

## A BRIEF REVIEW OF UBIQUITOUS LEARNING

### CİHAZ, YER VE ZAMANDAN BAĞIMSIZ ÖĞRENMENİN ÖZETLENMİŞ BİR DEĞERLENDİRMESİ

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#### Abstract

*One of the technologies that 21st century learners use to gain information is ubiquitous computing. There is a smart infra structure in this system that determines learners' learning style, location and personal situations. Learners get the right information at the right place in the right way with ubiquitous learning which arises out of this integrated technology. Ubiquitous learning may be associated with mobile technologies but it should not be named as a mobile learning. To unclutter this situation significant articles related with ubiquitous learning and subcategories are examined. As a result of this literature review, it is clearly seen that usage of ubiquitous learning in educational environment generally causes favorable outcomes and this type of learning environment is conducted with mobile technologies. Ubiquitous learning environment, origins of ubiquitous learning, ubiquitous learning in education, UL Applications in Today's and Tomorrow's Technology, various supporting devices in UL, Contextualized Effective Teaching Strategies with Ubiquitous Learning are the headlines examined in this literature review.*

**Keywords:** Ubiquitous Computing, Ubiquitous learning, information, technology, e-learning, mobile learning.

#### Öz

*21. yy öğrenenlerinin bilgiye erişmek için kullanabileceği teknolojilerden biri de "Her yerde hazır Bilişim (Ubiquitous Computing)" seçeneğidir. Bu sistemde, öğrencinin öğrenme stili, konumu ve kişisel özelliklerini tespit edebilen akıllı bir altyapı vardır. Bu teknolojinin entegrasyonu ile ortaya çıkan "cihaz, yer ve zamandan bağımsız öğrenme (Ubiquitous Learning)" ile öğrenenler doğru bilgiye doğru zamanda doğru şekilde ulaşabilmektedirler. Cihaz, yer ve zamandan bağımsız öğrenme mobil öğrenme ile ilişkilendirilebilir fakat bunu mobil öğrenme olarak adlandırmamak gerekir. Bu doğrultuda, alın yazında konuyla ilgili öne çıkan çalışmalar taranmış ve buna göre alt kategoriler oluşturulmuştur. Alan yazın tarama sonucunda, cihaz, yer ve zamandan bağımsız öğrenmenin, öğrenme ortamlarında kullanıldığında genellikle olumlu sonuçlar verdiği ve bu öğrenme ortamının mobil teknolojilerle gerçekleştirildiği açıkça görülmektedir. Cihaz, yer ve zamandan bağımsız öğrenme ortamı, cihaz, yer ve zamandan bağımsız öğrenmenin temelleri, eğitimde cihaz, yer ve zamandan bağımsız öğrenme, bugünün ve yarının teknolojisinde cihaz, yer ve zamandan bağımsız öğrenme uygulamaları, cihaz, yer ve zamandan bağımsız öğrenmeyi destekleyen cihazlar, cihaz, yer ve zamandan bağımsız öğrenmede kullanılan etkili öğretme stratejileri bu taramada incelenen başlıklardır.*

**Anahtar Kelimeler:** Her yerde hazır bilişim, Cihaz, yer ve zamandan bağımsız öğrenme, bilgi, teknoloji, elektronik öğrenme, mobil öğrenme.

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## Introduction

This study reviews definitions of ubiquitous computing and learning in educational environment and summarizes characteristics of ubiquitous learning, origins of ubiquitous learning, pedagogical basis of ubiquitous learning, UL in the context of today's and tomorrow's world, various supporting devices in UL, effective teaching strategies for a ubiquitous learning environment in detail. In addition, suggestions are made up how to use and integrate ubiquitous learning in to lessons.

Aim of this study is to give self-reflections, inquire applications of ubiquitous learning, search how technological solutions support educational environment with well-designed software and give reflections about future researches.

## Ubiquitous Learning Environment

There have been expectations to provide a qualified education for students' guiding themselves with the support of technology (Fabos& Young, 1999). Electronic learning is a revolutionary trend in educational environment which is supported by technology (Welsh, et. al., 2010). One of an electronic learning type is mobile learning. M-learning and e-learning are connected to each other for a further ubiquity and mobility. M-learning will comprise e-learning and wireless technology will be the novelty for educational technology (Keegan, 2002). Apart from the domains of e-learning and m-learning; ubiquitous learning includes more context awareness to supply a more content rich education for the learners in the true path (Zhao, Wan & Okamoto, 2010). Ubiquitous knowledge is an undeniable vision for next generation to implement ubiquitous computing and instructional theories (Peng, Su & Tsai, 2009).

Context-aware ubiquitous learning (u-learning) finds the situation of the learner in real world and enables guidance for them by combining wireless, mobile and context-awareness technologies (Hwang, Yang, Tsai & Yang, 2009). A ubiquitous learning environment (ULE) is process of learning which students do not have to make an extra effort to learn, besides information is available in the integrated objects and education is occurring all around them (Jones & Jo, 2004). Ubiquitous learning can be computer supported collaborative learning (CSCL) which is a kind of social and didactic contract (Dillenbourg, 1999). Ubiquitous learning is a way of providing interoperable, flawless and a covering technological support for a more qualified learning environment in appropriate place at the accurate time (Yang, 2006). According to (Ogata, Yin & Yano, 2004); Bomsdorf, (2005) describes ubiquitous learnings' characteristics in her article as; permanency, accessibility, immediacy, interactivity, situating of instructional activities and adaptability. Learners are aware of their work if it is not deleted purposefully. Furthermore, entire learning situation is recorded seamlessly every day. They may access to their work, document, or records from anywhere. That information is up to their needs. Therefore, learners are self-directed (Bomsdorf, 2005). No matter how far they are, they can get any knowledge rapidly. So, students have the chance to find solutions to their problems easily. If the learner wants to save questions they may find answers whenever they want. They can communicate with their friends and tutors in the form of synchronous or asynchronous communication (Bomsdorf, 2005).

With the support of that technology, tutors become more reachable and the information is easier to use. Getting the right information could be integrated in our daily life. Problems are presented naturally and students will need the necessary information to solve the problem.

Ubiquitous learning helps learner to realize the features of problem situations that make particular actions relevant. They can get the right information at the right place in the right way (Bomsdorf, 2005). In ubiquitous learning environment learners gain the right knowledge at the right situation and time in the right way and they know that they will not lose their duty. They get information immediately and interact with colleagues and instructors. The system has the ability to understand the student's style, location and personal situations (Yahya, et. al., 2010).

### **Origins of Ubiquitous Learning**

The founder of the phrase “ubiquitous computing”, Weiser (1993) asserts that ubiquitous computing is found for replacing updated computers in existing events of our life and he emphasizes all sizes and all shapes of computers will be available to each person. Ubiquitous computing underpins groundwork for ubiquitous learning and creates new conditions for both the learners and the professionals in educational environment (Cope & Kalantzis, 2009).

Ubiquitous computing has four beneficial effects to the performance of knowledge work. They are removal of time and space constraints to communication and removal of time and space again for knowledge work, support to take better decisions to access anything, it is easier to get rich signals about the organization (Lyytinen & Yoo, 2002). Ogata and Yano (2003) declares that ubiquitous learning is quickened with wireless technology, available networks, well-designed battery technology and the other software devices. Individual learning environment is embedded in to our lives with those technologies. Formerly, ubiquitous learning was used to support tourist and museum guides by explaining some facts about the environment such as an electronic guide book. Nowadays, ubiquitous learning takes place in educational settings and searched in different areas such as educational or technical situations which are used in classrooms or outdoor studies to come through of the restrictions of traditional education (Bomsdorf, 2005). Ubiquitous learning became popular with the augmentation of mobile devices. Students gain experience in a real world learning environment with the support of mobile devices, wireless communications and they even sense technologies (Hwang, et.al., 2011).

### **Ubiquitous Learning in Education**

Walker (2006) asserts that “Mobile learning is not something that people do; learning is what people do”. For a better educational environment, it is important to consider how mobile devices enhance learning and realize the constraints of those devices might put on students (Swan, Kratcoski and van'tHooft, 2007), on the other hand; there is a probability of students' being isolated during the usage of mobile devices (Ng, 2010). Learning process is completed with student control and technologies should be used appropriately so that socially based tools and technology can shift control to the learner (McLoughlin & Lee, 2010). E-learning which is a way of teaching and learning, includes all electronic media and a pedagogical foundation

is a prerequisite for an applicative e-learning implementation (Govindasamy, 2001). Shin, Choo, Behom (2011) are in the idea that smartphones will be significant tools for ubiquitous learning but acceptance will depend on how well the user interface supports educational contexts. Chen et. al. (2002) (cited in Bridgland & Blanchard, 2005) declares the main rules while preparing an m-learning activity in education as;

- The emergency of the learning necessity
- The requirement for knowledge information
- The dynamism of the learning environment
- The interactivity of the learning process
- The usability of the instructional activities
- The integration of information's content

Apart from rules to prepare an activity in m-learning; Cheng et.al. (2005) declares the required properties of ubiquitous learning. Their ideas about the properties are; anytime and anywhere learning is necessary for a person to find information without any constraint for a better learning effect. Right time right place learning is expected for instance a clerk should find the necessary answers of his/her questions. Seamless learning is another property; which means people may have the chance to learn without interruption even if they move from one place to another.

### **UL Applications in Today's and Tomorrow's Technology**

Yahya, Ahmad, Jalil, (2010) divides the three learning paradigms (u-learning, m-learning, e-learning) in to six different categories as; concept, permanency, accessibility, immediacy, interactivity, context-awareness. Distance education lasts for one hundred years with its traditions and experience in educational environment. Its most crucial property is to remove time and distance (Georgiev, Georgieva, & Smrikarov, 2004). E-learning is the most usable way to pursue distance education by conceiving very type of differences such as cultural background, technical experience, technological equipment and physical/cognitive abilities (Arditoet. al. 2006). Augmentation of lap top computer and technology usage in learning paradigms such as mobile computing and ubiquitous learning (Pierre, 2001). M-learning is part of e-learning and it is maintained with mobile and portable devices every time, everywhere (Georgiev et. al., 2004). E-learning is assistive for both the educators and the students during the learning process; administers the educational needs of students, enables content consistency and standardization (Berke & Wiseman, 2003). Early on; ubiquitous learning was used for tourist and museum guides which people got information about his/her current position (Bomsdorf, 2005). For instance, an electronic guidebook is used as an interactive science museum which people experience the technology support during their exploration and it combines the web based system with text, images, digital audio and video (Hsi, 2002).

### **Various Supporting Devices in UL**

Wireless networks and mobile devices are included in ubiquitous computing and mobile learning. Except mobile devices, wireless LAN (Local Area Network), GPRS (General Packet Radio Service), Bluetooth technologies, GSM (Global System

for Mobile Communications) are assistive technologies for mobile learning (Peng & Su & Tsai, 2009). RFID (Radio Frequency Identification) technique which is an assistive technology for outdoor learning and ubiquitous learning will be used widely in the future (Chen & Huang, 2012). U-learning environment is a system and it is supported with those devices: PDAs, Mobile phones, portable computers and tablet PDAs. Its' system is defined with three elements Content Producer System, Service Provider System, and Content Consumer System and (Sung, 2009). Jones et. al. (2004) defines the components of ubiquitous learning;

**Microprocessors:** Students' PDA gets the information by the support of sensor.

**ULE Server Module:** This module runs the network resources.

**Wireless technology:** Bluetooth and Wi-Fi are included in this technology.

**Sensors:** They are used to arrange movement and light intensities.

Taylor, (1980) asserted that computing has a great role in human learning and its' future role is wondered by educators. Computer usage is divided in to three parts;

1-Computer as tutor: Student is controlled by the computer.

2-Computer as tool: Students use it to meet their needs.

3-Computer as tutee: Students or the teachers learn programs to use the computer.

On the other hand; Roschelle (2003) is in the idea that technological devices for education are not controlled and programmed by students or the teachers. Recently, mobile learning has become one of the most popular trends with the movement of wireless communication. Technology such as RFID (Radio Frequency Identification) may provide positioning services (Tan & Liu & Chang, 2007); which a system used by the researches to find out students' learning in a museum with two personal digital assistants (PDAs) (Yatani, et.al. 2004). PDAs for u-learning support students to gain self-efficacy but there should be much more researches about PDAs influence on students' behaviors, learning processes and learning performances (Tsai & Tsai, C. & Hwang, 2010). Qr codes are another software tools in ubiquitous learning environment and often called as 2d codes/2d barcodes/mobile codes. They are matrix barcodes and mobile phones/smartphones read them with a free application (Ashford, 2010). Qr (quick response) codes are firstly used by a Japanese company Denso-Wave in 1994 and it was applied in vehicle parts manufacturing (Rouillard&Laroussi, 2008). Qr codes are used in educational field, for instance in a research students are given Qr codes to get information from HELLO (Handheld English Learning Organization) server to complete their pervasive learning task (Liu & Tan & Chu, 2010).

### **Contextualized Effective Teaching Strategies with Ubiquitous Learning**

Ubiquitous learning environment is applied in many different teaching areas such as physics, English language acquisition, mathematics, and so on. Ubiquitous learning environment is conducted to many students with many different experiments to explore new discussions in education. A context aware ubiquitous leaning environment is carried out with PhD students to perform single-crystal x-ray diffraction operations. Experiments revealed that innovations in science environment

are practicable and effective in educational settings and many other u-learning systems should be conducted to discover new impacts (Hwang et. al. 2009).

There are many points to consider about mobile learning such as being portable, low budget and accessible. Students and teachers should be mutually engaged to the social environment in other words practices should be learner centered, assessment centered and knowledge centered; communication features should be created appropriately (Roschelle, 2003). Findings show that ubiquitous cooperative learning is applicable and advantageous on deepening learners' knowledge and 3G wireless network and synchronous tools are the most usable network and tools in a ubiquitous learning environment (Huang et. al., 2008). Sung (2009) developed a ubiquitous learning environment to combine the adaptive learning environment with ubiquitous computing with mobile devices. In the u-learning environment it is seen that the system is favorable for multimedia learning environment and innovative learning environment. Learning through ubiquitous environment is popular in educational settings because experiments proved the applicability of handheld devices in collaborative learning. For instance group area network is used within learners to connect with wireless technology which is assistive in collaborative learning tasks (Chen et. al., 2008). In spite of their positive impacts on educational settings, mobile learning system may have restrictions such as not getting the real-time in historical sites, endangered animal habitats and geological landscapes. Information technology to improve learning is developed to support teachers deliver topics on site and help students to understand information (Liu et. al, 2009). Scientists do not always search the innovative effects of ubiquitous learning, they sometimes emphasize on the restrictions of it. They assert that students might get excited because of a deficient guide or lack of learning information/tools. A mind tool is created with a knowledge engineering approach to confront this problem (Chu et. al.,2010).

## Conclusion

Ubiquitous learning environment is as seen, becoming more popular day by day. Instructors, learners and business people prefer ubiquitous computing and learning since it is usable anywhere and anytime we want. Well-designed software may be an assistive technology for students' literacy development, reading skills and writing skills on the other hand technology will not take the place of good teaching (Connor et. al., 2014). It is clearly seen that assistive technology is part of educational environment and students get involved in to the lecture easily if there is well-designed software. Students may learn from many different sources but technology sometimes is not enough for a learning environment. Technology is applicable in problem solving areas since students may have the chance to create abstract topics with technological support (Jong, 2014). Teacher should give feedback, use the proper method and motivate students in a positive way. Learning is impacted from many different styles of students' motivation styles, cognitive discrepancies and prior knowledge. That's why adaptive learning technology is created to balance that dividedness by giving suitable information, feedback, materials and necessary recommendations (Graf & Kinshuk, 2014).

While learning a task, technology is nowadays definitely the major assistive material for a student. Students can create their graphics, do their assignments in an enjoyable way also it distracts them from the monotonous, traditional way. Ubiquitous

learning environment makes them feel relaxed and motivated. Of course the main advantages in using computers cannot be denied that a task that may get longer to do by hand writing conversely, with a handheld device it takes a shorter period of time which leads us to do our assignments, data organization and presentations, creation and editing of documents, calculations, graphics and the other necessary deals with a great convenience.

Technology-based learning carries out a great role to limited capacities, enhancing their visual and auditory information throughout a practical way and taps into multiple learning strategies. A research done with students how ubiquitous games in an English listening and speaking course impact students' learning. Liu and Chu (2010) prepared an effective learning environment with a quasi-experimental design. They find that self-learning and cooperation will support their satisfaction and learning. A future research may be conducted with secondary high school students to find out whether ubiquitous learning environment increases secondary high school students' phrasal verbs knowledge and to receive their opinions about the process. Aren't there any limitations of ubiquitous learning? May we say that is it better than traditional teaching methods? How will the dyslexic or disabled students are going to use it? There are many questions to be answered but the proof of usable technological devices' positive impact on students and teachers cannot be denied.

## References

- ARDITO, C., COSTABILE, M. F., DE MARSICO, M., LANZILOTTI, R., LEVIALDI, S., ROSELLI, T., & ROSSANO, V. (2006). "An approach to usability evaluation of e-learning applications". *Universal access in the information society*, 4(3), ss.270-283.
- ASHFORD, R., (2010), "QR codes and academic libraries Reaching mobile users". *College & Research Libraries News*, 71(10), ss. 526-530.
- BERKE, W. J., & WISEMAN, T. L. (2003). "The e-learning answer." *Nursing management*, 34, ss. 26-29.
- BOMSDORF, B., (2005), "Adaptation of learning spaces: Supporting ubiquitous learning in higher distance education", *Mobile Computing and Ambient Intelligence: The Challenge of Multimedia University of Hagen, Information Systems and Databases*, 58084 Hagen, Germany, ss. 1-13
- BRIDGLAND, A., & BLANCHARD, P., (2005), *Powerful, portable, personal computing: is m-learning and opportunity in e-learning?*, ss. 1-10.
- CHEN, C. C., & HUANG, T. C., (2012), *Learning in a u-Museum: Developing a context-aware ubiquitous learning environment*. *Computers & Education*, 59(3), ss. 873-883.
- CHEN, N. S., KINSHUK, C. W. W., WEI, C. W., & YANG, S. J., (2008), *Designing a Self-contained Group Area Network for Ubiquitous Learning*. *Educational Technology & Society*, 11(2), ss. 16-26.
- 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*. In *Advanced Information Networking and Applications*, 2005. AINA 2005. 19th International Conference on (Vol. 2, pp. 567-573). IEEE.
- CHU, H. C., HWANG, G. J., & TSAI, C. C., (2010), *A knowledge engineering approach to developing mind tools for context-aware ubiquitous learning*. *Computers & Education*, 54(1), ss. 289-297.
- CONNOR, C. M., GOLDMAN, S. R., & FISHMAN, B., (2014), *Technologies That Support Students' Literacy Development*. In *Handbook of Research on Educational Communications and Technology* (ss. 591-604). Springer New York.
- COPE, B., & KALANTZIS, M., (2009), *New media, new learning. Multiliteracies in motion: Current theory and practice*, ss. 87-103.
- DE JONG, T., (2014), *Emerging representation technologies for problem solving*. In *Handbook of Research on Educational Communications and Technology* (ss. 809-816). Springer New York.
- DILLENBOURG, P., (1999), *What do you mean by collaborative learning? P. Dillenbourg. Collaborative-learning: Cognitive and Computational Approaches*, Oxford: Elsevier, ss.1-19.
- FABOS, B., & YOUNG, M. D., (1999), *Telecommunication in the classroom: Rhetoric versus reality*. *Review of Educational Research*, 69(3), 217-259.
- GEORGIEV, T., GEORGIEVA, E., & SMRIKAROV, A., (2004), *M-Learning: A new stage of E-Learning*. In *Proceedings of the 5th international conference on Computer systems and technologies*, ss. 1-5.

- GRAF, S., KINSHUK, (2014), Technologies That Support Students' Literacy Development. In *Handbook of Research on Educational Communications and Technology* (ss. 771-779). Springer New York.
- GOVINDASAMY, T., (2001), Successful implementation of e-learning: Pedagogical considerations. *The Internet and Higher Education*, 4(3), ss. 287-299.
- HSI, S., (2002), The electronic guidebook: A study of user experiences using mobile web content in a museum setting. In *Wireless and Mobile Technologies in Education, 2002. Proceedings. IEEE International Workshop on* (ss. 48-54). IEEE.
- HUANG, Y. M., HUANG, T. C., & HSIEH, M. Y., (2008), Using Annotation Services in a Ubiquitous Jigsaw Cooperative Learning Environment. *Educational Technology & Society*, 11(2), ss. 3-15.
- HWANG, G., YANG, T., TSAI, C., YANG, S., (2009), A context-aware ubiquitous learning environment for conducting complex science experiments *Computers & Education* 53, ss. 402-413.
- HWANG, G., WU, C., TSENG, J., HUANG, I., (2011), Development of a ubiquitous learning platform based on a real-time help-seeking mechanism *British Journal of Educational Technology* 42(6), ss. 992-1002.
- KEEGAN, D., (2002), The future of learning: From e-learning to m-learning. Ericsson Competence Solutions: Dun Laoghaire, Ireland <http://www.fernuni-hagen.de/ZIFF/mlearn.htm>
- JONES, V., & JO, J. H., (2004), Ubiquitous learning environment: An adaptive teaching system using ubiquitous technology. In R. Atkinson, C. McBeath, D. Jonas-Dwyer, & R. Phillips (Eds.), *Beyond the comfort zone: Proceedings of the 21st ASCILITE conference* (ss. 468-474). Perth, 5-8 December. <http://www.ascilite.org.au/conferences/perth04/procs/jones.html>
- LIU, T. Y., TAN, T. H., & CHU, Y. L., (2010), QR code and augmented reality-supported mobile English learning system. In *Mobile multimedia processing* (ss. 37-52). Springer Berlin Heidelberg.
- LIU, T. Y., TAN, T. H., & CHU, Y. L., (2009), Outdoor Natural Science Learning with an RFID-Supported Immersive Ubiquitous Learning Environment. *Educational Technology & Society*, 12(4), ss. 161-175.
- LYYTINEN, K., & YOO, Y., (2002), Ubiquitous computing. *Communications of the ACM*, 45(12).
- MCLOUGHLIN, C., & LEE, M. J., (2010), Personalized and self-regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software. *Australasian Journal of Educational Technology*, 26(1).
- OGATA, H., & YANO, Y., (2003), How ubiquitous computing can support language learning. *Proc. of KEST*, ss. 1-6.
- OGATA, H., & YANO, Y., (2004), Context-aware support for computer-supported ubiquitous learning. In *Wireless and Mobile Technologies in Education, 2004. Proceedings. the 2nd IEEE International Workshop on* (ss. 27-34). IEEE.
- PENG, H., SU, Y.J., TSAI, C.C & C.C., (2009), Ubiquitous knowledge construction: mobile learning re-defined and a conceptual framework, *Innovations in Education and Teaching International*, 46(2), ss. 171-183, DOI: 10.1080/14703290902843828.
- PIERRE, S., (2001), Mobile computing and ubiquitous networking: concepts, technologies and challenges. *Telematics and Informatics*, 18(2), ss. 109-131.

- ROUILLARD, J., & LAROUCSI, M., (2008), Per Zoovasive: contextual pervasive QR codes as tool to provide an adaptive learning support. In Proceedings of the 5th international conference on Soft computing as transdisciplinary science and technology (ss. 542-548). ACM.
- ROSHELLE, J., (2003), Keynote paper: Unlocking the learning value of wireless mobile devices. *Journal of computer assisted learning*, 19 (3), ss. 260-272.
- SHIN, D. H., SHIN, Y. J., CHOO, H., & BEOM, K., (2011), Smartphones as smart pedagogical tools: Implications for smartphones as u-learning devices. *Computers in Human Behavior*, 27(6), ss. 2207-2214.
- SUNG, J. S., (2009), U-learning model design based on ubiquitous environment. *International Journal of Advanced Science and Technology*, 13, 77-88.
- SWAN, K., KRATCOSKI, A., & VAN'T HOOFT, M., (2007), Highly Mobile Devices, Pedagogical Possibilities, and How Teaching Needs to Be Re-conceptualized to Realize Them. *Educational Technology*, 47(3), ss. 10-12.
- 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), ss. 253-269.
- TAYLOR, R. P., (1980), Introduction. In R. P. Taylor (Ed.), *The computer in school: Tutor, tool, tutee* (pp. 1-10). New York: Teachers College Press.
- TSAI, P. S., TSAI, C. C., & HWANG, G. H., (2010), Elementary school students' attitudes and self-efficacy of using PDAs in a ubiquitous learning context. *Australasian Journal of Educational Technology*, 26(3).
- YAHYA, S., AHMAD, E. A., & JALIL, K. A., (2010), The definition and characteristics of ubiquitous learning: A discussion. *International Journal of Education and Development using Information and Communication Technology*, 6(1), 1.
- YANG, S. J. H., (2006), Context Aware Ubiquitous Learning Environments for Peer-to-Peer Collaborative Learning. *Educational Technology & Society*, 9 (1), ss. 188-201.
- YATANI, K., ONUMA, M., SUGIMOTO, M., & KUSUNOKI, F., (2004), Musex: A system for supporting children's collaborative learning in a museum with PDAs. *Systems and Computers in Japan*, 35(14), ss. 54-63.
- ZHAO, X., WAN X., OKAMOTO T., (2010), Adaptive content delivery in ubiquitous learning environment The 6th IEEE International Conference on Wireless, Mobile and Ubiquitous Technologies in Education (IEEE WMUTE 2010). Kaohsiung, TAIWAN.
- WALKER, K., (2006), Introduction: Mapping the landscape of mobile learning. In M. Sharples (Ed.), *Big issues in mobile learning: Report of a workshop by the kaleidoscope network of excellence mobile learning initiative*. University of Nottingham.
- WELSH, E. T., Wanberg, C. R., Brown, K. G., & Simmering, M. J., (2003), E-learning: emerging uses, empirical results and future directions. *International Journal of Training and Development*, 7(4), ss. 245-258.
- WEISER, M., (1993), Some computer science issues in ubiquitous computing *Communications of the Acm*, 36(7), ss. 75-84.