# Identifying Personalized Context-aware Knowledge Structure for Individual User in Ubiquitous Learning Environment

Stis Wu[1], Alex Chang[2], Maiga Chang[3], Tzu-Chien Liu[4], Jia-Sheng Heh[1]
[1]*Dept. of Information and Computer Engineering, Chung-Yuan Christian Univ., Taiwan*
[2]*Dept. of Electronic Engineering, Chung-Yuan Christian Univ., Taiwan*
[3]*School of Computing and Information Systems, Athabasca University, Canada*
[4]*Graduate Institute of Learning and Instruction, Central University, Taiwan*
stis@mcsl.ice.cycu.edu.tw, aslada@mcsl.ice.cycu.edu.tw, maiga@ms2.hinet.net, ltc@cc.ncu.edu.tw, jsheh@ice.cycu.edu.tw

## Abstract

*Ubiquitous learning extends e-learning from indoor to outdoor but also overcomes the weakness of mobile learning which only provides the specific domain knowledge to learners in particular learning environment. A ubiquitous learning environment covers the knowledge of different domains, hence, how to offer individual learner the learning sequence according to the learner's preference is an important issue. In order to solve the research issue, this paper first builds a context-awareness knowledge structure to store the different domain knowledge in a ubiquitous learning environment. After that, with pre-built stories and learning objects' characteristics, the system can aware of what domain knowledge learners are interesting with. Several exhibition rooms and artifacts in museum are used to demonstrate the idea of this research.*

**Keywords**: Context-awareness Knowledge Structure, Ubiquitous Learning Environment, Museum Learning, Pervasive Learning

## 1. Introduction

In the mobile learning environment, the learners could receive the learning materials provided by system according to where they are when learning in a mobile learning environment [1][2][7]. Ubiquitous learning becomes an interesting and important issue in e-learning field recently, focuses on making learners can do learning with their interest topics transparently and immediately with their various devices whenever and wherever they want.

The context-awareness learning system in this paper means the system can detect what the learners' status, such as learning results or requirements, and interests, and then the system provides suitable learning materials to the learners when they are learning in the real world [6].

There are four characteristics in ubiquitous learning environment [3]: (1) **context-aware**, the learners' learning performances and the learning environment information can be known by the ubiquitous learning system; (2) **personalization**, the learning resources learners might need can be provided according to learners' profiles and learning status; (3) **seamless**, learners' learning activities will not be stopped in ubiquitous learning even though they move to another lace; and, (4) **calm**, the learning materials will be delivered to learners automatically to avoid interrupting learners with different devices.

A knowledge structure suchlike concept map [4] [5] can represent what learner has learned. The knowledge structure is constructed based on the learners' thoughts about the learning object characteristics and attributes from learning in the real world. This research uses the story which talking about the characteristics and attributes of learning objects around the learners and constructs the personalized context-aware knowledge structure based on the feedbacks returned by the learners. As the result, there are two major issues in this paper: (1) what the stories and related questions should ask the learners? (2) how to know the preferences and interests of the individual learner in order to constructs his/her personalize context-aware knowledge structure?

The relations and definitions between the elements in the context-awareness knowledge structure are described in Section 2. Section 3 uses a six phases

0-7695-3108-3/08 $25.00 © 2008 IEEE
DOI 10.1109/WMUTE.2008.21

flow to construct the personalized context-aware knowledge structure. In Section 4, a real example of ubiquitous learning in the museum is built to demonstrate the effects of this research. Finally, Section 5 makes a conclusion and discusses the possible future works about personalized context-awareness knowledge structure.

## 2. Context-aware knowledge structure

This section first introduces the elements and layers in the context-aware knowledge structure; then, talks about the relations between two learning objects in the context-aware knowledge structure; and, finally illustrates the personalized context-aware knowledge structure for individual learner. The knowledge structure used in this paper is called Context-aware Knowledge Structure. The different knowledge domains might cover the same learning objects and its related characteristics, for example, both of the free-falling theory in physics and architectural engineering covers the learning object, the Piazza del Duomo.

The context-aware knowledge structure includes three layers as Figure 1 shows: (1) **Domain layer**, stores the subjects and topics in the learning environment, for examples, biology and china; (2) **Character layer**, stores the related characteristics which are corresponding to the domain layer, for examples, the dynasty and the color, are the related characteristics to china; and, (3) **Object layer**, represents the real learning objects and its features. Be notable is the related characteristics stored in the character layer should be observable, because the learning strategy in this research is asking learners to observe the learning objects.

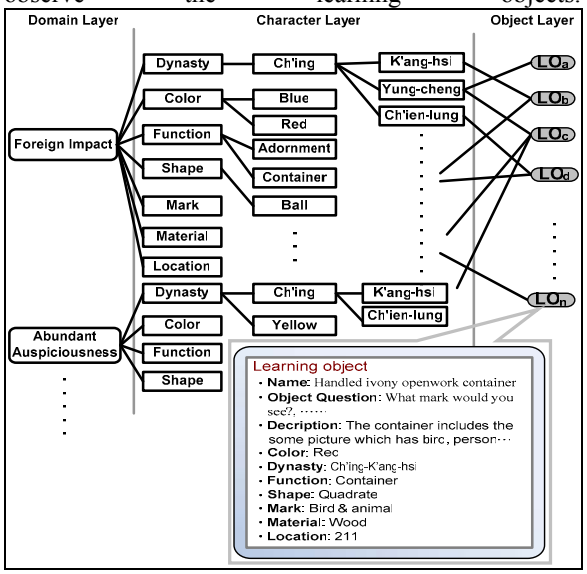


Figure 1. Context-aware knowledge structure

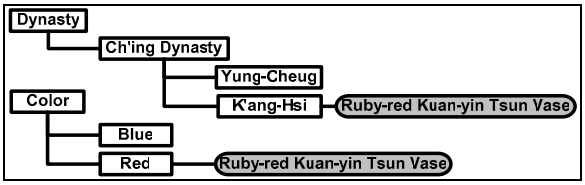


Figure 2. A context-awareness knowledge structure of an exhibition room in the museum (partial)

The characteristics in character layer have two different relations: (1) **inclusion relation**, is also called "part/is part of" relation, take the top part in Figure 2 for example, "Ch'ing dynasty" has two child nodes which are "Yung-Cheug" and "K'ang-Hsi". "Yung-Cheug" and "K'ang-Hsi" are parts of "Ch'ing Dynasty"; (2) **characteristic relation,** is also called "has attribute/is attribute of", take the bottom part in Figure 2 for example, the "Color" has two types, "Red" and "Blue". "Blue" and "Red" are the attributes of "Color".

The object layer is used to store the learning objects and its features suchlike the learning object description and the learning object color. The learning object characteristics are stored in the character layer. Take Ruby-red Kian-yin Tsun Vase in Figure 2 for example, the color is red and the dynasty is K'ang-Hsi dynasty. The two features, color and dynasty, are stored into different character layers.

Even the learners can observe the same learning objects in the real world. Their perceptions about the same learning objects might still different. Moreover, different learning activities should be given to learners depends on their preferences and learning object characteristics. As the result, the personalized context-aware knowledge structure for individual learner is necessary to extract for planning learning activities.

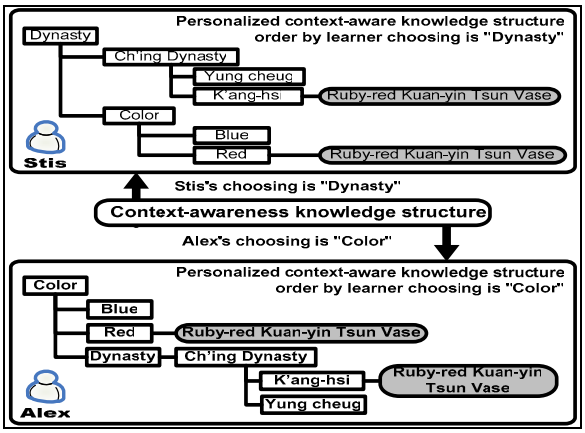


Figure 3. Examples of two personalized context-awareness knowledge structures

In Figure 3, there are two learners, Alex and Stis, have different viewpoints and/or preferences about the

artifacts in the museum. The top part of Figure 3 shows Stis' personalized context-aware knowledge structure. Stis prefers the characteristic, "Dynasty", rather than "Color", hence, his knowledge structure root is Dynasty. On the other hand, Alex has more interest in "Color" therefore his knowledge structure root is Color.

The personalized knowledge structure will be different with the individual learner thought and preference, and the width or depth of personalize knowledge structure depend on how much the learners think and how exquisite they know. The ways to understand the learners' preferences and to construct the personalized context-aware knowledge structure are designed in the next section.

## 3. Identifying Individual's Preference

This section first talks about the strategy of digging out the individual learner's interest and preference. After realizing individual's preference, we describe the operation flow of generating the personalized context-aware knowledge structure. This research wants to generate a personalized context-aware knowledge structure in ubiquitous learning environment for individual learner, and provide different learning objectives according to his/her own personalized knowledge structure automatically.

The whole construction flow of personalized context-aware knowledge structure involves six phases as Figure 4 shows:

1. Phase I: Learning materials analysis, the learning objects in real environment have a lot of information (or also called characteristics), which might cover different domains. In this phase, we need to analyze the learning objects in the real world and the characteristics which the learning objects have first. After this phase, the context-aware knowledge structure can be built.
2. Phase II: Basic personalized context-aware knowledge structure construction, because the personalized context-aware knowledge structure should be created according to the learners' preferences and interests. In this research, the simple stories which include the related learning object are made and provided to learners. The basic personalized context-aware knowledge structure for individual learner can be constructed depends on which stories the learners interest with.
3. Phase III: Personalized context-aware knowledge structure refinement, even if two learners choose the same story in phase II, their interests still might be a little different. In order to precisely refine the personalized context-aware knowledge structure, the system asks the learner some advance questions about the learning object characteristics involved in the story which the learner has chosen. Then, the personalized context knowledge structure is refined according to the learner's feedback.
4. Phase IV: Personalized context-aware knowledge structure generation, after repeating the phase II and III, the correspondent learning objects and characteristics the learner might need and/or interest with are clear. The learner's personalized context-aware knowledge structure is then can be generated in this phase.

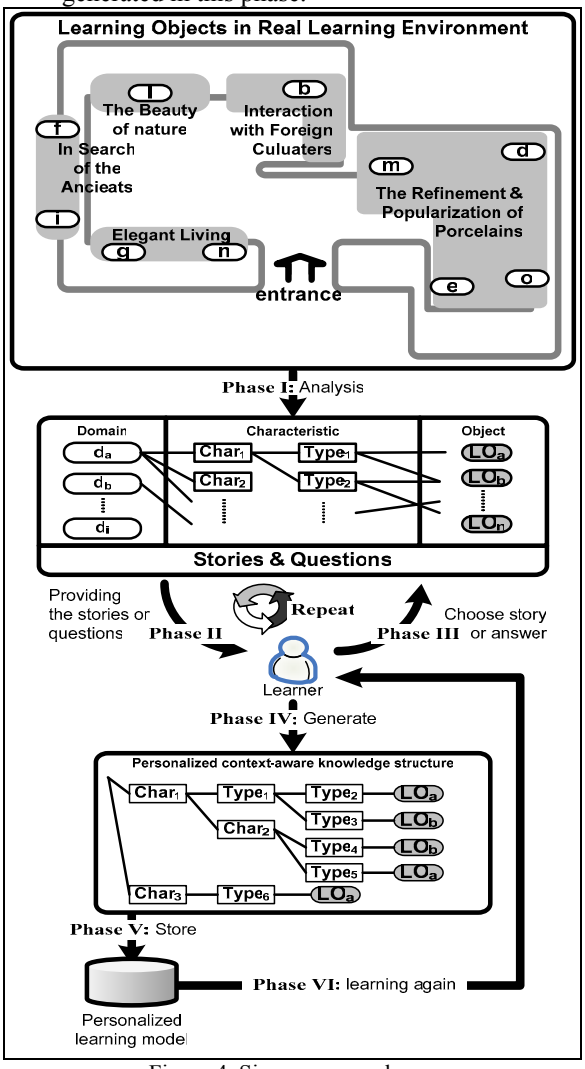


Figure 4. Six necessary phases

5. Phase V: Storing the personalized context-aware knowledge structure, if the learner visits in the

same or similar learning environment again, the system should be able to recognize what learning objects and its characteristics the learner have been observed or interested with immediately.

6. Phase VI: Next learning stage, when the learner visits a similar or new learning environment again, the system should be able to expand the pre-constructed personalized knowledge structure and plan new learning activities for the learner automatically.

Figure 5 shows the details of phase II to VI in Figure 4. The top part of Figure 5 explains the process of constructing and refining the personalized knowledge structure; and, the bottom part shows the process of updating the old knowledge structure when the learner visits the same ubiquitous learning environment again.

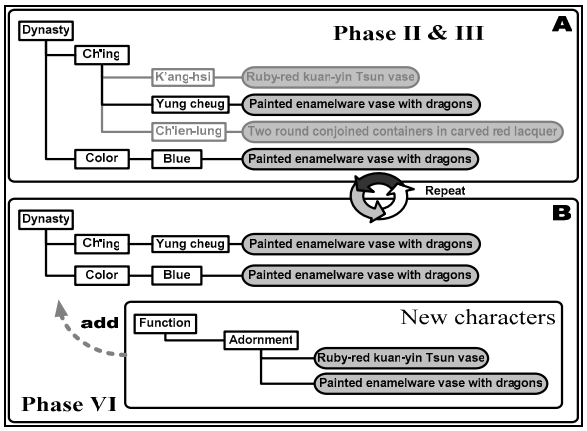


Figure 5. Construction, refinement and learning again

## 4. Complete Example

This section takes learning in a real museum for example. In a museum, there are many artifacts with different subjects and/or topics in the different rooms, for example, the Room 203 in a museum as Figure 6 shows, the "gray area" represents the subjects or topics suchlike "Elegant Living", "In Search of the Ancients", and "The Beauty of Nature"; "black circle" represents the artifacts (the learning objects) in the room. The number is the artifacts id. There are eleven learning objects in Room 203. According the Phase I described in Section 4, this paper wants to analysis results of learning objects and represents how to store the learning objects and its characteristics/attributes in the museum.

The learner then receive the story about the learning object characteristics which analyzed from phase I as Figure 7 shows. The story talks about the porcelain domain, if learner chooses this story, his/her basic personalized context-aware knowledge structure can be built based on the porcelain domain.

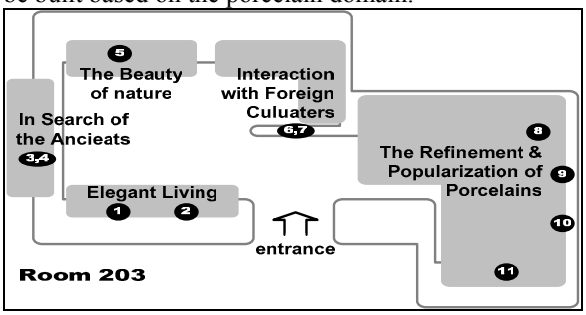


Figure 6. Room 203 in the museum

When the learner comes to the museum, the system first introduces and gives the learner three to five stories. The learner can pick one favorite story up after he/she read, and then the learner will receive the related questions about the story he/she chooses. Finally, the system will construct the personalized context-aware knowledge structure with the feedback from him/her.

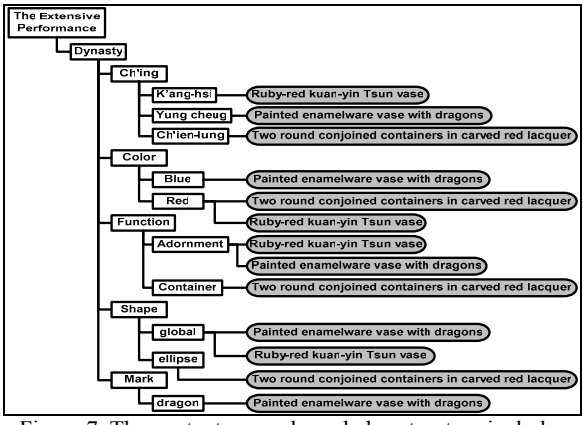


Figure 7. The context-aware knowledge structure includes the subject - "The vehemence of Hui Hong emerges" and the related characteristic - "Dynasty".

Taking the story in Figure 8 for example, after the learner chooses the story B which discusses about the Ming dynasty production domain. The correspondent question asks the learner about what he/she interests with. The different option includes specific characteristics. After the learner selecting a specific option, the system refines the personalized context-aware knowledge structure.

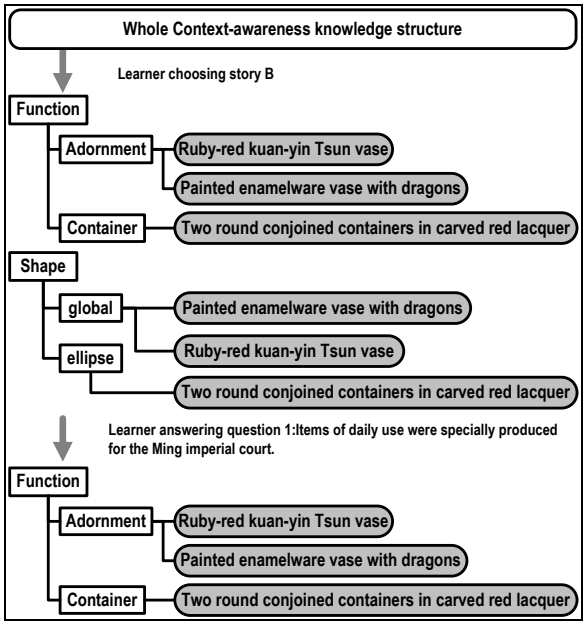


Figure 8. The process of constructing the personalized knowledge structure according to the learner's choices

## 5. Conclusions

This paper proposes a context-awareness knowledge structure for ubiquitous learning environment. The knowledge structure can represent several knowledge domains at the same environment. This research also designs a six-phase personalized knowledge structure construction process. The personalized context-aware knowledge structure can be built according to individual learner's preference and interests. The system uses story and correspondent questions to realize the learner's preference and interests and refines the personalized knowledge structure. If the learner visits the same or similar place again, the system can expand the pre-stored knowledge structure and plan new learning objects for the learner quickly and automatically.

There are still some issues could be discussed to improve the personalized context-aware knowledge structure construction. The first issue, for example, the learners can only choose one option to represent his/her interest now. The system might be able to provide the learner marking his/her preference ordering and apply data mining technique to find out the learner's preference sequence.

The second issue is to monitor the learner's learning behaviors in order to reduce the story and questions number when the learner visits the same place again. Learners' learning activities might also provide the information about their preferences, for example, if a learner spends much more time to observe the Ch'ing dynasty productions, then it might mean that he/she is interesting in either Ch'ing dynasty or the Ch'ing dynasty production.

## References

[1] Y. S. Chen, T. C. Kao, G. J. Yu, and J. P. Sheu, "A Mobile Butterfly-Watching Learning System for Supporting Independent Learning", *In the Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education*, Mar. 2004, Taiwan, pp. 11-18.

[2] A. Chang and M. Chang, "A Treasure Hunting Learning Model for Students Studying History and Culture in the Field with Cellphone", *In the Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies (ICALT 2006),* July 2006, pp.106-108.

[3] G. J. Hwang, "Criteria and Strategies of Ubiquitous Learning", *In the Proceedings of the IEEE International Conference on Sensor Networks, Ubiquitous, and Trustworthy Computing (SUTC 2006),* June 2006, *2*, pp. 72 - 77.

[4] J.D. Novak, "Applying learning psychology and philosophy of science to biology teaching", *The American Biology Teacher*, *43*(1), 1981, pp. 12-20.

[5] J.D.Novak and D.B Gowin, *Learning How to Learn*, New York: Cambridge University Press, 1984.

[6] J. H. Stephen, Yang, "Context Aware Ubiquitous Learning Environments for Peer-to-Peer Collaborative Learning", *Journal of Educational Technology & Society*, *9* (1), 2006, pp. 188-201.

[7] K. Yatani, M. Sugimoto, and F. Kusunoki, "Musex: A System for Supporting Children's Collaborative Learning in a Museum with PDAs", *In the Proceedings of the IEEE International Workshop on Wireless and Mobile Technology in Education*, March 2004, pp. 109–113.