A Context – Aware Mobile Learning Adaptive System for Supporting Foreigner Learning English

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***Abstract*— This paper represents a personalized context – aware mobile learning architecture for supporting student to learn English as foreign language in order to prepare for TOEFL test. It provides adaptive content for different learners based on context – awareness. In our model, the context includes location, time, manner as well as learner's knowledge. Through suggested topics as well as test questions, the learners will be supported adaptive content meeting their demands as well as their knowledge. Besides, this paper also describes CAMLES system prototype that allows the learner to learn adaptive materials for TOEFL test anytime in anywhere with mobile phone.**

m-learning, context-awareness, personalized learning, CAMLES

I. INTRODUCTION

Because of its portability, mobile technology is a growing trend in a wide range of activities in modern life such as: communication, entertainment, banking and education. Therefore, mobile learning is also emerging as important research in e-learning field. One of the benefits of mobile learning (m-learning) is the ability to provide and access learning materials anytime in anywhere. For two decades, Adaptive Hypermedia (AH) systems have been developed to provide the learners with adaptive learning materials based on their demands through evaluating learner model. Most AHs are designed for the personal computers, so it requires a definite location and time. Having restricted location and time, the learners find it difficult to approach the learning systems whenever they need. Consequently, the most recent generation of mobile learning research focuses on context – ware mobile learning application. With adaptive engine uses, the learners can easy browse the adapted course content as they want.

There have been several experiments and researches in the use of context–aware and its adaptation in mobile learning. One of which, in terms of context-ware, is pedagogical effectiveness, the technical and usability functions. Jane [1] noted that the common research aims within this topic included: "Supporting learners to learn/study at anytime and anywhere by taking into account a number of learning contexts, such as location and the available time for study" and "Facilitating situated learning for students where situated learning can be defined as activities that promote learning within an authentic context and culture".

Our research addresses the context-awareness adaptation in mobile learning that aims to support Vietnamese students to use the mobile devices such as mobile phone, Personal Digital Assistant (PDA) to learn English in order to prepare for TOEFL test. We are interested in the learner modeling as well as the context factors that affect the students. In addition, we also represent CAMLES (Context-Aware Mobile Learning English System) to support personalized mobile learning.

The rest of this paper is structured as followed: First, we will review the related researches on context-aware location dependent learning. In the next section, the context factors using in our model to adapt course content for each student is introduced. As for the fourth section, we represent our context-aware mobile learning, the CAMLES system that focuses on representing learner model and content model as well as the system design and architecture. System implementation with our experiments will also be described in section four. Finally, the discussions and conclusions are summarized.

II. LITERATURE REVIEW

Our literature review presents recent context–aware m-learning applications for language learning. Especially, those support students to learn foreign languages. These applications can be classified into two categories: context-aware location-independent learning and context-aware location-dependent learning. Learners can use the former anywhere that is not restricted in any specified locations. The later application, through location-tracking technologies such as GPS or WLAN, can automatically identify the learner's location as selecting appropriate learning resources for them is especially basic. Now, we focus on several typical applications:

- CAMCLL [2], context-aware location-independent learning, teaches Chinese to the students whose language levels are not enough to make conversations in Chinese by supporting appropriate sentences to different learners based on contexts. The CAMCLL context includes time, location, activities and learner levels. Adaptive engine of CAMCLL is based on ontology and rule-based matching.
- TenseITS [3] teaches English language to foreign students through meeting their demands. Learner model is designed based on four context factors: location, interruption/distraction, concentration and available time. Appropriate learning materials for different learners are selected based on the information represented in learner model.

- LOCH [4], context-aware location-dependent learning, supports students to learn Japanese while involving in real time situations. By monitoring the positions of the learners, teachers can establish the communication with the students and guide them. The context factor in LOCH system is location.
- English vocabulary learning [5] recommends vocabulary for different learners based on their location, time for their learning and individual abilities. This system uses WLAN to identify learner's position. In addition, it uses some techniques such as maximizing information strategy, evaluating the score of time characteristics and estimating the amount of learning words to select suitable vocabulary for different learners.
- TANGO [6] supports Japanese students to identify English words with physical objects via the use of mobile devices through RFID tag reader/writer. TANGO includes six modules to select appropriate English words based on learner models.
- MESLL [7] is designed to aids Japanese learners to learn Kanji or Chinese as a second language via SMS function or email. The learners send an email to the system in order to request a test. The system composes a test and feedbacks to them including adaptive English words as well as example sentences.

III. CONTEXT FACTORS TO ADAPT

Context is any information that can be used to characterize the situation of an entity such as a person, place or object that is considered relevant to the interaction between an user and an application [8]. Meanwhile, according to B.Hu, in m-learning, context is the set of suitable environmental states and settings based on situated roles between a learner and a tutor [9].

In our personalized m-learning model, it is suggested that context is the information that has impact on learners in learning activities. We assume that there are several factors having influence on adapting course materials in each learner. Location, time, manner, and learner's knowledge are context factors taken into account in our model. Firstly, location allows information and services to localize. In our model, location allows adaptation system to situated place where learners participate in the course. As S.Cui proposed in TenseITS [3], location is a special place where students use mobile devices to learn such as home, bus terminal, hotel, etc. Secondly, time refers to the instantaneous time of the day. Specially, the interval that the learner interacts with the system is important for an amount of course materials requiring the learners to learn. Thirdly, the manner of learning is considered as a factor of context using for adaptation. It mentions learner's attitudes such as concentration, interest level when they take part in the course. Finally, learner's knowledge is regarded as an oriental factor to determine what course content should be learned in the next stage.

Context – awareness describes a process in which context factors are used to target the provision of adaptive learning materials for the learner in interactive systems based on location, learner's preferences as well as learner's knowledge. This process includes two principal functions: 1) context interpretation and 2) context implementation [10]. The former collects the learner's input data. Following context processing, the later issues the output that is personalized according to the information reflecting learner modeling.

Reichenbancher [11] noted that there are four different levels of adaptation: information level, technology level, user interface level and presentation level. Focusing on information level, our model aims to adapt learning materials according to context factors mentioned above. In the next section, we will present our personalized mobile learning framework in deeply.

IV. CONTEXT AWARE MOBILE LEARNING ARCHITECTURE

In order to select personalized mobile learning materials based on the context as well as learner's preferences, we propose architecture with their layers described in Fig 1.

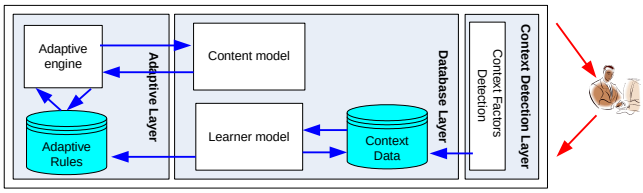

Figure 1. CAMLES Architecture

A. *Context-awareness detection layer*

The function of the context-awareness detection layer is to identify the context factors such as location, time interval, manner of learning and learner's knowledge that have impact on selecting adapted learning materials for different learners The core of this layer includes main functions: i) Detecting location, ii) Collecting time interval request, iii) Collecting the learner's preferences, iv) Testing for learner's knowledge evaluation.

B. *Database layer*

Database layer consists of context data, content data, learner's profile and test. First, the context data is the information about location, time, and manner that learners take part in the course via a mobile device. Secondly, the content data stores information about course materials that reflects in the content model. The learner profile represents personalized information of each learner including learner's interests, learner's knowledge level, and interval of time that learners requested. Finally, test data consists of several questions for testing student's knowledge level. Besides, test data also store the results of learner's test.

1) *Context data*

Context information includes two categories, the first is the information obtained from the learner's request such as location, interval of time to learn and concentration. These factors require the learners to fill in before they participate in the course. In this model, we define location as a place where the learners use mobile devices to take part in the course. It is not a specific place that is common place such as home, bus terminal, hotel, etc. Each location is described by a

corresponding discrete value in Table 1. This represents the factors that impact on learning activities such as concentration level, the frequency interruption as well as available time to learn. The lower value indicates that the location affecting context factors is higher, whereas the higher value indicates that impact is lower.

TABLE I. THE VALUE OF LOCATION FACTOR

No	Location	Value
1	Bus terminal	1
2	Restaurant	2
3	Outing	3
4	Campus	4
5	Home	5

Interval of time is available time that the learner will spend learning. In terms of time limit in using mobile device, we use four options of interval of time for choosing the time to learn. These are 15, 30, 45, and 60 minutes. Similarly, we use discrete values to identify the level of concentration. The learner can choose one of parameters before participating in the course. Those values are only used to assume the concentration of learner because selection cannot guarantee the learners will concentrate as they do.

The concentration parameter is designed to determine the learners' requirements about concentration on learning while student uses mobile device to browse the course. Three concentration levels are low, medium and high. Each of them also describes by discrete value that is 1, 2 and 3 respectively.

The second category is learner's knowledge that is assumed to be a context factor because of knowledge level variation. In our model, learner knowledge is evaluated in two ways. The first one is by several test questions at the first time they participate in the course. The second way occurs when learners finish one topic, the system requires they take several questions in order to test their knowledge on this topic. Through the test results, we classify learner knowledge into the five categories: poor, average, good, very good, excellent. Each level also describes by discrete value as showed in Table 2.

TABLE II. LEVEL KNOWLEDGE LEVEL

No	Learner knowledge level	Value
1	Poor	1
2	Average	2
3	Good	3
4	Very good	4
5	Excellent	5

2) Content Modeling

We describe the course content as the tree structure with hierarchical nodes that describe topics. They consist of several child nodes. The leaf is a node without child nodes. These contain topic content in detail. Each node includes some attributes to distinguish and they are the basis for adaptation processing. The learner model decides whether node chooses for different learner or not. It not only decides the numbers of nodes need to learn but also decides the depth of the tree content that learners are suggested to travel. There are some reasons why the course content is represented as tree structure instead of knowledge graph that modeled in our recent study, ACGS model [12] [13]. Those are: (1) The content of our scenario, the learning topic test support is hierarchical structure, (2) The content adaptation for different learner is to select suitable topics from the course so that it is the examine the tree processing to select nodes required to learn.

We denoted T (Topic) is the subject study, in which T_i (i = 1, 2, 3,...) is the subject of the T. Similarly, T_i^j (j = 1, 2, 3, ...) is the child of T_i. The topics are arranged under a tree from top to bottom according to the content of the topic. Each topic is a node of the tree. The topics above (as in the general topic) have content covers the content of the child (a subject in the details.) The child node will inherit the content of in the topic at parent level. But it only reflected in the general level, not go into detail on each issue that reflected the topic. It focused on the content corresponding to its position. This raises the problem is how that can be determined in accordance with the contents of that topic. Because threads are arranged according to each topic tree should have different altitudes. Depending on such topics as wide or narrow, there are many issues of concern or not specify which branches son was born. The principal topics with content relevant to general users have average knowledge on that topic. Learners can choose which topics to be able to absorb knowledge in accordance with their capabilities. At the higher topics the content more detail and depth. To be able to learn the content in these topics, the system requires students to understand well the content of lower-level topics. This requirement is entirely accurate, because the topics at high levels is inherited from the subject at a low level, may want to learn and understand the need to have certain knowledge about the problem. This knowledge was assessed through the learning process of users in low-level topics.

3) Learner modeling

One of the most important information in this layer is learner model data that is basic to select adaptive course content for different learner. It is designed from context factors as well as learner's knowledge. Because all context factors are represented by discrete values, the learner model also is described by them. In this model, we assume that learner model depends on context factors and learner knowledge. With context factors, we designed learner model whose value that calculated by value of location, concentration and time to learn as showed in Table 3. At this stage of the model, we assume that the value of learner model is aggregation all of context factors. Therefore, there are ten models of learners with values from 3 to 12 respectively.

TABLE III. THE VALUE REPRESENTS LEARNER MODEL BASED ON CONTEXT FACTORS: LOCATION, CONCENTRATION AND TIME

Low(1)				Medium (2)				High (3)			
15 (1)	*30 (2)*	*45 (3)*	*60 (4)*	*15 (1)*	*30 (2)*	*45 (3)*	*60 (4)*	*15 (1)*	*30 (2)*	*45 (3)*	*60 (4)*
3	4	5	6	4	5	6	7	5	6	7	8
4	5	6	7	5	6	7	8	6	7	8	9
5	6	7	8	6	7	8	9	7	8	9	10
6	7	8	9	7	8	9	10	8	9	10	11
7	8	9	10	8	9	10	11	9	10	11	12

Five row in Table 3 represents the value for location factor, the first row denoted location at Bus terminal which has minimum value and fifth row denoted location at Home which has maximum value. For instance, learner who is at *home* with concentration level is low and time to learner is 45 minutes. The learner model value is represented in Table 3 is value 9 (row 5^{th} and column 4^{th}).

As mentioned above, based on learner's knowledge factor, we define learner model as the aggregation of learner model that is based on context and knowledge as shown in Table 4. There are fourteen models of learner based on learner's knowledge level and context factors. These models are the basis for adaptation layer to select adaptive course content for different learners. For example, if the learner who can be at *home*, concentration level is *medium*, time to learn is *30 minutes* and knowledge level is *good* (This value is evaluated through the test question when learner participates the course), the learner model value is 11.

TABLE IV. LEARNER MODEL IS COMBINED CONTEXT FACTORS AND LEARNER'S KNOWLEDGE

	Learner's knowledge				
Learner Model	***1***	***2***	***3***	***4***	***5***
1	2	3	4	5	6
2	3	4	5	6	7
3	4	5	6	7	8
4	5	6	7	8	9
5	6	7	8	9	10
6	7	8	9	10	11
7	8	9	10	11	12
8	9	10	11	12	13
9	10	11	12	13	14
10	11	12	13	14	15

C. Adaptation layer

Adaptation layer include some functions designed to adapt learning materials for each learner. Based on the results of test as well as learner's background, Learner's knowledge evaluating component used to identify how learner's knowledge level is. Learner modeling component is constructed to determine all of the context factors such as location, time to learn, and learner's knowledge of different learners affecting to adaptation. The heart of this layer, learning resource selection component, is used to select appropriate adaptive learning content for each learners according to their learner modeling. We designed several rules to choose learning resources from content model as traveling of tree nodes. The child node describes detailed information about parent node. Therefore, if learner travels the tree deeply, the content obtained is more detailed.

Learning material is adapted to different learners in two ways. The first way is that when learner selects one topic from suggested list, the content belonging to this topic is adapted based on learner model of different learners. The second way occurs when the learners finish a test, the system recommends one or more topics that students need to learn.

We classify student into fourteen categories in order to adapt the course content.

The Rules we used to select learning resources in this model is if – then rules. The rules as described in the Table 5. Defended on learner model, the adaptive rules include three elements such as height of tree, number of topic and number of test question. The height of tree informs that how information detail is. The number of topic denotes the number of child nodes or sub topics of determine topics. Having several sub topics, the number of topics will decide how many topics are supplied to different learners. Similarly, the number of test questions denotes how many test questions will be required to take after different learners browsing the definite topics.

TABLE V. ADAPTIVE RULES ACCORDING TO LEARNER MODEL

No	**Learner model**	**Rules**		
		Height of tree	***Number of topic***	***Number of test question***
1	LM1	1	1	5
2	LM2	1	2	5
3	LM3	1	2	5
4	LM4	2	3	5
5	LM5	2	3	5
6	LM6	3	3	10
7	LM7	3	4	10
8	LM8	3	4	10
9	LM9	4	4	10
10	LM10	4	4	12
11	LM11	4	5	12
12	LM12	5	5	12
13	LM13	5	5	12
14	LM14	5	5	12

D. Main function

Our system aims to supply appropriate topics to different learners based on context factors that they chose as well as learner's knowledge through their test result. Therefore, we designed main functions as following to address it:

- Register: The first time using system, the learner is requested to fill-in register form to obtain an account to access the system.
- Getting context factors from learner: The learner inputs some parameters such as location, concentration, available time. Those are basic to construct learner model.
- Test learner's knowledge about TOEFL topics: After giving demands, the learners have two options are choice a topic to learn or take some question to test their knowledge. For testing, the system will randomize several questions form different topics for the learners. The test result is basic to evaluate learner's knowledge level.
- Suggest topic list for learners: In case of the learner's knowledge is evaluated, the system suggest the list of

appropriate topics for learner to choose. Otherwise, there is topic list for the learner selecting one to learn.

- Adapt content of suggested topic appropriate learner
- Choose appropriate test question from database to test learner's knowledge after they finish the topic.
- Suggest topics that learner need to learn based their test results

V. SYSTEM PROTOTYPE IMPLEMENTATION

We implemented CAMLES prototype based on J2ME technology. Therefore, mobile phone needs to support java program as well as GPRS or 3G. In order to use CAMLES, the learners need to download and install application alone in their mobile phone. At this stage, we develop content model consists of five main topics: Adjectives and Adverbs, Pronouns, Questions, The Noun Phrase and Commands. Those are considered parent topics for the entire contents of the system. Under each topic, there will be corresponding child topic, for example, the child of Adjectives and Adverbs topic are Adjectives, Adverbs. Adjectives topic has eight children: Manner, Place, Time, Frequency, Sentence, Degree, Interrogative and Relative. As mentioned above, will cover topics father general content of the topic, so Adjectives and Adverbs topic will contain two general themes of Adjectives and Adverbs, Adjectives topic will contain general theme of the eight children of it. Fig. 2 denotes an excerpt of tree.

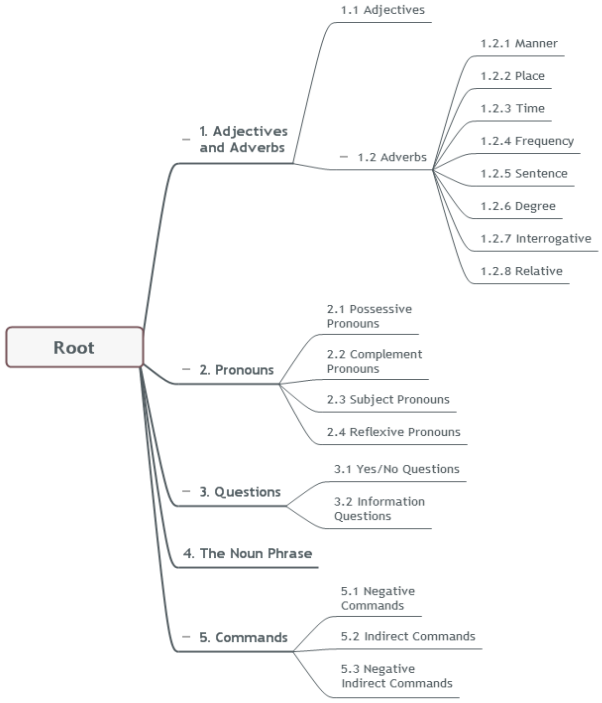

Figure 2. An excerpt of content model

The learner inputs context parameters via mobile interface. The topic content was adapted him. Finishing this topic, the system suggests some question test to evaluate learner's knowledge about topic and shows the test results as well as recommend in next screen.

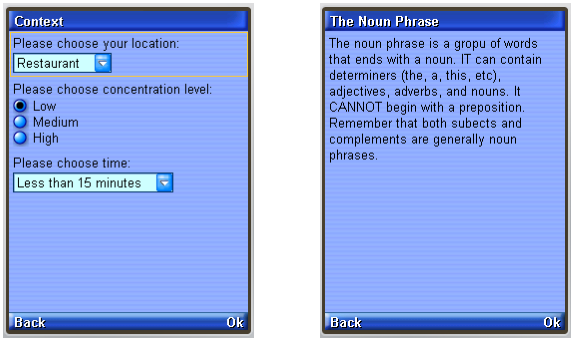

Figure 3. Learner inputs context parameters and adaptive content showed

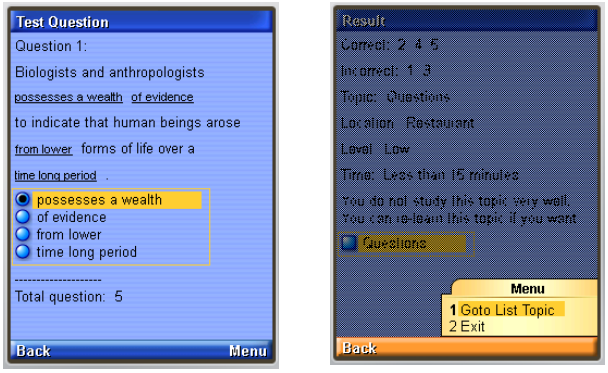

Figure 4. Test questions for evaluating learner's knowledge

To examine our experimentation, we designed a questionnaire includes six questions to survey 35 students who used CAMLES system with their mobile phone which supports GPRS or 3G to connect to Internet. In order to evaluate our system, students check to one of from 1 to 5 values that 1 was the lowest and 5 was the highest. We classify student into three categories: group one includes students who never taken the TOEFL test before, group two contain students who have taken TOEFL test and get below 450 score (paper test), and group three are students have get above 500 score. Table 6 shown average results of the questionnaire for each group.

TABLE VI. RESULT S OF QUESTION NAIRE

No	Question	Group1	Group2	Group3
1	Do you think the system was easy to use?	3.5	4.0	4.0
2	Would you like to use the system again?	4.5	4.0	3.5
3	Do you think the test question is appropriate for you?	3.0	4.5	4.0
4	The topic that system selects is appropriate for you?	4.5	4.0	3.5
5	Did you choose context factors as you in?	3.0	4.5	5.0

According to Question 1 and Question 2, the students satisfied with system and would like to use the system again. Question 3 results shown that the students who never taken TOEFL test before did not satisfy because the test questions we used in prototype are not easy. The results of this question also denote that the students, who have high test score before, satisfied with system. Average score of Question 4 is 3.5 that denote the topic is selected for such students not good enough because our content model does not have more topic as well as topic content in detail to support them. Question 5 to survey learners who choose the context whether true as they in or not. For instance, the learners can choose their location is at home while they at Bus terminal. Problem how to locate learner's location will resolve in the next stage through location base services. As you see, in Group 1 result, students who never take the TOEFL test before are interested in our system. However, Average score of Question 5 is 3.0 shown they often choose the context which is not true as they in. For example, they choice Restaurant location while they in class.

VI. DISSCUSION

Our target users are graduate students who intend to take TOEFL test. However, this approach can be applied to general learners to study English as a foreign language. Our model, context-aware location-dependent learning, adapts learning content according to context as well as learner's knowledge background. To find interests in our system, we compare it with early systems.

In TenseITS [3], learner's knowledge parameter only calculate at current stage, so if the learner, from second time, backs to the system with the same context factors such as inputted previously, the adaptive contents are similar. In our model, learner's knowledge background is stored and is evaluated after the students finish the topic. The results are basic for calculating learner model value for next time learners use system.

The CAMLL [2] is also based on learner level to adapt suitable sentences, however, how the learner level update learning progress has not been specified.

At this stage, our learner model is still not distinct for all context cases. Therefore, there are several different context have the same value in learner's model. In the future work, we will consider refining the content model as well as adaptive engine in order to match the learner's requests. One notable problem that is how to fragment content to display in accordance with the size of the mobile phone is also considered. In addition, we will improve user interface to meet demands of new users. We intend to deploy a web application version of this model, because of disadvantage of stand -alone application. The web application easy supports different model of mobile phone.

VII. CONCLUSION

This paper has introduced CAMLES, a context aware mobile learning for supporting Vietnamese students to learn English language to prepare for TOEFL test. It adapts learning materials according to the learner's knowledge as well as their location, their available time, their concentration. To do that, we focused to address critical problems such as representing content model, developing learning model as well as improve adaptive engine techniques. Besides, prototype of use was presented to illustrate the potential of applicability of our system.

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