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***Research paper***

# Ubiquitous Learning Environment and Technologies: A Review

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**Abstract**

In recent years, the education landscape is rapidly changing due to the advancement of information and communication technology infrastructure. The paradigm shift in educational landscape has changed the learner's behaviors from passive to active in their learning process. Ubiquitous learning is a new learning environment that integrates the benefit of e-learning and mobile learning. The technology plays an important role in supporting ubiquitous learning and a proper technology configuration to obtain learning information is a must. The support for those technology needs in ubiquitous learning is coming from computer-based technologies. The aim of the paper is to performed literature review for ubiquitous learning environment and providing specific information about ubiquitous learning concepts and the criteria that needed in the future research. It begins by briefly describing the transformation of learning environment, the concepts of ubiquitous learning, the characteristics of ubiquitous learning, the technical structure of ubiquitous learning and ubiquitous technologies devices in ubiquitous learning environment is also described. Finally, the comparative studies of ubiquitous learning environment framework are compared and discussed to further enhance the understanding of ubiquitous learning environment. The result showed that technology usage is vital within learners and educators in learning process. Therefore, it is important to have a medium that can be used to improve learning process to be more effective and the most important part to take a look for before implementing new technology into academic learning is the readiness of the infrastructure.

***Keywords***: *Ubiquitous Computing, Ubiquitous Learning, Ubiquitous Technologies Devices*

## 1. Introduction

Learning is when a person involves in the process of retrieving skill or knowledge. In other word, learning is not only pouring a person's mind with the various kinds of information. Knowledge is gained through interaction between the learners and educators with the environment [1]. In recent years, the education landscape in rapid changing due to the advancement of information and communication technology infrastructure. The paradigm shift in educational landscape has changed the learner's behaviours from passive to active in their learning process. In the traditional classroom, the educator is the only source of knowledge delivery and the learners are the recipients of the knowledge. The knowledge delivery content in this environment is usually delivered in writing or orally process. The knowledge transfer process is seen as "one to many" which the educators is the authority in the learning process and act as the main communicator whereas the educators are busy completing the syllabus for each of the subjects and the teaching and learning process is not involved in problem solving and critical thinking skills [2].

Then came the era of electronic learning (e-learning) which focusing on learning that using electronic media typically on the internet. E-learning can support the distance learning where learning can occur in anytime but in the fixed places [3]. It provides new sets of tools that enhance traditional learning in classroom to e-learning environment that using network connection. The learning process in the e-learning includes the combination of searching the information and collecting the information whereby the learners connected to the real world and the sources of the knowledge is gathered in different formats. In e-learning, educators is not seen as the only source for the knowledge delivery, the educators and learners could collaborate equally in creating and delivering the new knowledge content [4].

The next learning paradigm shift is blended learning. Blended learning is focusing on integration of traditional classroom learning with e-learning [5]. In addition, blended learning is a learning paradigm that accommodate learner in accessing information of learning in anytime and applies the use of technology in the physical classroom learning. The new generation of the learners that been known as digital natives has demanded to use mobile devices in their learning process that leads to the next paradigm shift which is mobile learning (M-Learning) and it is considered as extension of e-learning paradigm [6]. In m-learning, the learners use handheld devices such as mobile phones, smart phones and tablets to access the learning content using wireless connectivity. M-learning is not just learning with mobile devices, but through the mobility that has been offered by the mobile devices, learners can access their learning information anytime.

New development in wireless technologies and sensors network has led to new learning paradigm which is known as ubiquitous learning (u-learning) which is integrates the benefit of e-learning and m-learning to provide learning which happen anytime, anywhere, anyplace where the learning process happens continuously and is supported by ubiquitous computing technology and it is embedded in learner's social life without their consciousness [7]. Learning activities in u-learning also changed the whole landscape

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of learning from fixed places to anywhere and anytime using any types of devices. There is a need to conduct a new research that would fit with the exchanging environment from traditional learning to the u-learning.

The technology plays an important role in supporting ubiquitous learning and a proper technology configuration to obtain learning information is a must [8]. The support for those technology needs in ubiquitous learning is coming from ubiquitous computing that introduced by reference [9], who described that the most profound technologies are those that cannot be seen and used by people continuously in their daily life. The information in ubiquitous computing can be accessed by anyone through specific devices and enables tasks to be achieved by the user. In the academic environment, ubiquitous computing can be applied by the educators and learners to accommodate the learning by employing ubiquitous technologies and devices. Furthermore, the enhancement of wireless communication technology together with the advancement of computing technology nowadays helps out to support the expansion in ubiquitous computing that can support ubiquitous learning [10].

## 2. Literature Background

A literature background is a review and evaluation report of information that associated with this research. The main purpose of this section is to describe, summarize, evaluate and clarify each review of the related literature. It gives a theoretical base for this research and focused more on each aspect of this research from defining the right definition, comparison of the characteristics and reviews each literature clearly from this literature analysis. The support for those technology needs in ubiquitous learning is coming from computer-based technologies. However, the lack of the interaction is the constrain for learning activities whereby the learners can meet with difficulties such as learners feels demotivated and are not willing to participate and express themselves in their learning process activities and led to lost interest in extending their knowledge and skills. Thus, we need to allow learners to be in an interactive environment that is useful for learning. Therefore, the technology which support ubiquitous learning environment must be able to support learning interactions. In a society that using technology in daily life, the learners must be active in the learning environment and cannot be as receptive learners such in traditional learning. Thus, this study intends to discuss the benefit of ubiquitous technologies that can support the interaction in ubiquitous learning environment that constructed from literature review analysis.

### 2.1. Ubiquitous Learning Concept

Basically, the definitions of ubiquitous learning have been discussed in many literatures. However, it still has no any definitions that being accepted regarding the transformation in academic learning paradigms that changed so fast [11]. There have been multiple attempts from academic scholars to identify the main concepts of ubiquitous learning environment [12-13]. The most accepted definition of ubiquitous learning is "anywhere and anytime". The definition is trying to represent a learning environment that allows the learners to access the knowledge content using mobile devices via wireless or internet connection in anytime and anywhere. However, it is still a broader definition for ubiquitous learning whereby the definition almost similar with mobile learning environment that also convey the same meaning which learner can access knowledge content anywhere and anytime via wireless communication technologies [14]. A more focus definition of ubiquitous learning should focus on utilization of ubiquitous computing technologies into the learning environment which emphasizes the use of sensor technology.

However, as mentioned by reference [15], there is no clear definition of ubiquitous learning because of learning environment change quickly over the time. The assumption that can be made is many researchers have different views in defining the definition of ubiquitous learning. Therefore, the ubiquitous learning definition needs to be clarified before applying the terms into the research to avoid any misconception. In the following discussion the working definition of ubiquitous learning is:

"Learning that happens in anytime and anywhere in a right way with a right content using ubiquitous computing technology"

### 2.2. Ubiquitous Learning Paradigm Characteristics

Although ubiquitous learning is a new learning environment that attracts the academic scholars, the characteristic of ubiquitous learning remains unclear [15]. Our previous work has identified the comprehensive characteristic of ubiquitous learning paradigm. Further explanations of ubiquitous learning paradigm characteristics can be found in our previous work [16]. The characteristics of ubiquitous learning paradigm are:

1. Accessibility: Learners can access the system in various ways.
2. Adaptability: Learners learn at the right way with a right content in a right place.
3. Context Awareness: By accessing the database, the system can sense the learner location, personal and situation using ubiquitous computing technology.
4. Immediacy: Learners can get the information immediately when they want it.
5. Interactivity: Learners can interact with educators in virtual and physical environment settings.
6. Permanency: Learners can never lose their work unless it is being deleted.

In addition, based on several characteristics from several authors [15,17-23], comparison of ubiquitous learning paradigm characteristic that has been identified by several authors is given in Table 1.

**Table 1:** Comparison of Ubiquitous Learning Paradigm Characteristics [16]

| Characteristics | Authors |
|---|---|
| **Accessibility** | **Curtis et al 2002; Ogata & Yano 2004; Bomsdorf 2005; Yahya, Ahmad & Jalil, 2010; Zolkefley et al 2015** |
| Actively provides personalization | Chiu et al 2008 |
| **Adaptability** | **Curtis et al 2002; Ogata & Yano 2004; Bomsdorf 2005; Hwang et al 2008; Chiu et al 2008** |
| **Context Awareness** | **Hwang et al 2008; Chiu et al 2008; Yahya, Ahmad & Jalil, 2010; Zolkefley et al 2015** |
| **Immediacy** | **Curtis et al 2002; Ogata & Yano 2004; Bomsdorf 2005; Yahya, Ahmad & Jalil, 2010; Zolkefley et al 2015** |
| Integration of instructional activity | Chen et al 2002 |

| | |
|---|---|
| **Interactivity** | **Chen et al 2002; Ogata & Yano 2004; Bomsdorf 2005; Chiu et al 2008; Yahya, Ahmad & Jalil, 2010; Zolkefley et al 2015** |
| Initiative of knowledge acquisition | Chen et al 2002; Chiu et al 2008 |
| Learning community | Chiu et al 2008 |
| Mobility of learning settings | Chen et al 2002 |
| **Permanency** | **Curtis et al 2002; Ogata & Yano 2004; Yahya, Ahmad & Jalil, 2010; Zolkefley et al 2015** |
| Seamless learning | Hwang et al 2008; Chiu et al 2008 |
| Self-regulated learning | Chiu et al 2008 |
| Situating of instructional activity | Chen et al 2002; Ogata & Yano 2004; Bomsdorf 2005; Chiu et al 2008 |
| Urgency of learning needs | Chen et al 2002; Chiu et al 2008 |

## 2.3. Ubiquitous Technologies Devices in Ubiquitous Learning Environment

In the educational environment nowadays, educators and learners can take the benefit of the new trends in ubiquitous computing by employing ubiquitous devices and technologies in the learning environment. According to reference [24], teenagers who are the learners carry mobile devices in anywhere and anytime and the gadget become the important technology to them. Educators and higher institutions need to acknowledge this trend and adopt the latest technology into the learning environment. As illustrated in Figure 1, ubiquitous learning environment (ULE) act as a platform of the new learning paradigm that offering varied types of technology and become an important channel into the learning environment. This new type of environment is supported by ubiquitous computing technologies, including mobile devices, wireless sensor network and embedded computer devices [25]. In ULE, the usage of mobile devices are essential elements by enabling the learners to learn from anywhere in the world at anytime by using a variety of digital resources. Several researchers identified that ubiquitous learning seems quite similar to mobile learning in terms of learning at anytime and in anywhere. However, ubiquitous learning offering a more advanced system which it can be accessed regardless of time and place and allowing learners to get a new experience while surfing for getting the information. Therefore, previous studies have highlighted the importance of the usage of mobile devices in learning such as the most preferable activities of learning among teenagers using mobile devices are learning facts, languages and skills.

ULE also shared the same characteristics as mobile learning environment. The characteristics that have been shared are permanency, accessibility, interactivity and immediacy. However, ULE has other extra characteristic which is context awareness whereby ULE can sense the learner's personal, environment situations and locations and understand the learner's environment through the database [20]. Ubiquitous computing technologies and devices are being used in order to receive environmental data and provide the relevant information related to the learner context. Learners can access the information that they need in anytime, anywhere using any type of device with their own convenience. In addition, learner's also can learn in anyplace without having any restrictions. Moreover, ULE provides a new learning environment where learning process in this environment automatically sense learner's situation and condition without learner's consciousness. In order to fulfil the requirements, ULE integrates mobile devices and embedded computer devices using several types of network connections. ULE is supported by mobile devices such as smartphones. These varying types of devices that supported ULE connect to the internet using multiple network connections such WiFi, wireless local area network (WLAN), Bluetooth and near field communication (NFC). ULE also supported by embedded computer devices such as global positioning system (GPS) and radio frequency identification tags (RFID).

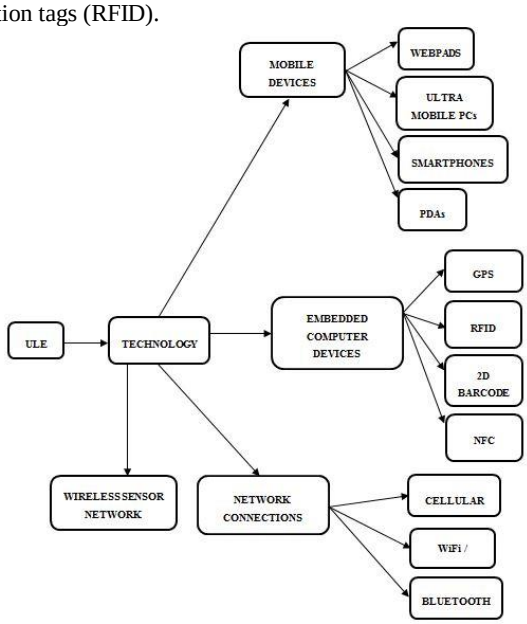



**Figure 1:** Multiple Types of Ubiquitous Technologies Devices in ULE

## 2.4. Ubiquitous Learning Environment Conceptual Framework

The first attempt in exploring the concept of ubiquitous learning environment is by reference [28], the authors proposes a conceptual framework for a Ubiquitous Learning Environment (ULE) design and implementation. The framework suggests a three dimensional subject of interaction (Human, Object, Artifact) for integrating the personal space, shared space, virtual space and real space. In addition, the work has been cited by many researchers as their foundation of concepts in ubiquitous learning environment in their research. In addition, the work has been cited by many researchers as their foundation of concepts in ubiquitous learning environment in their research [21, 29-31]. On the other hand, based on the holistic view, another model of the ubiquitous learning environment is being created by reference [29]. It was focused to explore the definition and characteristics of ubiquitous learning before formulating the model of the ubiquitous learning environment. Similar work is seen in [30] whereby the ubiquitous learning model formulates based on the description of the concept and characteristics of ubiquitous learning. However, the model was formulated using instructional design that integrated various levels and dimensions of learning environment. Another model of the ubiquitous learning environment that is based on ubiquitous computing was successfully constructed [31]. In the model, learners can access the information that they need in anytime, anywhere at any place without having any restrictions. In order to fulfil the requirements, the model integrates ubiquitous computing technologies that include mobile devices and embedded computer devices using several types of network connections. Furthermore, the con-

ceptual model in ubiquitous learning environment that focusing on language learning is successfully identified by reference [21]. The work claimed that integration between personal space and cyber spaces allows the educator and learner to acquire language learning resources. The complete analysis of the previous research in ubiquitous learning environment framework that consists from the types of environment, dimension and sub-dimension in ULE is given in Table 2 below.

**Table 2:** Analysis of Ubiquitous Learning Environment Framework

| Authors | Environment | Dimension | Sub-Dimension |
|---|---|---|---|
| Li et al., (2004) | Integrated learning environment that consists:<br>1. Social<br>2. Physical<br>3. Informational<br>4. Technical | 1. Who (Actions Subject)<br>2. What (Actions Subject)<br>3. How (Actions)<br>4. When (Time Proximity)<br>5. Where (Actions Space) | - Human<br>- Objects in real world<br>- Artifacts in virtual world |
| Zhan & Yuan (2009) | Integrates, connect and share the learning resources and the environment are:<br>1. Interoperable<br>2. Pervasive<br>3. Interactive<br>4. Seamless learning | 1. Physical environment<br>2. Informational environment<br>3. Technological environment<br>4. Interactive environment | - Network based interactive transmission<br>- Human-computer interaction environment<br>- Interpersonal interaction environment |
| AiHua (2010) | Integrated learning environment that consists:<br>1. Variety educational institutions<br>2. Workshops<br>3. Community<br>4. Families | 1. Educational environment<br>2. Educational services | - Teachers<br>- Students |
| Zolkefley et al., (2015) | Integrated learning environment that consists:<br>1. Technical<br>2. Physical<br>3. Informational<br>4. Social | Educational environment that happens between:<br>1. Academic Language Studies<br>2. Home<br>3. Outside | - People<br>- Artifacts<br>- Objects |
| Zhan & Yuan (2009) | Integrates, connect and share the learning resources and the environment are:<br>1. Interoperable<br>2. Pervasive<br>3. Interactive<br>4. Seamless learning | 1. Physical environment<br>2. Informational environment<br>3. Technological environment<br>4. Interactive environment | - Network based interactive transmission<br>- Human-computer interaction environment<br>- Interpersonal interaction environment |

Most of the previous conceptual frameworks which can be found in the Table 2 pertain to highlight on the development of ubiquitous learning system instead of trying to explore the interaction process between educators and learners that involved in the learning environment. For the interaction perspectives, most of conceptual framework identified the subjects in ULE but the aspect of the interaction in learning process between the learners has not been given much attention. To support our claim, a comparative study for the previous work of conceptual framework in ULE is given in Table 3 below. The comparative studies identified the focuses, the strength, the weakness and the opportunity for each of the conceptual framework. However, few researchers have been able to identified learning community and interaction component in ULE. So far, there has been little discussion about the interaction process that happened in ULE.

**Table 3:** Comparative Studies of Ubiquitous Learning Environment Framework

| Characteristics / Authors | Li et al., (2004) | Zhan & Yuan (2009) | AiHua (2010) | Zolkefley et al., (2015) |
|---|---|---|---|---|
| **Focuses** | Identify five-dimensional representation approach for modeling context and providing context-aware information. | It was focused to design ubiquitous learning environment according to holistic view perspectives. | It was focused to analyses and investigates the relationship between ubiquitous computing and ubiquitous learning for the functionality of the proposed model. | It was focused to design ubiquitous learning environment according to holistic view perspectives. |
| **Strength** | It provides context-awareness characteristic that support interoperability and adaptability in a ubiquitous learning environment. | It provides comprehensive of ubiquitous learning environment model by integrating informational, technological and interactive component into learning community. | It defines ubiquitous computing technology as technology that supported ubiquitous learning components. | It describes all the components that required in implementing a ubiquitous learning solution for language learning. |
| **Weakness** | Focuses on component for development for ubiquitous learning system only. | Focuses on providing three main components in ubiquitous learning environment but do not provide the details explanation. | Focuses on ubiquitous computing component only for ubiquitous learning development. | Focus on interaction in learning but do not provide any specific requirements that support the learning process. |
| **Opportunity** | Communicate, collaborate and coordinate with each other for educational quality and efficiency. | Every component collaborates with each other and no one in isolation state. | Improving learner's ability in searching the relevant information for their learning using ubiquitous computing technologies. | Every component collaborates with each other and no one in isolation state. |
| **Learning community** | ✓ | ✓ | × | ✓ |
| **Interaction component** | ✓ | ✓ | × | ✓ |
| **Interaction Process** | × | × | × | × |

To focus the definition of ubiquitous learning that shall focus on learning that happens in anytime and anywhere in a right way with a right content using ubiquitous computing technology, ubiquitous learning environment expected to provide the right content, in a right way and at the right time to the learners. The concept must be designed to support learning interaction process within the ubiquitous learning environment to lead to more interactive and effective learning environment.

## 3. Conclusion and Future Work

The paper provides the definition, characteristics and the evident of ubiquitous learning environment that can support learning in a better ways will benefit novice researcher in ubiquitous learning by providing a guide to enable the researcher in understanding the concepts and criteria that needed in ubiquitous learning research. In order to success in learning, learners need supportive environment that collaborate them in efficient ways. As a conclusion, the research found that technology usage is vital within learners and educators for learning in ubiquitous learning environment. It is necessary to consider the learning process by looking at the technology dimension. However, technology should facilitate the learning and not function as isolation learning from the social context. Further investigations of the ubiquitous learning environment with a possible focus to interaction process in learning and the requirements platform of technologies in ubiquitous learning environment are suggested.

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