A Computer-Assisted Approach for Designing Context-Aware Ubiquitous Learning Activities

Tzu-Chi Yang[1], Fan-Ray Kuo[2], Gwo-Jen Hwang[2] and Hui-Chun Chu[2]
[1]Department Information Management, National Chi Nan University.
[2]Department of Information and Learning Technology, National University of Tainan.
wilsonyang57@gmail.com,{revonkuo; gjhwang; carolchu}@mail.nutn.edu.tw

Abstract

Recent advance of wireless communication and sensor technologies has leaded the educational conception to a new area, called context-aware ubiquitous learning. The new conception of learning not only depicts significant advantages, but also reveals the difficulty of applying it. The major difficulty is owing to the lack of procedural guidance that assists the teachers in designing learning activities that bring the new learning conception into full play. To cope with this problem, this study proposes a procedural knowledge acquisition strategy for designing context-aware ubiquitous learning activities. In addition, a practical application is presented to show the effectiveness of the innovative approach.

1. Introduction

In recent years, wireless sensor technology has been progressed rapidly, which can transmit and receive messages via various ways of communications, such as coordinate, data, machine codes and temperature. A system equipped with wireless sensor technology is able to collect some states (or called “context”) from real world; that is, the system can sense student information and environmental information in the real world and then provide personalized services accordingly. Such a feature is often called “context awareness” [9].

More and more studies that take advantages of the context awareness features have been reported, especially in the development of ubiquitous learning (u-learning) environments that emphasizes the provision of any time and anywhere learning scenarios. For example, Ogata and Yano developed a system to assist overseas students in Japan to learn Japanese language [13]; Yang proposed a learning environment, which stores resources through peer to peer (P2P) model, for encouraging learning resource sharing [17].

Although the issues concerning web-based learning or mobile learning have been wide discussed, u-learning with context awareness features is still a novel way of learning in terms of research. Although several papers have presented the structure and curriculums for context-aware or ubiquitous learning, the way to design and to create the context-aware u-learning activities is seldom discussed. Past experiences show that developing a learning system by taking personal and environmental contexts into account is time-consuming [7], and planning a u-learning curriculum without any guidance is even more difficult. Therefore, in this paper, an innovative approach, UPAM (U-learning Procedure Acquisition Method), which can help domain experts (teachers) design u-learning activities by taking both the real world and virtual world environments into consideration.

2. Relevant research

In recent years, researchers of e-learning have noticed the progress of wireless communication and sensor technologies; therefore, the research issues have been progressed from e-learning to m-learning (mobile learning) and u-learning. Moreover, several significant characteristics of context-aware u-learning, which make it different from conventional m-learning or the broad-sense u-learning, have been discussed, including seamless services, context-aware services, and adaptive services [7].

2.1 Ubiquitous computing technologies

In recent years, a variety of wireless communication and context-aware products have been developed, such as sensors and actuators, RFID (Radio Frequency Identification) tags and cards, wireless communication equipment, mobile phones, PDAs (Personal Digital Assistant), and wearable computers. In this computing environment, anyone can make use of computers that are embedded everywhere in a public environment at any time. A student equipped with a mobile device can connect to any of them and access the network by using wireless communication technologies [19].

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Moreover, not only can a student access the network actively, but computers around the student can recognize the student's behaviors and offer various services according to the student's situations, the mobile terminal's facility, the network bandwidth, and so on [2]. Researchers call such a new computing conception the ubiquitous computing (u-computing).

Student assistance via u-computing technologies is realized by providing students with proper decisions or decision alternatives. That is, a ubiquitous computing technology-equipped system supplies students with timely information and relevant services by automatically sensing students' various context data and smartly generating proper results [14]. Furthermore, several approaches were purposed for building context ontology, which can be used to describe the structure of context hierarchy and the relationships among different contexts [1], [20].

2.2 Context-aware ubiquitous learning

Although u-learning has attracted lots of attentions from researchers all over the world, the criteria of developing a u-learning environment have not been clearly defined. Till now, researchers have different aspects about the term "u-learning". One aspect is "anywhere and anytime learning", which is a very broad sense definition of u-learning. With this definition, any learning environment allows students to carry mobile learning devices with wireless communication capability is a u-learning environment; that is, such a u-learning scenario is similar to that of the well-known mobile learning, which allows students to access teaching contents via wireless networks in any location at any time.

A stricter definition of u-learning is "learning with u-computing technology", which emphasizes not only the usage of wireless communications but also the sensor technology. The context-aware feature of u-computing environments allows the learning system to better understand the student's behaviors and the timely environmental parameters in the real world, such as the locations and behaviors of the student, the temperature and moisture of the learning environment [21]. Such contexts could be brief or detailed; for example, the location of the student could be described by a zip code or a physical address. In the following discussions, we shall focus on such a definition of u-learning and call it "context-aware u-learning" to distinguish it from the broad sense definition.

Among various contexts that can be sensed, researchers have indicated that "time" and "location" may be the most important and fundamental parameters for recognizing and describing a student's context [10]. For example, Ogata and Yano developed a u-learning system, which has been used to conduct students to learn Japanese under real-world situations [13]. The systems can provide students with appropriate expressions according to different contexts (e.g., occasions or locations) via mobile devices (e.g., PDA- Personal Digital Assistant). Rogers [16] integrated the learning experiences of indoor and outdoor activities by observation in the working scene. Students not only are capable of getting data, voice and images from the scene by observations, but also of gathering related information from learning activities via wireless networks. Recently, Joiner, Nethercott, Hull, and Reid [8] presented their studies of using context-aware devices applied in education by timely offering vocal statements of activities for students in the real conditions.

In the meanwhile, researchers attempted to find some principles and methods for designing u-learning activities. For example, Cheng et al. [3] demonstrated how a u-learning system provides adaptive services via four steps: (1) Setting instructional requirements for each of the student's learning actions. (2) Detecting the student's behaviors. (3) Comparing the requirements with the corresponding learning behaviors. (4) Providing personal support to the student.

Such a learning environment basically consists of the following components: (1). A set of sensors that are used to detect personal contexts (e.g., location and body temperature of the students) of and environmental contexts (e.g., temperature and moisture of the learning environment). (2). A server that records the contexts and provides active and passive supports to the students. (3). A mobile learning device for each student with which the student can receive the support or guide from the server as well as access information on the Internet. (4). Wireless networks that enable the communications among the mobile learning devices, the sensors and the server.

Another issue raised with context-aware u-learning is the representation of the interactions of all objects in the learning environment. It is an important and challenging issue for both of the system developer and the domain experts to define a u-learning course or activity that takes personal contexts and environmental contexts into considerations [7]. Henricksen and Indulska proposed a Context Modeling Language (CML), which reformulates the modeling concepts as extensions to Object-Role Modeling (ORM) [9]; Yuan and Chen used Resource Description Framework (RDF) and Resource Description Framework Schema (RDFS) to represent the context information of various learning scenarios [18]. In the meanwhile, an intelligent decision-making strategy and domain expert system with context-aware capability were also proposed [15]. In the following sections, a U-learning Procedure Acquisition Method (UPAM) is proposed based on the notations of these approaches.

3. U-learning procedure acquisition method (UPAM)

In a context-aware u-learning activity, several kinds of interactions between the students and the real-world contexts need to be taken into accounts. Usually, the domain expert will conduct several learning activities in a course unit. Each learning activity consists of several phases to guide the students to different learning contexts; furthermore, a phase consists of some relevant steps. Usually a learning activity is allowed to halt among phases; nevertheless, it would be better to prevent from the halt of the learning activity among steps, unless some accident has happened.

Three kinds of learning activities can be conducted in a context-aware u-learning environment.
(1). Learning material presentations based on the sequence of curriculum defined by the domain expert. Learning sequence and context awareness for this kind of curriculum design is not absolutely required. The learning sequence is set for making learning more systematic by guide students to learn in the real world with the supplemental materials provided by the learning system. In such a learning activity, usually the learning sequence would not affect the learning result. (2). A sequence of learning steps that guide the student to identify or classify a set of real-world objects. The purpose of the curriculum design not only emphasizes the learning sequence, but also evaluates if the students understand the concepts to be learned. Therefore, for such a learning activity, the learning sequences need to be more strictly followed than that of the former. (3). The training of a series of equipment operations as well as the operating procedure. The operating procedure and the operations of the equipment are highly correlated. The learning sequence of such a learning activity must be entirely followed.

According to the foregoing and the past experiences, we propose a U-learning Procedure Acquisition Method, short for UPAM, to assist domain experts to plan the context-aware u-learning activities in a more efficient and effective manner.

The UPAM algorithm consists of three phases: the first phase is to get context parameters for the learning activities; the structure of the learning activities is defined in the second phase; the content and relevant conditions for each learning step are defined in the third phase. In addition, this approach not only provides preview service to prevent the domain expert from feeling irritable, but also shows the progress of content acquisition to the experts. The UPAM algorithm is given as follow:

Phase 1: *Define context-aware parameters to be considered.*
1.1: Initially, Learning Area Set (LAS) is defined as the main activity zone and the Context Parameter Set (CPS) is defined as the environmental parameters of the main activity zone.
1.2: While (there are more sub-activity areas to be identified in the main activity area)
{
Add the new activity area to LAS and the corresponding environmental parameters to CPS.
}
1.3: FOR (each Sub-activity area i)
{
For (each device j in Sub-activity area i)
{
Add device j and the corresponding context parameters to CPS.
}
}
1.4: Add personal context parameters of the students to CPS.
1.5: Add the parameters of personal profile and learning portfolios to CPS.
1.6: Define the possible feedbacks that will be sent to the students via the mobile devices.

Phase 2: *Define the structure of the learning activity.*
2.1 Set the general attributes for the learning activity.
2.2 Construct the conspectus of the learning activity.
2.3 Preview the conspectus of the learning activity.

Phase 3: *Provide content and conditions for each learning step.*
3.1: FOR (each learning phase)
{
Give teaching content for each learning step in the phase.
Define finishing conditions for each learning step in the phase.
Confirm finishing conditions for each learning step in the phase.
Preview the teaching content and the learning procedure in the phase
}
3.2: Preview the entire procedure of curriculum (Optional).

In order to clearly present the results acquired by UPAM. Five context-aware parameters are used to define the structure of UPAM [6]:

(1) Personal context, including student's location, arrival time, body temperature, heartbeat rate, blood pressure etc. (2) Environmental context, including sensor's ID, location, temperature, humid, gradient of atmosphere and other environmental context and objects around the sensors. (3) Feedback returned from sensors equipped on learning device, which includes data from target object, such as temperature, pH of water, value of air pollution, shape of tree and color. (4) Personal information and learning portfolio derived from, including student's calendar, starting time to learning activity, the shortest and longest time to learn activity, internet on-line discussing statement, learning place, learning portfolio and sequence and the restriction of learning activity etc. (5) Environmental information derived from database, including detailed information about learning place, such as sequence of learning activity, location limitation and management rules, usage records, in location and equipments in learning place.

Although several previous studies have mentioned the use of the context-aware parameters in the learning activities, it is difficult for both the domain experts to define the context-aware parameters while designing the learning activities. The learning system developers might be more aware of the context-aware parameters; however, they are not the learning activity designers. Therefore, the most efficient and effective way of defining the parameters is to show the domain experts the candidate parameters and to guide them to make decisions, which is the strategy used in UPAM.

In addition to the definition of context-aware parameters, UPAM guides the domain experts to complete various contents for the learning activities, including (1) Context-aware parameters and architecture for curriculum; (2) Teaching content, procedure and finishing conditions for each step; (3) Additional information, such as expected learning path and the estimate for wireless sensor devices deployed. The learning path depends on the combination of curriculum scheme and complete condition of each step. Moreover, the estimate of wireless sensor devices relies on the integration of complete conditions for each step and context-aware parameters. Next section we will take case study to introduce how UPAM to be executed.

4. Development of a computer-assisted u-learning activity design system

To demonstrate the usefulness of our innovative approach, two experts with great experiences in planning u-learning curriculums were asked to organize the context-aware learning activity of a science course with UPAM. Sixth-grade students are the main students, and the aim of curriculum is to understand seasons changed on the Earth and time differences in different areas of the world.

The learning activity consists of a sequence of learning targets specified and organized by the teachers, such that the students can learn the domain knowledge by observing the real world objects with the guidance and support from the digital world. The learning system will actively and timely guide student to operate equipments, which may improve student's learning effect.

Illustration and system presentation for UPAM are shown in Figure 1. In phase 1, UPAM asked the expert to provide context-aware parameters by showing the most frequently used attributes. If none of the default parameters is preferred, the expert can add new parameters to the candidate attribute list.

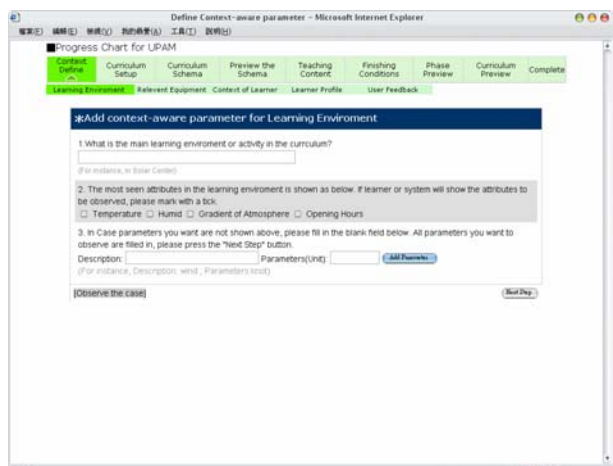

Figure 1. Context-aware Parameters Acquisition

After defining the context-aware parameters, the expert was asked to organize the learning events of the curriculum and establish dependent relationships among the parameters and the events. In order to manage the sequence of the learning events, it is necessary to set up finishing conditions for each step. During the learning process, the learning system will acquire learning contexts from the sensors or the mobile devices, and compare them with expected values. For the contexts that cannot be acquired from the sensors, such as the comprehension status of the student, the learning system will try to acquire the contexts by ask questions to the student through the mobile device. That is, the experts need to provide questions and the corresponding answers in advance.

Here is the scenario for illustrating these steps. First, students will be appointed to a projection screen; besides, they need to watch an appointed movie then. System will ask them the question after 10 seconds they arrive the appointed place, “What scene do you see in the movie? Option A, option B, option C.” The students are allowed to proceed to the next step if they select the correct answer.

If the step can not be completed after several trials, which implies that the students have encountered a problem in the learning activity, there are three alternative ways to deal with the situation (as shown in Figure 2):

(1) Lead to the specific step.
(2) Let the student select one of the following actions: “keeping the record and go next step”, “Asking the domain expert for help” and “Asking the classmates who have completed the step for help”.
(3) Inform the domain expert to terminate the current learning activity.

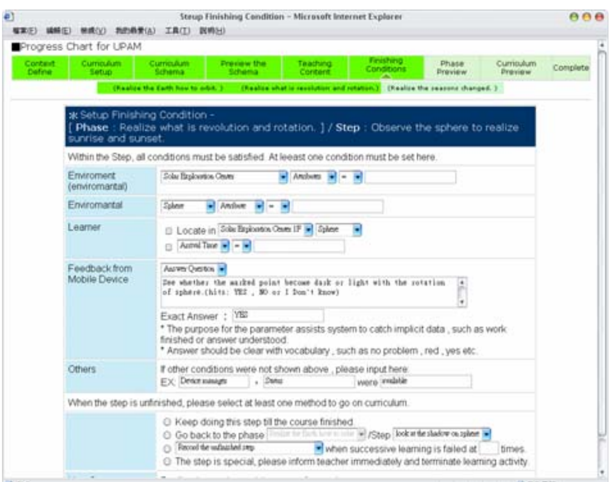

Figure 2. Setup finishing conditions

While assisting the domain expert to design learning activities, the UPAM will output related documentations accordingly, including: (1) Context-aware parameters, as shown in Tables 1 and 2. Table 1 depicts the context-aware parameters that the environment need as well as the relationships among them. Table 2 shows the parameters for describing the context of the student, the basic data and the learning portfolio of the student, and the feedbacks from the student. (2) Teaching content and procedure of the curriculum, as shown in Figure 3. (3) Additional information, such as learning sequence and the target locations for sensing students’ arrival, as shown in Table 3.

Table 1. Category for Context-aware Parameters

Context of the learning environment & Environmental data			
Major active area	attributes		
(Tropic of Cancer Solar Exploration Center)	(Opening hours)		
Sub active are area	attributes	equipments	Attributes of equipment
(The Nine Planets Exhibition Chamber)	(Opening hours)	(Projection Screen)	(Location) 、(Administrator)
		(Globe)	(Opening hours) 、(Location)
(World Time clock Exhibition Chamber)	(Opening hours)	(Projection Screen)	(Opening hours) 、(Location) 、(Administrator) 、(Usage status)
		(World Time clocks)	(Location)
…	…	…	…

Table 2. Context-aware parameters

(Context of Student)
(Location Info.)
(Student's profile and on-line behaviors)
(Tutor) 、(Name) 、(Reservation) 、(Emergency call) 、(Related experience)...etc.
(Student's feedbacks)
Multiple-choice Q&A

Table 3. Additional Information

Expected learning sequence of the curriculum.
[The Nine Planets Exhibition Chamber] → [The Nine Planets Exhibition Chamber- Globe] → [The Nine Planets Exhibition Chamber - Projection Screen] → [World Time clock Exhibition Chamber] → World Time clock Exhibition Chamber -[World Time clocks] → [World Time clock Exhibition Chamber - Projection Screen]…
Make sure the place where students must arrive.
[Tropic of Cancer Solar Exploration Center] [The Nine Planets Exhibition Chamber - Globe] [The Nine Planets Exhibition Chamber - Projection Screen] [The Nine Planets Exhibition Chamber] [World Time clock Exhibition Chamber - World Time clocks] [World Time clock Exhibition Chamber - Projection Screen] …

Figure 3 shows the UPAM interface for defining teaching materials, relevant parameters and finishing condition of each step.

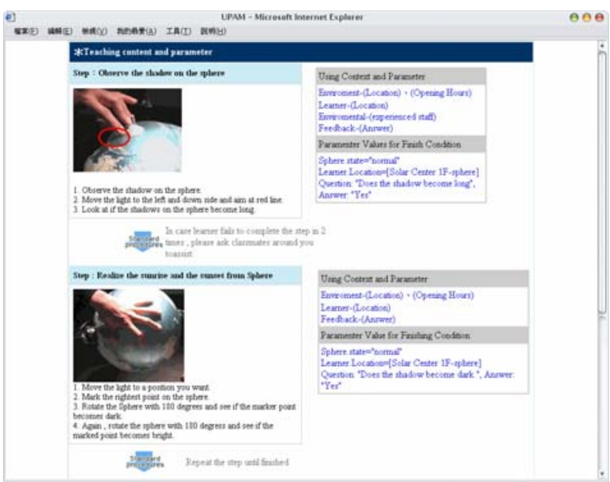

Figure 3. Teaching content and planned procedure

5. Conclusions and feature research

In this study, an innovative approach, UPAM, to acquire related data for curriculum is proposed, which can assist the domain experts to scheme curriculum in an efficient and effective way with friendly student interfaces. UPAM will produce some useful references, such as context-aware parameters, teaching content, planned procedure and additional information while guides the domain experts to design the learning activities. From the practical application on a science course, it can be seen that UPAM is capable of improving the efficiency and effectiveness of creating context-aware u-learning activities. In the future, more practical experiments will be conducted by applying UPAM to various kinds of science and language courses.

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