human learning and memory, practicing retrieval of information (by testing the information) has powerful effects on learning and long-term retention. And compared with repeated reading, repeated testing enhances learning more (Karpicke et al., 2009). Therefore, the quiz function is proposed. According to the theory of encoding specificity principle, the context of learning including the place, time, text, picture and so on can be encoded as retrieval cues and they are effective to activate the stored memory (E. Tulving & Thomson, 1973). Therefore, the quiz function, which makes use of the context data of learning log, is proposed. Firstly, according to the picture superiority effect, the learning logs with pictures are much more likely to be remembered rather than those without pictures (Nelson et al., 1976). For these two reasons, the quiz function taking advantages of the pictures, locations and so on is proposed. Three types of quizzes can be generated automatically by the system, which are yes/no quiz, text multiple-choice quiz and image multiple-choice quiz (shown in Figure 3.5).

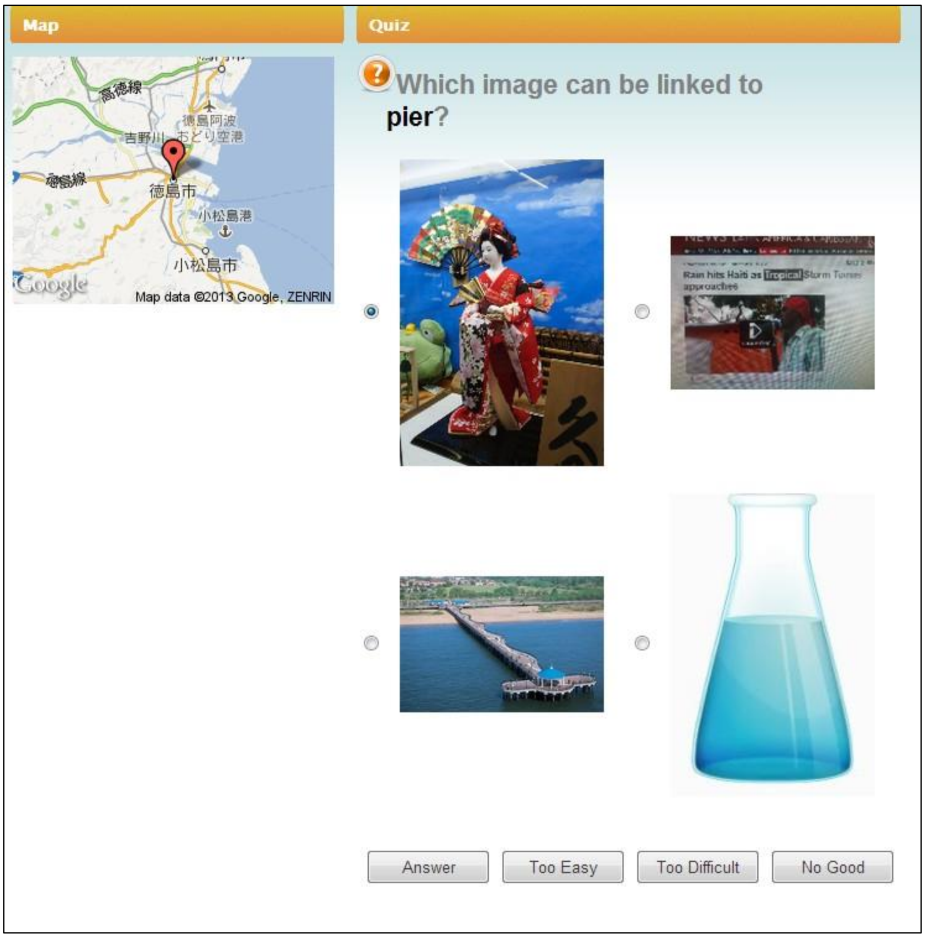

Figure 3.5 An example of quiz

3.5 Learning Log Navigator and Time-map functions

Learning log navigator provides mobile augmented reality that allows the learner to navigate through the learning logs. 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 LLOs 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 3.6(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 3.6(right)). This assists the learner to acquire new knowledge by discovering the existed LLOs and to recall his learning logs. In order to reduce the power consuming of the phone battery, the light-mode (blank screen) is developed. In this mode, the phone camera is turned off, and the system displays only information about the surrounding objects. Moreover, by touching the phone screen, a menu will be displayed; it provides the learners with additional facilities, such as displaying a list of all surrounding objects and photos capturing (Camera-mode).

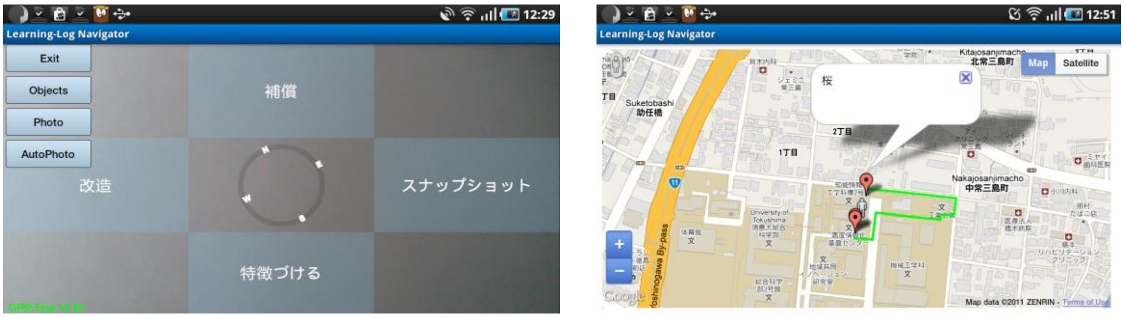

Figure 3.6 Navigator and a path to targeted learning logs

Time map function means that the user can scroll the timeline above and then the map below will display the learning logs recorded during learners' selected period. It is designed to help the learners to reflect what they have learned (Figure 3.7). More detailed description on the functions of SCROLL system can be found in (Hiroaki Ogata, Li, Bin, et al., 2010).

Figure 3.7 Interface of time-map

3.6 Learning Task: Learn by doing

According to the learning experience theory, learning is defined as the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience (Kolb, others. 1984). Therefore, to help learners to master new knowledge, a task-based learning function is designed in SCROLL called learning task, which aims to change the learners from watcher to doer.

Figure 3.8 Interface of adding a task script

The so-called learning task stands for a learning activity. The learners who are encouraged to reflect what they have learned by scripting their knowledge are responsible for creating learning tasks. It means that after a learner learns a serious of learning logs in an activity, he can organize these learning logs into a scenario. Meanwhile, such scenario can be recommended as learning task to the learners who have not experienced the learning activity. Through carrying out the assigned task, learners can practice the recommended new knowledge. And in order to help the learner finish the task smoothly, the system can provide a navigation function, which guides learners in each step. Figure 3.8 shows an example of learning task.

Chapter 4

Context-awareness and Personalization

4.1 Technological Process

4.1.1 Objectives of the method

According to Dev, a system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task (Dey, 2001). Hong and his team explain that a context-aware system must include three essential elements: sensors, processing and action. In their opinion, one goal of the context-aware systems is to acquire and utilize information on the context of a device in order to provide services that are appropriate to the particular people, place, time, event, etc (Hong et al., 2009). Byun & Cheverst address the technological process of context-aware system which is to extract, interpret and use context information and adapt its functionality to the current context of use (BYUN & Cheverst, 2010). Hwang & Yang declare there are five potential criteria of a context-aware u-learning environment which are shown as follows (Hwang, Tsai, & Yang, 2008):

(1) A context-aware u-learning environment is able to sensor the learner's situation or the situation of the real-world environment in which the learner is located.
(2) A context-aware u-learning environment should have provide adaptive supports to learners by sensoring their behaviours and contexts in both the cyber world and the real world.
(3) A context-aware u-learning environment is expected to provide the learners with personalized recommendation or hints in the right way, in the right place, and at the right time. At the same time, learners' personal and environmental contexts, their profiles and learning portfolio should be taken into account.
(4) A context-aware ubiquitous learning environment can enable the learners to learn seamlessly in different places.
(5) A context-aware ubiquitous learning environment is able to adapt the contents to different mobile devices.

Based on these previous findings, three objectives of our context-aware and personalized learning model are proposed, which are:

(1) By being aware of a learner's current context, especially the location and his activities, the system can support this learner's learning by making use of the detected context information. Learning context is thought to be used for learning in two directions. One is that the contexts may be encoded as retrieval cues when a learner learned something. And after that the contexts can activate the learner's memory for the knowledge. It means that we use them to help the learners recall what they have learned. The other is that the learning contexts in the real world can be helpful for the learners to master new knowledge. For

example, when the system recommends a learner to sudy a word such as “apple”, it is good for him if the system can guide him to see what is “apple”.

(2) The past learning context called “context history” should also be used for learners’ learning. Because such context data was collected when a learner was studying, it may help us to find out what kinds of charactors the learner has when he studies. In this study, it is called learning habit and to support a learner’ learning based on his learning habits is also thought to be meaningful.

(3) Personalized learning does not only include learning habit, but also refer to learners’ learning style and tailoring the learning contents to specified learner appropriately by considering his profile.

These three objectives are the principles for us to design our model and the rest part of this section gives a detailed introduction about the model.

4.1.2 Technological Process

As discussed in chapter 2, the elements of learning context in our study are collected from three aspects: learner, device and environment. Table 4.1 demonstrates the specific elements in each aspect.

Table 4.1 Elements of learning context

Aspect	Elements
Learner	Activities such as running, walking, sleeping, reading, playing and so on

Device	Battery, Internet connection, Screen lock status
Environment	Location, time, temperature, noise and so on

With the three kinds of context data, our model will monitor, analyse and dig the contexts, derive the learning habits from them and prepare proper learning objects for them. Figure 4.1 demonstrates the whole processing flow of the model. It follows the below steps:

(1) At the beginning, the system will check the availability of the context and judge whether it is possible for the learner to study now. Concretely speaking, it firstly checks the status of the device. For example, how much battery is left and whether the Internet is connected. Only the left battery is more than 20% and the mobile device is connected with the Internet, the context-aware service can be started. Moreover, the system also checks whether the time is too late for the learner. This is because if the time is too late and the notification may disturbs the users. The default "do not disturb" period is set between 1:00 am and 6:00 am and it can be changed by learners. If the time is not during this period, the availability is thought to be high. If the availability is low, the system will do nothing.

(2) If the device has a high availability, the learner's contexts will be checked whether they can meet the conditions of three context analyzer modules according to priority, which are context-based reminder module, context-based learning log recommendation module and learning habits based learning prompting module. If the contexts meet one of the modules, the system will prepare the relevant learning contents and then notify the learner.

(3) The first module is context-based reminder module. It means that the system will search whether there are learning logs near the learner which were uploaded by

him. If such learning logs existing, the system will firstly prepare quizzes which are relevant with those learning logs and then notify the learner with a piece of reminder message. And if the learner clicks the message, SCROLL will show the quizzes which are used to help learners to recall what he learned. If no such learning logs existing, the service will go to the next module.

(4) The second module is context-based learning log recommendation module. This module is to check whether there are some location-based learning logs near the learner which were uploaded by the other learners. If such learning logs existing, the system will save these learning logs on the learner's device and then notify him with a piece of recommendation message. If the learner clicks the message, the system will show a list showing them and can guide the learner to reach them through the learning log navigator function. If no such learning logs existing, the service will go to the next module.

(5) The third module is the learning habits based learning prompting module. This module is designed to examine whether the learner is in his preferred learning environment. For example, if the learner has a habit of studying at home, the system can detect whether he is in his preferred learning environment such as home. If the condition is met, the system will prepare some quizzes and then notify the learner with a piece of prompting message. And if the learner clicks the message, the system will show the learner with the quizzes. If the condition is not met, the system will do nothing.

(6) While the context data is being analyzed, it is also saved as context history at the same time. Data mining and clustering technology are used to analyze such data to find out individual learners' learning habits. Meanwhile, the learner's response to

the learning habits based recommendation can be used to improve the prediction of learners' learning habits.

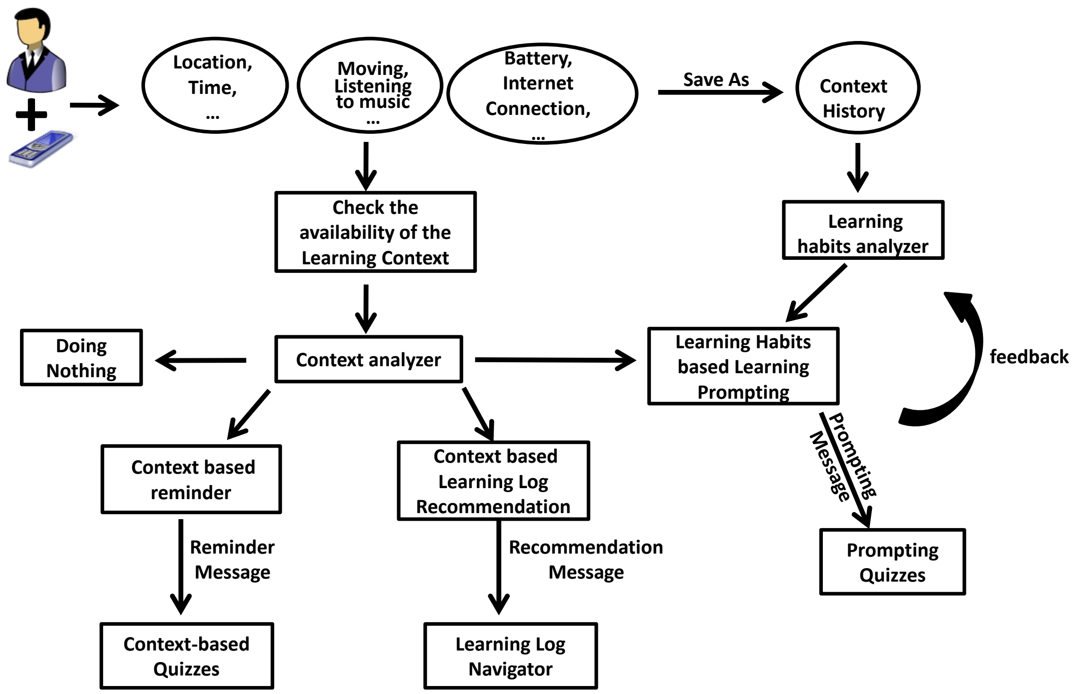

Figure 4.1 Workflow of the personalization and context-aware method

Throughout the whole processing flow, we think there are four important issues which needs more explanation. They are:

(1) How the context-based reminder module makes use of the learning contexts to help learners recall what they learned.

(2) How the context-based learning log recommendation module recommends specified learner with suitable learning logs

(3) How the learning habit based learning prompting module prompts learners to learn according to their learning habits and how to catch these learning habits by analyzing the context history data.

(4) How to provide the suitable learning contents including the quizzes and learning logs to each learner and how to suit their learning styles.

The following sections will introduce them respectively in details.

4.2 Context-base Reminder Module

4.3.1 How to recall the learning logs?

As talked in chapter 2, environmental context can affect learners' recall (Smith et al., 1978). Therefore, we employ the location data to help learners recall the location based learning logs they learned in this study. The context-based reminder module is responsible for this function. The concrete processing flow can be divided into three steps.

At the first step, SCROLL searches whether there are the learner's location-based learning logs in 50 meters from him. If these learning logs exist and the learner has not remembered them yet, the system will create quizzes related to the learning logs on server and push them to the learner's device. In order to judge whether a learner has remembered a learning log or not, we define if the learner answered the quizzes related to the learning log correctly twice, the system supposes that he has remembered the knowledge and the reverse is also true.

At the second step, after the client received the prepared context-based quizzes, the system will show the learner a piece of reminder message reading "Now you are near some learning logs you learned. Do you want to recall them in quizzes?" If he clicks the message, the system will show him the quizzes, which give the location information as hint for the learner.

At the third step, the system will check whether the reminder message is finally clicked or not by the learner. If it is not clicked, the system will remind the learner again when he comes to this place the next time. If the message is clicked and the quizzes are answered correctly, the reminder message for this learning log will not be shown again. But if the quizzes were answered incorrectly, the learner will be reminded again.

A scenario of the usage of context-based reminder module is shown in Figure 4.2. For instance, if a learner learns a word called "natto" which is a kind of traditional Japanese food in a supermarket, he can save this a learning log on the server. And if the learner visits the supermarket again, the system can provide a quiz related to "natto" to help the learner to recall what he learned.

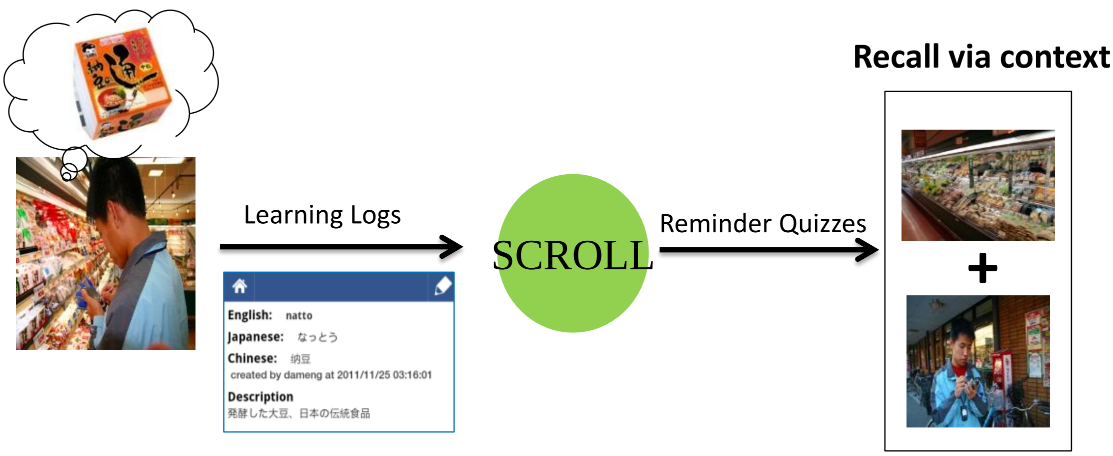

Figure 4.2 Recall via context

4.3.2 Recall what you learn in a similar learning context

As mentioned above, the learning context especially the location, in which learners learned the knowledge, can be used to remind learners of what they have learned. However, it is not frequent for a learner to go to the same place. Therefore, the efficacy of using learning context to remind learners is limited. To clear this problem, we propose a way to help learners to recall in a similar learning context. It means when a learner learned in a place, he cannot only be reminded near the same place but also near a similar place. For example, if the learner learned a word called "natto" in a supermarket, he would be provided with the reminder quizzes about "natto" near both this supermarket and any another supermarket.

To realize this, what we did is to assist learners to provide place tag for the learning logs when they upload them. When a learner inputs the contents on an android device, a service is started in the background which can search the names of the near places by using the location data obtained via GPS and Google Places API. Google Places API is a service provided by Google Inc., which returns information about places, such as the type of place, the user reviews about the place and so on ("Google Places API," 2013). Google Places API supports 96 types of places, such as airport, park, gas station, school and so on. It returns a list of place types which are near the current place and the system presents them for the learner. Then the learner can choose some of them as the place tags for his learning log (shown in Figure 4.3). Finally, if the system will not only check where the learner is but also what kind of place the learner is in. And then his past learning logs related with the place type will be reminded as well.

Figure 4. 3 The android interface of adding a learning log

4.3 Context-based Learning Logs Recommendation Module (CLLRM)

4.3.1 Learning Logs Recommendation based on Learning Context

As discussed in chapter 2, many context-aware studies in language learning filed recommends related learning contents to the learner by taking into account of his location. This study also proposes a context-based learning logs recommendation module which can recommend learning logs to the learner according to his learning contexts. The processing flow is similar to the flow of the context-based reminder module. It also has three steps.

At the first step, SCROLL searches whether there are other learners' location-based learning logs in 50 meters from the learner. If the learning logs contain his learning languages and they have not been recommended for the learner before, the system will push the learning logs to the learner's device.

At the second step, SCROLL will notify the learner with a piece of recommendation message to arouse his attention. The message says "Some other learners' learning logs are found near here. Would you like to view them?" If he clicks the message, a list of learning logs near the learner will be shown and the learning log navigator function can guide the learner to reach his preferred ones.

At the third step, the system also checks whether the recommendation message is finally clicked or not by the learner. If it is not clicked, the system will recommend the learner again when he comes to the place next time. If the message is clicked, these learning logs will be treated as the learner's recommended learning logs. And such learning logs will be examined in the quizzes after that.

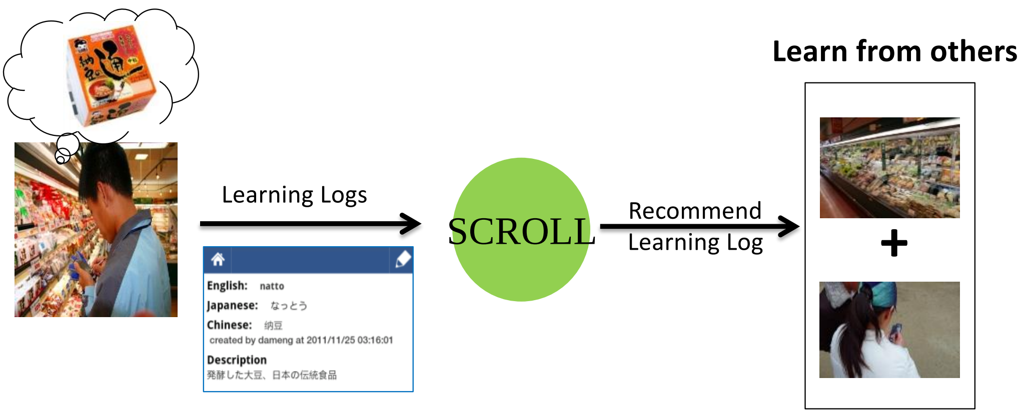

Figure 4.4 Context-based learning log recommendation

A scenario of the usage of context-based reminder module is shown in Figure 4.4.

For instance, if a Japanese learner learned the word "natto" and saved it as a learning log on the server. After that if another Japanese learner visits the supermarket, the system will recommend the learning log of "natto" to this learner.

4.4 Learning Habits Based Prompting Learning Module

4.4.1 Why learning habit?

Learning habits are defined as a learner's preferred styles that he usually adopts when he learn. For example, some learners prefer to study in the evening before sleep while someone maybe prefer to study in the morning after wake up. What's more, some People have the habit of reading books when they commute on the train or bus. Because such learning habits are related to learners' daily customs and habits and learners probably study at such condition, we propose to prompt learners to review what they have learned based on their learning habits. The learning habits are supposed to be useful for learners' study. The prevalence of smartphones makes it possible to detect learners' learning habits. This is because the smartphones which are always carried with by the learners can understand learners well.

Another reason of supporting learners' learning habits is because that we want to explore more about learners' context histories, which are the context data collected when the learner used SCROLL to study. As far as we concern, learning context cannot only be used for one time, but also repeatedly. To find out learners' learning habits is an implementation of using context histories. Until now, the system can make use of three kinds of context data including location, time, and speed. And the learning habits supported in our system involve where a learner usually studies (such as home, school or fast-food restaurants), when a learner prefers to study (e.g. after waking up in the morning or before sleeping at night) and whether a learner has a habit of studying on the commuting train. The following parts introduce the processing flow of the learning habit based prompting learning module and the concrete method to detect the learning habits.

4.4.2 Learning habit based Prompting learning

The processing flow of learning habit based prompting learning module also has three steps as other two modules. As mentioned above, three learning habits have been supported in this study involving where a learner usually studies, what time of a day the learner prefers to study and whether he has a habit of studying on the commuting train. Therefore, at the first step, SCROLL judges whether the learner is in his preferred environment. For instance, it checks whether the learner's GPS location is in his preferred learning area, whether now is his preferred learning time of a day, whether his moving speed is similar with the speed of his means of communication for commuting. If one of the conditions is met, it moves to the next step.

At the second step, the client fetches some quizzes from the server and the system then shows the learner a piece of message to prompt learning. For example, the message says “Now you are in the place where you usually study. Do you want to practise some quizzes now?” If he clicks the message, the system will show him the quizzes. The quizzes are to help him to recall what he learned and about the priority order of the quizzes will be introduced in the next section.

At the third step, the system will check whether the prompting message is finally clicked or not by the learner. Because the analysis of the learners’ habits is done one time per week, the learners’ responses can be used to improve the results of the prediction in the future. About this, it will be introduced the next part.

A scenario of the usage of this module is shown in Figure 4.5. For instance, if a Japanese learner learned the word “natto” and saved it as a learning log on the server. After that if this learner has a learning habit of studying at home and the system detects that he is at home now, the system will prompt him to do quizzes about what he learned, such as “natto”.

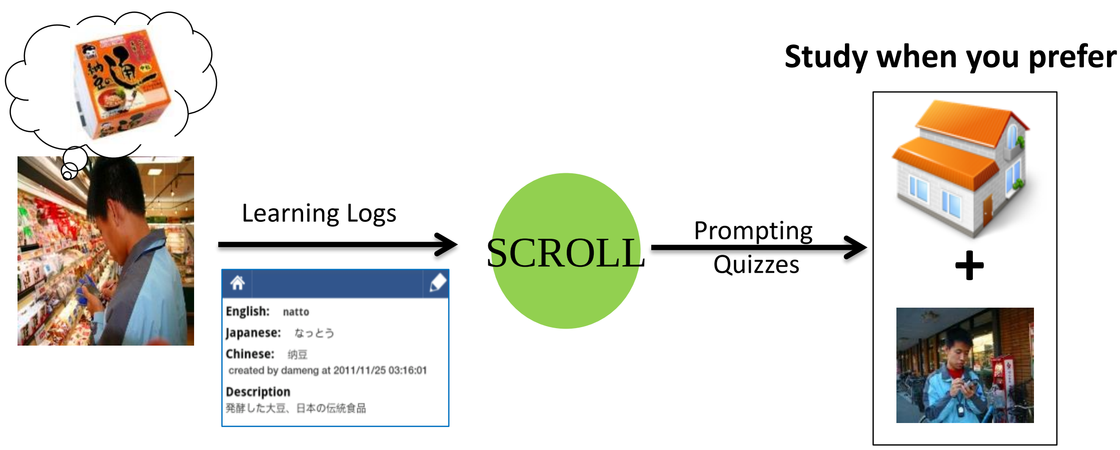

Figure 4.5 Learning habit based learning promting

4.4.3 Predication of learning habit

As mentioned above, until now there are three kind of learning habits supported in this study. This section will introduce how to acquire them respectively.

- How to find a learner's preferred learning place?

In the literature, there are many studies on finding users' significant place can be found (Kang, Welbourne, Stewart, & Borriello, 2005; Zhou, Bhatnagar, Shekhar, & Terveen, 2007). Usually, there are two approaches adopted: K-means clustering approach (Ashbrook & Starner, 2003) and density-based clustering approach (Ester, Kriegel, Sander, & Xu, 1996). In this study, we use the K-means clustering approach which is easy to implement.

The raw context data consists of longitude, latitude, speed and time-stamp. The data is collected when a learner uploads new learning logs or reviews learning logs or does quizzes. A set of raw data is called a point. The first step is to separate all the points according to the time-stamp and distance. It means that if the time-stamps of two points are close and the distance between the two points is not far, the two points are thought to be one learning data. So we can merge the two points into one by calculating the middle location and time. We set threshold of the time is 10 minutes and the distance is 100 meters. After this process, the system starts to cluster the points into clusters in the next step.

The basic clustering algorithm we adopted is borrowed from Ashbrook & Starner (2003). Firstly, we start with a point and search the other points near it in 50 meters. Then we will calculate the central location of these points and take the central point as a new point. Then we will find the other points near the new point in 50 meters. The procedure repeats until the central point does not move. At this time, the central location and the number of the children points will be considered as one cluster. Then the left points will be dealt with in the same procedure until no points remain. Finally, we will find out the cluster which has the most children. And the area surrounded by these children points is perceived as the learner's preferred learning place.

- How to find a learner's preferred learning time?

For the learners' preferred learning time, because the time of learning every day is a discrete random value, we determine to repeat observing the regularity of the learning time in several periods to examine whether a learner has such learning habit or not. Concretely speaking, we separate a day into 24 phases. Each phase stands for an hour. Then we count the number of times of learning collected from a two weeks period in different phase. The next two periods of four weeks will be observed as well. Finally, the frequency phase which occupies more than 25% of the all learning times in three periods will be thought as the learner's preferred learning time. Figure 4.6 shows a participator's data in our experiment and it is obvious to find that the time from 23:00 to 24:00 is her favourite learning time.

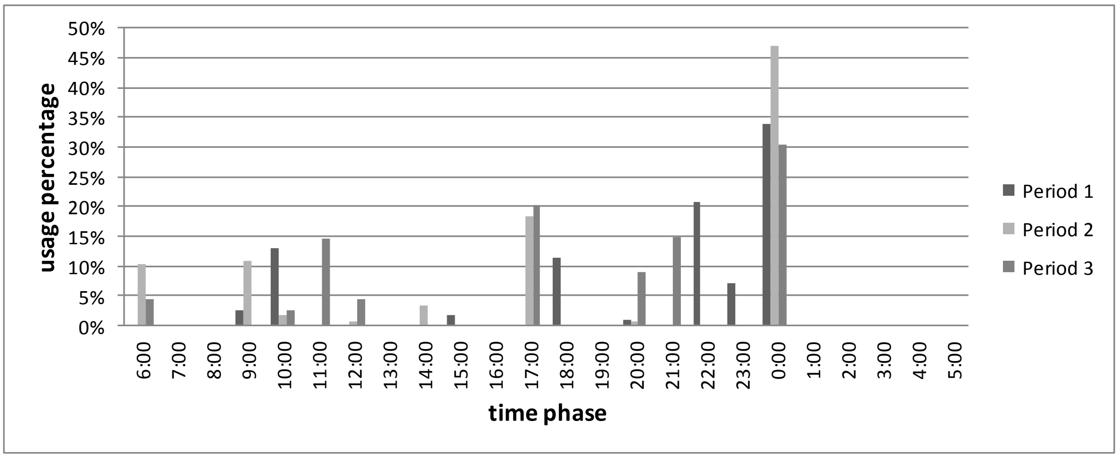

Figure 4.6 a learner's learning time in three phases

- How to check whether a learner has a habit of learning during commuting?

Considering how to discover whether a learner has a habit of studying on a commuter train or bus, the speed and the time parameters are needed. Another experiential fact is that the speed and the time of commuting are relatively stable. Consequently, we firstly search the data with high speed (10~50 km/h is thought as the speed of the bus while above 50km/h is thought as the speed of the train (Toshiaki, Ryota, Hirokazu, & Tadashi, 2005)) and then group the data containing time and speed into clusters as well. The differences of the time is within 60 minutes and the difference of the speed is within 3km/h is considered as the similar data. Therefore, if a cluster taking up 30% of the data existing, the system assumes this learner has the habit of studying on a commuter train or bus.

After achieved the learners' learning habits, the system can recommend messages when learners entered those environments. For example, when a learner stays in the place where he usually studies, a piece of message writing "The system guesses you are in a place where you usually do studies. Do you want to review what you have learned?" will be given. When it is his preferred learning time or when he is moving on a commuter train, he will receive a similar message as well. Finally, by checking the learners' response, the system can modify its prediction: if the system shows messages for him more than 3 times based on the same learning habit without any responses, this learning habit will be disabled.

4.4.4 Visualization and Customization of Learning habit

As Herlocker points out, it is important to explain the rationale behind recommendations to end-users (Herlocker, Konstan, & Riedl, 2000). This is because that the complexity of recommendation algorithms often prevents users from comprehending recommended results and can lead to trust issues when recommendations fail (Verbert et al., 2012). Therefore, it is important to provide explanations and justify decisions (O'Donovan, Smyth, Gretarsson, Bostandjiev, & Höllerer, 2008). The use of visualization techniques is an efficient way to provide users with insights in the recommendation process. For example, Zhao employs social visualizations to explain recommendation results by explicitly exposing relationships among content and people (S. Zhao et al., 2010). EL-Bishouty & Yano present the relationship and distance between peer learners with a visualized Knowledge Awareness Map (El-Bishouty, Ogata, & Yano, 2007).

After the system predicted learners' learning habits, it is also very important to notify the learners with the results and authorize learners to reset the results. This is because the learners know themselves better than the system and they should control the system instead of being controlled. Consequently, we propose a function for learner to view and customize their learning habits predicted by the system. Figure 4.7 illustrates the function. With this function, learners can view the prediction results of the system, such as the preferred learning place and learning time. What's more, they can also change them according to their wishes.

Figure 4.7 Visualization of learning habits

4.5 Tailor the learning contents to specified learner

As the literature review in chapter 2, how to tailor the learning contents to specified learner is a basic issue for personalized and adaptive learning. In this study, the learning contents are referred as learning logs and their related quizzes. There are two functions relying on the adaptive function in SCROLL, which are quiz function and learning log recommendation function. They are talked about in the rest of the section.

4.5.1 The mechanism of recommending learning logs

There are two ways to recommend learning logs. One is based on the attributes of learning logs. For example, in the navigator function the learner can receive the other learners' learning logs near him. The other way is taking into account learners' profiles. For example, when SCROLL recommends other learners' learning logs to a specified learner, it will make the judgement on three conditions which are whether the two learners study the same foreign language, whether they have same language ability level and whether they share same mother language. If the recommended learning logs are viewed by the learners, they will be composed into quizzes to be recalled later.

4.5.2 How quiz function runs?

As described in chapter 3, quizzes are used to help learners to recall what they have learned by taking advantage of the context data and the pictures. It means that quizzes play an important role in this study. So in this section, we will present how a personalized quiz is composed and what is the memory strategy of quizzes.

For learners, the learning logs which are their main learning objects in this study mainly consist of two types: their own learning logs and the other learners' ones. The other learners' learning logs mean the ones viewed by the learner. The learning logs that a learner studied will be organized into quizzes for the learners. A learner's studied learning logs are referred as the ones that he uploaded or viewed. Based on the to-be-recalled learning logs, SCROLL creates different quizzes for different learner. In addition, concerning about how to make up the choices of the multiple choice quizzes (as shown in Figure 4.8), the other learning logs that the learner studied are used.

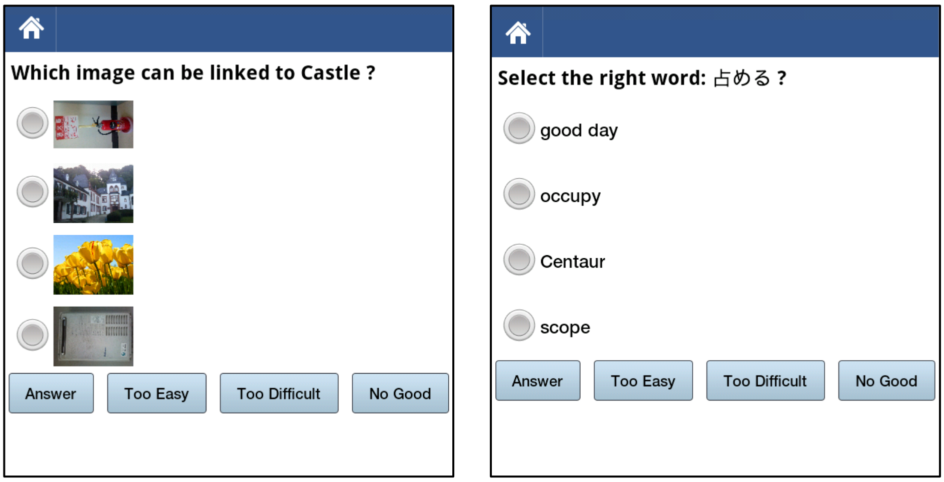

Figure 4.8 Multiple choice quiz for Android

As discussed in chapter 2, a proper memory strategy can help learners to overcome forgetting. In this study, we adopt a graduated-interval recall method proposed by Pimsleur (1967). Based on Pimsleur's finding, it is efficient for learners to recall if the recall interval is 5 times of the previous interval. Therefore, we adopt his recall method and the recall interval is followed the formula as below:

$$\mathrm{I(n)} = I_1 \times 5^{n-1}$$

In this formula, we set the first quiz recall interval (I_1) as 5 hours. It means that the quiz of the new learning log is available for the learner in 5 hours later after he uploads it. The next recall quiz will be available in 25 hours (about 1 day) later and then will be in 125 hours later (about 5 days). However, if the learner answered the quiz incorrectly, the next interval will be reset as the first interval. Actually, the system holds a queue for all the to-be-recalled learning logs and it determines which learning log should be tested in the next quiz. Figure 4.9 illustrates the process.

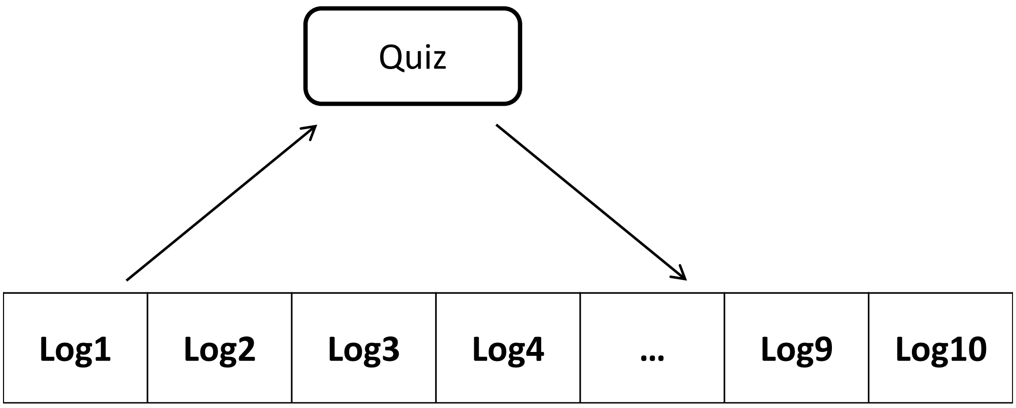

Figure 4.9 the queue of to-be-recalled learning logs

4.6 Scenario of Using Learning Log System

Up to now, SCROLL mainly focuses on language learning field. One typical scenario of its use is to assist international students to study Japanese in Japan. In this case, Japanese learners, who face rich learning contexts every day, can gain abundant of knowledge from their daily lives in different kinds of situations, such as shopping in the market, seeing a doctor in the hospital, having a haircut in a barbershop, visiting the museum and so on. They cannot only take down what they have learned in those situations, but also will receive support from the system to recall and review them after that. Figure 4.10 illustrates the workflow of the scenario. As shown, the learner learns a kind of traditional Japanese food called “natto” in a supermarket and he saves the knowledge as a learning log on SCROLL server. After that, there are three cases for the system to handle with the learning log.

(1) Recall via context: When the learner enters the supermarket again, the system will provide him with reminder quizzes in order to help him recall “natto”.

(2) Study when you prefer: If the system finds that the learner has a learning habit that he usually studies at home in the evening. And if the system detects that it is evening and the learner is at home, the system will prompt him to review what he learned.

(3) Learn from others: If another Japanese learner enters the supermarket and she has the same language ability with the previous learner, the system will recommend the learning log about “natto” for her.

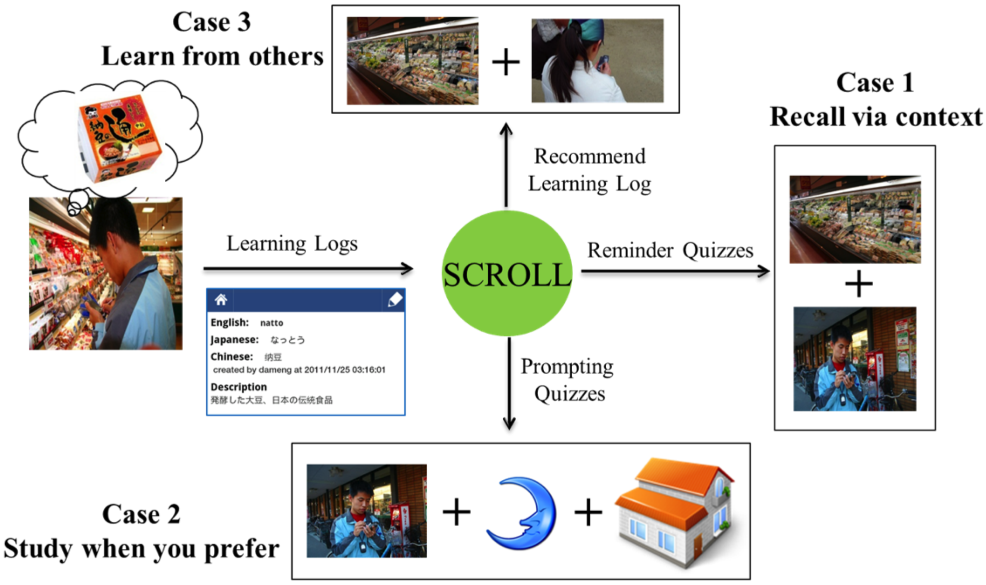

Figure 4.10 How SCROLL works

Chapter 5

System Implementation

5.1 Architecture of SCROLL

As shown in Figure 5.1, SCROLL adopts a kind of client-server architecture. Leaners can use the system by both browser and Android client. But because the context-awareness is dependent on the sensors of the smartphones, the context-aware recommendation function can only be supported on the Android devices. The server part is developed by Java and we use MySQL5.5 as database. Two frameworks including Spring MVC3.0 and Hibernate3.3 are used to implement the system. As shown in the Figure 5.1 of the SCROLL architecture, the server part is responsible for 4 functions. They are saving both learners' learning logs and the context data, analysing such data to detect their personal learning styles and preferences, creating quizzes based on learners' ability and learning history and recommending new learning contents based on what learners have learned. Besides the basic functions such as saving learners' learning logs and providing quizzes, the android client is designed to catch learners' context-data, do context-based recommendation and learning habit based prompting function. The server side exposes its API to the client part and the communication between the two sides is based on HTTP. Moreover, because the slow transmission rate of 3G always causes bad user experiences, the android client utilizes the SQLite (Android built-in Databases) as a cache. The synchronization mechanism is completed with the help of C2DM (Cloud to Device Messaging) provided by Google. C2DM is a lightweight service that sends data from the server to the Android client when some changes are made in the server part. The synchronization mechanism, how to implement both the server side and the client side and how to improve user experience will be discussed more in the rest part of this chapter.

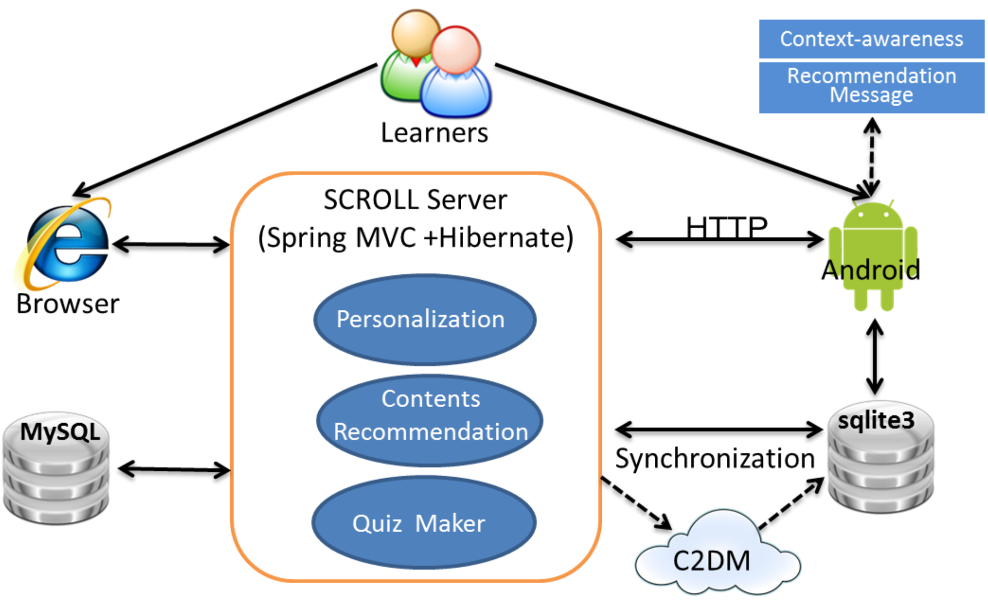

Figure 5.1 Architecture of SCROLL

5.1 Server Side

The server side is constructed on three layers: database layer, business layer and function layer. This design follows the MVC (Model-View-Control) model. As shown in Figure 5.2, the database layer includes four parts, which are learning objects, learners' profile, and learning history. Learning objects are the learning logs provided by the learner, which are introduced above. Learner's profile is a user model, which contains both a learner's static information such as the learning needs, nationality, interests and the dynamic information such as learners' preferred learning place, time, learning cycle and commute way and so on. The context-data stands for the location (latitude and longitude), time, and moving speed data collected when a learner uploads his learning logs, does quizzes and reviews what he learned. The learning history includes the answer state of the quizzes, the finish state of the learning task and the response state to the recommended learning logs.

Table 5.1 data structure

Data Type	Attributes
Learning Object	Multi-media file (photos, audios and videos), description of the knowledge, difficulty level, location, time, tags, category, location-based property
Leaner's Profile	Ability level, nationality, interests, mother language, study language, preferred learning time, learning place,

	commute way, memory cycle, personal night time
Context Data	Location (latitude, longitude), time, moving speed data captured when a learner uploads his learning logs, does quizzes and reviews his past learning logs.
Learning History	The answer state of the quizzes, the finish state of the learning task and the response state to the recommended learning logs

The business layer is implemented by using the four types of data in database layer. The business layer is responsible for the personalization, learning schedule manager, learning objects recommendation. The personalization and the learning schedule are introduced above. Here will mainly discuss about the learning objects recommendation.

The personalization function is based on the accumulated data and it increases the server burden sharply. Therefore, the analysis of the data is due to do once a week. The quartz which is an open source job scheduling service is used to start the analysis task on time.

The function layer is the view layer in MVC model. It contains the functions that are used by the learner directly such as the quiz function, learning task function and so on. The descriptions about the functions were given in the chapter 3.

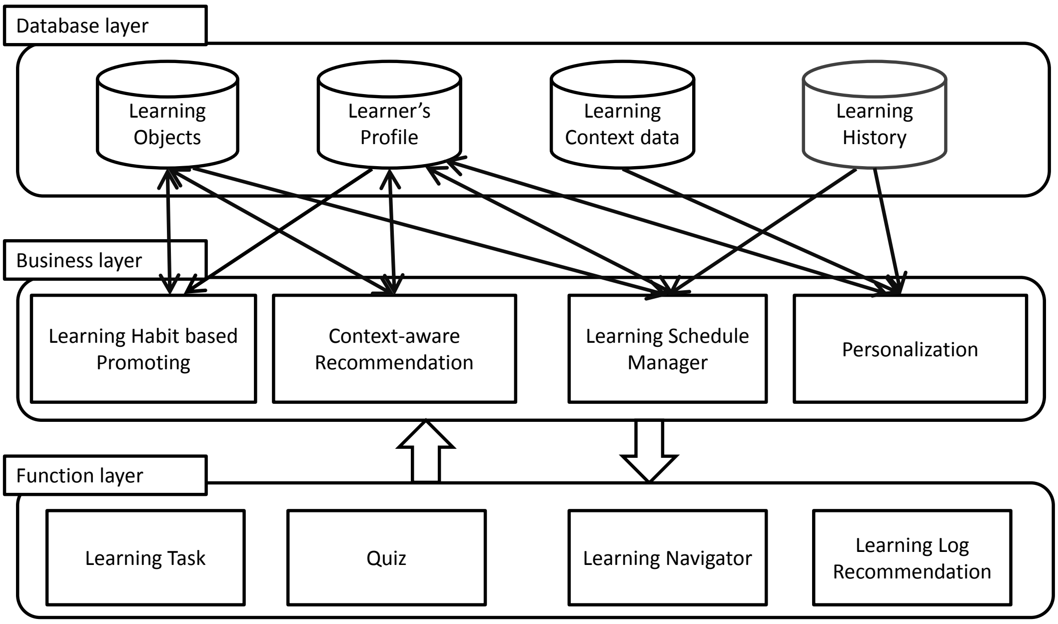

Figure 5.2 System Design

5.2 Client Side

As mentioned above, the client side is responsible for the context-aware recommendation and prompting. This section will firstly introduce about how to implement this. Besides, with the prices of the mobile devices such as smartphones and tablets getting cheaper and cheaper, more and more learners have more than one device. The learners' needs for learning seamlessly in different devices are aroused. Therefore, to synchronize the learners' learning data in different device is becoming very important. The synchronize mechanism is also introduced in the later section.

5.2.1How to support context aware function?

To implement the context-aware function, there should be two important issues to pay attention. The first one is that as Kukulska & Traxler said, usability influences whether learning is an engaging experience and will have an impact on learning effectiveness and efficiency (Kukulska-Hulme & Traxler, 2005). Therefore, improving the usability is a critical issue to develop the mobile application. And for a smartphone user, several things can affect his user experience. For instance, because the battery is a big limitation for smartphone, it may decrease learners' motivation to use SCROLL if it consumes too much battery. In addition, because the speed of 3G internet sometimes is not fast enough, the program may be interrupted when the user operates. So the user experience may be affected if the response time of user interfaces costs too long. The second issue is how to protect learners' privacy. Verbert points out that "privacy and legal protection rights are a major challenge that needs to be tackled when capturing and using contextual data for recommendation (Verbert et al., 2012)." How to overcome this challenge is also very important for this research.

By considering these two issues, we adopt a service to implement the context-aware function. This is because in Android OS, service runs in the background and it does not interrupt user's operation. And in order to reduce the battery consumption, the service runs every 15mins. What's more, we also try to protect learners' privacy when we implement the service. As Lonsdale discussed, there are three main principles of protecting user privacy, including (i) informed user consent: users must be made aware of what data is being gathered and what it is being used for, (ii) control: where consent has been given for the gathering and use of contextual data, users should be given information, access, and control over data, and (iii) security: the gathered data should be stored securely (Lonsdale, Baber, Sharples, & Arvanitis, 2004). Based on these three principles, we propose to give the learner more control authorities, which means the learner can control when to start and stop the service. And the learner should give us the authority of gather the data through the sensors such as GPS.

5.2.2 How to support Seamless learning: Synchronize mechanism

As mentioned above, the synchronize mechanism can be used to synchronize learners' learning data in different devices. Besides this goal, it can also bring other benefits for the learner. For example, because the transmission rate of 3G is not fast enough, it may cause delay when the learner uses the system in a 3G environment and decrease the user experience. However, our synchronize mechanism, which employs the database on the smartphones as the cache, can make the operation more smoothly. For example, a typical use of it is that before the system presents learning contents for a learner, the system will firstly fetch the data from the server, store it in the local database and then notify the learner with the recommendation message.

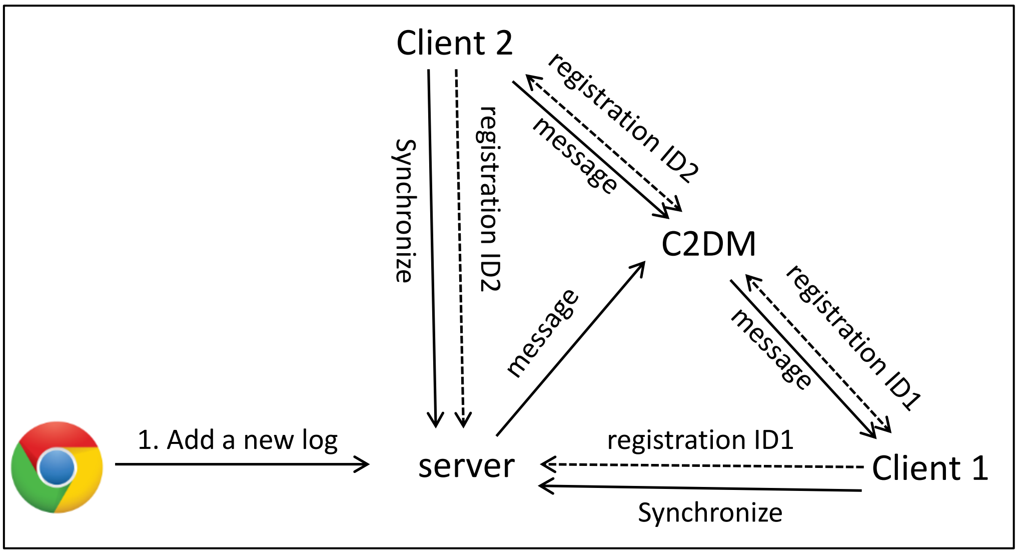

Figure 5.3 Server to Client Synchronize

The synchronize mechanism has two directions which are from the server side or from the client side. There are four learners' operations which causes synchronization. They are adding a new learning log, editing a learning log, deleting a learning log and doing quizzes. Here we take adding a new learning log as an example. Firstly, we will talk about how to synchronize from the server side if a learner adds a new log to the server through the browser (shown in Figure 5.3). At the beginning, when a learner logins SCROLL in different client, the clients firstly need to register on the C2DM server and each device will get a registration ID. And then the client saves the registration ID on the server of SCROLL. When a learner saves a new learning log on the server of SCROLL, the server will send a piece of message which contains the registration ID and the synchronize operation to the server. Then the C2DM will resend the message the assigned device. After the device received the message, it then started to synchronize the data with the server of SCROLL. The advantage of this mechanism is to save battery. This is because the device is waked up only when it received the message from the server of C2DM. When it starts to synchronize, the client server will firstly send an http request to the server of SCROLL. It will provide the information including the last synchronize time, the changed data and the time when the data was changed on the client. Then the server sends the changed data back to the client. The format of the returned data is json (JavaScript Object Notation) format and the data will be saved on the client.

As for the synchronization started from the client side, the data will be saved on the database on the android devices temporarily after a learner adds a new learning log through the android client (shown in Figure 5.4). Then it starts a service which is responsible for synchronizing the data in the background. This mechanism can bring learners several benefits as well. For example, the user can smoothly use the system without the delay caused by the data transmission. Moreover, the learner can use the system even though the device is not connected with the Internet. To synchronize the data with the server, the system adopts the same way described above.

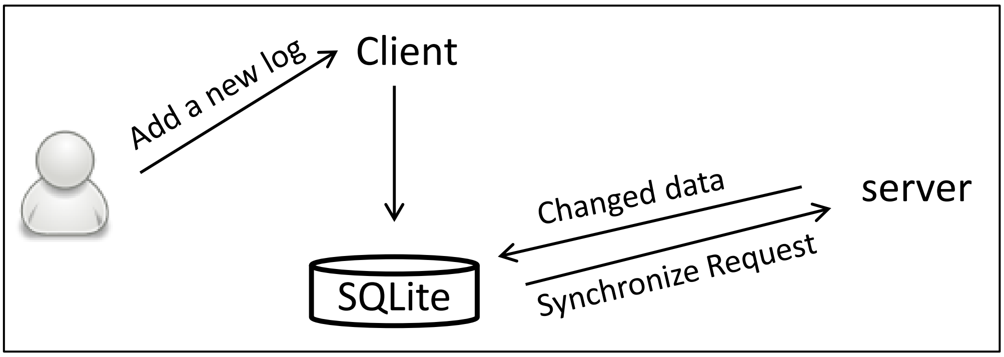

Figure 5.4 Client to Server Synchronize

Chapter 6

Evaluation and Results

As Verbert wrote in his paper, how to evaluate the contextual recommender system in technology enhanced learning is a challenge in this field (Verbert et al., 2012). In this research, a prototype development method is adopted. The merit of prototype development method is that after a prototype of the system is finished, the evaluation on it can be organized. And with the results obtained in an experiment, we can improve the system after the experiment and then evaluate it in the next time experiment. It means that it is possible to change the system design if necessary before the system is finally created. Until now, three experiments have been conducted to evaluate this study.

The first evaluation called experiment we was conducted after the basic functions of SCROLL such as adding learning log, doing quizzes and reviewing what you learned and so on were implemented. The objective of this experiment is to check whether learners could benefit from SCROLL more than paper-based note taking method. The results of experiment we proved the hypothesis. After that, a prototype of the context-aware and personalized learning model is developed, which provides the location based quiz reminder and learning logs recommendation functions. Then the second evaluation called experiment II was done. Through this experiment, a few things is to make sure. For instance, between the computers based SCROLL or smartphone based SCROLL which learners prefer and whether learners can really benefit from the contextual recommendation provided by the prototype model. Because the results were also positive, then the whole model introduced in chapter 4 was finished. And the third evaluation: experiment III was conducted. The aim of this experiment is to evaluate how learners benefit from the three kinds of contextual recommendation. Besides the questionnaire, all the participants were also interviewed after the experiment III.

This chapter introduces the details about the design and results of the three experiments. With the results of all experiments, the discussion about this study is given at the end of this chapter.

6.1 Evaluation I

6.1.1 Method

This experiment was done just after the basic functions of SCROLL were developed. The biggest objective of this evaluation is to check whether learners can benefit from SCROLL or not. Consequently, the experiment is designed to compare SCROLL-based English vocabulary learning with paper-based learning. It lasted two weeks from April 27th to May 11th in 2010.

The study group consisted of 20 Japanese university-sophomores (17 males, 3 females) who were taking the communicative English class at the University of Tokushima. The major of the students was engineering and they ranged in age between 19 and 21 years. None of them have any experience in using smartphones before. They underwent an initial test one week before the evaluation started. The test was a 60-item pre-test of words selected by the teacher. They were the names of the things easily found in our daily life such as staplers, rulers, glues, etc. The students were divided into 2 groups with the equal English proficiency according to the pre-test result. Each group consisted of 10 students and engaged in learning vocabulary listed in the pre-test, where Group A used smart phones (7 Sony-Ericsson Xperia and 3 HTC-03A) and SCROLL, while Group B learned the words in a conventional way, e.g., using a paper dictionary without technology. Since Group A has never used a smart phone, about one-hour briefing session was held for Group A students have to help them understand how to use smart phones and SCROLL. Evaluation was carried out over a period of two weeks. At the conclusion of the phase, the subjects underwent a post-test, the same vocabulary test as the pre-test. The full mark for pre- and post-test was 60. Further data was collected from the participants by means of questionnaires and the log data contained in the server.

6.1.2 Results

Since it turned out that only 5 subjects (hereafter Group A1) out of 10 of the test group used smart phones and SCROLL during the trial, the rest of the 5 subjects (hereafter

Group A2) were added into group B in the data analysis. The pre- to post-test differences between the mean test scores for Group A1 (with SCROLL) and for Group B (paper-based, without SCROLL) are shown in Table 1, along with the standard deviations for each test result. The analysis was undertaken using one-tail test. There was a significant improvement from pre- to post-test for both groups. Also, statistically significant difference was detected between A1 and B+A2. This indicates that the A1 students learned new words more efficiently and effectively by using SCROLL.

Table 6.1 Pre- and post-test results (full mark: 60)

GROUP	**PRE-TEST**	**POST-TEST**	**PRE -POST DIFFERENCE**	**T- AND P-VALUE**
A1 (N=5)	M = 19.50 SD = 5.24	M = 53.20 SD = 6.33	M = 33.70 SD = 11.29	t=2.01018 p=.029821*
B+A2 (N=15)	M = 19.50 SD = 4.63	M = 41.00 SD = 12.92	M = 21.50 SD = 11.88	

*<.05

According to the users' logs in SCROLL, the A1 students uploaded 15.6 leaning logs and did 112.6 quizzes on average. Figure 6.1 shows some examples of the learning logs uploaded in this experiment. The quantitative data suggest that some serious students engaged greatly with SCROLL for vocabulary learning. The correct answer rate of quizzes was 92.9%. A slight difference (4.1%) was found in the percentage of correct answers between the quizzes of the learning logs uploaded by them and by somebody else. The former (96.3%) was better than the latter (92.3%).

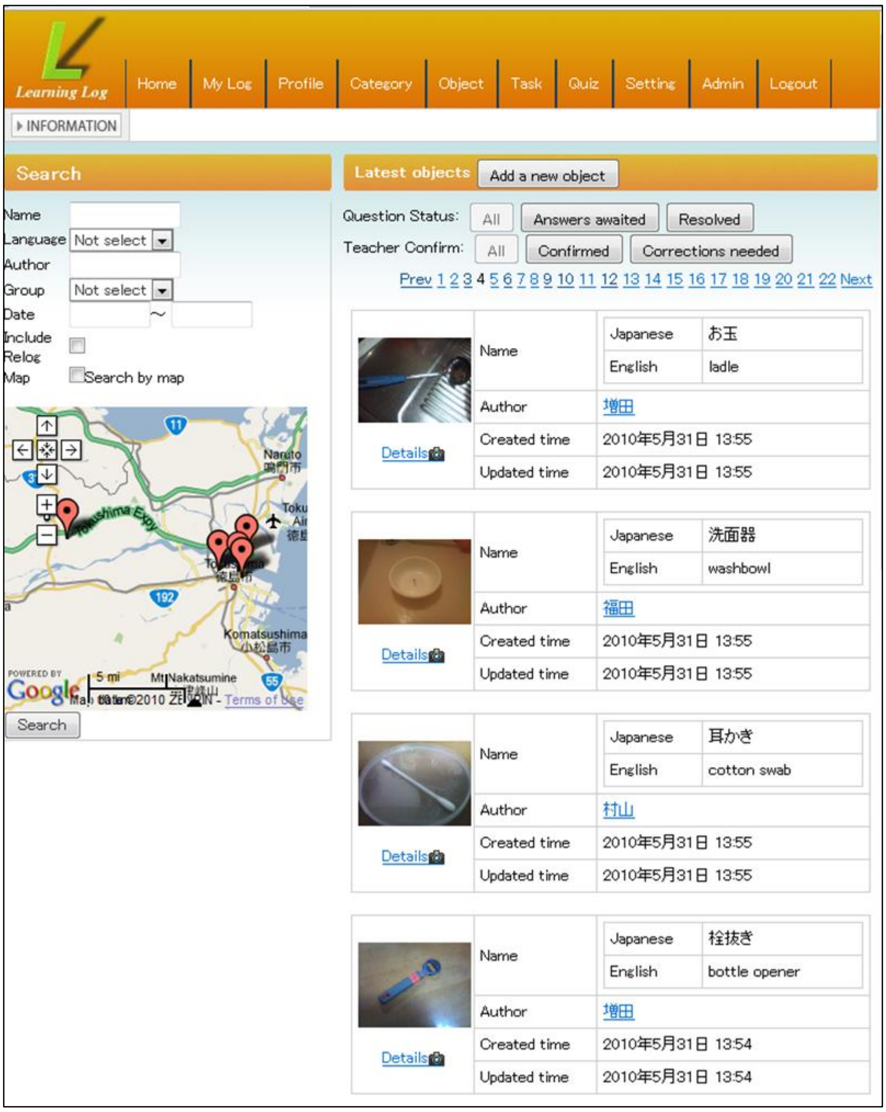

Figure 6.1 Learners' learning logs in experiment I

The result of the questionnaire answered by Group A1 is shown in Table 6.2. The highest mean score was 3.25 when asked whether it was useful to register learning logs. From the questionnaire response, there was no student of Group A1 who did not want to share learning logs. Also some students commented that it was helpful to see the images uploaded by other students. However, for some students, it seemed troublesome to use them because its short duration of battery or unstable Internet connection. Another explanation for the poor engagement is that even though they received the briefing, some did not understand fully how to use them. These are probably part of the reasons why 5 students of Group A did not show any involvement in SCROLL. Thus our next evaluation is being more carefully planned.

Table 6. 2 Result of the five-point-scale questionnaire

Question	Mean	SD
Was registering learning logs useful for growing your English vocabulary?	3.25	1.49
Was Smart Phone with SCROLL useful for vocabulary learning?	3.13	1.25
Was this system enjoyable?	3.00	1.31

6.2 Evaluation II

6.2.1 Method

The results of the experiment we proved that SCROLL could provide more efficient learning for learners compared with paper-based note-taking way. Problems were also found in the evaluation. For example, 5 participants dropped off during the evaluation. To improve the user experience, some new functions, which were designed to meet the learners' needs, were implemented, such as the navigation and time-map function. What's more, a prototype model for contextual recommendation was developed. This prototype model can provide the functions such as location based quiz reminder and learning log recommendation function. To evaluate it, the second experiment was conducted.

In experiment II, SCROLL was not only used to compare with paper based learning, but also the smartphone based SCROLL is used to compare with the PC based SCROLL. This is because to evaluate the efficiency of the smartphone based SCROLL is also one objective of this evaluation. In addition, another objective of this experiment is to check whether learners can accept the contextual recommendation or not. Therefore, the contextual recommendation way was compared with the user-customized push way. Consequently, in this experiment the participators would use 4 types of tools which are paper, SCROLL system based on PC+digital camera, Android client of SCROLL system without personalized learning and context-aware learning supported and Android client of SCROLL system with personalized learning and context-aware learning supported.

The study group consisted of 20 Japanese students including undergraduates and graduate students. The experiment cost 6 weeks. One week was taken as a phase during the experiment. All the students were asked to record the English words they learned every day. And when they use SCROLL system, they could also upload the photos about the learning contexts of the words. After each phase, a post-test would occur. The tests consisted of the English words each student learned in that week. It means the each participant had different post-test. Besides writing the Japanese meaning, students are also asked to fill out the remember state of each word. Four levels of remember states are provided which are remember, know, guess and unknown. The remember level means learner can both remember the meaning and the used context of the word. The know level means learners know the meaning of the word but forgot how to use it. The guess level means that learners remember the situation in which the word is used but forgot the meaning. The unknown means that learners forgot both the meaning and the situation. The remember, know and guess level means that learners' can recall part of the knowledge they learned. After the experiment, we did not only check how much learners had remembered, but also how much they could recall.

Figure 6.2 Xperia

In the first week, all the students underwent an initial test and based on the scores they were divided into two groups: Group A & B. Then, they were asked to spend the second week on getting used to the Sony-Ericsson Xperia Smartphone (shown in Figure 6.2). In the left 4 weeks, Group A used paper, SCROLL system based on PC+digital camera (short for PC+DC), Android client of SCROLL system without personalized learning and context-aware learning supported (short for Xperia-P), and Android client of SCROLL system with personalized learning and context-aware learning supported (short for Xperia+P) each one week. Group B used the tools in reverse order. Finally, they were asked to finish the questionnaire.

6.2.2 Results

After the experiment, the results were analysed from learners' post-tests, the log data stored in the server and the questionnaires. During the experiments, all the participators had learned 2275 leaning logs and finished 4419 quizzes. Figure 6.3 shows the learning logs uploaded in the experiment II.

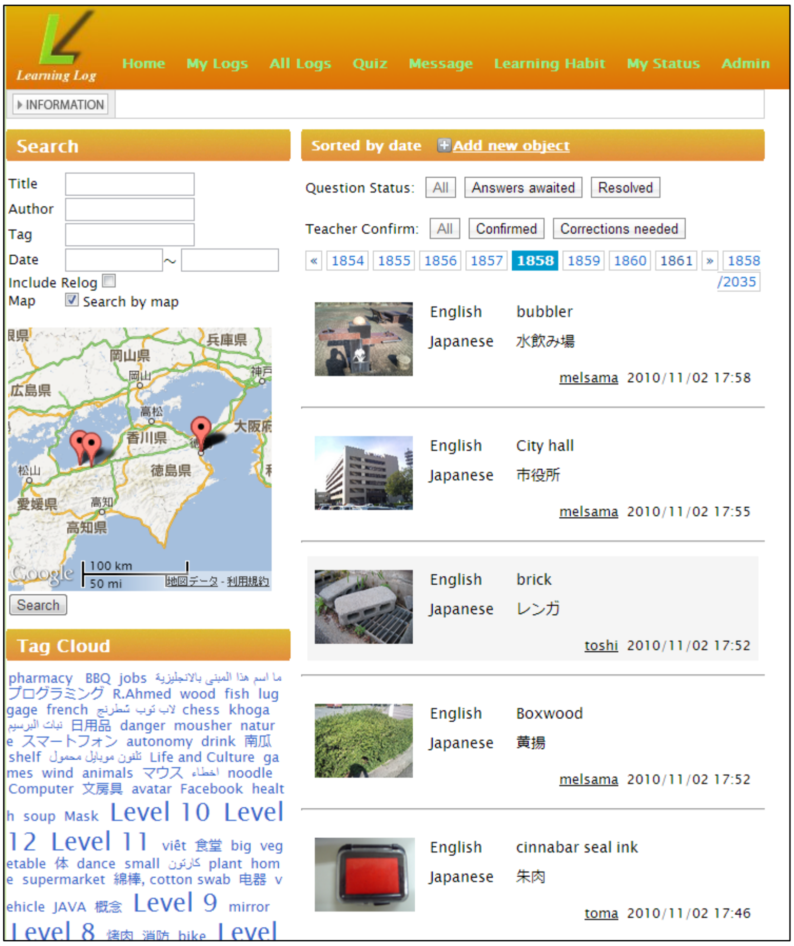

Figure 6.3 Learning logs uploaded in the second experiment

Table 6.3 shows the learners' average scores of the post-tests after each phase. Table 6.4 illustrates how much the learners retained the context or the situation of the learning logs they learned. Table 6.3 and 6.4 reveal that different tools affect learners differently. In the two phases of using Xperia, learners scored best and can recall the context or situation of the words used most among the three tools. In other words, the SCROLL system can not only help the learners retain what they have learned but also is very useful for them to recall the context or situation of the words used.

Table 6. 3 the Group A's and B's average scores of post-tests

	Paper	PC+DC	Xperia-P	Xperia+P
Group A	44.70	70.68	71.22	70.00
Group B	25.58	55.09	70.47	75.48
Average	35.14	62.88	70.84	72.74

Table 6. 4 recall percentage

	Paper	PC+DC	Xperia-P	Xperia+P
Group A	60.05%	74.22%	80.30%	74.89%
Group B	53.75%	67.76%	75.35%	82.15%
Average	56.90%	70.99%	77.82%	78.52%

As shown in Table 6.5 in the week without personalized learning and context-aware learning supported, the learners received the recommendation messages 56 times according their customized setting. They responded the recommendation 28 times and had 179 recommended quizzes. 50% of the recommendation messages were responded and for one recommended message, 6.39 quizzes were finished. In contrast, in the week with personalized learning and context-aware learning supported, the learners received recommendation messages 472 times from the system. 101 times were responded and 845 recommended quizzes were taken. For one recommendation message, 8.36 quizzes are finished but only 21.4% messages were responded. From this comparison, it is easy to see that the response rate of the recommendation provided by the user-customized push method is higher than that provided by the prototype of the context-aware and personalized learning model. However, the latter one is also meaningful. For example, the contextual recommendation can motivate learners do more quizzes. And the number of the responded messages for contextual recommendation is quite larger than that for user-customized method. So it means that learners need more recommendation if they are more suitable.

Table 6.5 Recommended messages

	Received messages	Responded messages	Responded Rate	Responded quizzes	Quiz number per time
Xperia - P	56	28	50%	179	6.39
Xperia + P	472	101	21.4%	845	8.36

Through the questionnaire, learners were asked about how they evaluate different learning tools. The results of the questionnaire show that all the participators thought comparing with writing in paper, it was more helpful to recall the situation or context of what they learned by using SCROLL system with GPS data and photos. About the four kinds of tools, 35% of them favoured the week of using Xperia+P and 30% favoured the week of using Xperia-P. 15% of participators liked paper best for they feel it easier to take note with paper. The others like the PC based SCROLL. Theses results also proved that compared with paper-based learning, leaners benefited from SCROLL more. And compared with computer based SCROLL, most of the learners prefer smartphone based SCROLL.

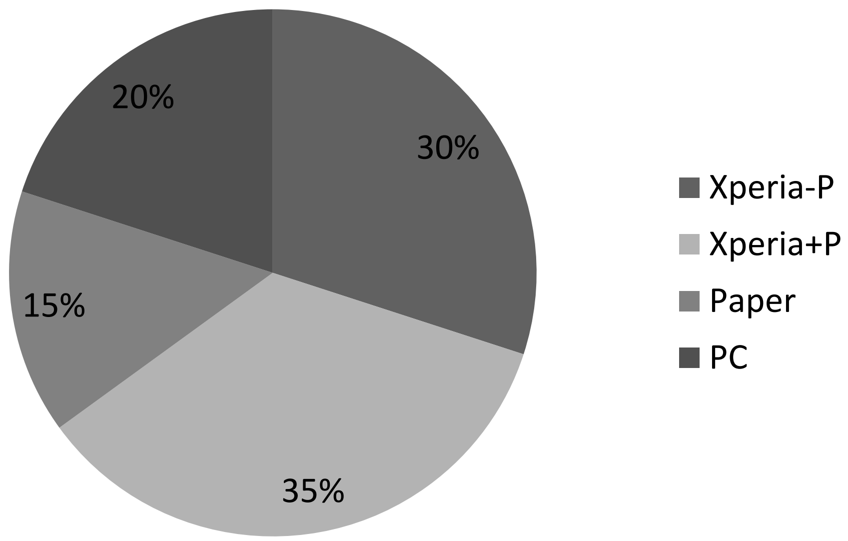

Figure 6.4 The percentage of learner's favorite learning tool

From the questionnaire, all the participants answered that they have their individual preferred study location and time. This means that it is possible to prompt them based on their learning habits.

After the experiment, some participants left their comments. For example, one learner said that by looking through other learners' learning logs, he learned a lot of words occurred in our daily lives such as vending machine, ashtray. Two of them sent us the similar opinions that by using SCROLL, they attached the consciousness of thinking the around things in English. Some of them also pointed out several problems for us. For example, one learner concerned that his GPS data could be seen by the others. Some of them also complained that they did not get used to the interface. It points out two issues. One is that learners concerned about their privacy. The other is that the user-experience needs to be improved.

Through the experiment II, two conclusions can be summarized. The first one is that as experiment we proved, learners can remember more by using SCROLL than paper-based note taking. And the pictures of the learning logs and the meta-data such as geography location can help learners recall more as well. In addition, comparing with digital camera and PC based SCROLL, most of the learners prefer to use the smartphone based SCROLL. The second one is that the response rate of the messages provided by the prototype of the context-aware and personalized model is lower than that of the customized recommendation message. But they responded more and did more quizzes in the contextual recommendation mode. It means that the contextual recommendation messages can motivate learners to study and they expect more precise recommendation. Additionally, learners' answers in questionnaire also show that all of them have learning habits. Therefore, after experiment II, the learning habit based learning prompting module was implemented.

In addition, some problems were found as well. For example, some of them concerned about their privacy because they did not want others to see where they studied. Also some of them complained that the interface was not easy to understand. Consequently after the experiment, the interface was redesigned. And to protect learners' privacy, the system offered the learner with the option of determining whether their learning logs can be shared public or not.

6.3 Evaluation III

6.3.1 Method

The main goal of the third experiment is to observe how the model works and how the learners benefits from the different kind of recommendation. And because the interface of SCROLL was improved after experiment II, the third experiment was also used to investigate how learners evaluate the usability of current SCROLL. To achieve the goals, a long-term experiment was conducted, which lasted nearly 3 months from April 15 to July 11 in 2011. 11 international students including 3 Chinese, 2 Taiwanese and 6 Korean participated in the experiment. All of them had been in Japan for less than a year and none of them had used smartphones. The device adopted was Galaxy Tab SC-01C (shown in Figure 6.5) produced by Samsung. The size of the device was 191×121×12.1mm. The transmission rate of 3G Internet was 300 kb/s.

The aim of conducting a long-term experiment is to accumulate learners' history data to make an accurate prediction. The experiment was separated into two steps. At the first step (April 15 ~ June 27), participants used the system freely to support their learning in daily lives. Then at the second step (June 28 ~ June 27) which lasted two weeks, we did a comparison on participants' learning performance by offering them the learning system with different recommendation mechanism. In the first week, the system sent each learner 3 pieces of recommendation messages randomly per day. The number of 3 is an approximate number on the basis of the presumption of the recommendation in the previous week. In the second week, the system provided them with the recommendation messages based on the analysis of the contexts and learning habits. After the experiment, the participators are asked to complete questionnaires. What's more, as Ververt points out in (Verbert et al., 2012), how to evaluate a contextual recommender systems in technology enhanced learning is a challenge. This is because the efficiency of the recommendation on learners' learning is not easy to be evaluated by quantitative analysis and the user experience is a more important issue for us. Therefore, after the week in which learners used the system with personalized and contextual recommendation mechanism, all the participants were interviewed.

Figure 6.5 Galaxy Tab

6.3.2 Results

This section describes the evaluation results. How the participants engaged in the experiment is checked by analysing their history data. Then, the results of their questionnaire are analysed and presented. After that, the learners' response rates on different kind of recommendation are examined. Finally, how the learners evaluate and benefit from the recommendation is analysed by reviewing their interviews.

During the first step of the experiment, 1564 learning logs (AVE=142.2, SD=62.8) were uploaded and 4232 quizzes (AVE = 384.7, SD=249.4) were done. That is, a learner records 1.95 learning logs and does 5.3 quizzes every day. It means that they engaged in the system well. But high Standard Deviations reveal that each learner's involvement differs greatly. Hence, we decide to focus on statistics on every learner's usage of the system. In figure 6.6, x axis stands for the number of the memorized learning log and y axis stands for the number of times of using SCROLL. If a learner answered correctly to the quiz about one learning log more than twice, this learning log is perceived as his memorized learning log. The number of times of usage consists of three parts: the number of learning logs that a learner uploaded, the number of times of he did quizzes and the number of times of viewing learning logs. Figure 6.6 indicates that the more a learner engages in the system, the more learning logs he can remember. It also proves one conclusion of the previous experiments that the learners can benefit from the system well.

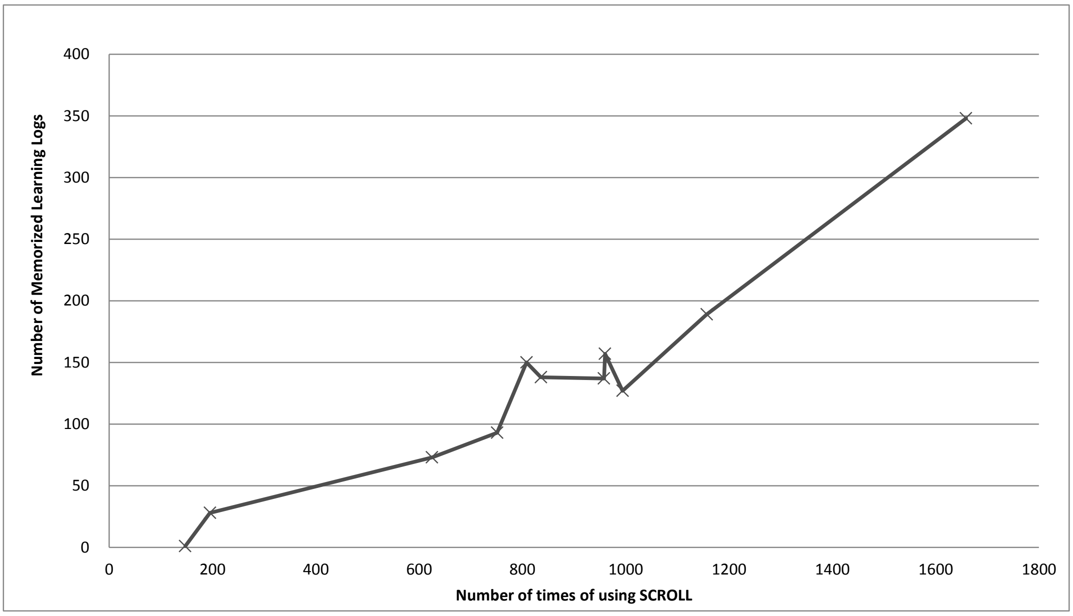

Figure 6.6 Number of memorized learning logs and number of times of using SCROLL

Table 6.6 shows the results of the questionnaire (A five-point Likert-scale is used, the responses to which were coded as 1 = strongly disagree through to 5 = strongly agree.). From Q1, we can see that the participants are satisified with using the improved SCROLL. From the last three questions, we can find that they evaluated highly the three kinds of recommendtion.

Table 6.6 Questions about SCROLL in questionnaire

Number	Question	Score	SD
Q1	Is it easy for you to use SCROLL?	4.6	0.48
Q2	Is it better to use SCROLL than to use paper?	4	1.04
Q3	How long do you spend on using SCROLL?	21.8	9.8
Q4	How do you evaluate location based reminder quiz messages?	4.1	0.539
Q5	How do you evaluate the recommendation message for other learners' learning logs which is based on your location?	3.9	1.136

Q6	How do you evaluate the prompting message which is based on your learning habits?	4.0	0.632

Then we focus on participants' learning performance in the second phase of the experiment. Table 6.7 presents an overview of the recommendation number and the response number in the two weeks. In the control week, the system randomly sent learners 224 pieces of recommendation messages and the participants responded only 19 pieces of them, rated 8.5%. In the experimental week, system sent 169 pieces of messages and the response rate increased to 33.1%. This increment demonstrates that comparing with the random recommendation, learners really benefited from the recommendation based on learning contexts and learning habits. Furthermore, through the questionnaire, 81.2% of the participants think that the recommendation messages have stimulated them to learn more.

Table 6.7 The recommendation messages and the response

	Total number	**Response number**	**Response rate**
1st week	224	19	8.5%
2nd week	169	56	33.1%

As in the second week the recommendation method include these three types, we would like to explore how the learners act on each type. Table 6.8 shows the total number of the recommendation messages, number of the response, response rate for three types of recommendation. From Table 6.8, we can see that learners responded the location-based quiz reminder messages most frequently and they also scored this type of recommendation highest. But the response rate of location-based learning logs recommendation is only 25%. It reveals that learners do not have enough interests on the learners' knowledge.

Table 6.8 The recommendation messages and the response

Recommendation Type	Total	Responses	Percentage
Location-based quiz reminder	87	35	40.2%
Location-based learning logs recommendation	72	18	25.0%
Learning habits based prompting	10	3	30.0%

Through the interview, the participants offered a lot of comments or episodes. By analysing what they said, we can learn more about what they benefit from the system and what they hope to improve. About the contextual recommendation, some of them told us as follows:

- It is very helpful for me to memorize what I have learned by doing quizzes. Especially, the location based learning logs are very impressive.
- I always forget how to read a kind of noodle called "kamatama udon". But it is very helpful to review it before I order it in an "udon shop".
- Honestly every Sunday I wanted to relax the whole day. But when the recommendation came to me, I realized that I had to study Japanese. It kept my motivation.

- It is very interesting to be recommended other learners' vocabulary about food.

From these words, we can see that learners can really benefit from the location based reminder quizzes. They can help learners easily recall what they have learned according to the context. We also find that the learning habit based prompting helps learners to keep motivation on learning. Their words reveal that some of them are interested in the recommendation of other learners' learning logs. However, one of them told us that "Sometimes the system alarms at classes. This embarrassed me." It means that the contextual recommendation still needs improvement. In addition, they also made comments on the quiz function as follows:

> "The advantage of the SCROLL system for me is that it gave me the motivation to study Japanese. And I can easily retain what I have learned, because the pictures I took usually help me to recall them."

The learners' comments also proved that the quiz function which makes use of the picture and the environmental context data is efficient on recalling. What's more, some positive and negative comments on SCROLL are also received as listed below:

- It is very convenient to record what I have learned, especially when I travel. Also, it is easy to review what I have learned.

- As I had to take a JLPT (Japanese Language Proficiency Test), it helped a lot to prepare for the examination.

- When I talk in Japanese, sometimes I forget the word I learned. But with this system, it is easier to recall them.

- SCROLL system is very good. But I prefer to use paper, because it is more convenient.
- The battery is draining too fast. Especially, the GPS consumes too much power.
- The speed of Internet is too slow.
- The Galaxy Tab is a little big. It is inconvenient to bring it with me.
- As a Chinese, it is very easy for me to know the Kanji meanings but difficult to understand its reading. However, the quizzes contain too much Kanji without its reading. It will be more useful if it provides the reading of the Kanji.

From these comments, we learn that some learners really benefit from the SCROLL system while some prefer to use paper. And because the context-aware function depends on GPS, some participants complain about the consumption of the battery. These limitations should be improved in the future.

6.4 Discussion

After the three experiments, we would like to have a discussion about the study in this section.

Firstly, through the results of three experiments, we can see that on one hand most of the learners benefited from SCROLL and especially after the interface was improved after the experiment II, participants evaluated SCROLL highly in the experiment III. Additionally, the results of the experiment II also prove that learners prefer the smartphone based SCROLL than web based. On the other hand, some of them learners told us that they prefer to use paper based notes than SCROLL in three experiments. As far as we concern, this can be accounted for in two reasons. The first one is that learners have got used to paper and paper can provide them more usability. For example, with papers they don’t need to worry about the battery, Internet speed and the usability of the system and so on. What’s more important, on the paper they can write down their notes in their own words and forms freely. But using SCROLL, learners are asked to write down their notes following a restricted form. The second reason is that all the participants in experiment we and III do not have android smartphones and they have not used to the device. But with the prevalence of the smartphone, more and more learners can enjoy SCROLL in the future.

The results of the experiment also prove that the location based quiz reminder and the learning habits based learning prompting are meaningful for learners. For example, through learners’ interview they told us that the reminder enhanced their recall and the prompting function kept their motivation. However, problems are also found. For example, the timing of some recommendation was not satisfied and the responses rates for all kinds of recommendation messages are relatively low. These things reveal that it is difficult to catch concrete learners’ contexts and their current learning motivation, because learners’ willingness to study is always changing but the predication of the system is static. To solve these problems, it is necessary to empower the learners to control the recommendation method more. It means that the learners should be able to customize the actions of the context-aware based and learning habits based recommendation. For example, the learner can customize the action of the device when the system recommends a piece of message. He can set that the device will ring a tone or vibrate when the system shows recommendation messages.

What’s more, through the experiment III, we learned that among the three kinds of recommendation, the location-based learning log recommendation was responded worst. It means that how to make other learners’ learning logs more attractive for specified learner is a to-be-solved problem in our future work. How to make use of the learning task function to solve this problem is being considered. In addition, even though we have evaluated the model as a whole, how each parameter in this model affects learners’ learning is not evaluated. Therefore, more evaluation on each parameter of our model needs to do in the future.

Chapter 7

Conclusions

This doctoral dissertation mainly describes a context-aware and personalized learning model that is built on a learning log system called SCROLL. This study is done in the background of the prevalence of smartphones, which are equipped with several kinds of sensors. Therefore, how to make use of the sensors to support language learning and how to facilitate the mobile based note taking in language learning become the objects of this study.

By doing the literature review on context-aware learning and personalized learning, we find that most researchers focus on how to offering the learners with the learning materials that are related to the context. But few of them employ learning context in other ways, such as taking the learning contexts as retrieval cues to help learners recall what they have learned. What’s more, the value of the context history is not being investigated enough as well. Therefore, the model we proposed mainly contributes to these two problems. In this study, in order to take the advantages of learning context, the model can offer location-based reminder quizzes, recommend other learners' learning logs based on location and prompt learners to study according to his learning habits. In addition, because one objective of SCROLL is to facilitate learners to easily record and recall what they have learned, so in order to help them recall efficiently, the system design of SCROLL is on the basis of several theories and studies on human memory, like the environmental context effects, picture superiority effect, and testing effect and so on.

To evaluate this study, three experiments were conducted to find answers to the following hypothetical questions.

1) Does SCROLL contribute to more effective language learning than the paper and PC (personal computer) based learning method?

2) Does the context-aware and personalized learning model serve the learner well?

Through the experiments, two conclusions can be achieved. Firstly, about SCROLL, most of learners prefer to use this kind of tool for efficient learning, because it not only can save learners' learning contents but also help them to recall them. Besides, the usability of our system satisfied most of the learners in the experiment III. However, we also find that there are still some limitations of SCROLL. One limitation is caused by the hardware, such as the low speed of the 3G, the insufficient battery and the barrier of using smartphones. Another one is caused by the software, which restricts the format of the learning log. But with the evolution of the mobile technology and the prevalence of smartphones, these limitations will be improved in the future.

Secondly, the context-aware and personalized model really facilities learners' learning. On one hand, as other researchers found, learners benefit from the recommendation of the learning materials related to the learner's contexts. On the other hand, utilizing the learning context as retrieval cues for learners to recall is also proved to be efficient. And the learning habits acquired by analysing the context histories are also proved as a meaningful way to accommodate learners. However, the low response rate on the contextual recommendation needs to be improved and the inconvenience causing by the recommendation is also a challenge for us.

As for our future work, there are mainly three issues for us to explore. The first one is that in order to catch learners' learning contexts more accurately, more kinds of context elements and learning habits should be taken into account, such as learners' schedule. The second one is to provide learners with more control on both the recommendation actions and the predictions of the system. For example, learners can decide the alarm type of the recommendation. The third one is that to increase the attraction of other learners' learning logs and make the learner to participate in learning from others should be investigated in the future.

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