MOBILE AUGMENTED REALITY IN SUPPORTING PEER ASSESSMENT: AN IMPLEMENTATION IN A FUNDAMENTAL DESIGN COURSE

Chung-Hsien Lan[1], Stefan Chao[2], Kinshuk[3] and Kuo-Hung Chao[4]
[1]*Assistant Professor, Taoyuan Innovation Institute of Technology,Taiwan*
[2]*Instructor, Taoyuan Innovation Institute of Technology,Taiwan*
[3]*Professor, Athabasca University, Canada*
[4]*PhD. Student, National Taiwan Normal University, Taiwan*

ABSTRACT

This study presents a conceptual framework for supporting mobile peer assessment by incorporating augmented reality technology to eliminate limitation of reviewing and assessing. According to the characteristics of mobile technology and augmented reality, students' work can be shown in various ways by considering the locations and situations. This study proposes a novel mobile peer-assessment system which incorporates augmented reality into the reviewing and assessing processes. The mechanism enables students to enhance work interpretation, frequently interact with peers, represent their thinking and reflect upon their own works. Moreover, the mobile AR technique provides personalized and location-based adaptive contents that enable individual students to interact with the mixed reality environment and to observe how works are possibly applied to the real world in the future. The overall process facilitates students in reviewing works based on various dimensions, acquiring important knowledge, fostering critical thinking skills and reflection as well as promoting meaningful learning.

KEYWORDS

Augmented reality, peer assessment, mobile learning

1. INTRODUCTION

Peer assessment has become increasingly popular in education due to the support of group learning and the enhancement of learning effectiveness. In peer assessment process, students participate cognitive activities including doing assignments, devising assessment criteria, reviewing, summarizing, clarifying, providing feedback, diagnosing errors, identifying missing knowledge or deviations and evaluating the quality of peers' work (Van Lehn, et al., 1995; Liu, et al., 1999; Sitthiworachart & Joy, 2003). The majority of previous studies emphasize conditions, methods and outcomes of peer assessment and focus on the quality of students' work, domain-specific skill and peer assessment skill for outcomes (Van Zundert, et al., 2010). In recent years, mobile technology provides the potential of creating innovation learning experiences. Students can acquire learning materials, share ideas, and construct knowledge anytime anywhere by using their own handheld devices. In order to eliminate the limitation of space and time, mobile peer assessment positively influences the assessment methods and outcomes and enables students to submit their own work, review peers' work, mark and provide feedback conveniently.

However, during the peer assessment process, providing students with sufficient information to review peers' work is preferable. Augmented reality (AR) is the technology that provides the right contents at the right place at the right time. The mobile AR technique is able to overlay virtual objects on the real work to present rich information to students and construct meaningful presentation by combining location-awareness and contextual learning. There is a positive relation between providing students with the opportunity to review peers' work based on the mobile AR technique and reflecting upon their own work.

In order to provide full insight into effective peer assessment processes, issues regarding content presentation as well as assessment methods require more attention.

Therefore, this study presents a conceptual framework for providing intelligent and mobile supports through incorporating the AR technique to enhance work presentation and the effectiveness of peer assessment. In this framework, students are able to review peers' work by using various dimensions and receive assessment results immediately. The difficulty of reviewing peers' work and understanding peers' thinking can be resolved and sufficient information representation enables accurate assessment. Most importantly, appropriate assessment criteria and rich feedback facilitate students to reflect upon their own work and improve the quality of their work.

2. PEER ASSESSMENT IN MOBILE LEARNING

Peer assessment has been widely recognized as an educational arrangement in which students assess peers' work and provide feedback (Van den Berg, et al., 2006), as well as a learning tool for improving student's performance in collaborative learning environment (Topping, et al., 2000). Various studies related to education, business, health and science on self and peer assessment in higher education have been proposed (Searby & Ewers, 1997; Ballantyne, et al., 2002; Prins, et al., 2005; Price & O'Donovan, 2006). These studies reveal that students who involve in the interactive assessment process can enhance their interpretation and reflection. Regarding how to effectively involve students in peer assessment, these processes including exploration of assessment criteria, presentation of works, assessment methods, coordination of assessment and feedback are very critical (Chen, 2010 ; Lan, et al., 2012). Most studies focus on the conditions, methods and outcomes (Van Zundert, et al., 2010) and have proposed computerized-based peer assessment systems to support the assessment process (Davies, 2000; Lin, et al., 2001). Appropriate technology applied in peer assessment can assist the reviewing and assessing activities. Computer networks facilitate students to participate in assessment activities anytime anywhere and enable teachers to review assessment progress. On-line peer assessment systems that can do away with conditions restricting various assessment activities in classrooms can eliminate the time and the cost in communicating with each other and printing out student work or assessment forms.

In recent years, students attempt to learn in various locations, and therefore mobile learning is becoming widespread. Mobile technology provides the potential of creating innovative learning experiences that can take place anytime and anywhere (Shih, 2010). Because of the characteristics of mobile technology such as ubiquity, smaller size, comparative affordability, and the prevalence of wireless networks, more and more researchers have developed application on handheld devices such as mobile phones, tablet computers and PDAs to support learning activities. Some studies have proposed the critical issue of how to use handheld devices to enhance assessment (Penuel, et al., 2007; Shin, et al., 2007). Students can use handheld devices to flexibly conduct project-based learning and self-assessment inside and outside classrooms. A few researchers have reported the findings about how to use mobile technology for self- and peer-assessment (Chen, 2010). Chen indicated that combining mobile technology with the concept of round-table presentations, the mobile self- and peer-assessment system can assist teachers to arrange assessment activities more flexibly and make students more attentive to presentation, interaction and feedback in the assessment process. However, most of these studies emphasize the exploration of assessment criteria, marking process and the promotion of feedback to enhance the effectiveness and reflection of self- and peer assessment. Actually, it is a very critical issue that students' work can be presented in detail during the assessing process. Through reviewing peers' work, students can understand how to mark and reflect upon their own work.

According to the characteristics of mobile technology, students' work can be shown in various ways by considering the locations and situations; moreover students can communicate with peers as well as observe peers' work anytime anywhere. This study proposes a novel mobile peer-assessment system which incorporates augmented reality into the reviewing and assessing process. The mechanism enables students to enhance work interpretation, frequently interact with peers, represent their thinking and reflect upon their work. Through the reviewing and interactive process, assessment accuracy and quality can be improved. The overall process facilitates students in fostering critical thinking skills and reflection as well as promoting meaningful learning.

3. PEER ASSESSMENT WITH MOBILE AUGMENTED REALITY

Augmented reality (AR) is the technology that shows the right contents for the right device to the proper person at the right place and at the right time (Chang & Tan, 2010; Chan, et al., 2010). It can overlay virtual objects on the real world to fulfill the feeling of immersion and therefore supplements user's everyday life with information, images, sounds, and other sensory information from their device. Shortly to say, through putting a virtual layer of information over the real world, AR pretends that virtual objects are real and presented at the right place. The widely accepted definition of AR is "Augmented Reality allows the user to see the real world, with virtual objects superimposed upon or composited with the real world. AR supplements reality, rather than completely replacing it."(Azuma, 1997; Azuma, et al., 2001). AR is thought to present certain advantages over more traditional ways of accessing information (Anastassova, 2007).

Alongside mobility, development of positioning technologies make it possible to keep track of students and provide them with tailored learning contents based on their real-time locations. Furthermore, location-based e-learning provides a personalized learning experience and helps in keeping the students engaged in the learning activities and enhancing their effectiveness (Chen, et al., 2007). Previous studies have indicated that the combination of location-awareness and a contextual learning approach can enable students to better construct meaningful contextualization of concepts (Michie, 1998; Patten, et al., 2006). For the purpose of locating virtual information at the right place in real word, tags or markers are necessary for recognition. AR recognizes the tag and gets its position as the position of the corresponded virtual information. There are two types of tags: one is so called "AR ToolKit marker". It's a monochrome graph surrounded by a square frame. The other one is full-on image recognition. The square frame of "AR ToolKit marker" transforms to a parallelogram when it be projected on the screen. By reversing this procedure of mapping a parallelogram to a square, the position and direction of the square frame in the real world can be detected, and then the virtual object information can be overlaid on the screen of the handheld device. However, real objects can be observed in various dimensions, but it is more difficult to recognize real objects than "AR ToolKit marker". Currently, it is still not quite at the stage of full-on image recognition, but other researchers are working on it. Because real object recognition does not need extra tags, it would become the most popular approach in the near future.

Few years ago, if someone wanted to show virtual information on real objects, he needed to wear some machines on his neck. These machines include one camera to capture images of the real word, a wireless network transporter to send images to computer systems and get feedback information that merges virtual objects with real-world images seamlessly, and a projector to show virtual information on real objects. However, it is not convenient at all. In recent years, significant advancements related to wireless and mobile technologies make handheld devices which combine several utilities to be the most convenient platform for the AR technique. The camera on the handheld device can capture images of real world, a compass can detect the direction of user's face, the GPS receiver can locate the position of users, and the monitor can show the images of the outcome that the mobile AR technique create, which can be text, table, image, video and their combination. Even more, extra components such as buttons or tables can be included for interaction. The mobile AR technique provides pliable mobility and a location independent service without constraining the individual to a specific area. According to the NMC Horizon Report 2012 K-12 Edition, AR supports visual and highly interactive forms of learning in education. Students can use it to construct new understanding based on interactions with virtual objects that bring underlying data to life as it responds to user input (NMC Horizon Report, 2012). Numerous researches has proposed that the AR technique can help students to learn in serious games, language learning, e-books, storytelling, driving guidance, and so on (Azuma, 1997; Van, et al., 2010; Chen & Tsai, 2010). By this way, AR holds the possibility to revolutionize the way in which information is demonstrated to people and has great potential for on-demand, context-aware, and collaborative training (Hollerer, 2001). Moreover, the mobile AR technique provides personalized and location-based adaptive contents for individual students to interact with the mobile viewing environment, and see how works are applied to the real environment in the future at the current place.

According to the above mentioned, the mobile AR technique can obviously support students to review peers' work during the peer assessment process. Formerly, in a design course, students only review the work based on assessment criteria such as originality, produce skill, colour scheme and so on but cannot view the usability of the work in the future in this environment where the assessor located. The most important functionality of a location-based mobile AR technique is to provide the proper contents according to students' current location.

The relevant applied contents in students' vicinity will be presented by the mobile AR technique automatically while students walk in the area. For example, how a painting can be hanged on the wall or become a fresco or how a handiwork will be if it is rebuild to a sculpture putting in this environment. "The incorporation of various rich sensors into new phones such as GPS location, wireless sensitivity, compass direction, accelerometer movement as well as sound and image recognition is enabling new ways in which we are able to interact with the world around us." (Nokia Research Center, 2009). The mobile AR technique can fuse digital media with the physical world to create the proper conditions for locative, contextual and situation-based demo scenarios. In this study, during the peer assessment process, assessors not only assess the works presented in front of them but also view the future application of target works. Therefore, assessors can judge the design skill of designers as well as the usability of the work in the future.

4. SYSTEM REALIZATION AND ILLUSTRATIVE EXAMPLE

4.1 System Architecture

Augmented reality is defined as a real-world environment whose elements are built upon computer-generated sensory input such as sound, video, graphics or GPS data. In the educational field, there are many situations cannot be experienced in the classroom. Augmented reality is the latest technology that can accommodate or modify their learning experience to their specific needs. So what AR allows us to do is to see virtual objects in a real world environment with the aid of camera and some display devices (monitor or head mounted display). Subsequently, the procedure of peer assessment enriched by the mobile AR technique is described. This procedure shows how AR can enhance the effectiveness of reviewing and assessing during peer assessment.

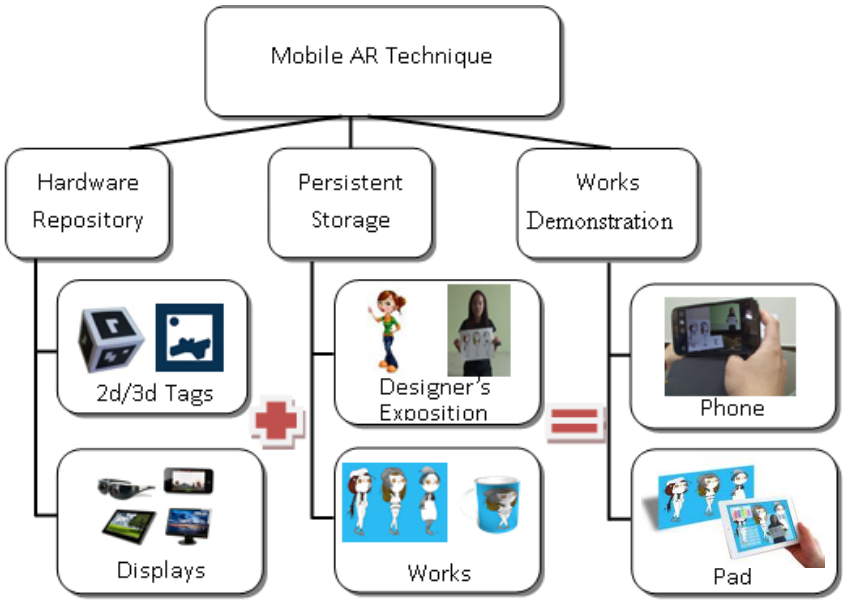

Figure 1. The Architecture of the Mobile AR Technique

The architecture of the mobile AR technique includes three parts such as hardware repository, persistent storage, and works demonstration as shown in Figure 1. In hardware repository, 2d/3d unique tags which are able to recognize and present virtual objects in right locations are necessary and mobile displays are included. Students' works and expositions of design about these works are categorized into persistent storage. These materials provide extra information of virtual objects. In the part of work demonstration, the result that overlay virtual object images on real object images can be presented on handheld devices such as mobile phones or tablets. Through incorporating the mobile AR technique into peer assessment, Figure 2 shows the framework of the mobile-AR peer-assessment system (MARPAS).

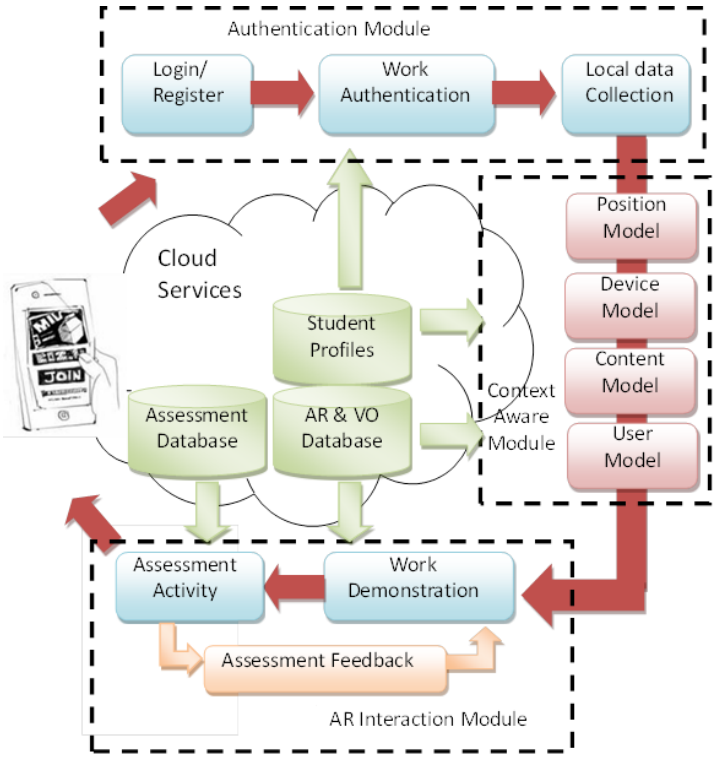

Figure 2. The Framework Of The Mobile Augmented Reality Peer Assessment System

There are three databases in the cloud, including the student profiles, the AR and virtual object database and the assessment database in Figure 2. At the beginning of the assessment activities, students must login to authenticate their identities. All data related to students have been built in the user database. Subsequently, the target work shows up in front of assessors, the system goes on getting all information including assessors' location, the direction that they face and the situation such as indoor or outdoor. These local data is collected by handheld devices and sent to the system. During the peer assessment process, all procedures are parted into three modules including the authentication module, the context aware module, and the AR interactive module. The authentication module enables right people to get right information to assess right works. The context aware module enables assessors to use right device to receive right context for assessment, and the AR interactive module enables assessors to review peers' works conveniently and intuitively such that the assessment can be more diversified and every assessee learns more from other works. In the context aware module, the system judges these local data and then choices a proper context for the assessor from the virtual object database. All data are ready for the AR technique to overlay on the real world image, and thus assessors mark these works more conveniently and accurately.

4.2 Walk-through Illustrative Example

Peer assessment was facilitated by working in small groups of three to four students. These students were better able to compare feedback from different peers to determine its relevance (Van Zundert, et al., 2010). Therefore, in this study, 50 undergraduates major in visual communication design enroll a fundamental design course and are arranged in small groups. The teacher assigns a painting work and then students can receive the notification on their own mobile phone or tablet. Students have three weeks to prepare their drafts and the exposition of their design ideas after which these are uploaded onto MARPAS, a mobile augmented reality peer assessment system. The AR application constructs the relation between the image of the draft and the exposition. Subsequently, during the assessment process, the teacher designs two activities in which students have to mark peers' work in an indoor environment as well as in an outdoor environment. These drafts are printed out as tags and posted in an exhibition and on an outside wall. The assessment situations in indoor and outdoor environments and the interfaces of MARPAS are presented in Figure 3.

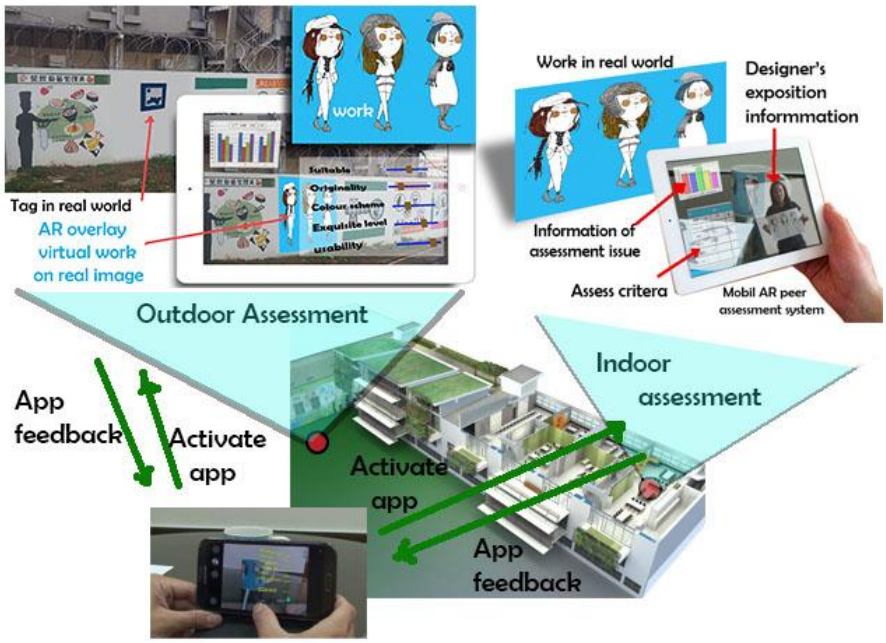

Figure 3. The Demonstration of the MARPAS

In the indoor situation, assessors go to the exhibition to capture the tag through their own camera on handheld devices. Then, they can see the work can be constructed as a physical produce in the real world. The introduction of assessees' work and the assessment criteria can be shown on the device at the same time. In the outdoor situation, assessors go to outside to capture the tag on the wall, and then the visual work is presented on the wall in the real world. Assessors can review the assessees' information and assessment criteria as well. However, assessment criteria are different based on the varied situations. For example, assessment criteria including suitable, originality and colour scheme have to be considered in the indoor assessment, and assessors mark the dimensions of suitable, exquisite level and usability in the outdoor assessment according to the features of outdoor situation. By this way assessors can mark the usability of the work at the current location. In addition, all assessment related to the work can be presented simultaneously on the device as shown as Figure 4, and therefore assessors are able to review other assessors' assessment and assessees can receive the assessment results.

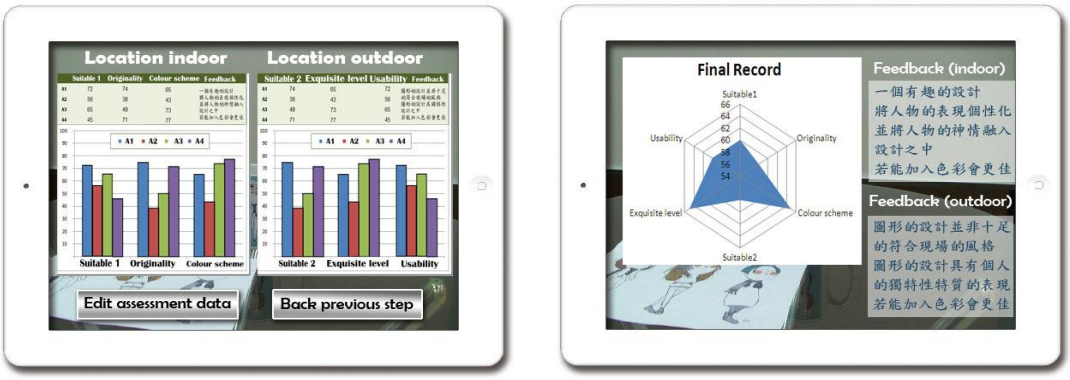

Figure 4. The Representation of Assessment Results

According to the different surroundings, students are not only able to acquire the relative explanation and representation of work but also apply appropriate assessment criteria that produce sufficient assessment results to mark peers' work. MARPAS facilitates students to observe other assessors' marking as well as receive assessment feedback. Therefore, students can reflect upon their work according to the various and meaningful feedback received.

5. CONCLUSIONS

This study has presented a framework for providing intelligent and mobile supports to enrich peer assessment. The limitation of time, space and devices can be eliminated. In this framework, students can review and assess peers' work represented with AR technology through combining virtual objects with the real world. Mobile AR technology provides flexible mobility and location-based adaptive contents to interact with the assessing work and the real world for individual students. Students can bring their own handheld devices to capture and acquire appropriate information at the right time in the right situation. By incorporating the techniques of AR, the proposed framework enables students to review peers' work in various ways and students can receive the assessment results immediately. The difficulty of reviewing peers' work and understanding peers' thinking can be resolved and sufficient information representation enables accurate assessment. In addition, appropriate assessment criteria and rich feedback facilitate students to reflect upon their own work and improve the quality of their work. Although the proposed framework has indicated the assistance of incorporating AR in peer assessment, considerable work remains to be done, including further large-scale classroom experiments and system adaptability.

REFERENCES

Anastassova, M. ,2007. User-Centred Design and Evaluation of Augmented Reality Systems for Industrial Applications: Some deadlocks and breakthroughs, *Proceedings of IEEE International Conference on Virtual Reality*, pp215-224.

Azuma, R. T. ,1997. A Survey of Augmented Reality, *Presence: Teleoperators and Virtual Environments*, Vol.6, No.4, pp355–385.

Azuma, R. et al, 2001. Recent advances in augmented reality, *IEEE Computer Graphics and Applications*, Vol.21, pp34–37.

Ballantyne et al, 2002. Developing procedures for implementing peer assessment in large classes using an action research process. *Assessment & Evaluation in Higher Education*, Vol.27, No.5, pp427–441.

Chang, W. and Tan, Q., 2010. Augmented Reality System Design and Scenario Study for Location-Based Adaptive Mobile Learning, *Proceedings of IEEE International Conference on Computational Science and Engineering*, pp20–27.

Chang, W. et al, 2010. Multi-Object Oriented Augmented Reality for Location-Based Adaptive Mobile Learning, *Proceedings of IEEE International Conference on Advanced Learning Technologies*, pp450–451.

Chen, C., 2010. The implementation and evaluation of a mobile self- and peer-assessment system. *Computers & Education*, Vol.*55*,No.1, pp229–236.

Chen, C., et al, 2007. Personalized Context-Aware Ubiquitous Learning System for Supporting Effectively English Vocabulary Learning, *Proceedings of IEEE International Conference on Advanced Learning Technologies*, pp1–3.

Chen, C. M. and Tsai, Y. N., 2010. Interactive Location-based Game for Supporting Effective English Learning, *International Journal of Intelligent Information Technology Application*, Vol.*3*, No.1, pp44-50.

Davies, P., 2000. Computerized Peer Assessment. *Innovations in Education & Training International*, Vol.37, No.4, pp346–355.

Hollerer, T. et al, 2001. User Interface Management Techniques for Collaborative Mobile Augmented Reality, *Computers and Graphics*, Vol.25, No.5, pp799-810.

Lan, C. et al, 2012. A Study in Negotiation-based Peer Assessment: Natural Language Applied in Assessment Representation. *International Conference on Computers in Education(ICCE)*.

Lin, S. et al, 2001. Web-based peer assessment: feedback for students with various thinking-styles. *Journal of Computer Assisted Learning*, Vol.17, pp420–432.

Liu, E. Z. et al, 1999. Student Participation in Computer Sciences Courses via the Network Peer Assessment System, *Advanced Research in Computers and Communications in Education*, Vol.2, pp744-747.

Michie, M., 1998. Factors influencing secondary science teachers to organise and conduct field trips, *Australian Science Teacher's Journal*, Vol.44, No.4, pp43-50.

NMC Horizon Report, 2012. *NMC Horizon Report: 2012 K-12 Edition*, http://www.nmc.org/publications/2012-horizon-report-k12.

Nokia Research Center, NRC., 2009. Mobile Mixed Reality: The Vision, *Nokia Technology Insights Series*.

Patten, B. et al, 2006. Designing collaborative, constructionist and contextual applications for handheld devices, *Computers & Education*, Vol.46, pp294–308.

Penuel, W. R. et al, 2007. Classroom assessment with handheld computers, *Ubiquitous Computing in Education*, pp103–125.

Price, M. and O'Donovan, B., 2006. Improving performance through enhancing student understanding of criteria and feedback, *Innovative Assessment in Higher Education*, pp100–109.

Prins, F. J. et al, 2005. Formative peer assessment in a CSCL environment: A case study, *Assessment and Evaluation in Higher Education*, Vol.30, No.4, pp417–444.

Searby, M. and Ewers, T., 1997. An Evaluation of the Use of Peer Assessment in Higher Education: A Case Study in the School of Music, Kingston University, *Assessment and Evaluation in Higher Education*, Vol.22, pp371-383.

Shin, N. et al, 2007. Findings from early research on one-to-one handheld use in K-12 education, *Ubiquitous Computing in Education*, pp19–39.

Sitthiworachart, J. and Joy, M., 2003. Web-Based Peer Assessment in Learning Computer Programming, *Proceedings of IEEE International Conference on Advanced Learning Technologies*, pp180-184.

Topping, K. J. et al, 2000. Formative Peer Assessment of Academic Writing Between Postgraduate Students. *Assessment & Evaluation in Higher Education*, Vol.25, No.2, pp149–169.

Van den Berg, B. A. M. et al, 2006. Peer assessment in university teaching: evaluating seven course designs, *Assessment & Evaluation in Higher Education*, Vol.31, pp19-36.

Van Krevelen et al, 2010. A Survey of Augmented Reality Technologies, Applications and Limitations, *The International Journal of Virtual Reality*, Vol.9, No.2, pp1-20.

Van Lehn, K. A. et al, 1995. Progress Report: Towards a Theory of Learning during Tutoring, Learning Research and Development Center, Univ. of Pittsburgh.

Van Zundert, M. et al, 2010. Effective peer assessment processes: Research findings and future directions. *Learning and Instruction*, Vol.20, No.4, pp270–279.