JSBET Journal of Social Business, Economics, and Technology

ISSN: XXXX-XXXX
Volume 1 Issue 1, March 2026

A Study on the New Learning Paradigm: A Review of Literature in Mobile and Ubiquitous Learning

*[1]Nisa Novia Avien Christy & [2]Kirya Mateeke Moses
[1]Faculty of Economics, Semarang University, Semarang, Indonesia
[2]Graduate School of Technological and Vocational Education National Yunlin University of Science and Technology, Taiwan

*Corresponding Author:
Email: nisa.novia@usm.ac.id

DOI:

ARTICLE HISTORY
Submit: January, 2026
Published: March, 2026

Page: 1-13

ABSTRACT
In recent years, the integration of technologies underlying ubiquitous computing and wireless communication with the supports of mobile devices have created innovative learning environment in schools. This article describes a new learning paradigm, known as mobile learning or m-learning and ubiquitous learning or u-learning. Instead of that, the article also aims at providing fundamental information related to m/u-learning for researchers who are interested in venturing this new area of ubiquitous computing. selected eight databases in technology enhanced learning for literature reviews. 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.

Keywords: Ubiquitous, E-Learning, M-Learning, U-Learning.

INTRODUCTION

Owing to the rapid advance and popularity of wireless communication and mobile technologies, mobile and ubiquitous learning has become more and more important (H.-C. Chu et al., 2010). Numerous studies about the use of mobile and wireless communication technologies in education have been reported, in which these technology-enhanced learning approaches are referred to as mobile or ubiquitous learning by the researchers (Chu et al., 2010; Shih et al., 2010). The advances in mobile technology and improvements in network infrastructure have further motivated educational institutions worldwide to practise mobile and ubiquitous learning (UNESCO, 2013). To illustrate the overall trend in its popularity, the number of items on Google Scholar related to mobile and ubiquitous learning have increased from 2,570 in 2007 to 6,550 in 2011, and 9,540 in 2016 (Wong, 2018) - a nearly 3 times increase in a decade.

In recent years, the integration of technologies underlying ubiquitous computing and wireless communication with the supports of mobile devices have created innovative learning environment in schools (Hung et al., 2010; Hwang & Chang, 2011), and this technology enhanced learning development allows learners to experience new learning situations beyond the classroom. This new development of school learning environments could offer learners a new way to infuse learning into

daily life with adaptive supports, and engage and motivate learners with anytime and anywhere learning. Regarding to the development, (Hwang et al., 2008) pointed out that the progress of wireless communication and sensor technologies have evolved the research and development of e-learning to mobile learning (m-learning), and now is evolving from m-learning to ubiquitous learning (u-learning). In addition, ubiquitous learning is characterized by providing intuitive ways for identifying right learning collaborators, right learning contents and right learning services in the right place at the right time (Yang, 2006), and ubiquitous learning environment could be distinguished into three kinds of learning service, i.e. seamless service, context-aware service, and adaptive service with regarding to its features and potentials for learning (Hwang et al., 2008). As such, it is crucial for researchers and practitioners to find effective ways to design, develop, and implement ubiquitous learning environments and technologies in a wide variety of learning settings for todays' learners.

There have been several definitions for mobile and ubiquitous learning. A widely accepted definition of mobile learning is 'using mobile technologies to facilitate learning', while a popular definition of ubiquitous learning is 'learning anywhere and at any time' (Hwang et al., 2008; Shih et al., 2011). Although these definitions have been given from different aspects, they share the same idea, that is, the mobile devices (e.g. personal digital assistants, cellular phones or portable computers) play an important role in the learning activities no matter whether the activities are conducted in the field or in the classroom (Chen et al., 2009; Hwang et al., 2009; Vavoula et al., 2009).

In the past decade, various studies concerning mobile and ubiquitous learning have been conducted in museums, classrooms or labs (Hall and Bannon, 2006). For instance, (Reynolds et al., 2010) arranged students to explore the museum environment and collections with mobile devices. (Chiou et al., 2010) also developed an adaptive navigation support system for guiding students to learn in museums with mobile devices. Furthermore, (Hwang & Chang, 2011) reported a learning activity of a local culture course, in which students were guided to learn in a temple using mobile devices.

In addition to these indoor activities, an increasing number of mobile or ubiquitous learning activities have been conducted in the field (Chu et al., 2008; Tan et al., 2007). For example, (Chu et al., 2010) conducted a ubiquitous learning activity for a natural science course, in which individual students were equipped with a mobile device that guided them to observe the features of plants in the school campus. In another study, Liu and Hwang, (2010) conducted a series of mobile learning activities for ecology observations and data collection in a wetland in southern Taiwan.

Mobile and ubiquitous learning (m/u-learning) support similar educational aspects, such as learner autonomy, continuity across contexts and situational learning (Hwang & Tsai, 2011). The hybrid nature of m/u-learning can help in extending the boundaries where learning happens (Traxler, 2009). However, it poses additional challenges for designing, monitoring and evaluating learning scenarios. On the one hand, learning design (LD) in these contexts is mainly done through authoring tools, often ad-hoc solutions connected to a specific learning space, domain, pedagogical approach, or student level. On the other hand, monitoring and evaluating learning activities in these environments are complex and demand collecting and combining data across different spaces and settings to achieve a general overview of the process (Muñoz-Cristóbal et al., 2018).

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

METHODOLOGY

Following the guidelines proposed by Kitchenham, & Charters (2007) for literature reviews, we selected eight databases in technology enhanced learning (IEEE XPLORE http://ieeex plore.ieee.org/ Xplore/home.jsp, SpringerLink http://link.springer.com, Routledge https://www.tandfonline.com, MDPI www.mdpi.com/journal/information, ScienceDirect http://www.sciencedirect.com, Scopus http://www.scopus.com/home.uri, Wiley http://onlin elibrary.wiley.com) and Google Scholar for relevant grey literature. The query reflects the kinds of learning we were focusing on and the research field where the proposal was framed, resulting in: ("mobile learning" OR "ubiquitous learning").

RESULTS AND DISCUSSION

M-learning and U-learning

Despite the growing research interest on m/u-learning (Fu & Hwang, 2018), there is no consensus about their definitions (Hwang & Tsai, 2011; Traxler, 2009). Early attempts to define both terms were techno-centric, while later ones connected them to several educational practices (Traxler, 2009). Nevertheless, m/u-learning are strongly interconnected and often used interchangeably (Hwang & Tsai, 2011). Various authors attribute to m/u-learning similar characteristics, such as the control and autonomy over learning, situational learning and spontaneity (Hwang & Tsai, 2011; Sharples et al., 2010). Furthermore, both can underpin hybrid learning environments that foster continuity and connectivity between formal and informal learning activities (Pimmer et al., 2016).

There are various definitions of mobile learning. One frequently adopted definition is the teaching mode that employs mobile technologies to provide learning materials, guidance or supports to learners (Sharples et al., 2009). Another, which is a broad-sense definition, refers to the learning mode that is not constrained by physical locations. Hwang et al., (2008) defined it as an instructional approach to promoting learning through mobile technologies, such that learners are capable of "anywhere and anytime learning." Several researchers have indicated that mobile technologies can intensify learning, enhance learners' learning motivation, interest, and learning achievements (Hwang & Wu, 2014; Reynolds et al., 2010; Shih et al., 2011), and shift learners from passive receivers to active learners (Wang et al., 2017). Scholars have emphasized that the popularity of mobile technologies might have provided an opportunity for conducting mobile learning activities; nevertheless, understanding learners' needs is the decisive factor affecting their willingness to use mobile technologies to learn (Y. Liu et al., 2010). In the past decade, mobile learning has been applied to various applications (Briz-Ponce et al., 2017; Chang et al., 2018; Chen & Hwang, 2017; Heflin et al., 2017; Tu & Hwang, 2018)

On the other hand, scholars have pointed out that understanding students' points of view regarding mobile learning can assist instructors in designing the instructional content; learners will also regard it as useful and beneficial. Smith & Walters (2012) specified that if students have opportunities to interact with the course content on mobile devices, their learning attitude becomes significantly more positive. Several scholars have employed mobile technologies or mobile computing technology to develop sports-specific feedback systems, which embedded sensors into relevant devices; athletes or coaches are able to obtain relevant analytical data or synchronous information feedback during the training process through mobile devices to complete their training at different levels (Baca et al., 2009; Baca & Kornfeind, 2006; Vales-Alonso et al., 2012; Vales-Alonso et al., 2010)

Ubiquitous learning is a relatively young field in which different disciplines converge such as education, pedagogy, psychology, computer sciences, information and communication technology, and cognitive sciences. Numerous and novel approaches have been conducted during the present decade that have enriched the body of knowledge in this promising arena, where the applications

support learning activities with the goal of improving students' learning achievements anytime, anywhere, and anyway (Cárdenas-Robledo & Peña-Ayala, 2018).

Comparing the Similarities and Differences of M-Learning and U-Learning

As pointed out by several scholars (Hwang et al., 2008; Kumpulainen et al., 2014; Liu et al., 2015; Liu & Hwang, 2010; Smørdal et al., 2014; Turan & Keser, 2014), m-learning provides services passively based on users' requests through mobile devices and wireless communication. However, u-learning systems with sensor technology are not only free from time and spatial limitations, but also offer active support and stress students' personalized curriculums; thus, the students can learn in a more independent way. On an overall scale, m-learning and u-learning have similar characteristics, including: permanency, accessibility, immediacy and interactivity (Chin & Chen, 2013). In contrast, however, the major differences include context-aware behaviour tracking, seamless learning and sensor technology (Chin & Chen, 2013; Hwang et al., 2008; Liu et al., 2015; Liu & Hwang, 2010).

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 analysing the table, we propose five characteristics from the combination of the researchers' ideas and consider the major differences. The characteristics are:

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

Table 1. Comparison of Learning Paradigms

Criteria	E-learning	M-learning	U-learning
Permanency	Learners can lose their work.	Learners may lose their work. Changes in learning devices or learning in moving will interrupt learning activities.	Learners can never lose their work unless it is purposefully deleted. In addition, all the learning processes are recorded continuously every day.
Accessibility	System access via computer network	System access via wireless networks.	System access via ubiquitous computing technologies. 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	Learners cannot get information immediately.	Learners get information immediately in fixed environments with specified mobile learning devices	Learners get any information immediately. Therefore, learners can solve problems quickly. Otherwise, the learner may record the questions and look for the answer later.
Interactivity	Learners' interaction is limited.	Learners can interact with peers, teachers, and experts in specified learning environment.	Learners can interact with experts, teachers, or peers in the form of synchronous or asynchronous communication. Hence, the experts are more reachable, and the knowledge is more available.
Context Awareness	The system cannot sense the learner's environment.	The system understands the learner's situation by accessing the database.	The system can understand the learner's environment via database and sensing the learner's location, personal and environmental situations.

Source: Bomsdorf, 2005

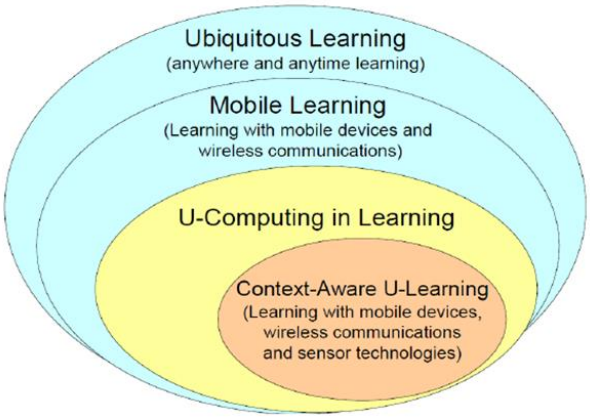

Figure 1. The relationships among ubiquitous learning, mobile learning, and context-aware ubiquitous learning. Adapted from Hwang, Tsai, and Yang (2008)

Concept and Related Works on Mobile and Ubiquitous Learning

With the increasing popularity of digital technology development and wireless internet technology, researchers, educators, and developers are offered more chances to design, develop, and implement more challenge and complicated teaching tasks for promoting knowledge and skills over and above subject content knowledge (Boyce et al., 2014). From the perspective of schools during the last decade, the ubiquitous nature of mobile technology has been recognized by many researchers and educators (Looi et al., 2014). The "anywhere and anytime learning" with the technological affordances of mobile technology has a very broad-sense definition. For more clarify, Hwang, Tsai, and Yang (2008) characterized the similarities and differences among ubiquitous learning, mobile learning and context-aware ubiquitous learning as display in Figure 1.

According to Hwang et al., (2008)'s conceptual idea, ubiquitous learning usually defined as any learning environment that allows students to access learning content in any location at any time, no matter whether wireless communications or mobile devices are employed or not, and mobile learning is defined as the learning environment which allows students to access learning content via mobile devices with wireless communications. In addition, mobile learning makes sense only when the technology in use is fully mobile with the support of internet network and when the users of the technology are also mobile while they learn (El-Hussein & Cronje, 2010; McQuiggan et al., 2015). While context, i.e. current time, the location of the user, behaviour of the learner, temperature and humidity of the learning environment, is an important aspect of mobile learning, an important affordance of the learning environment is context awareness. As such, a special definition of ubiquitous learning that employs mobile devices, wireless communications and sensor technologies in learning activities has been emerging and it is called context-aware ubiquitous learning (Hwang et al., 2008).

Since the anywhere and anytime learning has become one of the learning model trends, many scholars have conducted related research on how to use special functions of mobile devices for educational purposes in many possibilities. In the past decade, various studies concerning mobile and ubiquitous learning have been conducted in both inside and outside the school class, such as museums, classrooms or labs (Hall & Bannon, 2006). For example, Chu et al., (2010) and Hwang et al., (2011) developed a grid-based mind tool displayed on mobile device and employed as context-aware ubiquitous learning based on a knowledge engineering approach to guide elementary school students to observe the features of plants in a natural science course. The results showed that the context-aware ubiquitous learning approach not only promotes learning motivation, but it also improves the learning achievements of individual students. In context of mobile learning as abovementioned, (Wu et al., 2011) developed a repertory grid-oriented clinical mobile learning system for a nursing training program, and the results show that the innovative approach is helpful

to students in improving their learning achievements and attitude and reducing cognitive load during their learning. In addition Tsai et al. (2017) implemented a flexible means of ubiquitous learning with a mobile application of web-mediated computational thinking to help first-year university students for developing practical computing skills, and the result showed that students who received the treatment of ubiquitous learning could have significantly better computing skills than those without.

Srisawasdi et al. (2018) mentioned that the learning with mobile technologies offers a plethora of features and benefits that enable it to break the educational system wide open, engaging students in new ways and the mobility of learning makes educational experiences more meaningful. However, a challenge for the learning with mobile technologies in specific subject related to the pedagogical adoption of mobile technologies in school with regarding the affordances of mobile technologies (Kukulska-Hulme & Shield, 2008). Therefore, the next section would be used to present pedagogical opportunities to transform traditional class with the support of the learning with mobile technologies in various techniques proposed upon previous studies' evidences.

The opportunities for pedagogical transformation with mobile

During the past decade, every area of education and training has been affected by the advancement of mobile technology. Currently, mobile devices are everywhere, and mobile learning has emerged as a potential educational environment to transform the world of learning and also to obtain improvements in the learning field. Regarding the possibilities offered by mobile technology, this poses new opportunities and new challenges to the educational systems for transforming school learning experience. With the importance of studying pedagogical research and development and transforming existing instructional methods for this new opportunity, many instructional models were grounded on the theoretical aspects of mobile and ubiquitous learning for the last decade.

In order to promote the learning with mobile technologies, Hwang, et al (2017) pointed out that technologies should not just be used as a channel for providing learning materials; instead, teachers should design learning activities regarding the features of the technologies and the needs of the subjects to ensure that the use of the technologies has greatest effects on students' learning performances. In order to promote the transformation of pedagogical applications for mobile and ubiquitous learning, Lai & Hwang (2015) reviewed effective teaching strategies with the support of mobile technology from the previous studies and then proposed a series of mobile and ubiquitous learning approaches for bridging the in-class and outdoor instruction in school. These ten strategies are: guided learning, peer assessment, video sharing, synchronous sharing, issue-based discussion, computers as mindtools, project-based learning, digital storytelling, inquiry-based learning, and contextual mobile learning.

Learning Paradigm Shift

When applying a new type of LT (Learning Technology), we may need a new paradigm for guiding the use, design, implementation, and assessment of the technology (Richey, 1998; Rushby, 2005). e-Learning has become prevalent in all kinds of learning contexts since the mid-1990s, and Yang, Okamoto a& Tseng (2008) observe the Learning Technology field and indicate that context-aware u-learning is an emerging computer-supported learning paradigm. Based on this trend, we are experiencing a paradigm shift from conventional e-learning to m-learning (Rushby, 2005) and another from m-learning to context-aware u-learning (Hwang et al., 2008). The theoretical framework given in Figure 2 may help readers identify the important factors constituting a context-aware u-learning environment, and give a clearer picture of these shifts.

The learning paradigms category refers to the ways students acquire domain knowledge and perform activities in u-learning systems, as well as styles of teaching, pedagogical theories, and techniques. So, this section highlights a sample of works organized into the next nine subcategories:

Situated (Hwang & Chang, 2016), and authentic (Chen et al., 2016), inquiry-based learning (Vogel et al., 2014), social constructivism (Huang & Chiu, 2015), seamless (Wong et al., 2010), immersive (Nadolny, 2017), self-regulated learning (Tabuenca et al., 2015), learning by doing (Sánchez & Olivares, 2011), diverse theories (Lai et al., 2013), learning techniques (Chen et al., 2013), and other learning paradigms (Mintz et al., 2012).

Learning Environment

Many mobile learning researchers have noted that the quick progression of mobile technologies and wireless communication directly impacts learning. These advancements have spurred various novel issues in u-learning and m-learning, which are now being studied more in depth. U-learning and m-learning have some similarities to each other, including: permanency, accessibility, immediacy and interactivity (Huang et al., 2010). However, several significant characteristics of u-learning differentiate it from m-learning. For instance, u-learning includes seamless learning, context-aware computing and adaptive services (Hwang et al., 2008; Yang et al., 2007). Specifically, context-aware computing is regarded as a very important technology that enables students to learn anytime and anywhere. In an ideal u-learning environment, computer communication and sensory devices are embedded and integrated into daily real-life items, allowing students to immerse themselves fully into different learning situations (Hwang et al., 2008). Based on the above concept, Yang (2006) proposed a u-learning environment, which uses context-aware technologies to provide intuitive ways for collaborators to choose appropriate learning resources according to the situation and location (Yang, 2006), Ogata and Yano also provided a context-aware language learning support system for overseas students to learn polite Japanese expressions suitable for their particular situation, or based on their personal information (Ogata & Yano, 2004).

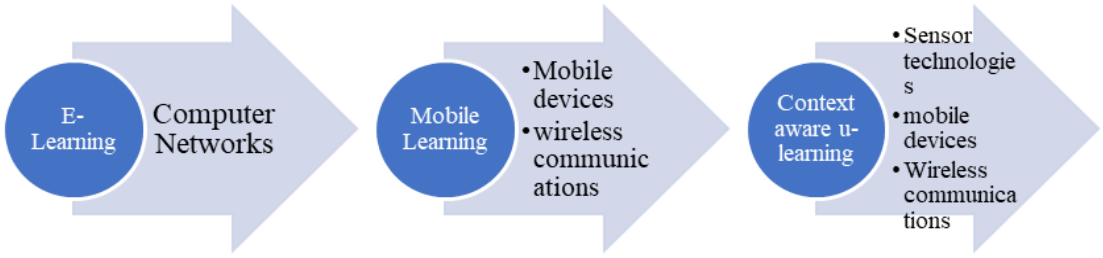

Figure 2. The Components of Paradigm Shift in E-Learning
Source: Liu & Hwang, 2010

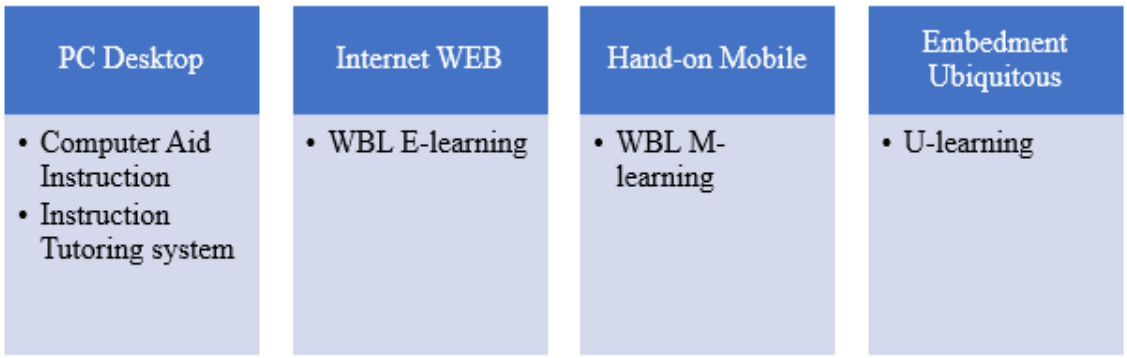

Figure 3. Trend of Learning Supporting System
Source: Cheng et al., 2005

Figure 3 Trend of learning of the learning supporting system proposed by Cheng's works (Cheng et al., 2005). As it is shown in Fig. 3, the computer aid instruction (CAI) and instruction tutoring system (ITS) are broadly presented in the education area since the first announcement of personal computer. Then, web-based learning (WBL) for electronics learning (e-learning) is widely used when internet technology becomes famous. Afterward, WBL for mobile learning (m-learning) is widely used when mobile technology and hand-on devices are generally used. Nowadays, u-learning becomes popular since ubiquitous computing and embedment technology have been widely introduced. It can be concluded that the developing technology has been paying the essential part to bolster learning.

Early inquiry in u-learning pays much consideration to the improvement of Ubiquitous Learning Environment (ULEs) in arranging to supply consistent ways of content delivery (Baber et al., 2004; Hwang et al., 2008; Lonsdale et al., 2004; Luckin et al., 2004). Numerous works centre on how to consistently coordinate the mobile devices and the learning system to achieve the objective of anywhere and anytime (Scott & Benlamri, 2010). Normally, ULE provides anywhere and anytime learning environment to the learners, the right learning resource, and the right content. This concept is generally called the context-aware concept. Consequently, many current works aim to provide the context-aware system to support the personalization of the learners through physical and virtual environments (Lee et al., 2012; Nino et al., 2007; Scott & Benlamri, 2010). Some works mainly focus on providing situation-based learning appropriately (T.-T. Wu et al., 2008). Although context-aware is widely introduced, learners' personalization is usually self-initiated by the learners (Poursaeed & Lee, 2010). To serve u-learning, this paper proposes the ULE, the smart learning environment, to provide the learning paths for the learners appropriately and adaptively.

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. One solution to the new problems arising from ubiquitous learning environments is to provide teachers with access to information that can help them monitor, investigate and assist students during the learning process. This type of approach has been used in other fields; for example, the business domain utilises Executive and Management Information Systems (EIS, MIS) to provide business leaders with access to current information in a way that they can understand quickly and easily. One of the best examples of this type of interface is Dashboards, which render information quickly and dynamically in order to provide decision makers with the tools they need to assess and deal with real-world problems (Maldonado et al., 2012; Verbert et al., 2013). These tools frequently make use of visualisation techniques, such as graphs and diagrams, to display complex information in a relatively simple manner. In the present study, a similar approach is proposed for ubiquitous learning environments in order to allow

teachers to be more effective in observing individual students, identifying struggling student groups and guiding whole classes as students engage in learning processes and demonstrate outcomes (Aljohani & Davis, 2012).

REFERENCES

Aljohani, N. R., & Davis, H. C. (2012). Significance of learning analytics in enhancing the mobile and pervasive learning environments. *2012 Sixth International Conference on Next Generation Mobile Applications, Services and Technologies*, 70–74.

Baber, C., Sharples, M., Vavoula, G., & Glew, P. (2004). A 'learning space'model to examine the suitability of different technologies for mobile learning. *Learning with Mobile Devices: Research and Development: A Book of Papers*, 21–25.

Baca, A., Dabnichki, P., Heller, M., & Kornfeind, P. (2009). Ubiquitous computing in sports: A review and analysis. *Journal of Sports Sciences, 27*(12), 1335–1346.

Baca, A., & Kornfeind, P. (2006). Rapid feedback systems for elite sports training. *IEEE Pervasive Computing, 5*(4), 70–76.

Barbosa, J., Hahn, R., Rabello, S., & Barbosa, D. (2008). Local: a model geared towards ubiquitous learning. *Proceedings of the 39th SIGCSE Technical Symposium on Computer Science Education*, 432–436.

Briz-Ponce, L., Pereira, A., Carvalho, L., Juanes-Méndez, J. A., & García-Peñalvo, F. J. (2017). Learning with mobile technologies–Students' behavior. *Computers in Human Behavior, 72*(1), 612–620.

Cárdenas-Robledo, L. A., & Peña-Ayala, A. (2018). Ubiquitous learning: A systematic review. *Telematics and Informatics, 35*(5), 1097–1132. https://doi.org/10.1016/j.tele.2018.01.009.

Chang, C. Y., Lai, C. L., & Hwang, G. J. (2018). Trends and research issues of mobile learning studies in nursing education: A review of academic publications from 1971 to 2016. *Computers and Education, 116*(3), 28–48. https://doi.org/10.1016/j.compedu.2017.09.001.

Chen, C.-H., & Hwang, G.-J. (2017). Effects of the team competition-based ubiquitous gaming approach on students' interactive patterns, collective efficacy and awareness of collaboration and communication. *Journal of Educational Technology & Society, 20*(1), 87–98.

Chen, Chao-Hsiu, Hwang, G., Yang, T., Chen, S., & Huang, S. (2009). Analysis of a ubiquitous performance support system for teachers. *Innovations in Education and Teaching International, 46*(4), 421–433.

Chen, Chih-Hung, Liu, G., & Hwang, G. (2016). Interaction between gaming and multistage guiding strategies on students' field trip mobile learning performance and motivation. *British Journal of Educational Technology, 47*(6), 1032–1050.

Chen, N., Wei, C., & Huang, Y. (2013). The integration of print and digital content for providing learners with constructive feedback using smartphones. *British Journal of Educational Technology, 44*(5), 837–845.

Cheng, Z., Sun, S., Kansen, M., Huang, T., & He, A. (2005). A personalized ubiquitous education support environment by comparing learning instructional requirement with learner's behavior. *19th International Conference on Advanced Information Networking and Applications, 2*, 567–573.

Chin, K.-Y., & Chen, Y.-L. (2013). A mobile learning support system for ubiquitous learning environments. *Procedia-Social and Behavioral Sciences, 73*, 14–21.

Chiou, C.-K., Tseng, J. C. R., Hwang, G.-J., & Heller, S. (2010). An adaptive navigation support system for conducting context-aware ubiquitous learning in museums. *Computers & Education, 55*(2), 834–845.

Chu, H.-C., Hwang, G.-J., Tsai, C.-C., & Tseng, J. C. R. (2010). A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education, 55*(4), 1618–1627.

Chu, H., Hwang, G., Huang, S., & Wu, T. (2008). *A knowledge engineering approach to developing e-libraries for mobile learning.* The Electronic Library.

Chu, H., Hwang, G., & Tseng, J. C. R. (2010). *An innovative approach for developing and employing electronic libraries to support context-aware ubiquitous learning*. The Electronic Library.

El-Hussein, M. O. M., & Cronje, J. C. (2010). Defining mobile learning in the higher education landscape. *Journal of Educational Technology & Society, 13*(3), 12–21.

Fu, Q.-K., & Hwang, G.-J. (2018). Trends in mobile technology-supported collaborative learning: A systematic review of journal publications from 2007 to 2016. *Computers & Education, 119,* 129–143.

Hall, T., & Bannon, L. (2006). Designing ubiquitous computing to enhance children's learning in museums. *Journal of Computer Assisted Learning, 22*(4), 231–243.

Heflin, H., Shewmaker, J., & Nguyen, J. (2017). Impact of mobile technology on student attitudes, engagement, and learning. *Computers & Education, 107*, 91–99.

Hsieh, H.-C., Chen, C.-M., & Hong, C.-M. (2007). Context-aware ubiquitous English learning in a campus environment. *Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007),* 351–353.

Huang, Y.-M., & Chiu, P.-S. (2015). The effectiveness of the meaningful learning-based evaluation for different achieving students in a ubiquitous learning context. *Computers & Education, 87*, 243–253.

Huang, Y.-M., Lin, Y.-T., & Cheng, S.-C. (2010). Effectiveness of a mobile plant learning system in a science curriculum in Taiwanese elementary education. *Computers & Education, 54*(1), 47–58.

Hung, P.-H., Lin, Y.-F., & Hwang, G.-J. (2010). Formative assessment design for PDA integrated ecology observation. *Journal of Educational Technology & Society, 13*(3), 33–42.

Hwang, G.-J., & Chang, H.-F. (2011). A formative assessment-based mobile learning approach to improving the learning attitudes and achievements of students. *Computers & Education, 56*(4), 1023–1031.

Hwang, G.-J., Tsai, C.-C., & Yang, S. J. H. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning. *Journal of Educational Technology & Society, 11*(2), 81–91.

Hwang, G.-J., & Wu, P.-H. (2014). Applications, impacts and trends of mobile technology-enhanced learning: a review of 2008–2012 publications in selected SSCI journals. *International Journal of Mobile Learning and Organisation, 8*(2), 83–95.

Hwang, G.-J., Yang, T.-C., Tsai, C.-C., & Yang, S. J. H. (2009). A context-aware ubiquitous learning environment for conducting complex science experiments. *Computers & Education, 53*(2), 402–413.

Hwang, G., & Chang, S. (2016). Effects of a peer competition-based mobile learning approach on students' affective domain exhibition in social studies courses. *British Journal of Educational Technology, 47*(6), 1217–1231.

Hwang, G. J., & Tsai, C. C. (2011). Research trends in mobile and ubiquitous learning: A review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology, 42(*4), 65–70. https://doi.org/10.1111/j.1467-8535.2011.01183.x.

Hwang, G., Shi, Y., & Chu, H. (2011). A concept map approach to developing collaborative Mindtools for context-aware ubiquitous learning. *British Journal of Educational Technology, 42*(5), 778–789.

Kitchenham, B., & Charters, S. (2007). *Guidelines for performing systematic literature reviews in software engineering.* Technical Report EBSE 2007-001, Keele University and Durham University Joint Report.

Kukulska-Hulme, A., & Shield, L. (2008). An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction. Kukulska-Hulme, A. and Shield, L.(2008). *An Overview of Mobile Assisted Language Learning: From Content Delivery to Supported Collaboration and Interaction. ReCALL, 20*(3), 271–289.

Kumpulainen, K., Karttunen, M., Juurola, L., & Mikkola, A. (2014). Towards children's creative museum engagement and collaborative sense-making. *Digital Creativity, 25*(3), 233–246.

Lai, H., Chang, C., Wen-Shiane, L., Fan, Y., & Wu, Y. (2013). The implementation of mobile learning in outdoor education: Application of QR codes. *British Journal of Educational Technology, 44*(2), E57–E62.

Lee, J. R., Jung, Y. J., Park, S. R., Yu, J., Jin, D., & Cho, K. (2012). A ubiquitous smart learning platform for the 21st smart learners in an advanced science and engineering education. *2012 15th International Conference on Network-Based Information Systems,* 733–738.

Liu, G.-Z., Kuo, F.-R., Shi, Y.-R., & Chen, Y.-W. (2015). Dedicated design and usability of a context-aware ubiquitous learning environment for developing receptive language skills: a case study. *International Journal of Mobile Learning and Organisation, 9*(1), 49–65.

Liu, G., & Hwang, G. (2010). A key step to understanding paradigm shifts in e-learning: towards context-aware ubiquitous learning. *British Journal of Educational Technology, 41*(2), E1–E9.

Liu, Y., Han, S., & Li, H. (2010). Understanding the factors driving m-learning adoption: A literature review. *Campus-Wide Information Systems, 27*(4), 210–226. https://doi.org/10.1108/10650741011073761.

Lonsdale, P., Baber, C., Sharples, M., & Arvanitis, T. N. (2004). A context awareness architecture for facilitating mobile learning. *Learning with Mobile Devices: Research and Development,* 79–85.

Luckin, R., Brewster, D., Pearce, D., Siddons-Corby, R., & du Boulay, B. (2004). SMILE: the creation of space for interaction through blended digital technology. *Learning with Mobile Devices: Research and Development. London: LSDA*, 87–93.

Maldonado, R. M., Kay, J., Yacef, K., & Schwendimann, B. (2012). An interactive teacher's dashboard for monitoring groups in a multi-tabletop learning environment. *International Conference on Intelligent Tutoring Systems,* 482–492.

McQuiggan, S., McQuiggan, J., Sabourin, J., & Kosturko, L. (2015). *Mobile learning: A handbook for developers, educators, and learners.* John Wiley & Sons.

Mintz, J., Branch, C., March, C., & Lerman, S. (2012). Key factors mediating the use of a mobile technology tool designed to develop social and life skills in children with Autistic Spectrum Disorders. *Computers & Education, 58*(1), 53–62.

Nadolny, L. (2017). Interactive print: The design of cognitive tasks in blended augmented reality and print documents. *British Journal of Educational Technology, 48*(3), 814–823.

Nino, C. P., Marques, J., Barbosa, D. N. F., Geyer, C. F. R., Barbosa, J. L. V., & Augustin, I. (2007). Context-aware model in a ubiquitous learning environment. *Fifth Annual IEEE International Conference on Pervasive Computing and Communications Workshops (PerComW'07)*, 182–186.

Ogata, H., & Yano, Y. (2004). Context-aware support for computer-supported ubiquitous learning. The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education, 2004. *Proceedings.*, 27–34.

Pimmer, C., Mateescu, M., & Gröhbiel, U. (2016). Mobile and ubiquitous learning in higher education settings. A systematic review of empirical studies. *Computers in Human Behavior, 63*, 490–501. https://doi.org/10.1016/j.chb.2016.05.057.

Poursaeed, B., & Lee, C.-S. (2010). Self-initiated curriculum planning, visualization and assessment in improving meaningful learning: A comparison between mobile and ubiquitous learning. *2010 International Conference on Technology for Education*, 107–113.

Reynolds, R., Walker, K., & Speight, C. (2010). Web-based museum trails on PDAs for university-level design students: Design and evaluation. *Computers & Education, 55*(3), 994–1003.

Sánchez, J., & Olivares, R. (2011). Problem solving and collaboration using mobile serious games. *Computers & Education, 57*(3), 1943–1952.

Scott, K., & Benlamri, R. (2010). Context-aware services for smart learning spaces. *IEEE Transactions on Learning Technologies, 3*(3), 214–227.

Sharples, M., Arnedillo-Sánchez, I., Milrad, M., & Vavoula, G. (2009). *Mobile learning. In Technology-enhanced learning*. 233–249. Springer.

Sharples, M., Taylor, J., & Vavoula, G. (2010). *A theory of learning for the mobile age. In Medienbildung in neuen Kulturräumen*. 87–99. Springer.

Shih, J.-L., Chuang, C.-W., & Hwang, G.-J. (2010). An inquiry-based mobile learning approach to enhancing social science learning effectiveness. *Journal of Educational Technology & Society, 13*(4), 50–62.

Shih, J., Hwang, G., Chu, Y., & Chuang, C. (2011). *An investigation-based learning model for using digital libraries to support mobile learning activities*. The Electronic Library.

Smith, S. L., & Walters, A. (2012). Mobile Learing: Engaging today's hospitality students. *Journal of Hospitality & Tourism Education, 24*(2–3), 45–49.

Smørdal, O., Stuedahl, D., & Sem, I. (2014). Experimental zones: two cases of exploring frames of participation in a dialogic museum. *Digital Creativity, 25*(3), 224–232.

Srisawasdi, N., Pondee, P., & Bunterm, T. (2018). Preparing pre-service teachers to integrate mobile technology into science laboratory learning: an evaluation of technology-integrated pedagogy module. *International Journal of Mobile Learning and Organisation, 12*(1), 1–17.

Tabuenca, B., Kalz, M., Drachsler, H., & Specht, M. (2015). Time will tell: The role of mobile learning analytics in self-regulated learning. *Computers & Education, 89*, 53–74.

Tan, T.-H., Liu, T.-Y., & Chang, C.-C. (2007). Development and evaluation of an RFID-based ubiquitous learning environment for outdoor learning. *Interactive Learning Environments, 15*(3), 253–269.

Traxler, J. (2009). *Learning in a Mobile Age International Journal of Mobile and Blended Learning*. Recuperado de Http://Www. Academia. Edu/171500/Learning_in_a_Mobile_Age.

Tsai, C.-W., Shen, P.-D., Tsai, M.-C., & Chen, W.-Y. (2017). Exploring the effects of web-mediated computational thinking on developing students' computing skills in a ubiquitous learning environment. *Interactive Learning Environments, 25*(6), 762–777.

Tu, Y.-F., & Hwang, G.-J. (2018). The roles of sensing technologies and learning strategies in library-associated mobile learning: a review of 2007-2016 journal publications. *International Journal of Mobile Learning and Organisation, 12*(1), 42–54.

Turan, B., & Keser, H. (2014). Museum guide mobile app: the case of the near east university classical car museum. *Procedia-Social and Behavioral Sciences, 131*, 278–285.

UNESCO. (2013). *Policy guidelines for mobile learning.* The United Nations Educational, Scientific and Cultural Organization. http://unesdoc.unesco.org/images/0021/002196/219641e.pdf.

Vales-Alonso, J, López-Matencio, P., Alcaraz, J. J., Sieiro-Lomba, J. L., Costa-Montenegro, E., & González-Castaño, F. J. (2012). A dynamic programming approach for ambient intelligence platforms in running sports based on markov decision processes. *In Human–Computer Systems Interaction: Backgrounds and Applications 2.* pp. 165–181. Springer.

Vales-Alonso, Javier, López-Matencio, P., Gonzalez-Castaño, F. J., Navarro-Hellín, H., Baños-Guirao, P. J., Pérez-Martínez, F. J., Martínez-Álvarez, R. P., González-Jiménez, D., Gil-Castiñeira, F., & Duro-Fernández, R. (2010). Ambient intelligence systems for personalized sport training. *Sensors, 10*(3), 2359–2385.

Vavoula, G., Sharples, M., Rudman, P., Meek, J., & Lonsdale, P. (2009). Myartspace: Design and evaluation of support for learning with multimedia phones between classrooms and museums. *Computers & Education, 53*(2), 286–299.

Verbert, K., Duval, E., Klerkx, J., Govaerts, S., & Santos, J. L. (2013). Learning analytics dashboard applications. *American Behavioral Scientist, 57*(10), 1500–1509..

Vogel, B., Kurti, A., Milrad, M., Johansson, E., & Müller, M. (2014). Mobile inquiry learning in Sweden: Development insights on interoperability, extensibility and sustainability of the LETS GO software system. *Journal of Educational Technology & Society, 17*(2), 43–57.

Wang, H. Y., Liu, G. Z., & Hwang, G. J. (2017). Integrating socio-cultural contexts and location-based systems for ubiquitous language learning in museums: A state of the art review of 2009–2014. *British Journal of Educational Technology, 48*(2), 653–671. https://doi.org/10.1111/bjet.12424.

Wong, B. T. M. (2018). *Success in Mobile and Ubiquitous Learning : Indicators of Effectiveness.* BRAIN: Broad Research in Artificial Intelligence & Neuroscience, Special Issue.

Wong, L.-H., Chin, C.-K., Tan, C.-L., & Liu, M. (2010). Students' personal and social meaning making in a Chinese idiom mobile learning environment. *Journal of Educational Technology & Society, 13*(4), 15–26.

Wu, P.-H., Hwang, G.-J., Tsai, C.-C., Chen, Y.-C., & Huang, Y.-M. (2011). A pilot study on conducting mobile learning activities for clinical nursing courses based on the repertory grid approach. *Nurse Education Today, 31*(8), e8–e15.

Wu, T.-T., Yang, T.-C., Hwang, G.-J., & Chu, H.-C. (2008). Conducting situated learning in a context-aware ubiquitous learning environment. *Fifth IEEE International Conference on Wireless, Mobile, and Ubiquitous Technology in Education (Wmute 2008)*, 82–86.

Xu, S., & Hu, Z. (2008). *Research of Ubiquitous Learning Application Environment. 2008 Seventh International Conference on Web-Based Learning*, 37–40.

Yang, S. J. H. (2006). Context aware ubiquitous learning environments for peer-to-peer collaborative learning. *Journal of Educational Technology & Society, 9*(1), 188–201.

Yang, S. J. H., Zhang, J., & Chen, I. Y. L. (2007). Ubiquitous provision of context-aware web services. *International Journal of Web Services Research (IJWSR), 4*(4), 83–103.