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A personalized recommendation-based mobile learning approach to improving the reading performance of EFL students

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ABSTRACT

In this paper, a personalized recommendation-based mobile language learning approach is proposed. A mobile learning system has been developed based on the approach by providing a reading material recommendation mechanism for guiding EFL (English as Foreign Language) students to read articles that match their preferences and knowledge levels, and a reading annotation module that enables students to take notes of English vocabulary translations for the reading content in individual or shared annotation mode. To evaluate the effectiveness of the proposed approach, an experiment was conducted on a senior high school English course by assigning three classes of students to two experimental groups and a control group. One experimental group learned with the recommendation system with the individual annotation function, the other experimental group learned with the recommendation system with the shared annotation function, while the students in the control group learned with the individual annotation function, but without the recommendation system. The experimental results show that both experimental groups outperformed the control group, but there was no difference in learning outcome between the two experimental groups in terms of learning achievements.

1. Introduction

The advancement of computer and multimedia technologies has encouraged researchers to develop more effective learning environments for English as Foreign Language (EFL) learners to enhance their reading comprehension (Chen, Chen, & Sun, 2010; Hsu, Hwang, & Chang, 2010). Educators have pointed out that the process of reading involves four main aspects: symbol decoding, vocabulary, comprehension, and reflection (Harris & Sipay, 1985). Mokhtari and Reichard (2002) further noted that readers should prioritize comprehending the content and meaning of their reading. Without sufficiently understanding the meaning of English vocabulary, encountered difficulties during reading may negatively impact learning performance; consequently, many EFL students might think that reading is difficult and complex (Lin, 2002; Segler, Pain, & Sorace, 2002). When reading English articles with unfamiliar words, students usually need to pause frequently to find references to these words. Such interruptions can result in poor comprehension of the flow or the context of what they are reading (Laufer & Hill, 2000). Researchers have pointed out that students who find it difficult to understand the vocabulary in the context of the article they are reading often find it difficult to comprehend the text as a whole (Laufer, 1997; Singer & Crouse, 1981). Consequently, a translation annotation function is provided in this study to help students comprehend the learning content by showing the translation of the annotated words. This translation annotation function combines a translation machine for individual usage with a note-taking function. Most English words have a variety of valid translations in Chinese. When the students look for a particular English word and select a Chinese translation for it, the Chinese meaning will be inserted immediately after the English word.

On the other hand, researchers have pointed out that one critical problem in reading instruction is the ignorance of personal factors (Klausmeier, Rossmiller, & Saily, 1977; Wu, 2004). In traditional English classes, a teacher needs to guide dozens of students to learn; therefore, it is common that identical instructional materials, especially reading articles, are prepared for every student (Liu, Chen, & Chang,

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2009). Consequently, for some students, the articles could be too easy to read, while for others, they might be too difficult. Such an article assignment strategy is likely to cause the students to lose interest in learning English. Researchers have indicated that it is improper to ask all students to read the same article because their reading achievements, learning preferences or needs are not the same (Hsu, 2008; Wu, 2004). The first step of reading instructional strategy is therefore to select articles with appropriate degrees of difficulty for individuals (Janzen & Stoller, 1998). To improve the reading performance of students, it is important to provide personalized reading material recommendations to individual students by taking their profile or learning performance into consideration (Liu, Liu, & Hwang, 2011).

In recent years, the advancement and popularity of mobile technologies have encouraged researchers as well as school teachers to adopt portable computers, mobile phones or Personal Digital Assistants in conducting learning activities (Hwang & Chang, 2011; Rogers & Price, 2009). For example, one case study in Japan required students to use cell phones to record one 30-s video on a teacher-selected topic each week, and found that the students were able to increase the number of words they spoke in one monologue. The study emphasizes that educators need to understand the benefits and challenges of integrating mobile devices as learning tools in their classrooms (Gromik, 2012). In another study, the ease of use of mobile-assisted language learning systems was found to be relatively important to passive learners, while the usefulness of such systems was emphasized more by active learners (Huang, Huang, & Lin, 2012). Mobile devices have been recognized as being an efficient tool of language learning since they enable students to learn and practice anywhere and anytime with personalized content and progress (Hwang & Tsai, 2011; Ogata, Saito, Paredes, San Martin, & Yano, 2008; Wong, Chin, Tan, & Liu, 2010). Through mobile phones, teachers have the potential to provide a rich learning environment for their students, although there may be a problem of a lack of willingness to try new mobile technologies to engage in mobile learning (Stockwell, 2010). Therefore, exploring perceptions of mobile-assisted language learning is still necessary.

If teachers continue to use one-size-fits-all methods for teaching, their students will not succeed (Looi et al., 2009). Most mobile learning involves learner-centered activities marked by flexibility, customization, collaboration, co-creation and so on (Cobcroft, Towers, Smith, & Bruns, 2006; Naismith, Lonsdale, Vavoula, & Sharples, 2004). Mobile technologies have the potential to provide and facilitate personalized learning and collaborative learning (Looi et al., 2009; Low & O'Connell, 2006). Desktop computers often limit learners in fixed physical settings, but mobile technology has the advantage of supporting the creation and sharing of ideas, no matter whether students are sitting close together or far apart. The current work in collaborative mobile language learning shows that mobile devices, with appropriate software, can be highly effective in supporting small group collaborative learning within the classroom, improving on what was possible to achieve without these tools (Valdivia & Nussbaum, 2007; Zurita & Nussbaum, 2004).

Mobility may not be an obvious feature here, but the design of the learning activity is predicated on close interaction, conversation and decision-making between members of a group, which includes some physical movement and can be difficult to achieve with the use of fixed computers (Kukulska-Hulme, 2009). For example, one study applied mobile devices in language learning in which the mobile device was used to display a text for reading aloud and this text could be marked up by peers to indicate errors in pronunciation. Learner–teacher communication and peer–peer communication and collaboration were facilitated through the software of audioconferencing via the mobile device (Kukulska-Hulme & Shield, 2008; Lan, Sung, & Chang, 2007). In addition, the mobile device also contributed to the student-led emergent grouping which was a flexible collaborative strategy and did not restrict the students' collaboration to having fixed partners (Wong, Boticki, Sun, & Looi, 2011). Due to the benefits of mobile devices in collaborative learning, this study developed a shared annotation function on mobile devices. The term "shared annotation" refers to the system function which allows translation annotations to be instantly shared between the members of each small group.

With mobile technologies, students can enjoy the ease of creating and sharing sentences even when they are on the move (Looi et al., 2009). Because Mobile-Assisted Language reading has features which allow students to sit in close proximity, either fully engaged with their learning on their devices or sharing their annotation of word meanings with other students, it is possible to create more collaborative and participatory learning experiences.

Consequently, in this study, a Mobile Adaptive Language Learning (MALL) system which includes a reading material recommendation module, an instant translation annotation module and a shared annotation module is proposed. When students use mobile technology, the system in this study can provide differentiated reading material, and the students are able to personalize their learning experiences in reading adaptive materials and have an opportunity to engage in the meaning-making process from their own experiences or from the annotation shared by their partners while reading (Lai, Yang, Chen, Ho, & Chan, 2007; Price & Rogers, 2004). To evaluate the effectiveness of the developed system, an experiment was conducted to compare the learning achievements, cognitive load, and technology acceptance degrees of three groups of students using different learning approaches. The students in the control group learned with the conventional mobile language learning approach; that is, they read the standard articles provided in the textbook with a translation annotation function. The students in Experimental Group One learned with MALL in the individual annotation mode, while those in Experimental Group Two learned with MALL in the shared annotation mode. Moreover, the following research questions were investigated to further probe the effects of the proposed approach:

(1) Are there significant differences between the learning achievements of the three groups of students after the learning activity?
(2) Do the three diverse treatments result in different cognitive loads for the students?
(3) What are the students' perceptions of the learning treatments in terms of perceived satisfaction, perceived usefulness and perceived ease of use?

2. Literature review

2.1. Computerized annotations

With the advance of network and computer technologies, many language reading activities are being carried out on the web or in electronic form (Huang, Chern, & Lin, 2009), and hence the provision of annotation facilities has become an effective way of helping students organize what they have read (Dror, 2007). Researchers have indicated that the provision of annotation functions, including annotation

recording, can reduce the cognitive load of students (Dror & Harnad, 2008). Makany, Kemp, and Dror (2009) further found that making annotations in a non-linear reading style is more effective for enhancing learning outcomes than in a linear reading style. Linear reading refers to reading articles from the beginning to the end sequentially. On the other hand, non-linear reading emphasizes that reading does not have to be in the linear way; instead, people can jump to and read any selected paragraph in an article based on what they need. For example, for people who care about the digital game marketing, it could be more efficient for them to jump to the selected paragraphs reporting the sales incomes of the game development companies in relevant articles than reading every article from the beginning. Reading learning materials on networks via mobile equipment potentially facilitate non-linear reading and annotations because students can read what they care about and take notes anytime and anywhere. Scholars have encouraged researchers to develop shared annotation platforms because they have found that around ninety percent of participants express positive feedback in a network annotation environment (Glover, Xu, & Hardaker, 2007).

Several scholars have indicated that students who mark points or take notes while reading tend to perform better than those who do not undertake any other activity at all while reading (Brown & Smiley, 1978). Quade (1996) has reported that students who use computers to take notes are more likely to achieve the expected learning outcomes than those who use pen and paper. Therefore, this study used a translation annotation mode that simulates the annotation process used when reading books in a traditional manner. It does not require specialized equipment such as digital pens or pointers for hovering over the target words to display the translation (Chang & Hsu, 2011).

2.2. Personalized recommendations

Although students of different ability need to receive different treatments, most online learning systems and curricula provide fixed teaching materials (Tang & McCalla, 2005). To cope with this problem, researchers have attempted to develop various recommendation systems or adaptive learning systems that provide personalized learning materials to individual students via analyzing their profiles or learning portfolios (Hsu, 2008; Reategui, Boff, & Campbell, 2008; Tang & McCalla, 2005; Triantafillou, Pomportsis, Demetriadis, & Georgiadou, 2004). For example, some studies have employed data mining or statistical methods to analyze the students' learning portfolios and profiles to determine the learning materials to be recommended to individual students (Hwang, Tsai, Tsai, & Tseng, 2008; Tzouveli, Mylonas, & Kollias, 2008). Researchers have indicated that such technology-enhanced learning environments can make positive contributions to students' learning outcomes (Dreyer & Nel, 2003; Harri-Augstein & Thomas, 2005).

In the meantime, several English learning systems with recommendation mechanisms have been developed. For example, Hsu (2008) developed an online personalized English learning recommendation system that provided English as Second Language (ESL) students with reading lessons based on the analysis of their preferences (reading behaviors), and Chen and Hsu (2008) developed the Personalized Intelligent Mobile learning System (PIMS) which can recommend English news articles to individual students based on their reading ability.

Most of the adaptive language learning systems advise students mainly via recommending materials (Tseng, Chu, Hwang, & Tsai, 2008). In this study, a mobile adaptive language learning system was developed by providing both material recommendation and reading annotation facilities to students to further improve their learning outcomes.

3. Development of a Mobile Adaptive Language Learning system

The Mobile Adaptive Language Learning system, MALL, includes a reading material recommendation function and a reading annotation function for assisting EFL students in improving their reading comprehension. Fig. 1 shows the framework of MALL, in which the databases

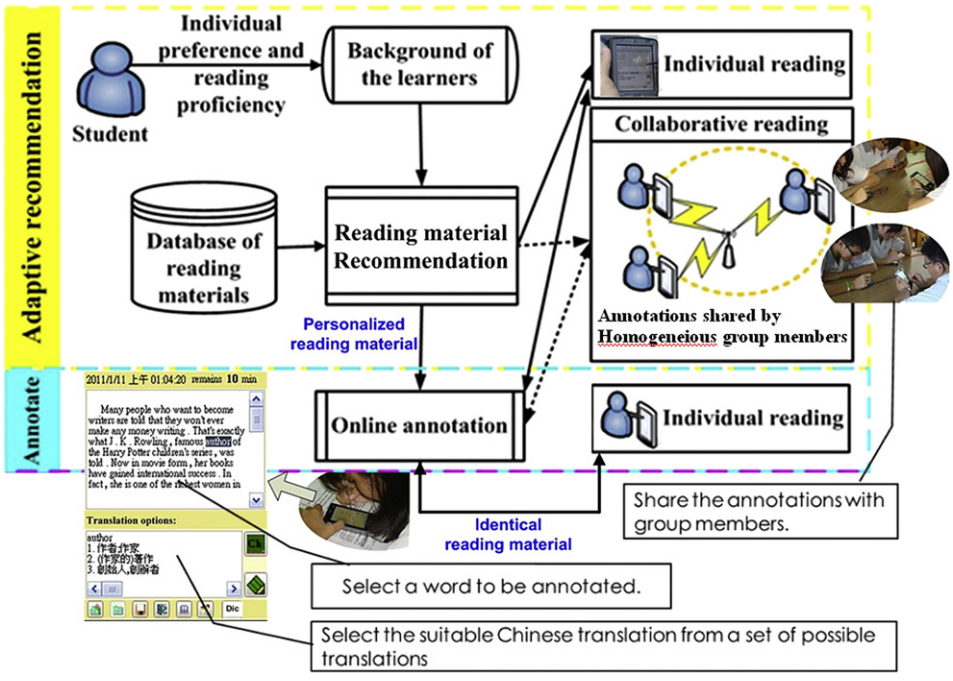

Fig. 1. System framework of MALL.

were developed with Microsoft Office Access, and the reading material recommendation system and the annotation system were developed with Microsoft VB.NET.

3.1. Reading material recommendation function

The reading material recommendation function was developed based on a well-known knowledge acquisition method, the repertory grid, which has been widely used by researchers for representing domain knowledge for differentiating a set of selected targets (Hwang, Sung, Hung, Yang, & Huang, 2012). A repertory grid can be viewed as a matrix, in which a set of constructs (traits and their opposites) are used to describe the similarities or differences between the selected targets, called elements. A 5-scale rating mechanism is usually used to represent the relationships between the elements and the constructs (Boose & Gaines, 1989; Chu & Hwang, 2008), where "5" represents that the element is very likely to have the trait, while "1" represents that the element is very likely to have the opposite characteristic of the trait.

In this study, a total of ninety-five articles suggested by the teachers were in the reading material database; that is, there were ninety-five elements in the repertory grid. The articles were categorized into three levels of difficulty (i.e., 26 elementary-level articles, 41 intermediate-level articles, and 28 intermediate-high-level articles) based on the definition of the General English Proficiency Test (GEPT) commissioned by the Ministry of Education in Taiwan (Roever & Pan, 2008).

The topics of these articles include "family life," "school life," "job related," "food," "entertainment," "biology or environment," "medical," "astronomy or geography," "art," "fashion," "information or science," "history" and "literature," which are the thirteen constructs used in the repertory grid for classifying the articles. Two experienced English teachers were asked to determine the relationship between the elements (articles) and the constructs (topics) using the 5-scale rating scheme. Table 1 shows an illustrative example of a repertory grid for classifying four articles (i.e., A66, A67, A71 and A72) based on six constructs (i.e., family life, school life, occupations, food, entertainment, and biology or environment).

Another repertory grid was used to characterize the students' reading preferences based on the data collected from a questionnaire that investigated their preferences in reading articles related to the thirteen topics. The degree of preference ranged from 1 to 5, where "5" represented "highly prefer," while "1" represented "less prefer." In addition, the students were asked to take a GEPT reading comprehension pre-test to evaluate their reading proficiency. If a student achieved a certain proficiency degree (e.g., elementary level), the reading articles of the next proficiency level (i.e., intermediate level) were assigned to them.

To recommend the most suitable articles to individual students, a personalized recommendation mechanism was developed based on the students' proficiency. The following similarity formula took the topics of the articles and the students' preferences into account.

$$Similarity(A_i, S_j) = 100 - Distance(A_i, S_j) = \sum_{k=1}^{N} \frac{\left|g_{i,k} - g_{j,k}\right|}{MaxScore - 1} \times \frac{100}{N} \quad (1)$$

In formula (1), N represents the number of constructs (or traits) and MaxScore is the maximum rating in the repertory grid; that is, N is equal to 13 and MaxScore is equal to 5 in the study. In addition, A_i represents the i-th article, S_j represents the j-th student, and $|g_{i,k} - g_{j,k}|$ represents the distance between the i-th article and the j-th student in terms of the k-th trait (topic of the learning content) in the repertory grid.

For instance, if the students passed the intermediate-level reading comprehension test, but failed to pass the intermediate-high-level test, the reading articles assigned to them were selected from the 28 intermediate-high-level articles. Moreover, the suitableness of each intermediate-high-level article for individual students was calculated based on the similarity formula. The reading recommendation mechanism then provided the students with the articles that best fitted their proficiency and preferences.

Fig. 2(a) shows a "school life" article recommended to a student who passed the intermediate-level test and was recommended to read the materials of the intermediate-high level, while Fig. 2(b) shows a "family life" article recommended to another student who failed to pass the elementary level. It can be seen that the recommended articles are recommended based on both their proficiency and preferences.

3.2. Reading annotation function

The reading annotation function provides two modes of annotation, that is, the vocabulary annotation mode and the shared annotation mode. The vocabulary annotation mode is used to assist individual students to take notes when reading the recommended articles. As shown in Fig. 3(a), students only need to choose a word to be annotated and then select the suitable Chinese translation from a set of possible translations of the word. It should be noted that each English word usually has several Chinese translations and choosing wrong translations might cause serious misunderstanding of the learning content; for example, the word "present" could mean "a gift," "report," "current," or other meanings, which are different words in Chinese. Therefore, selecting a suitable Chinese translation is important for helping students comprehend the meaning of the sentences.

Table 1
Illustrative example of a repertory grid.

Trait (5)	Articles				Opposite (1)
	A66	A67	A71	A72	
Easy	3	3	3	2	Difficult
Relevant to family life	1	1	4	1	Irrelevant to family life
Relevant to school life	1	1	4	1	Irrelevant to school life
Relevant to occupations	1	1	4	1	Irrelevant to occupations
Relevant to food	1	1	1	5	Irrelevant to food
Relevant to entertainment	1	1	1	4	Irrelevant to entertainment
Relevant to biology or environment	1	1	1	1	Irrelevant to biology or environment

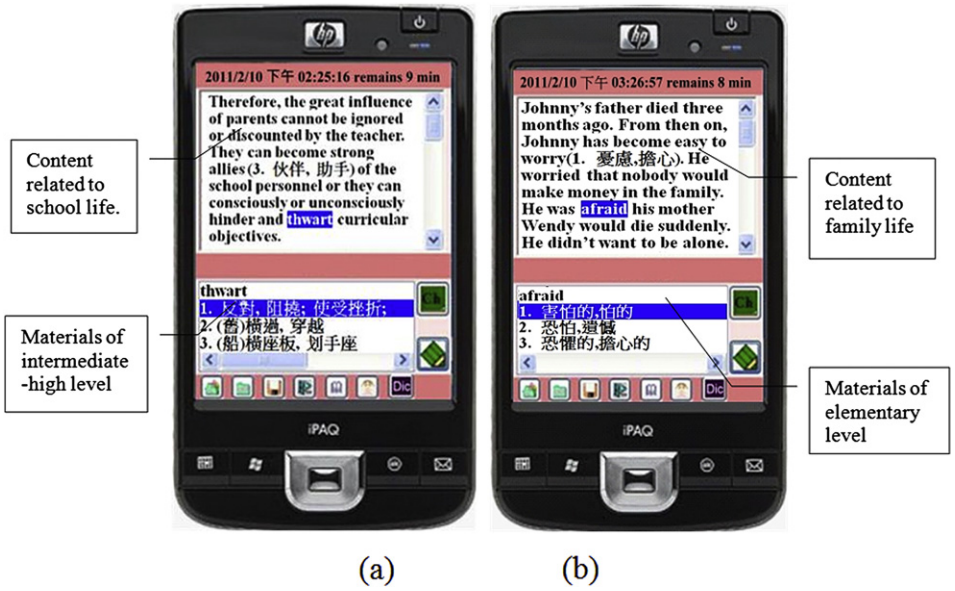

Fig. 2. Two articles recommended to individual students based on their learning proficiency and preferences.

The shared annotation mode is used to support collaborative reading (i.e., the students who are assigned the same articles are grouped to share their reading experiences and annotations), as shown in Fig. 3(b). When learning in the shared annotation mode, students synchronously receive the vocabulary annotations from group members if they are reading the same articles.

4. Method

To evaluate the effectiveness of the innovative approach, experiments were conducted on senior high school English classes to compare the learning achievements and the attitudes of the students who participated in the learning activity with different supportive environments.

4.1. Participants

A total of 108 EFL students from three classes of a senior high school in Taiwan participated in the experiment. The participants were eighteen years old on average. The three classes of students were chosen for several reasons. First, they had identical learning progress for the English course with the same learning content. Second, they were taught by the same teacher. Third, all of the students had learned

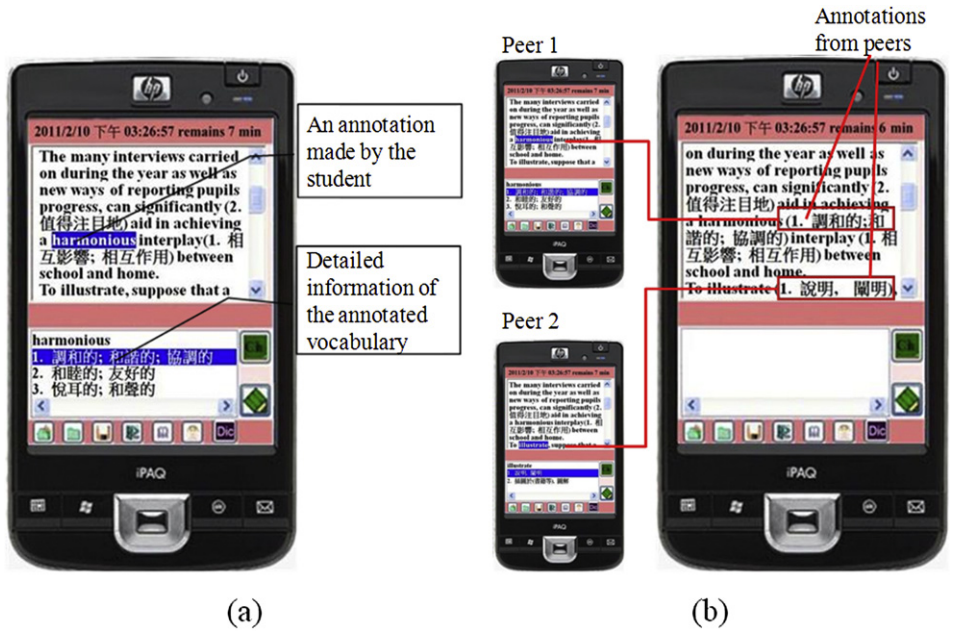

Fig. 3. Examples of vocabulary annotation mode and the shared annotation mode.

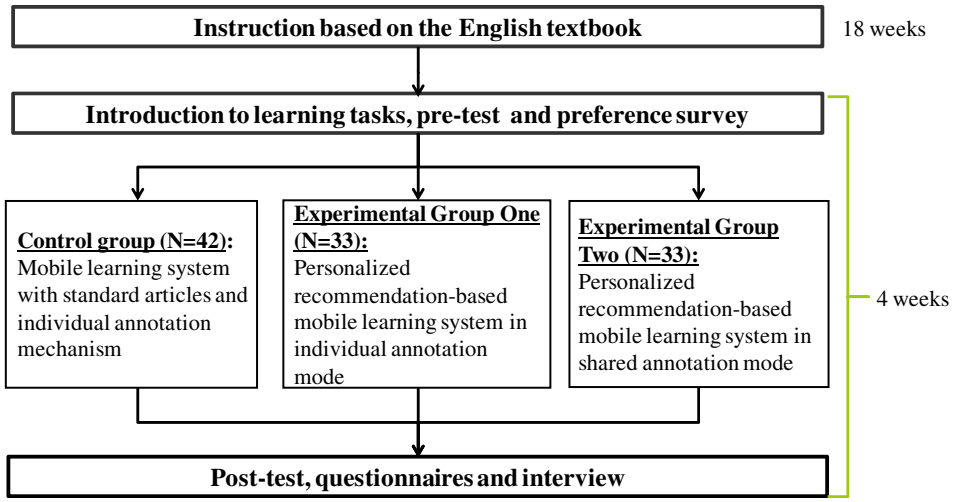

Fig. 4. Diagram of experiment design.

English for six years, implying that they had the prior knowledge of the learning content of the experiment. One class was assigned to be experimental group one, one class was experimental group two, and the other was the control group, making it a quasi-experimental design.

During the learning process, experimental group one, including 33 students, learned with the mobile learning approach with the individual annotation and the reading material recommendation mechanisms. Experimental group two, also including 33 students, learned with the mobile learning approach with the shared annotation and reading material recommendation mechanisms. The control group with 42 students learned with the mobile learning approach with the individual annotation function, but without the reading material recommendation mechanism.

4.2. Measuring tools

In this study, a pre-test, a post-test and the Technology Acceptance Model (TAM) and Cognitive Load questionnaires were used to evaluate the students' learning performance as well as their perceptions of learning with the proposed approach.

The test items were taken from the General English Proficiency Test commissioned by the Ministry of Education in Taiwan (Roever & Pan, 2008). The pre-test consisted of three groups of questions to examine the reading comprehension level of the students. It consisted of five multiple-choice items at the elementary level, ten multiple-choice items at the intermediate level, and ten multiple-choice items at the intermediate-high level, with a perfect score of 100. The post-test consisted of four reading texts, including one at the elementary level, two at the intermediate level, and one at the intermediate-high level. Each text included four multiple-choice items for assessing the students' reading comprehension. The perfect score of the post-test was 100.

The technology acceptance questionnaire originated from the questionnaire developed by Davis (1989). It consisted of 12 items with a seven-point Likert rating scheme, including 6 items for "Perceived ease of use" and 6 for "Perceived usefulness." The Cronbach's alpha values of the two dimensions were 0.90 for usefulness and 0.94 for ease of use (Davis, 1989). TAM aims to evaluate users' perceptions of information systems. The variable of perceived usefulness means that the users accept the system as being useful for achieving their objective, and the variable of perceived ease of use means that the users think of the system as being easy to operate for accomplishing their tasks (Davis, Bagozzi, & Warshaw, 1989).

The questionnaire of cognitive load was developed based on the cognitive load measure proposed by Paas, Renkl, and Sweller (2003). It consists of 4 items with a seven-point Likert rating scheme. The questionnaire consisted of two dimensions, that is, mental load and mental effort (Paas et al., 2003; Sweller, van Merrienboer, & Paas, 1998). Mental load is viewed as individual inner cognition loads when a person is simultaneously confronted with the stress of information amount and learning comprehension. The mental effort is treated as individual external cognition loads which are the pressure with regard to the methods of teaching, the difficulty degrees of the activities, and the suitability degrees of high-level thinking. The Cronbach's α values of mental effort and mental load in the scale are 0.86 and 0.85, respectively.

4.3. Experiment procedures

To evaluate the performance of the adaptive mobile-assisted language learning system, an experiment was conducted in a senior high school. Fig. 4 shows the flow chart of the experiment. Before the learning activity, all of the students received the 18-week instruction by the

Table 2
Descriptive data and ANCOVA of the post-test results.

Group	*N*	Mean	SD	Adjusted mean	*F*	Pairwise comparisons
Control group (a)	42	57.74	23.09	58.27	5.33*	b > a
Experimental group one (b)	33	71.21	16.68	70.96		c > a
Experimental group two (c)	33	68.94	15.35	69.01		

*$p < .05$.

Table 3
ANOVA results of the cognitive loads of the three groups.

	Group	*N*	Mean	SD	*F*	Post hoc tests
Mental load (intrinsic cognitive load)	Control group (a)	42	3.49	0.98	11.01*	a > b
	Experimental group one (b)	33	2.64	1.03		a > c
	Experimental group two (c)	33	2.48	1.02		
Mental effort (extrinsic cognitive load)	Control group (a)	42	3.65	1.16	18.68*	a > b
	Experimental group one (b)	33	2.52	0.85		a > c
	Experimental group two (c)	33	2.36	0.95		

*$p < .05$.

same teacher based on the English textbook. At the beginning of the learning activity, an orientation of the learning tasks was given; moreover, the students took the pre-test and the individual preference questionnaire. In other words, a pre-test and a questionnaire were administered to evaluate the English reading ability and preferences of the students.

Following that, a four-week learning activity was conducted. In each week, the three groups of students were scheduled to use the mobile devices to learn for one period (i.e., 50 min); that is, the three groups spent the same amount of time using the learning system. The students in Experimental Group One learned individually with the articles recommended by the learning system in the vocabulary annotation mode during the learning process. The students in Experimental Group Two learned with the articles recommended by the learning system in the shared annotation mode. That is, the students in both the experimental groups read the articles recommended based on their preferences and the reading proficiency levels, but those in Experimental Group Two were allowed to read the annotations made by their peers. On the other hand, the students in the control group learned with the standard articles provided in the textbook in the vocabulary annotation mode. After the end of the learning activity, the students took the post-test, and completed the Technology Acceptance Model questionnaire and the cognitive load measure; moreover, an interview was conducted to further investigate the perceptions of the students.

5. Results

5.1. Analysis of learning achievement

The aim of this study was to examine the effectiveness of the personalized reading material and mobile-assisted translation annotation in improving the learning achievement of the students. The mean values and standard deviations of the pre-test scores were 39.38 and 8.84 for the control group, 39.76 and 9.43 for experimental group one, and 40.79 and 11.83 for experimental group two. The ANOVA results show that there was no significant difference between the three groups (Scheffe Multiple Comparisons p value = .84); consequently, it is evident that the three groups of students had equivalent prior knowledge before the learning activity.

After the learning activity, analysis of covariance (ANCOVA) was used to test the differences between the three groups by using the pre-test scores as the covariate and the post-test scores as dependent variables, as shown in Table 2. The adjusted mean value of the post-test scores was 58.27 for the control group, 70.96 for experimental group one, and 69.01 for experimental group two. According to the results ($F = 5.33$, $p < .05$), there was a significant difference between the three groups; that is, the students who learned with the personalized reading materials assisted by mobile translation annotation showed significantly better learning achievements than those who learned with reading materials that did not necessarily match their learning preferences or reading proficiency. Moreover, it was found that the SD value of the control group was much higher than that of the experimental groups. This could be due to the relatively better learning gains of the low-achievement students in the experimental groups with the help of the reading recommendation function, such that the post-test scores of the low-achievement students were closer to those of the high-achievement students.

5.2. Analysis of cognitive load

Table 3 shows the ANOVA result of the cognitive load investigation of the three groups. The means and standard deviations of the questionnaire investigation results were 3.49 and 0.98 for the control group, 2.64 and 1.03 for experimental group one, and 2.48 and 1.02 for experimental group two. The ANOVA results show no significant difference between the two experimental groups ($p > .05$), showing that

Table 4
ANOVA results of the TAM of the three groups.

Scale	Groups	*N*	Mean	SD	*F*	Post hoc tests
Satisfaction	Control group (a)	42	5.15	1.04	3.79*	b > a
	Experimental group one (b)	33	5.70	0.79		
	Experimental group two (c)	33	5.29	0.69		
Usefulness	Control group (a)	42	5.45	0.90	1.08	
	Experimental group one (b)	33	5.72	0.87		
	Experimental group two (c)	33	5.50	0.59		
Ease of use	Control group (a)	42	5.37	0.73	0.46	
	Experimental group one (b)	33	5.55	0.81		
	Experimental group two (c)	33	5.44	0.90		

*$p < .05$.

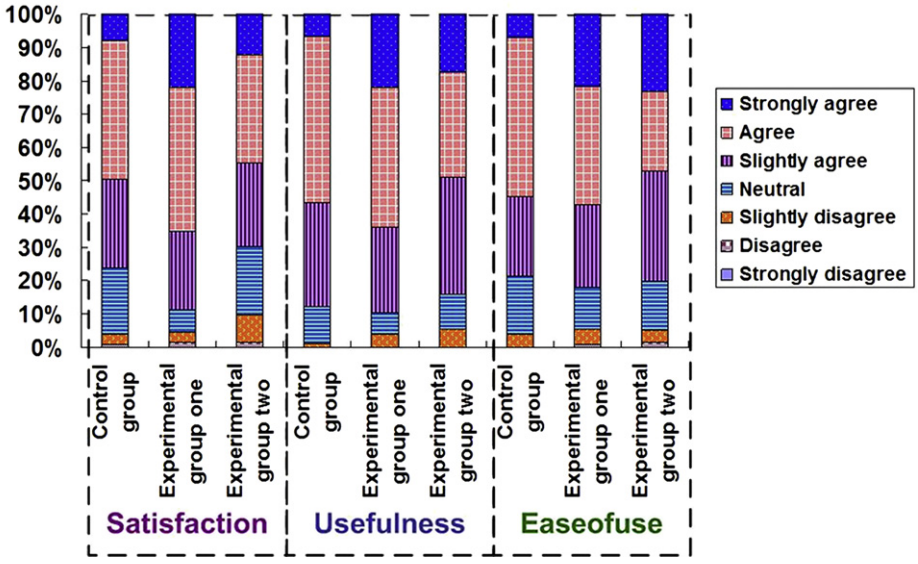

Fig. 5. The results of satisfaction, usefulness and ease of use in the three treatments.

the two groups of students had similar cognitive loads in the learning activity. In other words, after personalized treatment, there was no significant difference between individual reading and collaborative reading.

Table 3 also shows that the two experimental groups of students had significantly lower mental loads and mental efforts than the control group after the learning activity. As the adjusted means of the two experimental groups were significantly lower than those of the control group, it is concluded that the personalized mobile learning approach assisted by either individual or shared translation annotation had a significant impact on reducing students' cognitive loads during the learning activity.

5.3. Analysis of the Technology Acceptance Model

To better understand the students' perceptions of the different treatments in terms of "perceived satisfaction," "perceived usefulness" and "perceived ease of use," the ANOVA results of the TAM of the three groups are shown in Table 4. According to the ANOVA result for satisfaction ($F = 3.79$, $p < .05$), the average ratings for "perceived satisfaction" are 5.15, 5.7, 5.29 for the control group, and for experimental groups one and two, respectively. There was a significant difference between the control group and experimental group one in terms of satisfaction. The average ratings for "perceived usefulness" are 5.45, 5.72, and 5.50 for the control group and for experimental groups one and two, respectively; moreover, their average ratings for "perceived ease of use" are 5.37, 5.55, and 5.44. In comparison with the ratings given by the control group, it should be noted that the students in experimental group one gave higher ratings for "perceived satisfaction," implying that those students who individually read the personalized reading material that met their reading preference and proficiency revealed higher degrees of satisfaction than those who learned with the reading material that did not necessarily meet their reading preference or proficiency level.

Fig. 5 shows that most of the students in experimental groups one and two identified the usefulness of integrating the personalized reading material recommendation approach with the assistance of vocabulary translation annotation on mobile devices for improving their learning achievements. From the analysis result of the students' test scores, it was also evident that the personalized reading material recommendation approach did help the students in improving their learning achievements.

6. Discussion and conclusions

English has been recognized as being the most important foreign language in most non-English-speaking countries (Hsieh, 2011; Liu & Chu, 2010). In this study, a personalized mobile language learning system is proposed. It includes a reading material recommendation mechanism for guiding EFL students to read articles that meet their preferences and reading proficiency levels, and a reading annotation mechanism that allows the students to take notes of English vocabulary translations in different contexts on mobile devices during the learning process.

The experimental results show that students in both of the experimental groups who learned with the adaptive articles (i.e., the ones recommended by the learning system based on their preferences and reading proficiency levels) achieved significantly better reading comprehension in comparison with the students who read non-adaptive reading materials in the control group, implying that the personalized recommendation mechanism was helpful to the students in motivating them and improving their reading effectiveness. Such a finding conforms to what has been reported by some previous studies using desktop computers (Chen, Man, Yen, Jin, & Shih, 2010; Hsu, 2008). This also reveals that the adaptive mobile language learning approach not only advantaged the students from the aspect of learning anytime, but also benefited them in terms of learning efficiency and effectiveness.

In the meantime, the results of the questionnaire survey showed that the highest percentage (i.e., 88.6%) of the students in Experimental Group One were satisfied with using the mobile language learning system, and ninety percent of the students perceived its usefulness, while eighty-four percent of the students in Experimental Group Two perceived the system's usefulness. On the other hand, seventy-nine percent

of the students in the control group perceived the usefulness of the mobile learning system without reading material recommendations. Moreover, it was found that the participants in the two experimental groups showed significantly lower cognitive load and better learning attitude toward using the personalized mobile language learning system with the reading material recommendation mechanism to learn in comparison with the control group students who learned with the mobile learning system without reading material recommendations. Such findings imply that the personalized reading material recommendation mechanism was able to decrease cognitive load as well as promote the learning attitudes of the students during the mobile learning process.

On the other hand, no significant difference was found between the learning achievements of the two experimental groups, implying that the shared annotation mechanism did not result in significantly different effects on students' learning performance in comparison with the individual vocabulary annotation in this study. It can be implied from the questionnaire survey that the students in Experimental Group One perceived higher satisfaction than did the students of Experimental Group Two. In the interviews of the students in Experimental Group Two, two high-achievement students stated that they preferred to make annotations on their own. They complained that, in the shared annotation mode, they had to read the annotations from their peers with lower reading proficiency, and most of those annotations were useless to them; this was quite confusing for them and also disruptive. Similar findings were obtained from the cognitive load measuring results; that is, the students in Experimental Group Two showed higher extrinsic and intrinsic cognitive loads than those in Experimental Group One. For example, one student in Experimental Group Two indicated that in the shared annotation mode, he gained little assistance from peers, but most of the time, he needed to put up with interference (i.e., the useless annotations) from them, which caused pressure during the reading process. Therefore, he preferred individual reading and annotation. These findings imply that the effect of collaboration might not be as good as expected unless a better mechanism can be provided to help students filter undesirable annotations made by others.

Furthermore, in the interviews with the low-achievement students who were recommended to read elementary-level articles in Experimental Group two but did not make significant progress, three indicated that they did not benefit from the shared annotations since most of the annotations were made by their peers with the same reading proficiency level; consequently, some words that were difficult for them were not annotated by any of their peers. This finding reveals the drawback of having students of the same reading proficiency level share their annotations. In future studies, it might be more beneficial for the lower-achievement students if each assigned article is annotated by at least one higher-achievement student or a teaching assistant in the shared annotation mode.

The proposed approach can be generalized to other language learning activities in which instant translation and personalized reading material recommendation are needed. To execute the learning system, a computer server is needed; moreover, each student must be equipped with a mobile device with wireless communication facilities to interact with the learning system. The following guidelines are suggested for those who intend to introduce the proposed approach to their reading activities.

Step 1: Determine the difficulty and characteristics of the reading materials to be included in the database.
Step 2: Investigate students' preferences and reading proficiency.
Step 3: Provide a brief orientation of the use of mobile devices to the learners as well as the learning tasks. This step usually requires around 10 min.
Step 4. Group the students based on their reading competences. This can be done by conducting a pre-test.
Step 5: Conduct the learning activity. The time needed in this step depends on the number of articles to be read and the length of the articles. It is suggested that a series of short articles which require 10–15 min reading time can be considered.

In the future, it is suggested that the number of articles in the database should not only be continually increased to promote the chances of successfully matching the users' needs, but that the number of article categories should also be increased so that more students can get recommended articles. By trying to find and increase the number of article categories corresponding to their preferences in the future, it is hoped that the optimal or most suitable article can be easily found. Moreover, the development of this research and the experiments conducted to establish its efficacy were all based around synchronous learning in a general classroom setting. We encourage future studies to consider asynchronous learning and development to expand the application of this kind of learning to contexts outside the classroom.

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