

Looking into the Definition and Characteristics of U-Learning

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ABSTRACT

This paper describes a new learning paradigm, known as ubiquitous learning or u-learning, which is supported by the ubiquitous computing technologies. In addition, the paper also aims at providing specific information related to u-learning for researchers who are interested in venturing the new area of ubiquitous computing. The u-learning definition and characteristics are also compared and discussed. As a result, a conclusive definition of u-learning together with its characterization is proposed. 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

1.0 INTRODUCTION

Ubiquitous computing is a new trend of information and communication technologies, that utilize a large number of small computers with/out communication capabilities such as handheld terminals, smart mobile phones, sensor network nodes, contactless smart cards, Radio Frequency IDentification (RFIDs) and so on into the invisible part of everyday 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 e-learning to m-learning (mobile learning), and from m-learning to u-learning (ubiquitous 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 constructing 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 paper aims at providing specific information pertaining to u-learning; specifically for the researchers who are interested in venturing this newly established area of learning paradigm. In this paper, 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.

The outline of this paper is as the following: the introduction to the concept of ubiquitous computing and ubiquitous learning, supported with the illustration of u-learning scenario. This is followed by evaluation and discussion on the definition and characteristics of u-learning. Finally, some of the u-learning applications are explained and the conclusion is presented.

2.0 UBIQUITOUS COMPUTING

Ubiquitous computing is a new trend of information and communication technologies (Sakamura & Koshizuka, 2005). The term “ubiquitous computing” was coined by the 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).

2.1 Ubiquitous Computing Technologies

In recent years, a variety of wireless communication and sensor 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. A student equipped with a mobile device can connect to any of the devices and access the network by using wireless communication technologies (Uemukai et al, 2004).

Moreover, not only can a student access the network actively, but computers around the student can also 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 (Cheng & Marsic, 2002). 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 (Yang et al, 2006).

2.2 Ubiquitous Computing Technologies in Learning

Learning is a process of gaining knowledge or skill. One of the ultimate goals of "learning" is to increase the quality of our daily life. However, learning is not an automatic consequence of pouring information a learner's head. Knowledge is acquired through interaction between individuals and the environment. Many researchers and learners believe that *learning by doing* (Schank, 1995) is the best way for learning. Learning by doing works 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. Thus, 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.

3.0 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 e-learning and from e-learning to m-learning and now we are shifting to u-learning.

3.1 Scenario of Ubiquitous Learning

Figure 1 depicts the scenario of u-learning environment. 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.

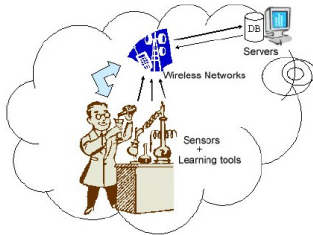


Figure 1: Concept of U-Learning (Kuo et al, 2007)

3.2 Previous Definitions of U-Learning

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 (Lyytinen & Yoo., 2002). This leads to ubiquitous learning (u-learning) that allows individual learning activities embedded in daily life. However, since the learning environments change so quickly, u-learning has not yet been clearly defined (Hwang, 2008). Until now, researchers have different views in defining the term “u-learning”.

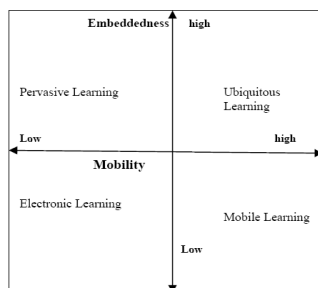


Figure 2: Classification of Learning Environments (Lyytinen & Yoo, 2002)

The view of “u-learning = e-learning + m-learning”, formulated from the integration of mobile learning (m-learning) into e-learning environments to form u-learning environment (Casey, 2005). This study supports the definition introduced by Ogata et al. (2004). The researchers categorize both pervasive learning and mobile

learning as ubiquitous learning through a comparison of four learning environments (Figure 2). However, the term u-learning environment (ULE) applies in the definitions may confused other researchers as well. The terms u-learning and u-learning environment hold different meaning. In general, the term ULE is used to support the overall definition of u-learning. U-learning environment refers to a situation or setting of pervasive learning (Boyinbode & Akintola, 2008) where students can become totally immersed in the learning process (Jones et al., 2004). 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, mobile learning (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 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).

3.3 New 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.

The definition makes it easier for the researchers in understanding the concept of u-learning and planning for further exploration in the area. As for the developers, it might assist them in the process of planning and developing an application based on a given scenario.

Mark Weiser indicated that ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user and will eventually blend into our daily lives. Based on the Weiser's view, ubiquitous computing environment is 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 (Zhang, 2005). Therefore, it is essential for us to include ubiquitous computing environment in the definition to clearly distinguish 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.

3.4 Existing Characteristics of U-Learning

U-learning aims to accommodate the life and work style by providing information at the right time and place the right way. 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 as the followings:

- *Urgency of learning need*: Mobile computing is used when there is something that is urgent for the learner
- *Initiative of knowledge acquisition*: Information provided by the wireless applications is based on the learners' requests. Therefore, learning becomes more self-directed
- *Mobility of learning setting*: Wireless technology makes it possible for learning to occur anytime and anywhere
- *Interactivity of learning process*: With wireless computing, the communication is efficient and effective. Students can interact with peers, friends, instructors, or materials through different media like audio, video, image or text

- *Situating of instructional activity*: With wireless applications, learning could be incorporated in the daily life. It promotes authentic learning
- *Integration of instructional content*: The wireless learning environment integrates many information resources and supports learners to do un-linear, multi-dimensional, and flexible learning and thinking.

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. These characteristics have been acknowledged by other researchers (Ogata & Yano, 2004, Chiu, 2008) to be the most prominent for u-learning. The characteristics are:

- *Adaptability*: Learners can get the right information at the right place with the right way.
- *Permanency*: Learners never lose their work unless it is purposefully deleted.
- *Accessibility*: Learners have access to their documents, data, or videos from anywhere.
- *Immediacy*: Wherever learners are, they can get any information immediately.

Most of the researchers refer to the characteristics that are proposed by Ogata & Yano in 2004. With reference to Chen et al. (2002) and Curtis et al (2002), they manage to identify the major characteristics of u-learning which comprise of the followings:

- *Permanency*: Learners never lose their work unless it is purposefully deleted. In addition, all the learning processes are recorded continuously every day.
- *Accessibility*: Learners have access to their documents, data, or videos from anywhere. That information is provided based on their requests. Therefore, the learning involved is self-directed.
- *Immediacy*: Wherever learners are, they can get any information immediately. Thus, learners can solve problems quickly. Otherwise, the learner can record the questions and look for the answer later.
- *Interactivity*: Learners can interact with experts, teachers, or peers in the form of synchronies or asynchronous communication. Hence, the experts are more reachable and the knowledge becomes more available.
- *Situating of instructional activities*: The learning could be embedded in our daily life. The problems encountered as well as the knowledge required are all presented in their natural and authentic forms. This helps learners notice the features of problem situations that make particular actions relevant.

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*: u-learning environment enables seamless learning at anywhere and anytime.
- *Context-aware services*: The u-learning environment is context-awareness, which based on learners' statuses or the situations of the authentic environment to provide the related information to learners.
- *Adaptive services*: u-learning environment able to offer more adaptive supports to the learners.

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, summarized the main characteristics of u-learning as follows:

- *Urgency of learning need*: The u-learning environment can be used for an urgent matter of learning.
- *Initiative of knowledge acquisition*: The u-learning systems can provide the information, which closes to learners' requests in time.
- *Interactivity of learning process*: Learners can communicate with peers, teachers, and experts effectively through the interfaces of u-learning systems.
- *Situation of instructional activity*: In u-learning environment, the learning process can be embedded in daily life, as well as the knowledge requirements are presented in authentic context.
- *Context-awareness*: The u-learning environment is context-awareness, which based on learners' statuses or the situations of the authentic environment to provide the related information to learners.
- *Actively provides personalized services*: Based on the context around learners, the u-learning systems would actively provide personalized supports to learners by the right way, in the right place, and at the right time.
- *Self-regulated learning*: Self-regulated learning is worth to discuss in the u-learning activity, in which learners could actively control their learning progresses by themselves. Moreover, such learning activities can also bring up learners' self-regulated abilities.
- *Seamless learning*: The u-learning environment enables seamless learning at anywhere and anytime. The learners are allowed to learn without being interrupted while moving from place to place.

- *Adapt the subject contents*: The u-learning environment is able to adapt the subject contents to suit the capability of various learning devices.
- *Learning community*: The u-learning environment help online community with bring field experience on the Internet to enrich the learning interaction between learners and teachers.

3.5 New 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 2. After analyzing the table, we propose five characteristics from the combination of the researchers' ideas researchers 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.

Permanency, accessibility, immediacy and interactivity are considered as common characteristics of u-learning. We

agree that context-awareness is the major characteristic that distinguishes u-learning from others.

In a ubiquitous learning environment, it is difficult for a learner to know that the other learner has the same knowledge even that they are at the same location. In this case, the learner needs to be aware of the other learners' interests that match his interest. Context-awareness can be defined as the ability of a program or device to sense various states of its environment or itself. Location, identity, time, and environment are the primary context types for characterizing the situation of a particular entity (Dey & Abowd, 2000). Therefore, by referring to Table 1.0, 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 & Yano, 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	Accessibility	Accessibility	Context-awareness	Initiative of	Accessibility

acquisition				knowledge acquisition	
Mobility of learning setting	Immediacy	Immediacy	Adaptive services	Interactivity of learning process	Immediacy
Interactivity of learning process	Adaptability	Adaptability		Situation of instructional activity	Interactivity
Situating of instructional activity		Situating of instructional activities		Context-awareness	Context-awareness
Integration of instructional content		Interactivity		Actively provides personalized services	
				Self-regulated learning	
				Seamless learning:	
				Adapt the subject contents	
				Learning community	

A comparison of learning paradigms based on the new characteristics 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.

4.0 UBIQUITOUS LEARNING APPLICATIONS

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 the special system only for ubiquitous learning, but it should be generally used for general applications.

5.0 CONCLUSION

The advancement of wireless and sensor technologies have promoted the learning styles 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 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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