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The definition and characteristics of ubiquitous learning: A discussion

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ABSTRACT

This article describes a new learning paradigm, known as ubiquitous learning or u-learning, which is supported by the ubiquitous computing technologies. Instead of that, the article also aims at providing fundamental information related to u-learning for researchers who are interested in venturing this new area of ubiquitous computing. The u-learning definition and characteristics are compared and discussed in proposing a conclusive definition of u-learning together with its characterization. Finally, some of the u-learning applications are explained to further enhance the understanding of u-learning concept.

Keywords: *Ubiquitous Computing, Ubiquitous learning, u-learning; definition; characteristic.*

INTRODUCTION

Ubiquitous computing can be considered as the new hype in the information and communication world. It is normally associated with a large number of small electronic devices (small computers) which have computation and communication capabilities such as smart mobile phones, contactless smart cards, handheld terminals, sensor network nodes, Radio Frequency IDentification (RFIDs) etc. which are being used in our daily life (Sakamura & Koshizuka,2005). These small computers are equipped with sensors and actuators, thus allowing them to interact with the living environment. In addition to that, the availability of communication functions enables data exchange within environment and devices. In the advent of this new technology, learning styles has progressed from electronic-learning (m-learning) to mobile-learning (m-learning) and from mobile-learning to ubiquitous-learning (u-learning).

Ubiquitous learning, also known as *u-learning* is based on ubiquitous technology. The most significant role of ubiquitous computing technology in u-learning is to construct a ubiquitous learning environment, which enables anyone to learn at anyplace at anytime. Nonetheless, the definition and characteristic of u-learning is still unclear and being debated by the research community. Researchers have different views in defining and characterizing u-learning, thus, leads to misconception and misunderstanding of the original idea of u-learning.

Therefore, this article aims at providing fundamental information pertaining to u-learning; specifically for the researchers who are interested in venturing this newly established area of ubiquitous computing. In this article, the concept of ubiquitous computing and how the technology is applied in learning environment will be discussed. Later, we will review various attempts to define and provide characterizations of u-learning. Finally, we will present our own definition and characterization of u-learning and discuss some applications in u-learning.

UBIQUITOUS COMPUTING

According to Sakamura & Koshizuka (2005), ubiquitous computing can be considered as “a new trend of information and communication technologies”. The term “ubiquitous computing” was coined by late Mark Weiser (1952 – 1999), described as “the calm technology, that recedes into

the background of our lives". His vision allows people and the environment with the combination of various computational technologies to exchange information and services at anytime and anywhere (Weiser, 1991).

Ubiquitous Computing Technologies

Computing and communication technologies are among the key technologies that forming ubiquitous computing. The advancement of computing technologies together with the enhancement of wireless communication technologies nowadays help out to support the expansion of ubiquitous computing. In recent years, a variety of computing and communication technologies 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.

Ubiquitous Computing Technologies in Learning

A person is said to be learning, when he/she is in the process of acquiring knowledge or skill. Therefore, it cannot be assumed that by pouring a person's head with information, he/she is said to be learning. Knowledge is acquired through interaction between individual and the environment. Therefore, many researchers and learners believe that *learning by doing* (Schank, 1995) is the best way for learning. Learning by doing teaches implicitly rather than explicitly but things that are learned implicitly need only be experienced in the proper way at the proper time. Thus, we need to allow students to be in an environment that is useful to their interests. However, this way of learning is difficult to apply without having a proper methodology to obtain learning information from the real situations. With the advancement and deployment of ubiquitous computing technologies, the process of learning from the environment becomes easier. This is when the technology allows the process of information sharing and communication to happen naturally, constantly and continuously throughout the day. For instance, a student equipped with a mobile device can connect to any other devices, and access the network by using wireless communication technologies (Uemukai et al., 2004). In addition, it is also suggested that the computers used by the student would be able to supply students with information and relevant services when they need it, by automatically sensing the context data and smartly generating what is required (Cheng & Marsic, 2002). This vision was also shared by Yang et al. (2006).

UBIQUITOUS LEARNING

Ubiquitous learning or u-learning is a new learning paradigm. It is said to be an expansion of previous learning paradigms as we move from conventional learning to electronic-learning (e-learning) and from e-learning to mobile-learning (m-learning) and now we are shifting to u-learning. Three of these major learning paradigms which include e-learning, m-learning and u-learning will be compared in the next section to provide further understanding of the learning concepts.

Various Definitions of U-Learning

According to Lyytinen & Yoo (2002), "the evolution of ubiquitous computing has been accelerated by the improvement of wireless telecommunications capabilities, open networks, continued increases in computing power, improved battery technology, and the emergence of flexible software architectures". This leads to u-learning that allows individual learning activities embedded in daily life. However, as mentioned by Hwang (2008), there is no clear definition of u-learning due to rapid changes of the learning environments. Until now, researchers have different views in defining the term "u-learning".

Figure 1 illustrates the classification of four learning environments according to Ogata and Yano (2004) with reference to four dimensions of ubiquitous computing by Lyytinen and Yoo (2002). From the figure, it was observed that the *Desktop-Computer Assisted Learning* systems provide low mobility and low level of embeddedness. Therefore, the learning environment is fixed. Compared to desktop-computer assisted learning, *Mobile Learning* is basically about increasing learners' capability in order to hold together their learning environment, thus enabling them to learn at anytime and anywhere. In *Pervasive Computing*, learner may obtain information from their learning environment via the communication between the embedded devices and environment. However, this makes the availability of pervasive learning are highly localized and limited. These limitations of pervasive learning have been overcome by *Ubiquitous Learning* through the integration of high mobility into the learning environment. The communication between devices and the embedded computers in the environment allows learner to learn while they are moving, hence, attaching them to their learning environment. It is obviously shows that the level of embeddedness and mobility of devices do have a significant impact on the learning environment.

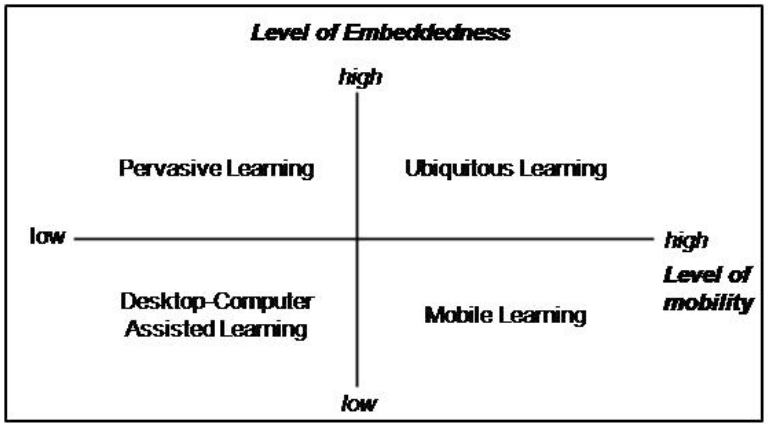

Figure 1: Classification of learning environments. (Ogata and Yano, 2004)

Ogata et al. (2004) introduced their definition of u-learning by comparing the classification of learning environments. From the comparison, the researchers categorized both pervasive learning and mobile learning as ubiquitous computing. Later, study by Dey Casey (2005) supported this definition when he formulated the view of "u-learning = e-learning + m-learning" from the integration of m-learning into e-learning environments in order to form u-learning environments. However, the term u-learning environment (ULE) applies in both definitions are quite confusing. The terms "u-learning" and "u-learning environment" hold different meaning. In general, the term "u-learning environment" is used to support the overall definition of u-learning. According to Boyinbode & Akintola (2008), "U-learning environment (ULE) refers to a situation or setting of pervasive learning". In addition, according to Jones et al. (2004), in ULE, students can become totally immersed in the learning process. So, it is clearly shows that u-learning should be implemented in a u-learning environment.

A broader definition of u-learning is "anywhere and anytime learning". The definition is referring to any environment that allows any mobile learning devices to access the learning and teaching contents via wireless networks in any location at anytime. To compare with, m-learning has been defined as "learning that takes place via wireless devices such as mobile phones, Personal

Digital Assistants (PDAs), or laptop computers" (Dochev & Hristov, 2006). Apparently, these definitions are almost alike. However, when learner's mobility is concern, the definition is much more significant to mobile learning concept as learning goes on everywhere. Therefore, the u-learning definition needs to be clearly defined to avoid from any misconception while applying the terms.

To hold the principle of "anywhere and anytime learning", the definition has been expanded. The commonly used definition of u-learning is "learning with u-computing technology" (Yang et al., 2008). Even so, the definition has been argued by Hwang et al. (2008) who claim that "learning with u-computing technology" is a more appropriate for m-learning. As the result, the term "context-aware u-learning" is used to distinguish the definition of u-learning and the concept of m-learning. Concretely, RFIDs, contactless smart cards, sensor network nodes, and mobile devices are parts of ubiquitous computing technology. As a final point, u-learning can be defined as "a new learning paradigm in which we learn about anything at anytime, anywhere utilizing ubiquitous computing technology and infrastructure" (Sakamura & Koshizuka, 2005; Boyinbode & Akintola, 2008).

The Proposed Definition of U-learning

The terms "anywhere and anytime learning" and "learning with ubiquitous computing technology" raise confusion between researchers. Thus, we propose the following definition of u-learning.

U-learning is a learning paradigm which takes place in a ubiquitous computing environment that enables learning the right thing at the right place and time in the right way.

We believe that the definition makes it easier for the researchers in understanding the concept of u-learning and assist them in further exploration of the area. As for the developers, it might support them in the process of planning and developing an application based on a given scenario. According to Mark Weiser (1991), ubiquitous computing is the method of increasing the usage of computers and makes it available throughout the physical environment. As a result, the computers will be effectively invisible to the user, and eventually blend into their daily lives.To support the statement, Zhang (2005) defines ubiquitous computing environment as "a well-defined area that incorporates a collection of embedded systems (computers, sensors, user interfaces, and infrastructure of services) which is enhanced by computing and communication technologies". Therefore, we make it essential to include ubiquitous computing environment in the definition as to clearly distinguish between the definition on u-learning and the concept of m-learning.

In this definition also, we avoid using the term "anything, anywhere and anytime". This is due to the challenge of an information-rich world in providing the right thing, at the right time, at the right place the right way (Fisher, 2001) and not only to make information available at anytime, anyplace, and in any form. The main purpose of doing so is to help out learners in getting the exact information that they are looking for at the moment.

Characteristics of U-Learning

At this point of discussion, perhaps we can conclude that the objective of u-learning is to provide the right information at the right time and place for accommodating life and work style. Even though u-learning has attracted the attention of researchers, the criteria or characteristics for the establishment of u-learning are still unclear (Hwang, 2006). For that reason, there have been various attempts to identify u-learning characteristics.

Chen et al. (2002) identify six characteristics of m-learning and ever since then have been adapted by various researchers to be part of the u-learning characteristics. The characteristics are *urgency of learning need, initiative of knowledge acquisition*, *mobility of learning setting*, *interactivity of learning process, situating of instructional activity,* and *integration of instructional content.*

The first attempt in proposing the u-learning characteristic was by Curtis (2002). Compared to Chen, Curtis listed characteristics that were based on three unique key affordances to handheld computing. The characteristics which include *permanency, accessibility,* and *immediacy* have been acknowledged by other researchers (Ogata, 2004; Ogata & Yano, 2004; Chiu, 2008) to be the most prominent for u-learning.

Hiroaki Ogata and Yoneo Yano (2004) expanded the characteristics by considering the learners mobility within the embedded-computing environments. They manage to identify another two major characteristics of u-learning, which are *interactivity* and *situating of instructional activities.* Therefore, with reference to Chen et al. (2002) and Curtis et al. (2002), the major characteristics of u-learning are *permanency, accessibility, immediacy, interactivity* and *situating of instructional activities.*

In previous discussion, Hwang et al. (2008) found that it is more appropriate to apply "context-aware u-learning" when defining the term u-learning. In reference to the definition, he proposed several significant characteristics of u-learning which include *seamless services, context-aware services* and *adaptive services.*

Finally, Chiu et al. (2008) considered utilizing context-aware and ubiquitous computing technologies in learning environments that encourage the motive and performance of learners. Hence, he summarized the main characteristics of u-learning as follows: *urgency of learning need*, *initiative of knowledge acquisition*, *interactivity of learning process*, *situation of instructional activity, context-awareness*, *actively provides personalized services, self-regulated learning*, *seamless learning*, *adapt the subject contents,* and *learning community.*

The Proposed Characteristics of U-Learning

We summarize the characteristics that have been put forward by the researchers and discover that there are considerable overlaps between the characteristics as shown in Table 1. After analyzing the table, we propose five characteristics from the combination of the researchers' ideas and take into account the major differences. The characteristics are:

- *Permanency*: The information remains unless the learners purposely remove it.
- *Accessibility*: The information is always available whenever the learners need to use it.
- *Immediacy*: The information can be retrieved immediately by the learners.
- *Interactivity*: The learners can interact with peers, teachers, and experts efficiently and effectively through different media.
- *Context-awareness*: The environment can adapt to the learners real situation to provide adequate information for the learners.

With reference to Table 1, it is obviously indicate that *permanency*, *accessibility*, *immediacy* and *interactivity* are considered as common characteristics of u-learning. Instead of that, we also agree that context-awareness is the major characteristic that distinguishes u-learning from others. Dey & Abowd (2000) define context-awareness as "the ability of a program or device to sense various states of its environment or itself". As according to them, location, identity, time, and environment are the primary context types for characterizing the situation of a particular entity. In a ubiquitous learning environment, it is difficult for a learner to know that the other learner has the

same knowledge even that though they are at the same location. In this case, the learner needs to be aware of the other learners' interests that match his interest. Therefore, by referring to Table 1, it is obvious that adaptability, situating of instructional activities and seamless learning characteristics are part of context - awareness characteristic.

***Table 1**: Comparison of U-Learning Characteristics.*

Chen et al., 2002	Curtis et al., 2002	Ogata, 2004	Hwang, 2008	Chiu et al., 2008	Proposed characteristics
Urgency of learning needs	Permanency	Permanency	Seamless services	Urgency of learning need	Permanency
Initiative of knowledge acquisition	Accessibility	Accessibility	Context-awareness	Initiative of knowledge acquisition	Accessibility
Mobility of learning setting	Immediacy	Immediacy	Adaptive services	Interactivity of learning process	Immediacy
Interactivity of learning process		Interactivity		Situation of instructional activity	Interactivity
Situating of instructional activity		Situating of instructional activities		Context-awareness	Context-awareness
Integration of instructional content				Actively provides personalized services	
				Self-regulated learning	
				Seamless learning	
				Adapt the subject contents	
				Learning community	

Together in this study, the comparison of three major learning paradigms is shown in Table 2.

***Table 2**: Comparison of Learning Paradigms.*

Criteria	u-learning	m-learning	e-learning
Concept	Learn the right thing at the right place and time in the right way.	Learn at the right place and time.	Learn at the right time.
Permanency	Learners can never lose their work.	Learners may lose their work. Changes in learning devices or learning in moving will interrupt learning activities.	Learners can lose their work.
Accessibility	System access via ubiquitous computing technologies.	System access via wireless networks.	System access via computer network
Immediacy	Learners get information immediately.	Learners get information immediately in fixed environments with specified mobile learning devices.	Learners cannot get information immediately.
Interactivity	Learners' interaction with peers, teachers, and experts effectively through the interfaces of u-learning systems.	Learners can interact with peers, teachers, and experts in specified learning environment.	Learners' interaction is limited.
Context-awareness	The system can understand the learner's environment via database and sensing the learner's location, personal and environmental situations.	The system understands the learner's situation by accessing the database.	The system cannot sense the learner's environment.

UBIQUITOUS LEARNING APPLICATIONS

Figure 2 depicts the scenario of u-learning. For instance, when a student gets into the lab or stands in front of an instrument, the devices will sense and detect the situation of the student and transfer the information to the server. All the related rules and procedures will be displayed to the student based on the information received.

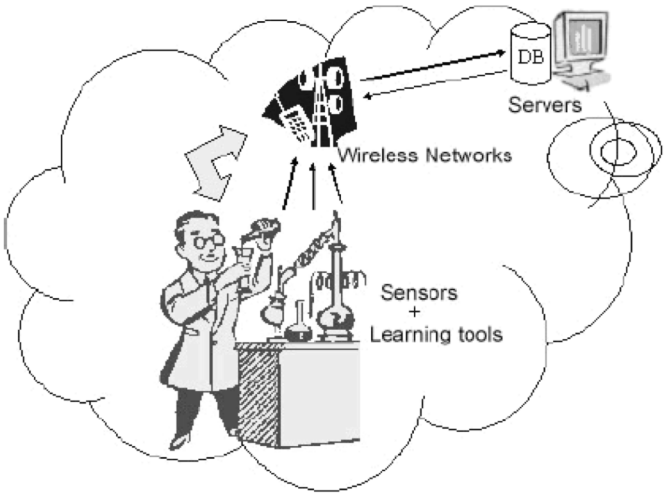

***Figure 2**: Concept of U-Learning (Kuo et al., 2007)*

Currently, ubiquitous learning is carried out in various educational settings and investigated in different directions such as ubiquitous pedagogy, classroom-centered u-learning mode, specific curriculum centered u-learning mode, faculty education for the implementation of u-learning, development standards of u-learning resources and development of u-learning instructional management system (Zhang, 2008; Bomsdorf, 2006).

Most of u-learning applications are extended from ubiquitous computing projects. Ken Sakamura (cited in Sakamura & Koshizuka, 2005) has been leading ubiquitous computing research projects for more than 20 years since 1984. The first ubiquitous computing project is the TRON (The Realtime Operating System Nucleus) Project, which involves the development of a group of real-time operating systems for ubiquitous computing environments. Sakamura proceeded with the Ubiquitous ID Project in 2003 where his team managed to establish new information and communication infrastructure of ubiquitous computing for the 21st century and also developed and deployed the new ubiquitous computing architecture, Ubiquitous ID Architecture that enables various context-aware information services at anytime and anywhere.

In fact, u-learning applications started to bloom in early 2000. In 2004, Hiroaki Ogata together with his team introduced Tag Added Learning Objects (TANGO), a computer which supported ubiquitous learning project for supporting learning in the real world. Later, u-learning applications started to focus on language learning systems such as Japanese Polite Expressions Learning Assisting System (JAPELAS), Japanese Mimicry and Onomatopoeia Learning Assisting System (JAMIOLAS) and Language-learning Outside the Classroom with Handhelds (LOCH). (Ogata & Yano, 2004).

Instead of supporting language learning, u-learning is used to enhance the functions of museums through digital technology. Another important project which utilizes the concept is food traceability project which mainly targets to increase the visibility of total food chain. The traceability function based on u-learning concept is also possible to be applied in drug traceability, which is useful for u-learning of drugs. Most importantly, the system of u-learning should not be a special system only for ubiquitous learning, but it should be generally used for other applications as well.

CONCLUSION

The advancement of computing and communication technologies have promoted the learning paradigms from conventional learning to e-learning, from e-learning to m-learning and now it is evolving to u-learning. U-learning aims at accommodating learners in their learning style by providing adequate information at anytime and anywhere as they wish for it. To promote a more effective application of u-learning, we have provided definitions and characteristics of u-learning. These definitions and characteristics will assist researchers in understanding the concept of u-learning and help application designers to plan and develop u-learning applications. Based on the definitions and characteristics, we have proposed our own u-learning definition and characteristics which incorporates the previous definition. In addition, the proposed definition also introduced a more meaningful term which agrees with the current learning environment. In an effort to substantiate this claim, we have done comparison between established definitions, characteristics and other learning paradigms. Through the use of these definitions and characteristics, we hope to further increase our understanding of u-learning.

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