2D Barcode and Augmented Reality Supported English Learning System

Tsung-Yu Liu*, Tan-Hsu Tan* and Yu-Ling Chu**
*National Taipei University of Technology, Taipei, Taiwan**
*Taipei Municipal Chengyuan High School, Taipei, Taiwan***
joye.liu@msa.hinet.net, thtan@ntut.edu.tw, chu_yuling@tp.edu.tw

Abstract

This study aims to construct a 2D barcode and handheld augmented reality supported learning system called HELLO (Handheld English Language Learning Organization), to improve students' English level. The HELLO integrates the 2D barcodes, the Internet, augmented reality, mobile computing and database technologies. The proposed system consists of two subsystems: an English learning management system and a mobile learning tools system. A four-week pilot study and questionnaire survey were conducted in college to evaluate effects of proposed learning system and student learning attitudes. Furthermore, the evaluation results indicate that 2D barcodes and augmented reality technology are useful for English learning.

1. Introduction

The economy has grown rapidly in Asia recently due to the frequent commerce activities between the Asian and Western countries. After Taiwan entered the World Trade Organization (WTO), the Department of Education in Taiwan put a large number of resources into building an English learning environment for improving student English ability. In order to allow students have better English ability to meet the need of work after graduation. Most of colleges have begun to execute projects for English education. Among those projects, e-Learning is a requisite and important item. For this reason, how to construct an English learning environment in college to increase students' learning motivation and improve their English level is a priority to be solved. Therefore, this study aims to construct an interactive, mobile and context-aware English learning system to meet the requirement mentioned above. Through this system and designed context-aware mobile learning game, students can perform context-aware learning to improve their English level effectively at any time and anywhere.

The rest of this article is organized as follows. Section 2 describes some related work. Section 3 presents our work. Section 4 illustrates the architecture of the HELLO system. Section 5 describes an evaluation. Section 6 presents the evaluation results. Section 7 draws conclusions and future works.

2. Related Work

Mobile learning (m-Learning) offers a new way to infuse learning into daily life. M-learning uses mobile computing technologies to enhance the learning experience; these technologies can be blended to engage and motivate learners, at any time and anywhere. The advantages of m-learning over e-learning include flexibility, low cost, small size and ease of use [1]. Many researches on mobile learning have been conducted in order to improve learning achievement [2-4]. For instance, Uther et *al.* [5] developed an adaptive computer-assisted language learning software called Mobile Adaptive CALL (MAC) for mobile devices. MAC is aimed at helping Japanese-English speakers in perceptually distinguishing the non-native /r/ and /l/ English phonemic contrast with a visual aid. Tan and Liu [6] based on mobile computing and information technologies have developed a mobile-based interactive learning environment called MOBILE for assisting English language learning. This research revealed that with the help of MOBILE, the learning motivation and effects can be improved.

Context-aware systems with features such as context-sensitive data retrieval, engaging learning experiences and improving learning effectiveness have been employed in various learning activities in recent years [7]. A number of studies have used this concept to build context-aware systems for learning [8-9]. For instance, the Tag Added learNinG Objects (TANGO) system can detect objects around learners and provide them with object-related language learning materials by RFID technology [10]. Based on radio frequency identification (RFID) technology and mobile computing, Liu and Tan [11] have developed an Environment of Ubiquitous Learning with

6th IEEE/ACIS International Conference on Computer and Information Science (ICIS 2007)
0-7695-2841-4/07 $25.00 © 2007 IEEE

Educational Resources (EULER) to perform outdoor teaching in places that lack the capacity to effectively present information. Its experimental result showed that the proposed system significantly improved student motivation and learning.

Mobile game-based learning (MGBL) is hot a burgeoning topic in e-Learning. The concept of MGBL is using games to draw the attention of learners and make their learning effective. Many studies have found that MGBL can improve learning motivation and interest, as well as develop creativity and interpersonal relationships [12-15]. For instance, an Environmental Detectives game [12] was developed by MIT and Microsoft in the Games-to-Teach project. It is a handheld PC game where player plays the role of scientist to investigate a rash of health problems stemming from point-source pollution problems. In the immersive learning environment, learners experience real feelings and emotions as they do in a real world. Immersive learning integrates several new technologies like Augmented Reality (AR) and self-adaptation, as well as applies psychology to create an immersive learning experience. In augmented reality, digital objects are embedded into the real environment. In augmented virtuality, real objects are embedded into virtual ones. In virtual reality, the surrounding environment is completely digital [13]. Several studies have developed AR based learning games to explore how the AR technologies influence learning. For instance, Daniel et al. developed a handheld AR educational application in which a virtual character teaches users about art history. This study explored how augmented reality offers benefits on effective and engaging educational application [14]. Based on the mobile game and AR, Ferdinand et *al.* [15] developed a digital game-Eduventure to explore the motivation and engagement effected by computer and video games for learning. Moreover, Facer et *al.* [16] developed a handheld AR game called Savannah, which was designed to encourage students to understand animal behavior. Students played the role of lions in a savannah, navigating the augmented environments with a handheld device. The findings from this research provided interesting insights into the extent to which handheld AR game might be employed as a learning tool.

3. Our Work

Many positioning technologies have been used to get context-aware information, such as 802.11, IrDA, RFID and GPS. In addition to this, 2D barcode technology has many benefits and it has potential to be applied in various fields. The comparison of aforementioned positioning technologies is shown in Table 1. 2D barcode has many advantages including large storage capacity, high information density, strong encoding, strong error-correcting, high reliability, low cost, and ease of printing. A variant of this technology, the Quick Response (QR) Codes created by Japanese corporation Denso-Wave in 1994 and placed in the public domain. QR Code was designed for rapid reading using CCD array cameras and image processing technology. More recently, the inclusion of QR Code reading software in camera phones in Taiwan has become more and more popular. Therefore, this study used QR Code technology to conduct context-aware learning, and puts a number of QR barcodes around campuses. The fundamental concept of the proposed English learning system in this study is that the digitized learning materials are stored in a learning server. The link information between context-aware materials and learning zones is defined in 2D barcodes. Following the guide map to approach learning zones, each student carries a PDA phone having a video camera and wireless local area network (WLAN). A student can use the guide map displayed on PDA screen to approach a zone in campus and uses the PDA phone to decrypt the 2D barcode which was printed on a paper and was attached on a wall or information board in the zone. The detected 2D barcode information is then sent to the learning server for querying content via a WLAN. The learning server sends context-aware content to student's handheld learning device. Then using AR technology, the learning device superimposes a 3D animated virtual learning partner (VLP) over the real world zone image to create a new image presented on the learning device by AR technology. The student can complete the context-aware learning process by talking to the VLP. Figure 1 shows the learning device and QR barcode.

Table 1. The comparison of positioning technologies.

Characteristics	802.11	GPS	RFID	2D barcode
Positioning accuracy	Low	Low	High	High
Indoor	Yes	No	Yes	Yes
Outdoor	Yes	Yes	Yes	Yes
Interactive supporting	Yes	Yes	Yes	Yes
Context-awareness	Low	Low	High	Middle
Sensor technology	Auto	Auto	Auto	Passive
Cost	High	Low	High	Low
Cover Area	Micro	Wide	Micro	Micro
Practicability	Low	Low	High	High

This study attempts to explore the applicability and benefits of mobile technology to English learning, and also

increasing students' learning interest and motivation. To achieve this goal, this study integrates 2D barcodes, the Internet, mobile computing, wireless communication and database technologies to construct an interactive, mobile and context-aware learning environment, Handheld English Language Learning Organization (HELLO).

Figure 1. Snapshot of the learning device and QR barcode.

4. The System Architecture

The HELLO consists of two subsystems— the HELLO server is a learning server and the m-Tools is a software application. Figure 2 presents the architecture of HELLO. Teachers and system administrators can utilize personal computers to connect with HELLO server via using the Internet. The functions of HELLO server are:

- Content Management (CM) unit: College affairs stipulate self-study courses and store the learning materials in the Content Database (CDB).
- Assessment Management (AM) unit: College teachers can give assessments to students to evaluate their learning results.
- Portfolio Management (PM) unit: Students can upload their portfolios onto Evaluation Database (EDB) then teachers can review students' portfolios and give grades through the PM unit.
- Forum unit: Through this unit, teachers can instruct students and classmates can share learning experience with each other.
- Push unit: The push unit automatically deliveries a daily sentence to students to offer practical conversation materials.

Students hold a PDA phone installed with the m-Tools to pursue mobile English learning. The functionalities of m-Tools are:

- Listening and Reading: The m-Player can be used to download course matearials and then student can read articles/news, or listen to conversation from the HELLO server.
- Playing : The m-Player can be used to play learning game or English songs.
- Speaking: To improve speaking ability, students can utilize the m-Speaker. The m-Speaker superimposes the VLP on the learning zone image (captured from the m-Camera); students feel like talking to a person in the real world. The m-Speaker automatically stores students' speaking patterns and displays a graph comparing their sounds with those of the virtual teacher. By referring to this graph, students can correct their pronunciation.
- Writing: Students can utilize the m-Writer to pen an article or diary in English.
- Context-awareness: When students hold a PDA phone near a zone attached with a 2D barcode, the m-Reader on the PDA phone will decrypt the internal code that the PDA phone will send to the HELLO server. The HELLO server will download context-aware content to the PDA phone.
- Evaluation: Each student can use the m-Test to take tests and evaluate his/her learning achievement. Moreover, learning records can be stored in the m-Portfolio through the Human Control Interface (HCI) after each student finished his/her learning tasks. Upon completion, the student learning portfolio can be uploaded into the EDB of HELLO server for the teacher's review.

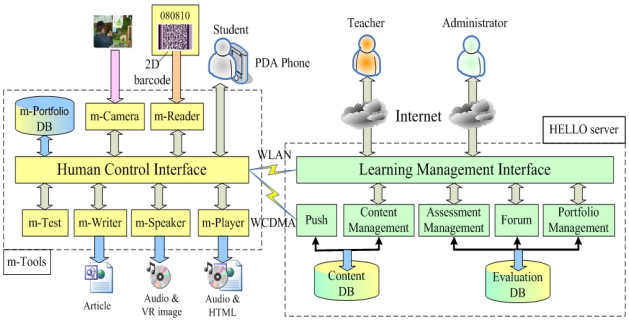

Figure 2. The architecture of HELLO.

5. Evaluation

This study designed a course was entitled, "My Student Life." The course topics include classrooms, libraries, language center, gymnasiums, restaurants, dormitories, stadiums, cafeterias, gallery, and computer center. Mobile gamed-based learning, immersive learning and context-aware learning were adopted as pedagogic strategies. The learning goals of this course were as follows: 1) to foster the abilities of listening, speaking and reading, 2) to increase learning motivation through the designed learning game, and 3) to enable students to learn in a real environment, and then perform the context-aware learning through 2D barcode technology. A four-week experiment was conducted with twenty college students. The experimental procedure was described as follows.

In the self-study phase (first two weeks), teachers introduced the HELLO system and demonstrated how to use the learning tools. A mobile game-based pedagogic strategy was employed in the self-learning process. Students used PDA phones installed with the m-Tools. A campus map appeared on the screen after students launched the game "My Student Life" on the PDA phone. The campus map had many zones marked on the map. Students just clicked the zone they wanted, and then the m-Player opened materials related to that zone. For instance, when a student selected the zone 'Library', a library was displayed on the PDA phone. Students could further choose the reading room to read an article, the newsroom to read news, or the multimedia room to watch a movie at their will. The key point is that students could learn at any time and anywhere without going to a real library.

In the context-aware learning phase (the rest of two weeks), students employed the HELLO system to carry out the learning activity entitled, "Campus Tour". Each student used a PDA phone installed with m-Tools and followed the guide map appeared on the screen to perform context-aware learning activities. Figure 4 depicts a guide map of the "Campus Tour" learning activity. When approaching a zone, a student used the PDA phone to take a picture and decrypt the 2D barcode. The detected identification code of the 2D barcode was then sent to the HELLO server via a WLAN. The HELLO server located students and then sent the context-aware contents back to their PDA phones. The VLP was superimposed with the zone image on the PDA screen. Then students practiced conversation with the VLPs, just like they talked with real partners in the real world. Figure 3 illustrates the 2D barcode, augmented reality, the Internet, mobile computing and database technologies based context-aware and immersive learning scenario. Students visited the next zone after completing a conversation with VLP at a particular zone until they had visited all zones. Students accessed context-aware content related to the location and achieved context-aware learning. Figure 5 illustrates an example of the learning activity. Figure 6 illustrates an example of the AR learning material.

After the experiment had been completed, a questionnaire survey was given to twenty students to know their opinion. A seven-point Likert-scale was used for all questions: 1 denotes strong disagreement, and 7 denotes strong agreement. A one-sample t-test was applied to analyze the answers to the questionnaires to determine the degree of perceived usefulness, ease of use and attitudes toward the use of the HELLO. The questions about the experiment included:

A. Easiness of the HELLO
- A1. I think that the user interface of the m-Tools is friendly.
- A2. I think that the functions of the m-Tools are sufficient.

B. Usefulness of HELLO
- B1. Applying the game-based HELLO to assist English learning can increase my learning interest and motivation.
- B2. Applying the HELLO to assist English learning can increase my listening ability.
- B3. Applying the HELLO to assist English learning can increase my speaking ability.
- B4. Applying the HELLO to assist English learning can increase my reading ability.
- B5. Applying the HELLO to assist English learning can increase my writing ability.

C. Attitudes toward usage
- C1. I like to use the HELLO to assist English learning after class.
- C2. I hope other courses will also use the HELLO to assist learning.

D. Usefulness of VLP
- D1. The VLP seems to be part of the real world.
- D2. The VLP is helpful for completing the learning activity.

A total of twenty valid questionnaires were submitted, with a response rate of 100%.

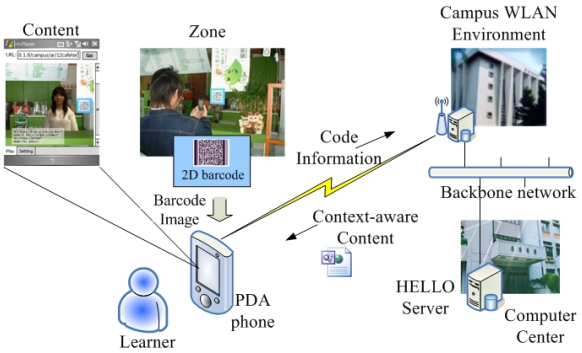

Figure 3. The context-aware learning scenario.

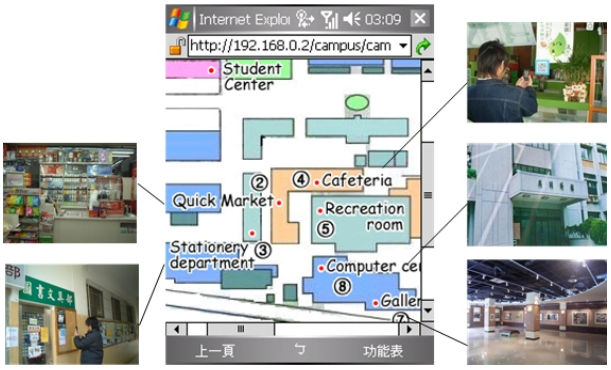

Figure 4. The guide map of "Campus Tour" activity

Figure 5. Example of the "Campus Tour" learning activity: a student talking with the virtual learning partner to practice conversation in the restaurant.

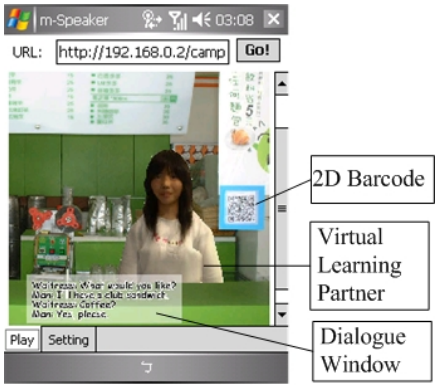

Figure 6. Example of the augmented reality learning material.

6. Results

Table 2 shows the statistical results of the survey on learning attitudes and the acceptance of technologies. The responses to the item A1 indicate that most students think that the HELLO is easy to use (m=6.10). The responses to the item A2 (m=5.80) indicate that the system functions are convenient and sufficient for learning. The response result of the item B1 (m=6.05) indicates that the HELLO can increase motivation to learn. The results on the items B2, B3 and B4 (m=6.20, 5.40 and 6.45) indicate that the HELLO can improve listening, speaking and reading ability. The result on the item B5 (m=2.65) indicates that the HELLO can not improve writing ability. The reason is that writing on a keyboard-less PDA is not convenient. The learning effect is not very well. Therefore, how to improve students' writing ability is an important challenge in this study. The responses to the item C1 (m=6.20) indicate that most students like to use the HELLO to learn after class. Responses to the item C2 (m=6.15) indicate that most students would like to use the HELLO in other courses. Responses to the item D1 (m=5.90) indicate that VLP seems to be part of the real world. Responses to the item D2 and D3 (m=6.10 and 6.15) indicate that VLP is helpful and can improve learning experience. This study adopted the Cronbach alpha coefficient to evaluate the internal consistency reliability of the questionnaire. Table 1 reveals that all Cronbach alphas in this experiment exceeded 0.7, indicating the high reliability of the used questionnaire. All resulting p-values were under 0.01, indicating that perceived ease of use, usefulness and attitudes toward the use of the HELLO were significantly favorable.

Table 2. The statistical results of the survey.

Item	t	Mean	SD	p	Alpha
A1.	13.07	6.10	0.72	0.000**	0.76
A2.	10.48	5.80	0.77	0.000**	
B1.	12.07	6.05	0.76	0.000**	
B2.	14.13	6.20	0.70	0.000**	
B3.	9.20	5.40	0.68	0.000**	0.75
B4.	18.11	6.45	0.60	0.000**	
B5.	-6.46	2.65	0.93	0.000**	
C1.	15.98	6.20	0.61	0.000**	0.76
C2.	12.90	6.15	0.75	0.000**	
D1	13.26	5.90	0.64	0.000**	
D2.	11.91	6.10	0.79	0.000**	0.73
D3.	14.33	6.15	0.67	0.000**	

d.f.=19, μ=4, *p<0.05, **p<0.01

7. Conclusions and Future Work

This study has constructed a 2D barcode and handheld augmented reality supported English learning system – HELLO with effective functions and plentiful learning materials to help English learning. A pilot experiment was performed with twenty college students at the National Taipei University of Technology. MGBL and context-aware learning pedagogic strategies were adopted; a mobile learning game entitled "My Student Life" and a learning activity entitled "Campus Tour" were employed in campus for four-week experiment. A questionnaire survey was administered at the end of experiment. The survey results indicate that most students think that the HELLO is easy to use and useful in English learning, further indicating that 2D barcodes and augmented reality technology are useful for providing context-aware learning experiences in learning activities. We will adjust our proposed learning system based on the experimental results and the participants' feedback to conduct a full scale study in the future.

Reference

[1] Jones, V., and Jo, J. H., "Ubiquitous learning environment: An adaptive teaching system using ubiquitous technology", In Proceedings of the 21st ASCILITE (Australasian Society for Computers in Learning in Tertiary Education) Conference, Perth, Australia: ASCILITE, 2004, pp. 468-474.

[2] Chen, Y. S., Kao, T. C., and Sheu, J. P., "A mobile learning system for scaffolding bird watching learning", Journal of Computer Assisted Learning, 2003, 19(3), pp. 347-359.

[3] Soloway, E., Norris, C., Blumenfeld, P., Fishman, B., Krajcik, J., and Marx, R, "Handheld Devices are Ready-at-Hand", Communications of the ACM, 2001, 44, 15-20.

[4] Zurita, G., and Nussbaum, M., "Mobile computer supported collaborative learning", Computers & Education, 2004, 42(3), 289-314.

[5] Uther, M., Zipitria, I., Singh, P., and Uther, J., "Mobile Adaptive CALL (MAC): A case-study in developing a mobile learning application for speech/audio language training", In Proceedings of the International Workshop on Wireless and Mobile Technology in Education (WMTE), 2005, pp.187-191.

[6] Tan, T. H. and Liu, T. Y., "The MObile-Based Interactive Learning Environment (MOBILE) and a case study for assisting elementary school english learning", In Proceedings of IEEE International Conference on Advanced Learning Technologies (ICALT 2004), pp.530-534.

[7] Cooper, J., "Engaging the [Museum] Visitor: Relevance, participation & motivation in hypermedia design", In Proceedings of International Conference on Hypermedia and Interactivity in Museums (ICHIM), Cambridge, England, 1993.

[8] Chou, S. C., Hsieh, W. T., Gandon, F. L., and Sadeh, N. M., "Semantic Web Technologies for Context-Aware Museum Tour Guide Applications", In Proceedings of the International Conference on. Advanced Information Networking and Applications (AINA), 2005, pp.709-714.

[9] Yatani, K., Sugimoto, M., and Kusunoki, F., "Musex: A system for supporting children's collaborative learning in a museum with PDAs", In Proceedings of the International Workshop on Wireless and Mobile Technology in Education (WMTE), 2004, pp.109-113.

[10] Ogata, H., Akamatsu, R., and Yano, Y., "TANGO: Computer supported vocabulary learning with RFID tags", Journal of Japanese Society for Information and Systems in Education, 2005, 22(1), pp.30-35.

[11] Liu, T. Y., Tan, T. H., and Chu, Y. L., "The ubiquitous museum learning environment: concept, design, implementation, and a case study", In Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT2006), Kerkrade, Netherlands, pp. 989-991.

[12] Antonellis, I., Bouras, C., and Poulopoulos, V., "Game based learning for mobile users", Paper presented at the 6th International GAME – ON Conference on the theme: Computer Games: AI and Mobile Users, 27 - 30 July 2005, Louisville, Kentucky, USA.

[13] Hughes, C. E., Stapleton, C. B., Hughes, D. E., and Smith, E. M. (2005). Mixed reality in education entertainment, and training. IEEE Computer Graphics and Applications. pp. 24-30.

[14] Daniel, W., Billinghurst, M., and Dieter, S., "How real should virtual characters be?" In Proceedings of the ACM SigCHI International Conference on Advances in Computer Entertainment Technology 2006 (ACE 2006), 14th - 16th June, Hollywood,USA.

[15] Ferdinand, P., Müller, S., Ritschel, T. and Wechselberger, U., "The Eduventure – A new approach of digital game based learning combining virtual and mobile augmented reality games episodes", Pre-Conference Workshop "Game based Learning" of DeLFI 2005 and GMW 2005 Conference, Rostock, 13. September 2005, Germany.

[16] Facer, K., Stanton, D., Joiner, R., Reid, J., Hull, R., and Kirk, D., "Savannah: a mobile gaming experience to support the development of children's understanding of animal behavior", Journal of Computer Assisted Learning, 2004, 20, pp.399-409.