From e-Knowledge Sharing to m-Knowledge Sharing: A Theoretical Framework

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Abstract. The adoption of mobile devices has been rapidly increasing in recent years. Therefore, researchers have been exploring the possibilities of using various types of mobile technologies such as Location-based Services (LBS) to facilitate learning and knowledge sharing. There is an enormous amount of studies concern about those technologies individually, but there is no or very few of them aims to integrate them to establish a comprehensive mobile learning or sharing system. In this study, Centre for Cyber Learning of HKU SPACE proposed an theoretical framework that facilitates the integration of an existing e-learning system and mobile technologies. This paper also reviews several mobile technologies and applications that shed light on the proposed framework, specifies the architecture and components, introduces the new features, as well as discusses how the proposed features could enhance learning experience.

Keywords: e-learning, location-based service, knowledge sharing, mobile learning, iOS, Android.

1 Introduction

Mobile devices and their related technologies are ubiquitous and they have been permeated through almost all aspects of our daily life (Mifsud and Mørch, 2010). Mobile phones and tablet devices have become indispensable gadgets or tools to many people, especially young people who use them as a collaborative platform for sharing information. According to the demographic data of a research with learners as subjects, there was 100% ownership of mobile phones among the 502 subjects (Beng Lee, 2013). In Hong Kong, the number of mobile service subscribers was boosted to 15.95 million in 2012, and total mobile data usage recorded a remarkable surge to 6,347 Terabytes per month, or an average of 666.9 Mbytes per mobile user in a month (HKSAR the Information Services Department, 2013). This implies that people not only consider mobiles device as leisure gadgets, but also, to a certain extent, seriously use them as an Internet communicator, or even a desktop computer replacement. The tremendous amount of mobile device adoption attracts more and more parties to spend efforts in developing mobile apps and have shifted their attention from the

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conventional desktop computing environment to the new mobile environment. As young people are a frequent mobile user group, some Universities have started delivering part of their courses in mobile form (Cavus, 2010; Morris, 2010) and research indicated that learners have become more accept the use of mobile devices for learning over the past years (Stockwell, 2010).

In education, although the trend of converting conventional or web materials to mobile formats is increasing, most of the conversions only catered the form factors such as screen size and resolution, very few of them tried to make use of the unique features of modern mobile devices. Those features or technologies, including Quick Response (QR) Codes, Location-based Services (LBS), Augmented Reality (AR), Near Field Communications (NFC), and so on, have been widely and maturely adopted for entertainment or commerce purposes. If they are properly integrated with existing learning resources, learning and knowledge sharing may become more effective and interesting. We are currently managing a web-based e-learning system called SOUL 2.0, and this theoretical discusses the feasibilities of enhancing and expanding the functions of the e-learning system through adopting the latest mobile technologies. This paper reviews those technologies and their applications in education and knowledge sharing. It then describes how those technologies could be integrated into the current e-learning platform and discusses how the enhanced and new features could be beneficial to learning and knowledge sharing processes.

2 From e-Learning to m-Learning to u-Learning

In the past decade, e-learning or e-knowledge sharing has been widely adopted in education institutes and organizations for knowledge sharing and teaching purposes. It was also arguably one of the most powerful responses to the growing need for education (Zhao et al., 2010). In general, e-learning is commonly known as the use of multimedia and information and communication technologies (ICT) in education. In practice, e-learning or e-knowledge sharing could be conducted asynchronously or synchronously. Asynchronous e-learning is commonly facilitated by media sharing such as files, e-mails and discussion boards, where the learners and instructors do not need to participate simultaneously. Therefore, asynchronous e-learning makes it possible for learners to log on to an e-learning environment at any time, and download documents or send messages to instructors or peers. Learners may spend more time refining their contributions, which are generally considered more thoughtful when comparing with the synchronous one (Hrastinski, 2007). In contrast, Synchronous e-learning is commonly supported by real-time media such as video-conferencing and chat room, such that learners and instructors experience more social connection and could avoid frustration by asking and answering questions in real time. This kind of real-time interaction is believed to be an advantage over the asynchronous one. It is because isolation can be overcome by more continued contact, particularly synchronously, and by becoming aware of themselves as members of a community rather than as isolated individuals communicating with the computer (Haythornthwaite and Kazmer, 2002). As both asynchronous and synchronous e-learning modes cannot replace each other, for the two widely used Learning Management Systems (LMS) for e-learning, namely Blackboard Inc. (or its predecessor, WebCT) and Moodle (Yau et al, 2009; Unal and Unal, 2010), they both consist of modules that support the two e-learning modes, such as virtual classroom, whiteboard, resource sharing, etc. As the e-learning platforms were targeted for desktop or laptop computers, when they run in mobile devices, their user interfaces may not be fit in the relatively smaller screen; buttons, links and text may be too tiny to be navigated with; and some resources such as Adobe Flash may not be accessible. Therefore, developers of the platforms have started to create mobile compatible versions. For example, Moodle version 2.5, which was just released in May 2013, is the first version that supports mobile apps.

One limitation of e-learning or e- knowledge sharing is their immobility. Therefore, mobile learning (m-learning) was evolved from e-learning in order to facilitate learners and instructors who equipped with mobile devices to access learning resources through various wireless technologies such as Wi-Fi and cellular networks. Although m-learning is often considered as an extension or conversion of e-learning, its usability and quality depend on developers' awareness of the limitations and advantages of mobile devices (Parsons and Ryu, 2006). To learners, m-learning offers higher flexibility because electronic contents could be delivered to them anytime and anywhere when Internet connectivity is available to their mobile devices. Recently, a new concept of m-learning called "ubiquitous learning" (u-learning) was introduced (Zhao et al., 2010). It could be regarded as a subset of m-learning and emphasizes context awareness, such that learning environments can be accessed in various context and situations (Mandula et al., 2011). Conventionally, instructors are the primary sources of the knowledge resources, but in u-learning, learners also have the opportunity to access extra resources that may or may not be prepared by their instructors, where the context of the resources depends on the locations of the learners. For instance, Mandula et al. (2011) implemented a u-learning system that is equipped with Near Field Communication (NFC) technology. When a learner who carries a mobile device and comes in proximity of a location, say a library, the device displays the information about the latest journals, newsletters, and books.

In order to implement quality m-learning or u-learning, the adoption of mobile technologies is essential. Researchers have been attempting to explore the possibilities of using various types of mobile technologies to facilitate learning and knowledge sharing, including Quick Response (QR) Codes (Lai et al., 2013), Augmented Reality (AR) (Kamarainen et al. 2013; Yuen et al., 2013), Location-based Services (LBS) (Clough, 2010; FitzGerald, 2012), and so on. However, most of them are individual or small-scale projects. Having the experiences on customizing and maintaining an e-learning platform, we believe that if those technologies are applied and integrated into the existing e-learning platform that is mature and already rich of resources, the consequential benefits and potential is countless. Just imagine if the above-mentioned NFC system is linked with a platform that stores the learner profiles and learning materials. When a learner walks near the library, the information shown on his or her device is the reference materials that the learner is really interested in, and the device is capable to suggest the articles according to his or her learning progresses of the subjects that he or she is currently studying. A step further, the device can show the nearest locations of the suggested books and journals so that the learner can save time and focuses more on his/her study. Before discussing the feasibilities of the integration and the applications, the underlying mobile technologies are described in the subsequent section.

3 Mobile Technologies in Education

With the advancement of hardware and software, mobile devices nowadays could act as computing tools, and even provide some functions that an ordinary computer cannot provide. Few years ago before smartphones became popular, it was hard to imagine such tiny devices can embed so many technologies inside, where those technologies may change the future of our learning patterns and styles. This section presents some of those technologies and how they are used in education.

3.1 Quick Response (QR) Codes

QR codes are two-dimensional barcode symbols. Although Denso Wave Incorporated owns the patent rights on QR code technology, it is free of any license because the company decided not to exercise the rights. Depending on the versions used, a QR code symbol can store up to around 2,900 Bytes (Denso-wave, 2012). Moreover, providing that no more than 30% of a QR code symbol is damaged, the information stored in the symbol is still decodable (Lai et al., 2013). QR codes are popular in mobile applications because this technology only requires using a built-in camera, which is almost a standard component of todays' mobile devices. As generally a QR code symbol do not store much data, in common practice it is used to encode a web address (or URL), short text, or an identifier. For example, Figure 1 shows a QR code that represents an URL to Centre for Cyber Learning of The University of Hong Kong, School of Professional and Continuing Education. Interested readers may use the "Goggles" function of the "Google" app or other QR code apps to scan the symbol. One advantage of QR codes is that it can redirect mobile app users to resources precisely, without the hassle of typing long texts by using the relatively small virtual keyboard of mobile devices.

Fig. 1. A QR Code Example

There are few contributions that adopted QR codes for outdoor learning. For instance, Lai et al. (2013) implemented an outdoor education information system that combines natural and cultural environment information using QR codes. The learners participated in the study equipped mobile devices, and maps that is printed with QR codes. When they arrived at the locations as specified in their maps, they used their mobile devices to scan the related QR codes, and then their devices downloaded the learning resources and information that are associated with their current locations. In another study, Chin and Chen (2013) proposed an Android-based mobile learning support system that allows learners to receive teaching materials on mobile devices, and control learning paces by themselves. When a learner uses the mobile app to scan a QR code, the content learning function decodes it and downloads the corresponding teaching materials or tasks. The app also uploads the learning progress and outcome to the centralized database when any task is completed.

3.2 Augmented Reality (AR)

AR is a growing phenomenon on mobile devices. According to the New Media Consortium Report 2011, AR is the highest-rated topic by its advisory board, with widespread time-to-adoption being only two to three years (Johnson et al., 2011). However, AR is not a very new technology. Over a decade ago, Azuma et al. (2001) already defined AR as the combination of virtual and real objects in a real environment; a system that aligns/registers virtual and read objects with each other; and that runs interactively in real time. AR is believed to have a huge impact on mobile devices because users are no more constrained to a desktop computer that is located at a static location. Instead, mobile AR apps could be dynamic and across contexts. As FitzGerald et al. (2012) suggested, mobile AR brings in new aspects to learning, it fosters the mobility of users, their geographical position the physical place where learning to can occur, and it enables formal learning to connect with informal learning. Research also revealed that using AR for education can appeal to learners at a much more personal level, promoting engagement and motivation amongst its users (Luckin and Stanton Fraser, 2011). For knowledge sharing, AR could also bridge the gap between digital and physical world through the concept of “AR books”. An AR book is a physical book that consists of visible or hidden AR markers on its pages, when the camera of a mobile device captures a marker, the AR book app will display a corresponding 3D model or animation. For example, a learner reads an AR book that teaches how to make puppets. If the learner intents to see a virtual 3D puppet, he or she can point the camera of a mobile device to the book. On the screen of the mobile device, a virtual 3D puppet, which is viewable in different angles, overlays on the AR book (Figure 2). In reality, of course the learner sees nothing on the book page but virtually, on the screen of the device, he or she sees a 3D puppet stands on the book page, which is helpful for understanding concepts immediately. This example confirms the definition that “AR is the combination of virtual and real objects in a real environment”. Yuen et al. (2013) introduced some interesting AR books such as “The Future is Wild: The Living Book” and “MagicBook”, as well as few AR games for education purposes.

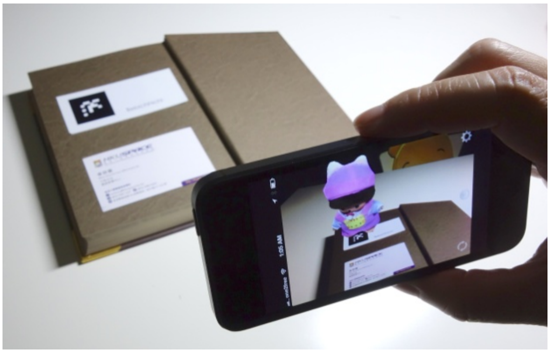

Fig. 2. An AR Example

3.3 Near Field Communications (NFC)

NFC, as its name implies, is a short-range wireless communication technology that used to capture the data of remote objects. Its operation is based on the Radio Frequency Identification (RFID) technology that allows fast exchanges of small amount of data between mobile devices (or computers) and objects with RFID tags. Although NFC is emerging as the leading standard for mobile payments, it is believed to have wider applications because of the "touch to exchange information" feature (Mandula et al., 2011). One successful NFC application is the Octopus card that was firstly introduced in 1997 (Octopus Hong Kong, 2013). It is a smart card that stores values for authentication purposes and making electronic payments, where the adoption rate is currently over 95% of Hong Kong population. NFC is built in most Android mobile devices today. For other mobile systems such as Apple iOS, NFC can be achieved by plugging external readers to the devices. For education, in addition to the study of Mandula et al. (2011) (described in section 2), there are more examples. In an u-learning project called "TRON", the researchers intended to increase the intelligibility of total food chains by embedding RFID tags onto foods (Sakamura and Koshizuka, 2005). Learners can learn relevant information about foods by accessing the tags by using a device with RFID tag scanning capability. Similarly, Ogata and Yano (2004) developed a "Tag Added learNinG Objects (TANGO)" system, which makes use of the location of a learner to detect various real-world objects associated with RFID tags in order to provide educational information. For outdoors education, Huang et al. (2010) developed a mobile plant learning system that allows learners to access the information about different plants with tags embedded, and other relevant information according to the positions of the learners.

3.4 Location-Based Services (LBS)

LBS are quite unlike the above-mentioned technologies that are implementable on both mobile and stationary devices, and could be more usable on mobile devices. Instead, a LBS is rather meaningless for stationary computers such as desktop or laptop computers because the system of a LBS have to know the geographical positions of the devices using that service. This is achieved through the use of positioning technologies, such as global positioning system (GPS), transmitters locations of cellular networks, and Wi-Fi (FitzGerald, 2012). Moreover, most LBS provide dynamic contents according to the geographical positions of the users, even some stationary computers are capable to identify their fixed geographical positions, they cannot utilize the potential of LBS as the contents are also remain stationary. One of the well-known LBS applications is map such as Google Maps, which is available for every mobile device nowadays. Those map applications could locate user positions and indicate nearby information that would interest the users. LBS are also the indispensible ingredients for social media apps like facebook that connects users around the world. The LBS features including “Status”, “Photo”, “Check In”, and so on, allows users to record their current locations and make information sharing become more interesting. With LBS, researchers also have been contributing some interesting studies. For example, a GPS-enabled treasure hurt activity called “Geocaching” was being explored for the possibility of informal learning (Clough, 2010). Participants hide Geocaches at particular physical locations that are accessible to the general public, and provide clues on where to find it. Learning opportunities were found to be both intentional and accidental, as participants would sometimes find out information about a local area as a by-product of seeking out the cache. In addition, there was a project called “MyArtSpace”, which encouraged learners to visit art galleries or museums (Vavoula et al., 2009). The learners can record their experiences using mobile devices through the collection of tags in galleries and museums, and enable their own creation and uploads of multimedia materials such as images, sounds, and text. Then the uploaded digital materials were accessed and discussed in a classroom setting. Thus the LBS and other underlying technologies bridged informal and formal learning in that study. For more theoretical information for creating LBS in knowledge sharing, FitzGerald’s authoring framework is worthy to refer to (FitzGerald, 2012). The framework has been designed to guide the authoring of user-generated content so that it can be used for informal learning about learners’ immediate surroundings.

The mobile technologies discussed above are not the exhaustive list of all mobile technologies nowadays but they could be the most popular technologies that are used for the studies of mobile or ubiquitous learning and knowledge sharing. However the importance of other mobile technologies such as push notifications, multi-touch controls, varies of sensors like accelerometer and gyroscope, etc. should not be neglected as they may be useful for learning and knowledge sharing and make the process more attractive and lively. The next section presents a theoretical framework for integrating some of the said mobile technologies and discusses some feasible applications of the proposed concept.

4 The Theoretical Framework

We are currently maintaining and enhancing an e-learning system called SOUL 2.0, where the development is based on Moodle, a widely adopted open source course management system (moodle.org). One important feature in Moodle is its openness and therefore there are hundreds of plug-ins and add-ons available to be downloaded for free. Moodle’s openness does not only make Moodle highly customizable, but also offer possibilities to implement innovative functions. Inspired from the reviewed studies and our experiences, we believe that, with careful refinements and proper add-ons, the existing e-learning system could be evolved into a mobile or ubiquitous learning and knowledge sharing system. Figure 3 illustrates the framework that integrates the Moodle-based system with mobile technologies.

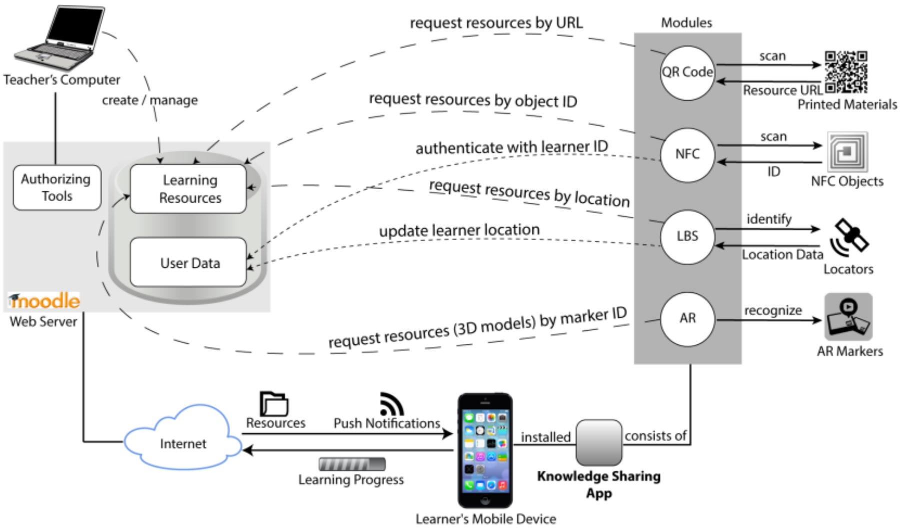

Fig. 3. The theoretical framework for m-knowledge sharing

On the left hand side of Figure 3, there is a web server installed with Moodle software (version 2.4 or above). It is basically a large database that contains user data and learning resources (or called course data officially), as well as offering a suite of authoring tools for instructors or contributors to create learning activities. As Moodle is open for developing software plug-ins to it, it is possible to communicate with any mobile devices. Fortunately, this part has not to be implemented from scratch because starting from version 2.4, Moodle officially supports mobile apps so that the basic features of Moodle are ready to present on mobile devices. At the bottom of the diagram, there is a mobile device for learners, which is already installed with a knowledge sharing app. On one hand, as depicted on the right of Figure 3, the app consists of some software modules that manipulate the mobile technologies introduced in the previous section. On the other hand, the app communicates with the web server using the secure web services infrastructure, aims to receive resources and push notifications, as well as sending back any learning progress. It is worthy to describe push notification briefly here. In contrast with "pull" technologies like website browsing, where the users have to visit a website to see if it has any update actively (i.e., users "pull" information from server), push notification is a service that information update is initiated by the server so that users do not need to perform any regular check (i.e., server "push" information to users) (Charland and Leroux, 2011).

For the mobile modules, their underlying technologies and relevant applications are discussed in the last section. Notably, the dash lines in the diagram represent logical interactions such that the more complicated physical paths (e.g., AR module -> app -> mobile device -> Internet -> web server…) are simplified for a clearer representation. Most importantly, this framework suggests that each module could be used in a standalone fashion, or collaborates with each other in order to provide more tailor-made and enjoyable learning experiences to users. Take a scenario as an example, the app always knows the geographical locations of learners through *LBS* and updates the location data with the server time-to-time. When a learner walks near a museum, the server *pushes* the information about the museum and suggestions that really interests the learner by analyzing his or her profile: the museum has a section showing the history of dinosaurs and the learner has to do a coursework report about the evolution of creatures. The learner sees a dinosaur skeleton and would like to know how the dinosaur looks like when it is alive. He or she points the camera of the mobile device to the *AR* marker that is placed next to the skeleton, and the screen shows a virtual 3D dinosaur standing next to the real skeleton. After interacting with the virtual dinosaur, the learner scans the *QR codes* that were printed on the information board, and then he or she can view videos, photos, and any text contents that are not shown on the board. Finally the learner could share those materials to the server so that other interested learners are also benefited from this learning progress. Noteworthy, this example does not only describe the interactions between the software modules, but also brings out the concept that in this mobile age, knowledge sharing is multi-directional and multi-dimensional such that a knowledge receiver is also a knowledge provider, and the knowledge sources could be conveyed in varies formats.

The proposed framework could also enhance the current e-learning and campus experience. For instance, most lecture materials are prepared in digital format (e.g., PDF), but many learners still like to print hardcopies for better readability. From this transition period until the day of totally paperless, reference contents of a handout, such as photos and long articles could be presented in small QR codes. This does not only decrease the number of pages and provide more variety formats of references, but also keeps track of the viewing logs as part of the learning progress. Those viewing logs may consist of “who”, “what”, “when”, and “where” information, which could be valuable for refining course materials or even evaluating learners’ learning behaviors. For NFC usages, tags could be placed on library books so that learners could obtain summary and table of contents of a book before taking the book off the shelf; tags may also be attached on laboratory apparatus so that learners could see the usage guides before using them to conduct experiments. If the learner ID card of a campus is a smartcard, it is also feasible to login the system by placing the learner ID card on a NFC ready mobile device. It may sound useless because typing username and password is fast even using the tiny virtual keyboard or a mobile device. However if we are considerable with visually impaired learners, this authentication method becomes meaningful. Content-to-speech is popular so those learners can hear the learning materials, but how can they login the system themselves? How about face or voice recognitions? Those technologies are not yet reliable and insecure. How about fingerprint? There are very few mobile devices having this feature and the campus has to handle one more privacy issue. Last but not least, since AR is capable to visualize three-dimensional objects and scenes, it shall be especially useful for academic subjects that rely on graphical presentations such as architecture and mechanical engineering. Since one AR marker can be recognized by many mobile devices simultaneously, each learner of a group can see the same 3D object in different angles on their devices. The group discussion becomes more engaging and interactive as the learner could share their observations and comments from “different point of views”.

5 Conclusions

This paper presents a theoretical framework for integrating mobile technologies and a mature e-learning system to form a mobile or ubiquitous learning and knowledge sharing system. Although several applications of the proposed frameworks are introduced, they are just the tip of the iceberg. With the advancement of mobile technologies such that more and more features will be embedded in such a small device, the possibilities for mobile learning and knowledge sharing are countless. And with this trend, the boundary between e-learning m-learning, and even u-learning will be more blurred. Therefore, for parties that implement e-learning, it is worthy to spend efforts to investigate those possibilities now. It is hoped that the purposed framework could act as a useful reference for them.

References

1. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., MacIntyre, B.: Recent advances in augmented reality. IEEE Computer Graphics and Applications 21(6), 34–47 (2001)
2. Beng Lee, C.: Exploring the relationship between intention to use mobile phone as a visualization tool and regulation of cognition. Computers & Education (2012)
3. Cavus, N.: The evaluation of Learning Management Systems using an artificial intelligence fuzzy logic algorithm. Advances in Engineering Software 41(2), 248–254 (2010)
4. Charland, A., Leroux, B.: Mobile application development: web vs. native. Communications of the ACM 54(5), 49–53 (2011)
5. Chin, K.Y., Chen, Y.L.: A Mobile Learning Support System for Ubiquitous Learning Environments. Procedia-Social and Behavioral Sciences 73, 14–21 (2013)
6. Clough, G.: Geolearners: Location-based informal learning with mobile and social technologies. IEEE Transactions on Learning Technologies 3(1), 33–44 (2010)
7. Denso-Wave, Version and Maximum capacity table (2012), `http://www.denso-wave.com/` (Archived from the original on September 15, 2012)
8. FitzGerald, E.: Creating user-generated content for location-based learning: an authoring framework. Journal of Computer Assisted Learning 28(3), 195–207 (2012)
9. FitzGerald, E., Adams, A., Ferguson, R., Gaved, M., Mor, Y., Thomas, R.: Augmented reality and mobile learning: the state of the art (2012)
10. Haythornthwaite, C., Kazmer, M.M.: Bringing the Internet home. In: The Internet in Everyday Life, pp. 431–464 (2002)
11. Hrastinski, S.: The potential of synchronous communication to enhance participation in online discussions (2007)
12. Huang, Y.M., Lin, Y.T., Cheng, S.C.: Effectiveness of a mobile plant learning system in a science curriculum in Taiwanese elementary education. Computers & Education 54(1), 47–58 (2010)

13. Johnson, L., Smith, R., Willis, H., Levine, A., Haywood, K.: The 2011 horizon report. The New Media Consortium, Austin (2011)
14. Kamarainen, A.M., Metcalf, S., Grotzer, T., Browne, A., Mazzuca, D., Tutwiler, M.S., Dede, C.: EcoMOBILE: Integrating Augmented Reality and Probeware with Environmental Education Field Trips. Computers & Education (2013)
15. Lai, H.C., Chang, C.Y., Wen-Shiane, L., Fan, Y.L., Wu, Y.T.: The implementation of mobile learning in outdoor education: Application of QR codes. British Journal of Educational Technology 62, E57–E62 (2013)
16. Luckin, R., Fraser, D.S.: Limitless or pointless? An evaluation of augmented reality technology in the school and home. International Journal of Technology Enhanced Learning 3(5), 510–524 (2011)
17. Mandula, K., Meda, S.R., Jain, D.K., Kambham, R.: Implementation of Ubiquitous Learning System Using Sensor Technologies. In: 2011 IEEE International Conference on Technology for Education (T4E), pp. 142–148. IEEE (July 2011)
18. Mifsud, L., Mørch, A.I.: Reconsidering off-task: a comparative study of PDA-mediated activities in four classrooms. Journal of Computer Assisted Learning 26(3), 190–201 (2010)
19. Morris, D.: E-confidence or incompetence: Are teachers ready to teach in the 21st century? World Journal on Educational Technology 2(2), 142–155 (2010)
20. Octopus Hong Kong, `http://www.octopus.com.hk/about-us/milestones/en/index.html` (last accessed on June 2013)
21. Ogata, H., Yano, Y.: Context-aware support for computer-supported ubiquitous learning. In: Proceedings of the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education, pp. 27–34. IEEE (2004)
22. Parsons, D., Ryu, H.: A framework for assessing the quality of mobile learning. In: Proceedings of the 6th IEEE International Conference on Advanced Learning Technologies, Kerkrade, The Netherlands (April 2006)
23. Sakamura, K., Koshizuka, N.: Ubiquitous computing technologies for ubiquitous learning. In: IEEE International Workshop on Wireless and Mobile Technologies in Education, WMTE 2005, pp. 11–20. IEEE (November 2005)
24. Stockwell, G.: Using mobile phones for vocabulary activities: Examining the effect of the platform. Language Learning & Technology 14(2), 95–110 (2010)
25. Unal, Z., Unal, A.: Exploring Preservice Teachers' Satisfaction with Online Teaching and Learning Tools: Blackboard vs. Moodle? In: World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education, vol. 2010(1), pp. 2741–2747 (October 2010)
26. Vavoula, G., Sharples, M., Rudman, P., Meek, J., Lonsdale, P.: Myartspace: Design and evaluation of support for learning with multimedia phones between classrooms and museums. Computers & Education 53(2), 286–299 (2009)
27. Yau, J., Lam, J., Cheung, K.S.: A Review of e-Learning Platforms in the Age of e-Learning 2.0. In: Wang, F.L., Fong, J., Zhang, L., Lee, V.S.K. (eds.) ICHL 2009. LNCS, vol. 5685, pp. 208–217. Springer, Heidelberg (2009)
28. Yuen, S.C.Y., Yaoyuneyong, G., Johnson, E.: Augmented Reality and Education: Applications and Potentials. In: Reshaping Learning, pp. 385–414. Springer, Heidelberg (2013)
29. Zhao, X., Wan, X., Okamoto, T.: Adaptive content delivery in ubiquitous learning environment. In: 2010 6th IEEE International Conference on Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE), pp. 19–26. IEEE (April 2010)