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Learning in a u-Museum: Developing a context-aware ubiquitous learning environment

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ABSTRACT

Context-awareness techniques can support learners in learning without time or location constraints by using mobile devices and associated learning activities in a real learning environment. Enrichment of context-aware technologies has enabled students to learn in an environment that integrates learning resources from both the real world and the digital world. Although learning outside of the traditional classroom is an innovative teaching approach, the two main problems are the lack of proper learning strategies and the capacity to acquire knowledge on subjects effectively. To manage these problems, this study proposes a context-aware ubiquitous learning system (CAULS) based on radio-frequency identification (RFID), wireless network, embedded handheld device, and database technologies to detect and examine real-world learning behaviors of students. A case study of an aboriginal education course was conducted in classrooms and at the Atayal u-Museum in Taiwan. Participants included elementary school teachers and students. We also designed and used a questionnaire based on the Unified Theory of Acceptance and Use of Technology (UTAUT) theory to measure the willingness for adoption or usage of the proposed system. The experimental results demonstrated that this innovative approach can enhance their learning intention. Furthermore, the results of a posttest survey revealed that most students' testing scores improved significantly, further indicating the effectiveness of the CAULS.

1. Introduction

The rapid development of wireless network technologies has enabled people to conveniently access the Internet from more diverse locations. Wireless local area network (WLAN) offers an excellent solution for schools wishing to establish internet infrastructure. Additionally, the pervasiveness of handheld mobile devices, such as Tablet PC, PDA and smart phone, has transformed learning modes from e-learning to m-learning. Particularly, compared with traditional classroom learning, m-learning overcomes limitations of learning time and space. Thus, the advantages of m-learning are suitable to apply during authentic learning activities. Recently, the concept of 'context-aware ubiquitous learning' has been further proposed to emphasize the characteristics of learning the 'right content' at the 'right time' and 'right place', and also to facilitate a seamless ubiquitous learning environment that supports learning without constraints of time or place (Ogata & Yano, 2004). The so called 'context-aware ubiquitous learning' (Rogers et al., 2005) thus requires the detection of learner context information and provides learning with different learning content via mobile devices in response to different learning contexts.

Currently, teachers often introduce cultural differences through filmstrips in the classroom, teach outdoors, and conduct exercise experiments to help students in local and aboriginal education courses. Outdoor teaching is widely recognized as the most feasible among these methods; therefore, elementary school teachers in Taiwan teach outdoors frequently (Tan, Liu, & Chang, 2007). However, most outdoor teaching approaches are ineffective because students lack expert assistance and convenient outdoor learning tools. Students often do not learn sufficient or useful knowledge without observing teaching materials carefully in outdoor teaching (Chen, Kao, & Sheu, 2003; Tan et al., 2007). This situation influences the learning achievement of students with authentic activities in outdoor teaching. Therefore, the application of information technology on outdoor teaching has become an attractive research topic (Huang, Chiu, Liu, & Chen, 2011; Huang, Huang, Huang, & Lin, 2012).

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In the past decade, various computer-assisted and web-based learning systems have been constructed to provide a more adaptive learning environment with richness of learning resources (Chu, Hwang, Tsai, & Chen, 2009; Huang, Huang, & Chen, 2007; Tsai, 2009; Wang, 2009). Considerable attention has been focused on novel learning approaches with appropriate educational software tools and convenient environments (Hwang, Tseng, & Hwang, 2008), such as activity theoretical approach (McAvinia & Oliver, 2004), computer scaffolding (Sharma & Hannafin, 2007; Chen, Chang, Chen, Huang, & Chen, in press), Web 2.0 technology (So, Seow, & Looi, 2009), and e-Portfolio (Chen, Wu, & Jen, 2011; Huang & Wu, 2011). These learning approaches have been applied successfully in traditional classroom teaching. However, several researchers and experienced educators have emphasized the importance and necessity of “authentic activities,” in which students can work with real-world problems (Baloian, Pino, & Hardings, 2011; Chu, Hwang, Tsai, & Tseng, 2010). Authentic learning activities that integrate content and process offer the opportunity to increase student experience with authentic activities by achieving improved content understanding (So & Kong, 2010). Moreover, in traditional Web-based learning environments, all learning content in a curriculum are sequenced by hyperlinks, but no concrete sequence exists and is without navigation support. Researchers found that an inappropriate navigation support in Web-based learning tends to result in disorientation during learning processes, thereby reducing learning efficacy. Likewise, Web-based training often provides students with less one-on-one attention from the instructor, and the feedback they received is probably unlikely to be face-to-face. Furthermore, the biggest challenge that Web-based learning poses to many students is in maintaining motivation. When the paradigm shifts to context-aware u-learning environments, the navigation supports, real-time interaction, and student motivation will be enhanced because students are learning around actual space rather than cyberspace (Liu & Chu, 2010).

Because of the rapid growth of wireless communication and mobile technology development, mobile learning is becoming a popular approach to learning. The continual development of the Radio-frequency identification (RFID) technique will fulfill ubiquitous learning (u-learning). Improvements in technology and the rapidly declining price trend will expand the scope of future RFID applications. The application of the RFID technique in teaching and learning activities will not restrict this type of learning in a physical classroom, and learning materials will not be textbooks. The RFID technology is able to provide students with sufficient prearranged information whenever they go through the predetermined learning locations (Hwang, Kuo, Yin, & Chuang, 2010). Moreover, the RFID technology may assist the learning system to detect and record the learning behaviors of students in a real environment. This type of sensing technology may enable mobile learning to provide learners with an alternative approach to manage problems in a real-world context, and effectuate the learning system to interact with learners more actively (Chen, in press; Ogata & Yano, 2004). Compared with GPS, WLAN can provide precise location information in both indoor and outdoor environments and has been widely implemented in most public areas and school environments (Kupper, 2005). WLAN positioning is a more suitable method of enabling the development of “context-aware ubiquitous learning” that can provide learning content associated with learning contexts and assists learners in context-based learning in a campus environment. In addition, the WLAN and RFID technologies are synergistically used to provide a platform for a higher-performance positioning process, in which the strong identification capabilities of RFID technology enable increasing the accuracy of positioning systems through WLAN fingerprinting. Thus, the RFID technology would be suitable to apply in the u-Museum environment in this research. Consequently, this study constructed a context-aware ubiquitous learning system (CAULS) based on RFID technology and PDA handheld reader equipment. This study applied a three-tier teaching strategy to improve the teaching and learning process. Moreover, this study also designed learning materials through context-aware interfaces, and subsequently provided personalized learning support for each learner. Finally, this study proposes the outdoor teaching tool CAULS, which is useful for supporting learners in enhancing their motivations and performance with authentic activities.

2. Relevant research

In earlier studies, mobile learning focused on implementing learning systems to “supplement” learners, to learn in authentic learning environments. For example, Chen et al. (2003) designed an outdoor mobile learning activity on birdwatching by using handheld devices to show learning sheets and supplementary materials. Ogata and Yano (2004) proposed JAPELAS and TANGO systems to guide students to learn Japanese in real-world circumstances. These systems may provide students with adequate expressions on the basis of various contexts through mobile devices. Rogers et al. (2005) used mobile devices to allow children to observe and collect data in the woodlands. Consequently, they claimed that digital augmentation was a promising approach to enhance the learning process, especially by encouraging the dovetailing of exploring and reflecting when indoors and outdoors. Currently, researchers have attempted to use sensing or wireless technologies to provide more effective learning tools. Several technique reports or best practices have been proposed from related consulting companies or suppliers of RFID technologies. RFID is a wireless sensor technology based on electromagnetic signal detection. In addition, RFID is an identification system in which an electronic appliance is attached to an item and uses radio frequencies to communicate with other appliances. The two most important components in an RFID system are the RFID tag (an electronic identification device attached to the item to be tracked) and the RFID reader (a device that can sense and extract data from the tag). Once extracted, the RFID reader usually transmits the data to another server/system running edge applications through RFID middleware software that translates reader observations before passing them forward. Several academic studies obtained optimal results in educational experiments; for example, Chen, Chang, Lin, and Yu (2008) used a wireless network, handheld device, and RFID to build a context-aware writing system (C-Writing) in ubiquitous learning environments. As demonstrated by the results, this system attracted the attention of learners and helped them improve learning performance efficiently. Subsequently, Hwang, Yang, Tsai, and Yang (2009) proposed a context-aware ubiquitous learning system with RFID communication and sensing technologies to support researchers who lacked practical experience by using single-crystal X-ray diffraction operations (Hwang et al., 2009). Moreover, Chiou, Tseng, Hwang, and Heller (2010) presented the navigation support problem for context-aware ubiquitous learning, and two navigation support algorithms (Chiou et al., 2010). Their goal was to enhance the efficiency of learning and navigation. As demonstrated by the results, this approach is useful to improve the achievements of learners and to help them use learning resources more efficiently.

In a context-aware ubiquitous learning environment, individual students are guided to learn in a real-world situation with support or instructions from a computer system or using a mobile device to access the digital content via wireless communications. This is where the learning system is able to detect and record the learning behaviors of students in both the real world and the virtual world with the help of the sensor technology (Hwang et al., 2009; Ogata & Yano, 2004). The connection between learner-centered and real-world-situated learning has