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Context-aware and Personalization Method in Ubiquitous Learning Log System

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ABSTRACT

This paper explores a context-aware and personalization method in Mobile Learning system based on ubiquitous learning logs. Ubiquitous learning log stands for the log of knowledge or learning experience acquired ubiquitously. We construct a ubiquitous learning log system called SCROLL (System for Capturing and Reminding of Learning Log). Our research focuses on helping learners recall what they have learned making use of the learning contexts and learners' learning habits. Our measures consist of three main actions, which are to recommend learning objects in accordance with both learners' needs and contexts, to detect their learning habits using the context history and to prompt them to review what they have learned regarding their learning habits. What's more, by monitoring learners' reaction on the recommendation or prompting, the system can improve its prediction. An experiment was conducted to evaluate SCROLL and our method. The results of the experiment demonstrate that the learners benefited from the system and the context based recommendation and learning habit based prompting also motivated them to study more.

Keywords

Personalized mobile learning, Ubiquitous learning log, Context-aware learning, Learning habit

Introduction

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. In 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. 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).

Our research primarily investigates the capabilities of the sensors of smartphones in context-aware and personalization mobile learning, because we find that the equipped 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. Then, the system can recommend learning objects for a specified learner taking into account both the context and his study needs. On the other hand, it can track learners' contextual data as context history when they learn something using smartphones and catch individual's personal learning habits through analyzing the context history. Therefore, both learners' learning habits and their current context information will be interacted to support learning. These two basic ideas are applied to our method.

We developed a system called SCROLL (System for Capturing and Reminding of Learning Log) that allows learners to log 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 (Ogata Li, Hou, et al., 2010). The goals of SCROLL are lying in helping users to easily record their learning experiences and recall

them via the context, recommending other learners' learning experiences for them, finding out individuals' learning habits and supporting their learning in accordance with personal learning habits.
The rest of the paper is constructed as follows. Section 2 introduces our ubiquitous learning log system covering a primary scenario of its use, its main functions and architecture. In section 3, the workflow of the context-aware and personalization method is presented and then we explain it in terms of its three aspects. In section 4, we describe an experiment to evaluate the system and method, and the results of the experiment are given. Finally, we have a discussion about the results of the experiment and give the conclusions in section 5.

Ubiquitous learning log system

With the evolution of the mobile devices, our lives are changing rapidly. For example, usually we take memos or notes (such as schedules, plans or task lists) in our pocketbooks. But now more and more people prefer to record these messages with their cell phones. For many people it is a simpler way, since the information can be stored in much more ways such as texts, photos, audios and videos and so on. Researches have also focused on facilitating this kind of "informal note taking" (Dai, Lutters, & Bower, 2005; Lin, Lutters, & Kim, 2004). However, besides informal note-taking we also take formal notes. For example, many language learners have vocabulary notebooks. We call these kinds of formal notes as learning logs. In this paper, a learning log is defined as a recorded form of knowledge or learning experience acquired in our daily lives and it serves as memory storage for notable or important knowledge to review, to remind and to reflect. In order to support such formal note taking and reminding, we design and implement our ubiquitous learning log system called SCROLL.

What is SCROLL

The aim of SCROLL is to aid 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 himself, 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.

To simplify the process of capturing the learning experience, the system provides a well-defined form to illustrate a 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 1(1) is the interface of adding a new learning log and Figure 1(2) is an example of 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 (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.

SCROLL also provides some other functions such as navigator and Time map. Navigator is a function providing the learner with a live direct view of the physical real-world environment augmented by a real time contextual awareness of the surrounding learning logs (Figure 1(4)). Additionally, when a learning log is selected in the navigator, the system will show a path (route) for the learner to reach to the selected object from his/her current location (Figure 1(5)). 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. More detailed description on the functions of SCROLL system can be found in (Ogata, Li, Bin, et al., 2010).

(1) Add a learning log (2) A learning log (3) Quiz

(4) Navigator (5) A path to learning logs

Figure 1. Interface of SCROLL

The 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 language learners, who face rich learning contexts every day, can gain much 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 can not 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 2 illustrates the workflow of the scenario.

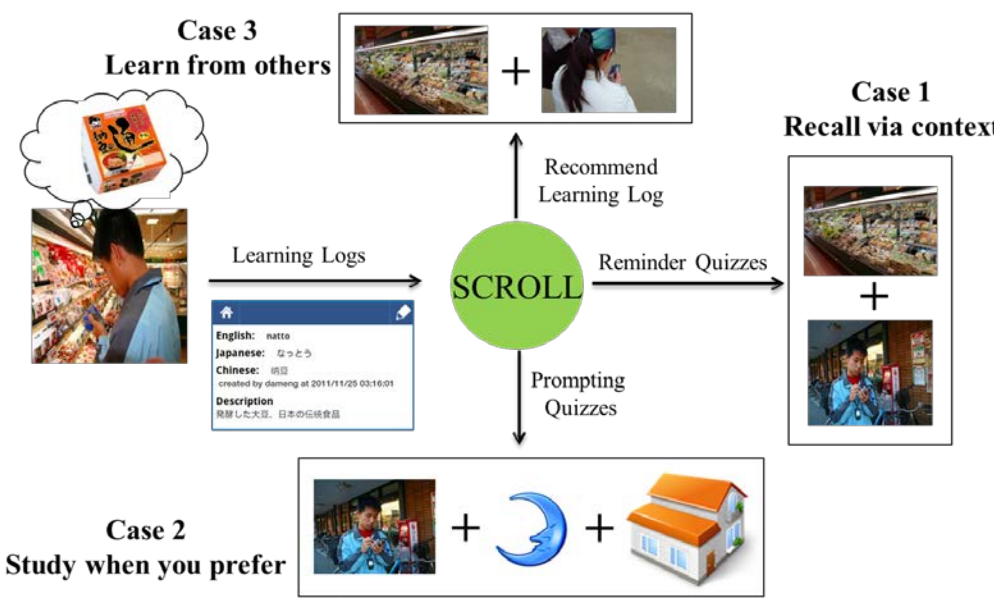

Figure 2. How SCROLL works

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.

The context-aware and personalization method we propose in the rest of paper is responsible for these three cases.

Recall what we have learned

An important goal of SCROLL system is to help learners recall what they have learned after they uploaded their learning logs. When a learner captures his learning log, besides the location based property mentioned above, a number of things are designed for learners to encode as retrieval cues. For instance, according to the picture superiority effect, the learning logs with pictures are much more likely to be remembered rather than those without pictures (Nelson, Reed, & Walling, 1976). In addition, 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, Butler, Roediger, & others, 2009). 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. Figure 1(3) shows an image multiple-choice quiz generated based on the meta-data of learning logs.

Context-aware and personalization method

There are two objectives to adopt context-awareness and personalization in SCROLL:

- By being aware of a learner’s current context, especially the location information, the system can detect whether a learner is near to the place where he uploaded a learning log and whether there are location-based learning logs recorded by other learners close to him. If either requirement is met and the availability of the device is high, the system will show him a quiz based on the knowledge he gained around there or notify him the surrounding learning logs added by others.
- The system can record the context data when a learner uses the system to study as his context history and then catches his learning habits by making use of the context history. If the learning habits exist and the circumstance meets the learning habits, the system will show a piece of recommendation message to encourage him to review what he has learned.

To achieve these two goals, the system will monitor, analyze and dig learners’ contexts, derive the learning habits from them and prepare proper learning objects for them. Figure 3 demonstrates the whole processing flow of the method. It follows the below steps:

1. The system collects a learner’s context information from three parts: his activity, the status of device and the environmental data.
2. Then it analyzes the context and checks status of the device: for example, how much battery is left and whether the Internet is connected. If the availability is low, the system will do nothing.
3. If the device has a high availability, the system will check whether there is location-based knowledge near the learner. If existing, the system will provide location-dependent quizzes or recommend learning logs for him.
4. If there is no location-based knowledge for the learner, the method will examine if the learner is in his preferred learning context. If so, the system will show messages to encourage him/her to study.
5. All context data remains as context history to detect individual learners’ learning habits. Finally the learner’s response to the learning habits based recommendation is used to improve the learning habit detecting method.

The above processing flow reveals that the method consists of three terms, which are learners' current context, their learning habits and the learning objects. The following sections will introduce them respectively in detail.

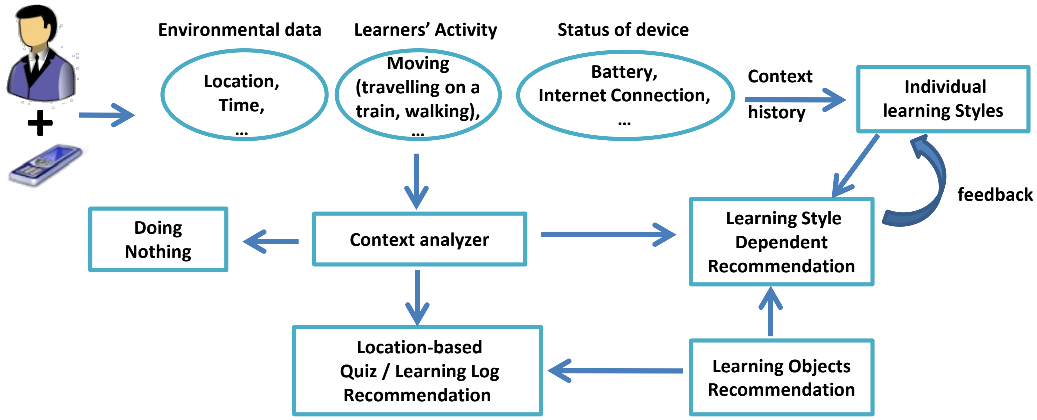

Figure 3. Workflow of the personalization and context-aware method

Learners' context

A lot of studies on context-aware computing can be found in the literature. Here we'd like to highlight some of them. For example, Hwang and his team have done abundant of research in this field. Their studies cover learning activities based context-ware learning and learning tools supported context-aware learning. For example, 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. Ogata & Yano developed a system called JAMIOLAS which utilizes the environmental data to support Japanese learner to master the Japanese mimetic words and onomatopoeia (Ogata, Miyata, Hou, & Yano, 2010). Also some context-aware research explores location and time (or schedule) to recommend appropriate contents for learners (Clough, 2010; Nguyen, Hanoi, & Van Cong, 2012; Yau & Joy, 2010). By consulting these literatures, this study focuses the context on three aspects:

- Learner's activity: Learner's activity involves their motion (e.g. walking, running, travelling on the train or bus or sitting still) and what they do with the devices (e.g. listening to the music through earphone, surfing on the internet, or doing learning with SCROLL).
- Status of device: The status of device includes the battery, the Internet connection (3G, Wi-Fi or no connection), and the type of the ringtone (vibrate status or ringtone).
- Environmental data: The environment involves the location, time, temperature, weather and so on.

Based on the above data, the system will operate as follows:

1. Firstly, it will check the availability of the context. For example, whether the battery is enough (more than 20%), whether the Internet is connected, and whether the user is moving in a high speed and so on. 5km/h is thought as the average human walking speed (Knoblauch, Pietrucha, & Nitzburg, 1996) and exceeding 5km/h is treated as high speed.
2. If these conditions are satisfied, the system then will ascertain whether there are learning objects near him (within 50 meters) by using the location data. The learning objects include two parts: those he learned and those that he may want to learn.
3. If the learning objects he learned exist, the system will give a piece of message reading "Now you are near some learning logs you learned. Do you want to recall them in quizzes?" If he replied the message, the system will give him quizzes considering the place as a retrieval cue.
4. If the learning objects that meet his learning requirement, the system will show a piece of message saying "Some other learners' learning logs are found near here. Would you like to view them?" If they click the message, the system then shows a list of the learning logs and can navigate learners to the specified learning logs via navigator function.

5. Finally, the system will check whether the message is responded. If not responded, the system will recommend one more time when the user comes to the place again. But total the number of times of recommendation in the same area cannot exceed three times.

Additionally, the contextual data will be recorded as context history. In the literature, the context history, which is also believed to be useful, has not been fully utilized (Chen & Kotz, 2000). In our study, it will be reused for analyzing the learners' learning habits. We will introduce this part in the next section.

Learners' personal learning habits

Learning habits are defined as a learner's habits when he learns. Learning habits play a very important role in learning because usually they are related to learners' daily customs and habits. With the mobile learning growing more and more important, many researchers have focused their studies on learners' learning habits or learning preferences. For example, Yau & Joy (2011) focus on learners' learning preferences including location of study, noise/distraction level in location and time of day. Hsieh & Lee (2012) employ learners' memory cycle, ability level and other learning preferences to support their English learning. Different from other researches, the learning habits supported in our system involve where a learner usually studies (such as home, school or fast-food restaurants), whether a learner has a habit of studying on the commuting train and when a learner prefers to study (e.g. after waking up in the morning or before sleeping at night). The context histories, collected when the learners use SCROLL, are utilized to detect whether a learner has any of the three learning habits. Three kinds of data including location, time, and speed are made use of. The following parts introduce the concrete method to detect the learning habits.

Since the time of learning every day is a discrete random value, we observed 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 shows a participator's data in our experiment. It is obvious that the time from 23:00 to 24:00 is her favorite learning time.

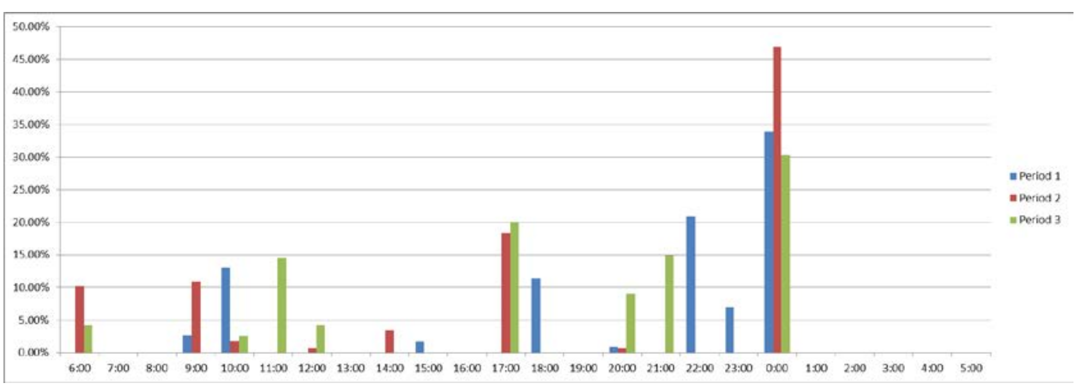

Figure 4. A learner's learning time in three phases

Considering how to find a learner's preferred learning place, many studies on finding users' significant place can be found (Ashbrook & Starner, 2003; Kang, Welbourne, Stewart, & Borriello, 2005; Zhou, Bhatnagar, Shekhar, & Terveen, 2007). We adopt a K-means algorithm. Firstly, we group a learner's learning locations into clusters. A cluster is a circle area whose radius is within 50 meters. Then, the scope that contains more than 30% of the learning location data is perceived as the learner' preferred learning location. 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 saying "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.

Learning objects

In this study, a learner's learning objects can be separated into two types: the learning logs that he learned (the ones that he uploaded or glanced through) and the ones recommended by the system. In order to provide learners with appropriate learning objects, when to remind them of the learned learning logs and what to recommend for them are two important issues. The former one is about the timing to show learners their learned learning logs in quizzes. The system adopts the graduated-interval recall method proposed by Pimsleur (Pimsleur, 1967). The intervals are 5 hour, 1 day, 5 days, 25 days, 4 months, and 2 years and so on. That is to say, after a learner added a learning log, the quiz about it will be available after 5 hours and then after 1 day and so on. Learners will be reminded continually. With respect to what to recommend, the system firstly takes into account the profile of the owner to recommend learning objects. It means that the learning log whose owner has the same study language and mother language will be recommended firstly. Also, the two learners should have same language abilities. And the recommended learning logs are followed in the order of reference times.

Evaluation and results

Method

There are two goals for us to evaluate the system and the method. Firstly we intend to investigate what kinds of benefits the system can bring for the learners and what kinds of improvements are needed by the learners. Secondly, we would like to observe how the learners act on the different kind of recommendation and what the limitations of the recommendation method are. To achieve the two goals, we conducted an experiment which lasted from April 15 to July 11 in 2011. 11 international students including 3 Chinese, 2 Taiwanese and 6 Korean participated. All of them have been in Japan for less than a year. The device adopted is Galaxy Tab SC-01C produced by Samsung. The transmission rate of 3G is 300 kb/s.

The experiment is divided into two steps. The first step (April 15~June 27) is used to evaluate the system. During this period, learners used the system to support their learning in daily lives. After more than 10 weeks of accumulating learners' learning history data, our experiment started the second step. This step is used to observe the context-aware and personalization method. It lasted two weeks. The first week was taken as a comparison, in which we 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.

Results

This section we will introduce the results of our experiment by analyzing the user history data and the results of the tests and the questionnaires. The results of two steps of the experiment are introduced separately.

At 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 5, x axis stands for the number of the memorized learning logs 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 saved, the number of times he did quizzes and the number of times of viewing learning logs. Figure 5 indicates that the more a learner engages in the system, the more learning logs he can remember.

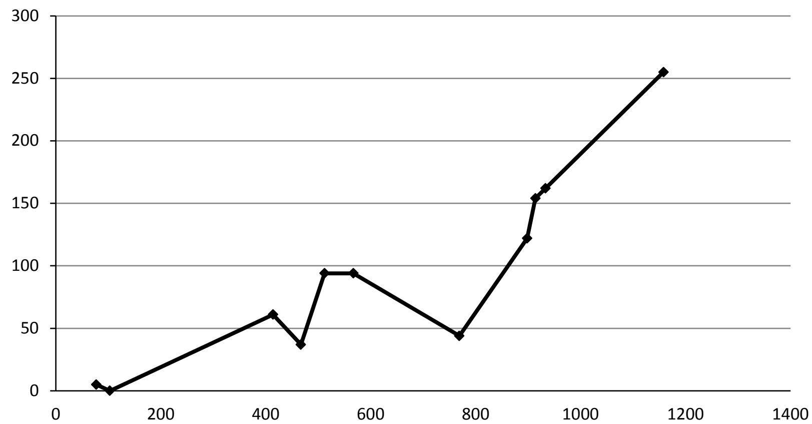

Figure 5. Number of memorized learning logs and number of times of using SCROLL

The questionnaire also asked the learners about how they evaluted the system. Table 1 shows the results (A five-point Likert-scale is used, the responses to which were coded as 1 = strongly disagree through to 5 = strongly agree.). From both Q1 and Q2, we can see that the system has a high usability and learners are satisified with using it instead of paper.

Table 1. 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

The second step of the experiment lasted two weeks. The first week is the control week and the second week is the experimental week. Table 2 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, according to the result of the questionnaire, 81.2% of the participants think the recommendation messages have stimulated them to learn more.

Table 2. 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 includes these three types, we would like to explore how the learners act on each type. Table 3 shows the total number of the recommendation messages, number of the response, response rate, average of evaluation score and the SD (Standard Deviation) of the evaluation score for three types of recommendation. From Table 3, we can see that learners responded the location-based quiz reminder messages most frequently and they also scored this type of recommendation highest.

Table 3. The recommendation messages and the response

Recommendation Type	Total	Responses	Percentage	Evaluation	SD
Location-based quiz reminder	87	35	40.2%	4.1	0.539
Location-based learning logs recommendation	72	18	25.0%	3.9	1.136
Learning habits based prompting	10	3	30.0%	4.0	0.632

Comments from the participants

After the experiment, we also asked the participants to give their comments and share the episodes of using SCROLL system. Here we firstly pick out some positive comments and episodes:

- It is very helpful for me to memorize what I have learned by doing quizzes. Especially, the location based learning logs are very impressive.
- It is very interesting to be recommended other learners' vocabulary about food.
- It is very convenient to record what I have learned, especially when I travel. Also, it is easy to review what I have learned.
- 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.
- As I had to take a JLPT (Japanese Language Proficiency Test), it helped a lot to prepare for the examination.
- 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.
- 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".
- When I talk in Japanese, sometimes I forget the word I learned. But with this system, it is easier to recall them.

From the positive comments and the episodes, we learn that learners benefit from the SCROLL system and the method well. The advantages such as easily capturing learning logs, reviewing old knowledge when in need, recalling via pictures and quizzes and keeping motivations via system recommendation and so on are mentioned in their comments. However, there are still some deficiencies reported by the participants:

- 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 learn its pronunciation. However, the quizzes contain too many Kanji without its phonetic information. It will be more useful if it provides them.
- Sometimes the system alarms at classes. This embarrassed me.

From the above comments, we learn that battery, the Internet and the size of the device are unsatisfactory and the recommendation system is still with some limitations. In addition, some special functions are requested and some of them still prefer to use the traditional way to keep record of knowledge.

Discussion and conclusions

With the results of the experiment and the comments provided by the participants, we would like to have a discussion about the study.

- According to the questionnaire, SCROLL is helpful for most of learners to record and review their learning logs. Compared with paper-based note taking, it facilitates learners retrieving their learning logs anytime and anywhere. However, there are still learners who prefer to use paper. This can be accounted for by the reason that some learners are more used to paper. For example, with papers they don't need to worry about the battery, internet speed and the usability of the system and so on. Besides, they can freely write on the paper, whatever they want to. On the contrary, in order to share with other learners and easily to be understood by the system, learners have to follow the template. This is a limitation of the system and it should be enhanced in the future work.

- The results of the experiment also prove that most learners benefit from the context-aware based recommendation and learning habits based prompting. The recommendation and prompting messages are provided in a relatively appropriate context and exert positive effects on keeping learners' motivation and recalling their old knowledge. However, the responses rates on the recommendation messages are relatively low and some users complained they were disturbed by the recommendation messages during classes. It is found out 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. Consequently, it is necessary to empower the learners to control the recommendation method more so that they can customize the actions of the context-aware based and learning habit based recommendation. That way after the system achieved their learning habits, learners can view their own learning habits, and can change them. For example, a learner can determine the place where he usually studies in the map and he can change the place if he wishes. What's more, the learner can customize the action of the device when the system sends a recommendation message. For instance, he can set that the device will ring a tone or vibrate when the system shows recommendation messages.

- Through the experiment, we learned that in some cases it was difficult for a learner to master other learners' learning logs, even though they made correct answers to the quizzes. In our opinion, the learning log is a kind of knowledge with experience. Learners can learn more through experience than only viewing the other learners' experience. Therefore, it is necessary to help learners to experience other learners' learning logs. This is a very important issue in this study.

To conclude this paper, two aspects of things should be touched upon. Firstly, about the learning log system, we have found that most learners prefer to use this kind of tool for efficient learning, because it not only can store learners' learning contents but also help them to recall them. Besides, the usability of our system satisfied most of the learners. However, there are still some limitations such as the low speed of the 3G, the insufficient battery and the barrier to use the smartphones existed. But with the evolution of the mobile technology, this trend is inevitable. And besides language learning, other kinds of learning should be supported as well.

Secondly, learning log does not only contain knowledge and experience, but also record learners' learning context history information. Such information provides us a possible approach to know learners better, such as their learning habits. Besides, the smartphones can catch learners' current learning context. Our research has proved that these two kinds of data can be used to support learners' learning. However, because learners' activities are not always consistent with learning habits and the sensor technology cannot detect the learners' whole learning context perfectly, the learners' response rates to the recommendation are not satisfied. But we believe that the smartphones will be equipped more different kinds of sensors in the future and the device will know learners' better. As for our future work, we will try to use both learners' schedule and learning habits to catch learners' learning contexts more accurately.

Acknowledgements

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