Computers & Education 55 (2010) 630–643

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Using ubiquitous games in an English listening and speaking course: Impact on learning outcomes and motivation

Tsung-Yu Liu [a,*], Yu-Ling Chu [b,1]

[a] Dept. of Multimedia and Game Science, Lunghwa University of Science and Technology, Taoyuan, No. 300, Sec. 1, Wanshou Rd., Guishan, Taoyuan county 333, Taiwan, ROC
[b] Dept. of Electrical Engineering, National Taipei University of Technology, No. 1, Sec. 3, Chung-hsiao E. Rd., Taipei, 10608, Taiwan, ROC

ARTICLE INFO

Article history:
Received 24 November 2009
Received in revised form
19 February 2010
Accepted 28 February 2010

Keywords:
Cooperative/collaborative learning
Interactive learning environments
Teaching/learning strategies
Pedagogical issues

ABSTRACT

This paper reports the results of a study which aimed to investigate how ubiquitous games influence English learning achievement and motivation through a context-aware ubiquitous learning environment. An English curriculum was conducted on a school campus by using a context-aware ubiquitous learning environment called the Handheld English Language Learning Organization (HELLO). HELLO helps students to engage in learning activities based on the ARCS motivation theory, involving various educational strategies, including ubiquitous game-based learning, collaborative learning, and context-aware learning. Two groups of students participated in the learning activities prescribed in a curriculum by separately using ubiquitous game-based learning and non-gaming learning. The curriculum, entitled 'My Campus', included three learning activities, namely 'Campus Environment', 'Campus Life' and 'Campus Story'. Participants included high school teachers and juniors. During the experiment, tests, a survey, and interviews were conducted for the students. The evaluation results of the learning outcomes and learning motivation demonstrated that incorporating ubiquitous games into the English learning process could achieve a better learning outcomes and motivation than using non-gaming method. They further revealed a positive relationship between learning outcomes and motivation.

1. Introduction

Because commerce, travel, and academic activities frequently focus on English, it is the most popular language in the world and has become the most important foreign language (known as EFL) in many non-English-speaking countries. The ways in which students' listening, speaking, reading and writing abilities can be improved are critical issues in these countries. Therefore, developing effective and efficient approaches to increasing practical opportunities in actual contexts, and thus, improving students' English learning outcomes and motivation has become an extremely important research topic. Many studies have been conducted to explore possible factors which may influence learners' language learning (Chamot, 1987; Reiss, 1983), and the results of these studies indicate that factors such as age, gender, motivation, personality, learning styles, and learning strategies, have an influence on learners' language learning outcomes (Bremner, 1999; Ehrman & Oxford, 1989; Green & Oxford, 1995).

Among the above mentioned factors, the use of language learning strategies (LLS) is considered to be an important one (Ehrman & Oxford, 1989), and many studies indicate that training students to use LLS can help their language learning (Canale & Swain, 1980; Oxford, 1990; Segler, Pain, & Sorace, 2002). Rigney (1978) defined learning strategies as being "operations and procedures that students may use to acquire, retain, and retrieve different kinds of knowledge and performance" (p. 165). Similarly, Rubin (1987) described learning strategies as being "any set of operations, steps, plans, or routines used by the learner to facilitate the obtaining, retrieval, and use of information" (p. 19). In addition, Oxford (1990), and added that "learning strategies are specific actions taken by learners to make learning easier, faster, more enjoyable, more self-directed, more effective, and more transferable to new situations" (p. 8). Thus, language learning strategies play an essential role in promoting learners' language learning performances. Oxford (1990) classified the learning strategies into two categories — direct strategies, including memory, cognitive, and compensation strategies; and indirect strategies including meta-cognitive, affective, and social strategies.

* Corresponding author. Tel.: +886 2 82093211x5816.
E-mail addresses: joye.liu@msa.hinet.net (T.-Y. Liu), chu_yuling@tp.edu.tw (Y.-L. Chu).
[1] Tel.: +886 2 2771 2171.

0360-1315/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.compedu.2010.02.023

Studying in high schools, self-learning and e-learning have become generally accepted methods for improving English ability. Moreover, using appropriate learning strategies and developing effective learning activities which support English learning is an important topic in the field of computer-assisted language learning (CALL) (Collins, 2005). Advances in wireless communication technology have created a new learning model called mobile learning (m-learning). M-learning has afforded a new way to infuse learning into daily life. M-learning uses mobile computing technologies to enhance learning, and these technologies can be blended together to engage and motivate learners anytime, anywhere. M-learning has many advantages over e-learning, including flexibility, mobility, convenience, low cost, and user-friendliness (Jones & Jo, 2004).

Kukulska-Hulme (2005) argued that mobile-assisted language learning (MALL) has an excellent potential to provide students with rich, real-time, convenient, collaborative, contextual and continuous learning experiences, both inside and outside the classroom. For this reason, many MALL activities and strategies have been successfully developed, and used to aid English learning. The following can be cited as examples of such learning activities: mobile-device-supported collaborative early EFL reading activities were conducted to promote students' reading motivation (Lan, Sung, & Chang, 2007), a learning strategy based on the Fuzzy Item Response Theory (FIRT) was adopted to support effective and efficient English reading (Chen & Hsu, 2008), a learning memory cycle strategy was used to help learners to memorize English vocabulary efficiently (Chen & Chung, 2008), a collaborative learning strategy was adopted to provide knowledge-aware language learning information (Ogata & Yano, 2004), a learning on the move (LOTM) and a Vidioms activity were employed to enhance students' vocabulary ability (Thornton & Houser, 2005), a highly interactive learning activity was developed to support reading for ESL (English as a Second Language) learners (Chang, Chan, & Yang, 2007) and a picture annotation-based learning content delivering strategy was used to help learners with higher verbal ability (Chen, Hsieh, & Kinshuk, 2008).

Although enhancing vocabulary and reading ability is important, training English listening and speaking is also essential in English learning. The aforementioned studies have effectively developed MALL activities using appropriate learning strategies and methods to aid reading; however, few investigations have delved into the relationship between learning strategies, learning achievement, and the application of MALL in English speaking and listening courses. Conventional listening and speaking learning approaches, in particular, have several drawbacks. The first of which is that students lack sufficient opportunity to practice conversation with their English teachers, classmates, and native English speakers. Secondly, schools lack appropriate English learning tools (including software and hardware) for coaching individual listening and speaking. Students have to rely on books and audio CDs as their major learning materials, which leads to deficiencies in spoken English. Thirdly, students lack courage to speak, since they are worried about their classmates laughing at them due to their poor English skills.

In order to hone their English skills, nonnative English countries have different policies. The Korean government created a real English learning environment in three English-speaking villages to enhance the level of English of its compatriots. Therefore, our research strives to devise low-cost methods of designing an effective English learning environment and adopt appropriate learning strategies in designing an effective curriculum for countries with no relevant educational policy or sufficient financial backing. This study attempts to address the following five major research questions:

- How can effective learning activities be developed to enhance learning outcomes and motivation?
- How can a low-cost English learning environment be created in a real situation?
- What is the difference between the learning outcomes of our proposed learning method and those of the traditional learning method in English learning?
- What is the difference between the learning motivation behind our proposed learning method and that behind the traditional learning method in English learning?
- What is the relationship between learning outcomes and learning motivation?

2. Method

2.1. Research design

This study adopted a quasi-experimental design. We divided students into two groups – an experimental group and a control group – that were formed from two classes. The teams were formed using students from the same class so that team members shared a good rapport with one other; this was done in order to avoid possible inaccuracies in the experimental results. Tests were used to evaluate the significant difference in the learning outcomes for different learning intervention. Quantitative analysis was also used to evaluate the students' motivation. Qualitative data were collected from interviews and were used to understand the students' opinions and explain the experimental results.

2.2. Curriculum design

In this study, the constructivism and motivation theories have been applied to the curriculum design. With regard to the constructivism theory, Merrill (1994) claimed that teaching activities should be designed for learners who in the past played passive roles, merely accepting information, but who have now come to actively build on the knowledge gained during the learning process. It is after all one of the most important educational goals to enable students to put the knowledge they have acquired into practice. Ericsson, Krampe, & Tesch-Römer (1993) argued that deliberate practice is the most effective method for enhancing the current performance level. Regarding the motivation theory, Noels, Pelletier, Clément, & Vallerand, 2000 presented an empirical study to provide evidence on how extrinsic motivation (EM) and intrinsic motivation (IM) conformed to the second and foreign language (L2) field. Extrinsically motivated behaviors are those actions carried out to achieve some intended goal, such as earning a reward or avoiding punishment (Noels et al., 2000). In contrast, intrinsic motivation (IM) refers to the motivation to engage in an activity because doing so is enjoyable and fulfilling (Noels et al., 2000). McMahon (2006) argued that students' active motivation will push them to strive for better performance, achievement, and ability.

This study applied Keller's attention, relevance, confidence, and satisfaction (ARCS) motivation model, a model useful for the creation of various student-centric instructional tasks (Keller, 1987; Keller & Suzuki, 2004). By creating an effective learning environment and interesting learning activities, we can stimulate students' visual and auditory senses in order to draw their attention and induce their learning motivation. We will provide students with opportunities for self-learning and cooperation. As the course content is designed to be closely related to life experiences, students can really perceive the importance of learning. Besides, we also expect to offer students with opportunities to accomplish challenging tasks, build their confidence, and gain a sense of satisfaction from task accomplishment. For the above objectives, we need to develop a learning strategy that can make the course more attractive, increase students' life experiences and confidence, and provide students with challenges so that they can experience a sense of satisfaction from overcoming them.

In the Game Generation, computer games comply with the children's contemporary needs, habits and interests (Henderson, 2005). Olson et al. (2007) pointed out that children who have never played computer games are quite rare since gaming is regarded as a social activity for children. Game-based learning (GBL) is designed to combine learning and game playing, so it will improve the ability of the player to retain education subjects and apply them to the real world. Educational games encompass educational objectives and subject matter that have the potential to enable learning more learner-centered, easier, enjoyable, interesting, efficiency and effective (Prensky, 2001; Virvou, Katsionis, & Manos, 2005). GBL can improve students' learning achievement, learning motivation, and attention (McFarlance, Sparrowhawk, & Heald, 2002). Eow, Ali, Mahmud, & Baki (2009) pointed out that playing educational computer games is beneficial to most children, since games enhance their creativity in more diverse ways as compared to conventional learning. Numerous studies have found that GBL can improve learning motivation and interest (Papastergiou, 2008; Tüzün, Yilmaz-Soylu, Karakus, İnal, & Kizilkaya, 2009), as well as develop creativity and interpersonal relationships (Schwabe et al., 2005; Lepper, Iyenger, & Corpus (2005)) demonstrated that computer games raise the efficiency of learning, since they increase intrinsic motivation, and link the goals of 'winning the game' and 'learning the material'. Yu, Chang, Liu, and Chan (2002) reported that the use of a game for high school English learning could increase students' satisfaction of the learning experience. Ranalli (2008) designed simulation games called 'SIMs' for language learners; his study found statistically significant improvements in vocabulary knowledge. Therefore, this study adopted the GBL learning tactic in its course design in order to effectively engage learning interest and increase motivation.

In addition, task-based language learning (TBLL) focuses on asking students to complete meaningful tasks using the target language. The characteristics of TBLL are interaction, student-centered focus, meaningful materials, fluency language production, learning in the real world, and clear learning goals (Willis, 1996). Nunan (1992) stated that TBLL increases student conversations, relaxes the classroom atmosphere, and reinforces students' comprehensible input. Willis (1996) pointed out that, in TBLL, students can learn by doing, and Kiernan and Aizawa (2004) further argue that second language acquisition is best promoted through task-based learning. They claimed that TBLL is an effective pedagogical approach in communicative language learning. On the other hand, collaborative learning can improve the cognitive activity of students (Hartup, 1992) and increase learning motivation and satisfaction (Ushioda, 1996). According to Luchini et al. (2002), handheld computers especially made an impact on collaborative learning. Students can use the handhelds to coordinate collaboration between them, while they are exchanging information across the wireless network (Stanton, Neale, & Bayon, 2002). Omaggio (1986) suggested that effective language teaching should provide more practice opportunities in real situations and should guide students to complete a task collaboratively. It further used context-aware learning tactics in order to enhance students' authentic learning experience in a real situation. It also used collaborative TBLL learning tactics in developing activities to afford opportunities for competition, enable successful learning, and eventually provide satisfaction to the students.

Moreover, ubiquitous games are developed using ubiquitous technology and game science; in the real environment, players can use devices or equipment at any time and location to play interactive games involving a portion of physical objects and a portion of virtual ones, which allow them to feel personally and physically involved in the games. In ubiquitous learning (u-learning), ubiquitous computing occurs all around the learner, whether or not they are aware of it. Liu, Tan, and Chu (2009) argued that the characteristics of u-learning as being permanency, accessibility, immediacy, interactivity, situation, calmness, adaptability, seamlessness, and immersion. Ubiquitous learning games (ULGs) are ubiquitous games for educational purposes that were developed using different learning tactics. Employing ULGs in the course could enable more interesting, motivative, and effective learning as well as increase immersive and collaborative learning experience. Therefore, this study made use of ubiquitous games in designing the curriculum.

The curriculum included topics related to the library, health clinic, auditorium, computer classroom, laboratory, store, classroom, and playground zone. An eight-week experiment was conducted during class time, and a 45 min course was conducted each week. The curriculum was named 'My Campus', and was designed in five phases, as shown in Table 1. The learning goals of this curriculum were as follows: to enhance English learning, to increase English learning interest and motivation through the designed learning games and to enable students to learn in a real environment. The students in the experimental group used gaming learning approach (using HELLO), while the students in the control group used a non-gaming learning approach (using printed materials and CD players). The two groups used the same course content although the interfaces they used during the classes were different. Table 2 represents a sample of the dialogue.

The curriculum used tests to evaluate students' learning achievement. The goal of the tests was to evaluate students' English listening and speaking skills, on the basis of necessary phonetics, a large vocabulary, and good grammar. Each test included a listening and a speaking section. The listening section was composed of twenty questions. The students listened to the questions, and then selected their answers from multiple choice options, and wrote them down on the question paper or on a PDA phone. Table 3 demonstrates a sample listening question. The speaking section was composed of 10 questions. The students listened to the questions and recorded their spoken answers on a voice recorder or PDA phone, after which the teacher gave a grade, having listened to the answers.

2.3. System design

According to the aforementioned literature, u-learning could increase learning opportunities and performance because it enables learning to take place anytime and anywhere. U-learning (ubiquitous learning) not only enables students to achieve their learning goals at any given time or location but also cultivates their ability to gain new knowledge and develop problem-solving abilities (Liu et al., 2009). Therefore, in order to enable learning at any time and location and effectively increase practicing opportunities and improve English

Table 1
Course design.

Phase	Control group	Experimental group
Preparation (Week 1)	The teachers explained the experimental objectives and evaluation methods. The teachers administered a pre-test.	The teachers explained the experimental objectives and evaluation methods. The teachers administered a pre-test.
'Campus Environment' activity (Week 2–Week 3)	The students used printed materials and audio CDs to learn during their free time. The teachers gave Test #1.	The students employed the HELLO to play a ubiquitous learning game in which they used PDA phones to practice listening and speaking during their free time. The teachers gave Test #1.
'Campus Life' activity (Week 4–Week 5)	The students used printed materials with a zone-related map and audio CDs to learn in classroom during class time. The teachers administered Test #2.	The students employed the HELLO to perform a treasure hunt game which used a context-aware u-learning strategy outdoors during class time. The teachers administered Test #2.
'Campus Story' activity (Week 6–Week 7)	The students employed a digital voice recorder to collaboratively perform a story relay race in the classroom during class time. The teachers gave Test #3.	The students employed the HELLO to collaboratively perform a story relay race which used a collaborative TBLL strategy in an actual context during class time. The teachers gave Test #3.
Evaluation (Week 8)	The teachers administered a post-test.	The teachers administered a post-test.

learning, this study adopted the ubiquitous computing technology for the creation of a ubiquitous learning environment for English learning.

Moreover, integrating handheld device and augmented reality (AR) technology into mobile games can increase learning by immersion as well as provide a richer learning experience. In AR, digital objects are embedded into the real environment, which provides the realization of the probability of immersive learning. Whiteside (2002) pointed out that immersive learning is effective if it engages the learner holistically, cognitively, emotionally, and even physically, by using a combination of designed virtual reality techniques. Various mobile AR learning games have been devised to explore the academic achievement of these technologies for learning. For example, Ferdinand, Müller, Ritschel, and Wechselberger (2005) developed a digital game-Eduventure based on mobile gaming and augmented reality to explore and maximize the learning motivation and engagement achieved by computer and video games.

In order to enable students to experience the feelings and emotions that they do in the real world in a virtual environment and with virtual objects, this study incorporated an AR feature into the system. A u-learning environment called HELLO (since "hello" is the first English word learned by most Taiwanese children) was proposed for conducting ubiquitous learning in an English listening and speaking course. Fig. 1 illustrates the architecture of HELLO. Based on the characteristics of u-learning and immersive learning, HELLO possesses the following features:

- Permanence: students' learning portfolios can be uploaded into the Evaluation Database (EDB) of the HELLO server, making them available for teachers to review. Teachers can review students' portfolios and give grades through the Portfolio Agent.
- Accessibility: teachers input materials and assessments into the Content Database (CDB) through the Content Agent, Assessment Agent, and Push Agent. Each student has a mobile device with which he or she can communicate with the HELLO server. From these mobile devices, students can access materials via a wireless local area network (WLAN) and/or the WCDMA. Students utilize a u-Browser tool to download papers, news, learning games, English comics, English songs, listening materials and conversational materials from the HELLO server. They then use the u-Browser tool to play, listen to and watch learning materials.
- Immediacy: teachers utilize a personal computer to access the HELLO server via the Internet. In addition, students can use the u-test tool to take tests and evaluate their learning progress immediately.
- Interactivity: students can operate learning objects and interact with peers, learning devices, digital content, the real environment and virtual objects in the real world, but also collaboratively complete a common task and share their experiences with each other.
- Situation: students practice listening and speaking in real situations.
- Seamlessness: the learning process is not interrupted when students' locations change.
- Calmness: the Push Agent automatically delivers a daily English sentence to students' mobile devices via the Wideband Code Division Multiple Access (WCDMA) network.
- Adaptability: students may use different devices (e.g. PDAs, PDA phones or smart phones) to learn English.
- Immersion: students utilize the u-Speaker to talk to a virtual learning tutor (VLT) which is in the form of an animated-speaking agent which appears on the mobile device. The u-Speaker tool superimposes the VLT on the learning zone image (captured from the u-Camera), and this makes students feel as though they are talking to a person in the real world.

Table 2
Sample of dialogue.

Zone: Store
Tutor: What do you want?
Learner: How much is the sandwich?
Tutor: It's thirty-eight NT dollars.
Learner: How much is the bread?
Tutor: It's twenty-three NT dollars.
Learner: Okay. I want a sandwich and two bread. How much are they?
Tutor: They are eighty-four NT dollars.
Learner: Here you are.
Tutor: Thank you very much.

Table 3
Sample of listening question.

Zone: Store
Q: What did you have for lunch?
(A) It's too early to take a break.
(B) I ordered something in the store.
(C) I ate a sandwich.
(D) I didn't have dinner with him

- Context awareness: each student takes a PDA phone near a zone which is attached to a 2-D bar code. The u-QRcode tool on the PDA phone uses the phone camera to photograph the barcode and interpret the image as data. This data is used to access learning material from the server relevant to the location, and display it on the PDA phone.
- Individuality: students can select proper learning materials according to personal ability, interest, requirement, objective, and schedule.

2.4. Equipment

The HELLO server station is a desktop computer equipped with Windows server 2003, SQL server 2005, and an Internet connection. The students utilized PDA phones to perform the learning activities. The PDA phone was a wireless enabled Dopod CHT 9100 PDA phone with Windows Mobile 5, wireless LAN (IEEE 802.11b), Bluetooth, camera, and memory card. Additionally, numerous Quick Response (QR) code tags were attached to a lot of information boards. Each board was placed on the wall of the specific learning zone (such as the playground). Each QR code tag could be interpreted to a web link (such as http://www.hello.edu.tw/playground/index.htm) which pointed to the location of the relevant learning content.

2.5. Participants

The participants included 64 seventh grade students, 13 or 14 years of age, and 3 high school teachers. The students were assigned to either the experimental or the control group. Each group had 4 teams and each team had eight members. Two of the teachers had taught English for more than 10 years at the junior high school. One teacher had taught computer classes for more than 5 years, so he installed, managed, and maintained the computer system for the study. All three participating teachers had at least two years' experience of computer-assisted instruction. In Taiwan, students begin to learn English in the first grade and begin to learn Computer Science in the third grade. Therefore, students acquire the basic skills needed to use information technology to assist with English learning from an early age.

2.6. Procedures

The teachers demonstrated how to use the HELLO functions, and introduced the learning activities to the students before they began. A diagram briefly outlining the experimental procedures and data analysis is depicted in Fig. 2.

During the preparation phase, students were divided into control and experimental groups. The teachers administered a pre-test to the two groups in order to understand the prerequisite conditions of the students, and explained the experimental purpose, goals, outlines, and evaluation methods to the two groups.

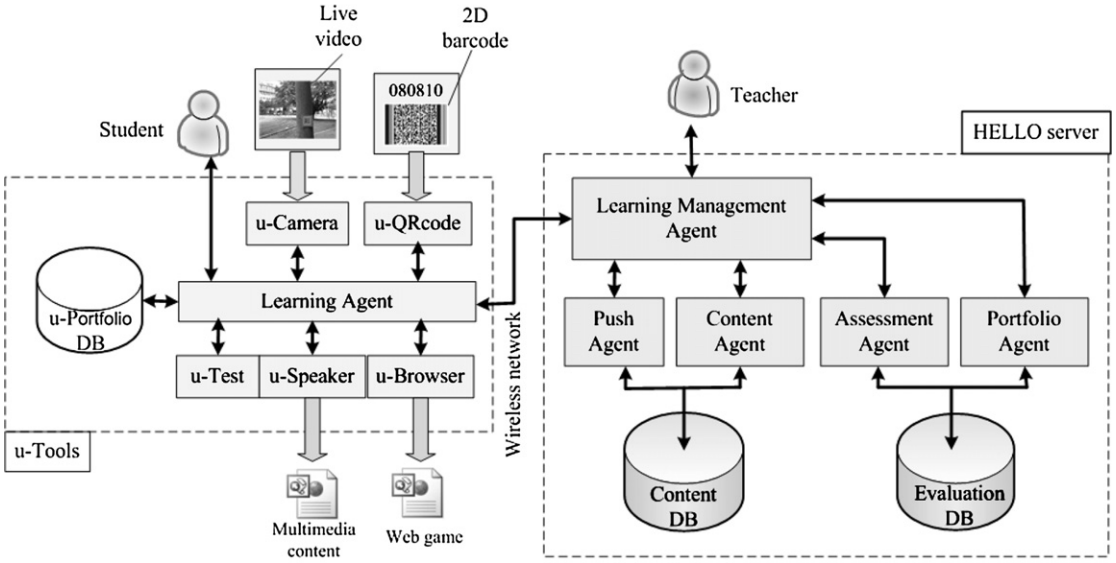

Fig. 1. Architecture of HELLO.

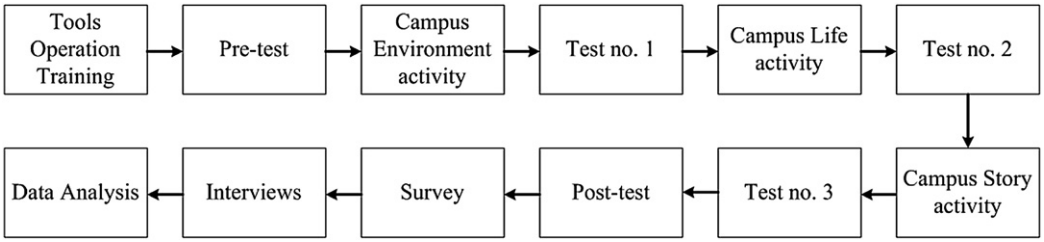

Fig. 2. Diagram outlining the procedure of the case study.

During the 'Campus Environment' activity phase, the experimental group used the HELLO to execute self-learning game (named 'Campus Environment' ubiquitous game). Each student in the experimental group had a PDA phone installed, with u-tools for English learning. The u-tools included several tools which can be used to access self-study English songs, listening materials, and conversational materials from the HELLO server via the WLAN. When the students launched the game, a campus map appeared on the screen of each PDA phone. This map contained numerous zones, each of which was clearly marked. Fig. 2 depicts the 'Campus Environment' computer game. Students moved the character into the learning zone, and the u-Browser then opened zone-related materials. For instance, when a student selected the zone, 'Library', a library appeared on the PDA phone. The student could then choose the movies in order to practice an English conversation or watch an English movie clip. The key aspect of these options is that they enable students to learn without the constraints of time and place, and without having to visit a real library. In contrast, the students in the control group learned zone-related audio conversations by using CD/MP3 players and printed materials during their free time. Furthermore, they could use PDA phones or CD players to learn after school or during their free time. The teachers administered Test #1 to both groups at the end of this phase.

During the 'Campus Life' activity phase, the students in the experimental group used the HELLO to conduct a treasure hunt game (named 'Campus Life' ubiquitous game), which was designed based upon the context-aware ubiquitous game-based learning strategy. Students in the experimental group were asked to practice listening and speaking related to the learning zones. Fig. 3 illustrates the context-aware u-learning game scenario. Each student used a PDA phone installed with u-tools, and followed a guide map on the screen to play the learning game. In order to approach the learning zones, each student followed the guide map on his or her PDA phone, which was equipped with a video camera and hooked up to the WLAN, in order to complete the learning process. For instance, when approaching the real 'Library' zone, a student could use his or her PDA phone to take a picture of the 2-D bar code beside the library, and then decrypt the 2-D bar code. The detected identification of the barcode was then sent to the HELLO server, which located the student and returned situation-related conversational material to the student's PDA phone. The VLT was then superimposed with the zone video on the PDA screen. The student

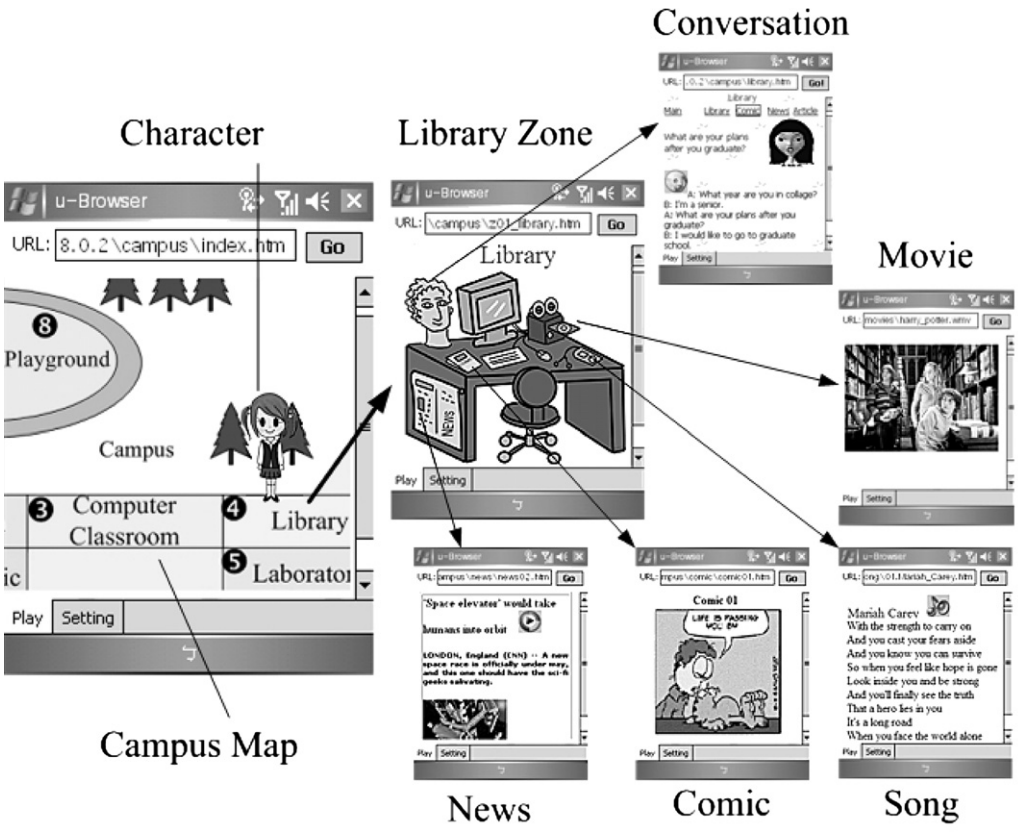

Fig. 3. Self-learning game entitled 'Campus Environment' for experimental group.

could then practice a library-related conversation with the VLT, just as he or she would talk with an actual person in a simulated way. The VLT played the role of speaker 'Tutor' and the student played the role of speaker 'Learner'. The VLT spoke the first sentence, and then the student spoke the next sentence following the prompt of conversation sentences in sequence. The conversation between the VLT and the student can be stored into a PDA phone by means of an embedded software recorder, and can then be uploaded onto a server for instructors to grade. The students were thus able to access context-aware content related to locations, enabling context-aware learning. This features makes students feel as though they are talking to an actual person. Upon completing a conversation with the VLT in a particular zone, the student was given a virtual golden coin and a hint relating to the next zone. Then he or she proceeded to the next zone, and continued until all of the assigned zones had been visited. The student who got all of the available virtual coins was eligible to receive a real gift as a reward. Meanwhile, the students in the control group continued to use CD/MP3 players and printed materials to learn conversations in the classroom. The teachers administered Test #2 to both groups at the end of this phase (Fig. 4).

During the 'Campus Story' activity phase, the designed collaborative learning activity was a story relay race, which was designed based upon a collaborative TBLL strategy. In the beginning, the students could listen to several sample stories, after which they were asked to edit a story collaboratively. Students in the experimental group used the HELLO to play the story relay race game (named 'Campus Story' ubiquitous game). Each team in the experimental group had to select five zones on the map, and then each member had to visit one zone and create a piece of a story about each zone. Each member orally recorded the piece of the story on the PDA phone. Upon successfully completing a piece of a story in a given zone, each member handed his or her baton (PDA phone) to the next member, who listened to the previous story piece and walked to the next zone, continuing in this manner until all of the team members had passed through their five selected zones. In contrast, the students in the control group completed stories by using digital voice recorders in the classroom. The teachers assigned a grade to each team depending upon the creativity and quality of their story. Table 4 represents the best campus story created by the experimental group Team #3.

During the evaluation phase, the teachers administered a listening and speaking test to the students as a post-test, in order to evaluate the outcome of their learning. In order to evaluate student satisfaction with the proposed learning games, a survey was conducted with the experimental group students upon completion of the course. A survey containing 16 questions divided into five groups was administered, and in order to understand the students' perception, in-depth interviews were conducted upon completion of the survey.

2.7. Research hypotheses

According to the research purposes and research questions, the research hypotheses are as follows:

1. In the dimension of "Attention" (perceptual arousal, inquiry arousal, and variability)
   H_{A1}: The students who receive different intervention show no significant difference in the attractiveness of the content of the learning materials.
   H_{A2}. The students who receive different intervention show no significant difference in the attractiveness of the presentation of learning materials.
   H_{A3}. The students who receive different intervention show no significant difference in the attractiveness of the active nature of the learning activities.
   H_{A4}. The students who receive different intervention show no significant difference in their curiosity toward the active nature of the learning activities.
   H_{A5}. The students who receive different intervention show no significant difference in their interest in the 'Campus Environment' activity.

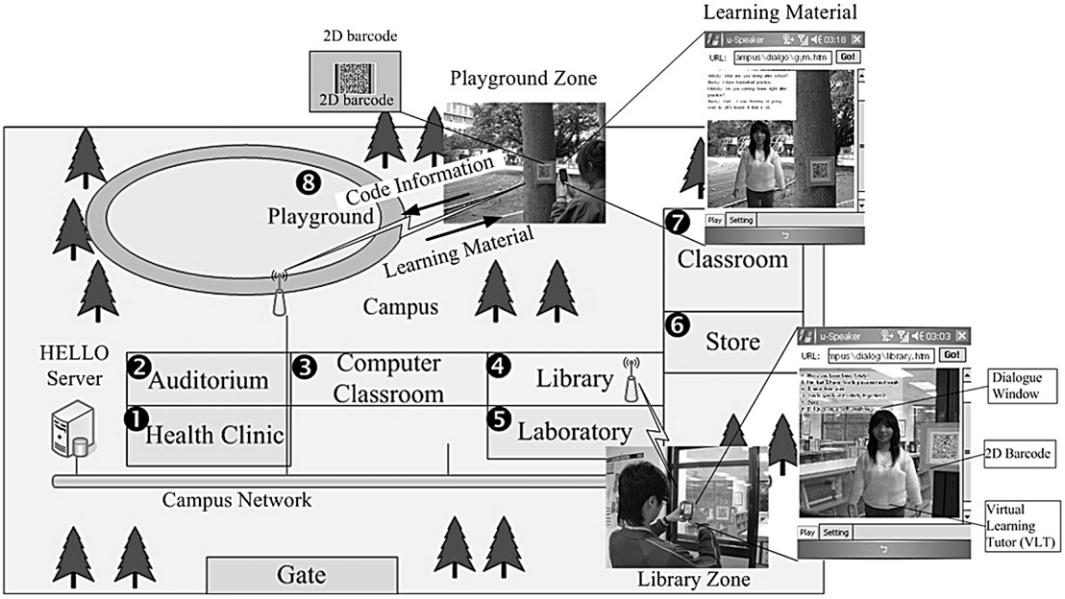

Fig. 4. Scenario of the context-aware u-learning game entitled 'Campus Life': students practice conversation with a virtual learning tutor in the learning zones.

Table 4
Example of a campus story.

Student1. One morning, I heard a meow when I bought a pen in store. I found a black cat crouching in the corner. Student2. Next day, I saw the same black cat in my classroom. It looked very hungry, so I opened my lunch box and gave the cat a fish. I called it 'Siao-Hei'. Student3. Several days away, my classmate said that he saw a dead cat under a tree beside the playground. When I went there, I noticed that dead cat was not 'Siao-Hei'. I was hoping that 'Siao-Hei' is still alive.	Student4. One day, I saw 'Siao-Hei' appearing in front of the health clinic. The cat took some bread and ran away. Student5. I followed 'Siao-Hei' then entered into the store. I found that 'Siao-Hei' was feeding her two little kittens. I gave the bread I had in my hand to 'Siao-Hei'. I hope her kittens can grow up soon.

H_{A6}. The students who receive different intervention show no significant difference in their interest in the 'Campus Life' activity.
H_{A7}. The students who receive different intervention show no significant difference in their interest in the 'Campus Story' activity.

2. In the dimension of "Relevance" (familiarity, motive matching, goal orientation)
   H_{R1}. The students who receive different intervention show no significant difference in the link between the curriculum and their knowledge.
   H_{R2}. The students who receive different intervention show no significant difference in the link between the curriculum and their daily experiences.
   H_{R3}. The students who receive different intervention show no significant difference in thinking that the course is worthy of learn.
   H_{R4}. The students who receive different intervention show no significant difference in thinking that the 'Campus Environment' activity is helpful to them.
   H_{R5}. The students who receive different intervention show no significant difference in thinking that the 'Campus Life' activity is helpful to them.
   H_{R6}. The students who receive different intervention show no significant difference in thinking that the 'Campus Story' activity is helpful to them.
3. In the dimension of "Confidence" (expectancy for success, challenge setting, attribute molding)
   H_{C1}. The students who receive different intervention show no significant difference in believing that the progressing method of learning activities meets their expectations.
   H_{C2}. The students who receive different intervention show no significant difference in controlling the progress of learning activity.
   H_{C3}. The students who receive different intervention show no significant difference in having the confidence to accomplish all activities.
   H_{C4}. The students who receive different intervention show no significant difference in having the confidence to apply what they learn from this course to their everyday life.
4. In the dimension of "Satisfaction" (natural consequences, positive consequences, and equity)
   H_{S1}. The students who receive different intervention show no significant difference in their enjoyment of the 'Campus Environment' activity.
   H_{S2}. The students who receive different intervention show no significant difference in their enjoyment of the 'Campus Life' activity.
   H_{S3}. The students who receive different intervention show no significant difference in their enjoyment of the 'Campus Story' activity.
   H_{S4}. The students who receive different intervention show no significant difference in being satisfied by their achievement in the 'Campus Environment' activity.
   H_{S5}. The students who receive different intervention show no significant difference in being satisfied with their achievement in the 'Campus Life' activity.
   H_{S6}. The students who receive different intervention show no significant difference in being satisfied with their learning achievement in the 'Campus Story' activity.

2.8. Data collection

Both qualitative and quantitative methods were used to collect data. Quantitative data included the test scores of both groups and the survey of the experimental group. A score for each test, ranging between 0 and 100, was given by teachers for examining academic achievement. The internal consistency reliability of the pre-test, test#1, test#2, test#3, and post-test were 0.78, 0.74, 0.82, 0.84, and 0.81 respectively with 64 samples. All of the Cronbach's α value of tests exceeded 0.7, indicating a high reliability of the tests used in this study.

The survey was administered to students for examining learning motivation and learner satisfaction. Based on the Keller's ARCS modal, we developed English learning motivation scale. This survey comprised four sub-scales: attention (Group A), relevance (Group R), confidence (Group C) and satisfaction (Group S) with a total of 23 questions which are listed in Table 5. Responses to all questions were on a five-point Likert-scale, from 5 for "strongly agree" to 1 for "strongly disagree." The Cronbach's α for each sub-scale was 0.86, 0.87, 0.86, and 0.90, respectively, and for the survey was 0.91. These alpha coefficients exceeded 0.85, which confirmed the internal consistency of the survey.

In-depth interviews were conducted to explore students' points of view, feelings, and perspectives. The researcher interviewed the students for 15 min to understand their opinions about the learning activities. The interviews contained five questions, which are as follows:

1. "Do you think the method of English learning employed in this course is interesting? Why or Why not?"
2. "Do you think the method of English learning employed in this course is attractive? Why or Why not?"
3. "Do you think the method of English learning employed in this course is useful? Why or Why not?"
4. "Do you think this course improved your confidence in learning English? Why or Why not?"
5. "Are you satisfied with your English learning achievement? Why or Why not?"

Table 5
The survey questions.

Item	Question	Item	Question
A1	The themes of the learning materials draw my attention.	C1	The progressing method of learning activities meets my expectations.
A2	The manner in which the learning materials are presented helps me focus my attention.	C2	I can control my progress in the learning activity.
A3	I can concentrate on the learning activities.	C3	I am confident that I can accomplish all the activities.
A4	The learning activities can arouse my curiosity.	C4	I am confident that I can apply what I learn from this course to my daily life.
A5	The 'Campus Environment' activity in this course is interesting to me.	S1	I enjoy the 'Campus Environment' activity.
A6	I find the 'Campus Life' activity in this course interesting.	S2	I enjoy the 'Campus Life' activity.
A7	I find the 'Campus Story' activity in this course interesting.	S3	I enjoy the 'Campus Story' activity.
R1	I can link the content of this course to the knowledge that I am already familiar with.	S4	I am satisfied with my learning achievement in the 'Campus Environment' activity.
R2	The content of this course is linked to my daily experiences.	S5	I am satisfied with my learning achievement in the 'Campus Life' activity.
R3	The content of this course is worth learning.	S6	I am satisfied with my learning achievement in the 'Campus Story' activity.
R4	The 'Campus Environment' activity in this course has been very helpful to me.		
R5	The 'Campus Life' activity in this course has been very helpful to me.		
R6	The 'Campus Story' activity in this course has been very helpful to me.		

The process of the in-depth interviews was recorded on an audio recorder, and the quantitative data was supported by a set of qualitative means.

2.9. Data analysis

The SPSS (Statistical Package for the Social Science, version 15) was used to score the data and answer the research questions. The significance level was set at $p < 0.05$ for all statistical analysis, as is standard practice.

The learning performance was taken from the experimental and control group students' test scores. This study adopted Cronbach's α coefficient in order to evaluate the internal consistency reliability of the tests. Cronbach's α coefficient ranges between 0 and 1, and Nunnaly (1978) suggests that 0.7 is an acceptable minimum reliability coefficient. We conducted ANCOVA with a pre-test as a covariate to investigate the outcomes of students in different groups.

The learning motivation and learner satisfaction of the statistical results of the questionnaire were obtained using a one-way ANOVA. Descriptive statistics, including frequencies, means, and standard deviations were used to calculate subject responses to the questions in the questionnaire.

The qualitative data included the responses from the audio records obtained form an in-depth interview. Analytic procedures – organizing the data; generating categories, themes, and patterns; testing the emergent hypotheses against the data; searching for alternative explanations for the data; and writing the report (proposed by Marshall & Rossman (1989)) – were adopted to analyze the qualitative data obtained in this study.

3. Results and discussions

3.1. Learning outcomes

The result (significance > 0.05) of Levene's test for the equality of variances indicates that the assumption of the homogeneity of variances in the groups is satisfied. In addition, the test results (significance > 0.05) of between-subjects effects, which indicate the assumption of homogeneity of regression coefficients for the two groups, is satisfactory for the remainder of the tests. With this in hand, an ANCOVA analysis was performed using the pre-test as a covariate. Table 6 presents the mean grades and standard deviation of evaluations for each test.

In Phase 1, the preparation phase, the teachers distributed a pre-test to both groups of students. In Phase 2, the 'Campus Environment' activity, the ANCOVA result of Test #1 ($F = 13.07$, $p < 0.05$) indicated that the average grades of the experimental group exceeded those of the control group by about six points. This difference was significant because it demonstrated the effectiveness of the HELLO in improving learning. According to the interviews, this improvement occurred because the HELLO provides many interesting learning materials.

In Phase 3, the 'Campus Life' activity, the ANCOVA result of Test #2 ($F = 20.17$, $p < 0.05$) indicated that the average grade of the experimental group significantly exceeded that of the control group by eight and a half points. According to the interviews, this occurred because the HELLO provides an interesting context-aware immersive activity which can improve the learning experience in listening and speaking, further increasing students' results.

In Phase 4, the 'Campus Story' activity (a story relay race), the ANCOVA result of Test #3 ($F = 11.68$, $p < 0.05$) indicated that the average grade of the experimental group exceeded that of the control group by eight points. According to the interviews, this occurred because the experimental group students practiced their speaking in real situations, collaborated in their tasks in real conditions, and completed their creation in actual situations.

In Phase 5, the evaluation phase, the ANCOVA result ($F = 15.56$, $p < 0.05$) indicated that the average grade of the experimental group significantly exceeded that of the control group in the post-test by eight points.

Table 6
Mean grades and S.D. of evaluations for each test.

Item	Experimental group			Control group			*F*
	Mean	SD	SE	Mean	SD	SE	
Pre-test	74.06	11.32	2.00	75.47	10.03	1.77	–
Test 1	82.03	5.37	0.95	76.66	6.35	1.12	13.07*
Test 2	86.88	7.04	1.24	78.44	7.77	1.37	20.17*
Test 3	85.63	9.57	1.69	77.53	9.76	1.72	11.68*
Post-test	89.44	7.45	1.32	81.25	9.59	1.70	15.56*

$N = 64$; $F_{0.95}(1,61) = 4.00$; $^{*}p < 0.05$.

3.2. Learning motivation

Thus, the grades of the experimental group students were better than those of the control group students. Furthermore, we hoped to understand the relationship between the learning performance and learning attitudes by using three different learning strategies of English learning. Therefore, a questionnaire was administered to the experimental group students after the post-test. A total of 64 valid questionnaires were submitted, with a response rate of 100%. The results of Levene's test are listed in Table 7. The results (Sig. > 0.05) of Levene's test for equality of variances indicate that the assumption of the homogeneity of variances in each item is satisfactory. Accordingly, an ANOVA was then performed. The ANOVA evaluation results of learning motivation are listed in Table 8.

Responses to item A1 indicated that there wasn't a significant difference in the attractiveness of contents of learning materials: F=0.15, *Sig.* = 0.699 >0.05. Most of the students in experimental group pointed out that they could learn much more daily conversation. Responses to item A2 indicated that there was a significant difference in the attractiveness of the presentation of learning materials: $F = 11.675$, *Sig.* = 0.001 <0.05. Responses to item A3 indicated that there was a significant difference in the attractiveness of the active nature of the learning activities: $F = 17.75$, *Sig.* = 0.000 <0.05. Responses to item A4 indicated that there was a significant difference in students' curiosity toward the active nature of the learning activities: $F = 28.459$, *Sig.* = 0.000 <0.05. Responses to item A5 indicated that there was a significant difference in students' interest in the 'Campus Environment' activity: $F = 24.591$, *Sig.* = 0.000 <0.05. Responses to item A6 indicated that there was a significant difference in students' interest in the 'Campus Life' activity: $F = 21.502$, *Sig.* = 0.000 <0.05. Responses to item A7 indicated that there was a significant difference in students' interest in the 'Campus Story' activity: $F = 7.757$, *Sig.* = 0.007 <0.05. Students in the experimental group pointed out that games could enhance their concentration and encourage their learning through play, and therefore they thought the learning activities were interesting.

Responses to item R1 indicated that there wasn't a significant difference in the link between the curriculum and students' knowledge: $F = 0.109$, *Sig.* = 0.743 > 0.05. Responses to item R2 indicated that there wasn't a significant difference in the link between the curriculum and students' daily experiences: $F = 0.038$, *Sig.* = 0.847 > 0.05. Responses to item R3 indicated that there wasn't a significant difference in thinking that the course is worthy of learn: $F = 1.066$, *Sig.* = 0.306 > 0.05. Responses to item R4 indicated that there was a significant difference in thinking that the 'Campus Environment' activity is helpful to students: $F = 27.941$, *Sig.* = 0.000 <0.05. Many students in the experimental group thought that the 'Campus Environment' ubiquitous game could help their listening skill. Responses to item R5 indicated that there was a significant difference in thinking that the 'Campus Life' activity is helpful to students: $F = 21.462$, *Sig.* = 0.000 <0.05. Responses to item R6 indicated that there was a significant difference in thinking that the 'Campus Story' activity is helpful to students: $F = 5.327$, *Sig.* = 0.024 <0.05. Students in the experimental group stated that completing a task collaboratively in a real context encouraged them to accrue more creations than they did in the classroom.

Responses to item C1 indicated that there was a significant difference in believing that the progressing method of learning activities meets students' expectations: $F = 16.634$, *Sig.* = 0.000 <0.05. Students in the experimental group indicated that these learning activities were a real learning experience which they could not possibly gain from textbooks and audio CDs. Responses to item C2 indicated that there wasn't a significant difference in controlling the progress of learning activity: $F = 0.615$, *Sig.* = 0.436 > 0.05. Responses to item C3 indicated that there wasn't a significant difference in having the confidence to accomplish all activities: $F = 0.958$, *Sig.* = 0.332 > 0.05. Responses to item C4 indicated that there was a significant difference in having the confidence to apply what they learn from this course to students' everyday life: $F = 9.945$, *Sig.* = 0.002 <0.05. In the interviews, students in the experimental group stated that they rarely practiced speaking

Table 7
The results of Levene's test.

Item	Levene statistic	Sig.	Item	Levene statistic	Sig.
A1	0.064	0.802*	C1	0.014	0.906*
A2	1.103	0.298*	C2	2.213	0.142*
A3	1.671	0.201*	C3	0.336	0.564*
A4	0.904	0.345*	C4	0.260	0.612*
A5	2.359	0.130*	S1	0.619	0.435*
A6	0.309	0.580*	S2	0.200	0.656*
A7	0.632	0.430*	S3	0.773	0.383*
R1	0.045	0.833*	S4	1.613	0.209*
R2	0.749	0.390*	S5	0.004	0.947*
R3	1.534	0.220*	S6	0.004	0.951*
R4	0.181	0.672*			
R5	0.000	1.000*			
R6	2.999	0.088*			

* $p < 0.05$.

Table 8
The evaluation results of learning motivation.

Item	Experimental group							Control group							F	Sig.
	Strongly agreed	Agreed	Partial agreed	Disagreed	Strongly disagreed	M	SD	Strongly agreed	Agreed	Partial agreed	Disagreed	Strongly disagreed	M	SD		
A1	7 (21.9%)	19 (59.4%)	6 (18.8%)	0 (0%)	0 (0%)	4.03	0.65	8 (25.0%)	19 (59.4%)	5 (15.6%)	0 (0%)	0 (0%)	4.09	0.64	0.151	0.699
A2	9 (28.1%)	16 (50.0%)	7 (21.9%)	0 (0%)	0 (0%)	4.09	0.73	3 (9.4%)	11 (34.4%)	15 (46.9%)	3 (9.4%)	0 (0%)	3.44	0.80	11.675	0.001*
A3	11 (34.4%)	17 (53.1%)	4 (12.5%)	0 (0%)	0 (0%)	4.22	0.66	2 (6.3%)	14 (43.8%)	14 (43.8%)	2 (6.3%)	0 (0%)	3.47	0.76	17.750	0.000*
A4	11 (34.4%)	15 (46.9%)	6 (18/8%)	0 (0%)	0 (0%)	4.16	0.72	12 (37.5%)	14 (43.8%)	6 (18.8%)	0 (0%)	0 (0%)	3.28	0.58	28.459	0.000*
A5	8 (25.0%)	19 (59.4%)	5 (15.6%)	0 (0%)	0 (0%)	4.09	0.64	0 (0%)	13 (40.6%)	15 (46.9%)	4 (12.5%)	0 (0%)	3.25	0.72	24.591	0.000*
A6	15 (46.9%)	13 (40.6%)	3 (9.4%)	1 (3.1%)	0 (0%)	4.31	0.78	1 (3.1%)	15 (46.9%)	14 (43.8%)	2 (6.3%)	0 (0%)	3.47	0.67	21.502	0.000*
A7	13 (40.6%)	14 (43.8%)	3 (9.4%)	2 (6.3%)	0 (0%)	4.19	0.86	3 (9.4%)	15 (46.9%)	14 (43.8%)	0 (0%)	0 (0%)	3.66	0.65	7.757	0.007*
R1	8 (25.0%)	21 (65.6%)	1 (3.1%)	2 (6.3%)	0 (0%)	4.09	0.73	8 (25.0%)	19 (59.4%)	3 (9.4%)	2 (6.3%)	0 (0%)	4.03	0.78	0.109	0.743
R2	10 (31.3%)	17 (53.1%)	5 (15.6%)	0 (0%)	0 (0%)	4.16	0.68	8 (25.0%)	20 (62.5%)	4 (12.5%)	0 (0%)	0 (0%)	4.13	0.61	0.038	0.847
R3	11 (34.4%)	18 (56.3%)	3 (9.4%)	0 (0%)	0 (0%)	4.25	0.62	7 (21.9%)	21 (65.6%)	4 (12.5%)	0 (0%)	0 (0%)	4.09	0.59	1.066	0.306
R4	10 (31.3%)	17 (53.1%)	5 (15.6%)	0 (0%)	0 (0%)	4.16	0.68	0 (0%)	12 (37.5%)	19 (59.4%)	1 (3.1%)	0 (0%)	3.34	0.55	27.941	0.000*
R5	12 (37.5%)	16 (50.0%)	4 (12.5%)	0 (0%)	0 (0%)	4.25	0.67	1 (3.1%)	15 (46.9%)	15 (46.9%)	1 (3.1%)	0 (0%)	3.50	0.62	21.462	0.000*
R6	6 (18.8%)	22 (68.8%)	3 (9.4%)	1 (3.1%)	0 (0%)	4.03	0.65	2 (6.3%)	18 (56.3%)	11 (34.4%)	1 (3.1%)	0 (0%)	3.66	0.65	5.327	0.024*
C1	9 (28.1%)	15 (46.9%)	8 (25.0%)	0 (0%)	0 (0%)	4.03	0.74	0 (0%)	13 (40.6%)	17 (53.1%)	2 (6.3%)	0 (0%)	3.34	0.60	16.634	0.000*
C2	10 (31.3%)	17 (53.1%)	5 (15.6%)	0 (0%)	0 (0%)	4.16	0.68	5 (15.6%)	22 (68.8%)	5 (15.6%)	0 (0%)	0 (0%)	4.03	0.59	0.615	0.436
C3	8 (25.0%)	23 (71.9%)	1 (3.1%)	0 (0%)	0 (0%)	4.22	0.49	6 (18.7%)	23 (71.9%)	3 (9.4%)	0 (0%)	0 (0%)	4.09	0.53	0.958	0.332
C4	7 (21.9%)	18 (56.3%)	7 (21.9%)	0 (0%)	0 (0%)	4.03	0.69	1 (3.1%)	15 (46.9%)	16 (50.0%)	0 (0%)	0 (0%)	3.53	0.57	9.945	0.002*
S1	11 (34.4%)	14 (43.8%)	5 (15.6%)	2 (6.3%)	0 (0%)	4.06	0.88	0 (0%)	15 (46.9%)	15 (46.9%)	2 (6.3%)	0 (0%)	3.41	0.61	12.003	0.001*
S2	12 (37.5%)	16 (50.0%)	4 (12.5%)	0 (0%)	0 (0%)	4.25	0.67	0 (0%)	17 (53.1%)	14 (43.8%)	1 (3.1%)	0 (0%)	3.50	0.57	23.250	0.000*
S3	11 (34.4%)	15 (46.9%)	6 (18.8%)	0 (0%)	0 (0%)	4.16	0.72	1 (3.1%)	18 (56.3%)	13 (40.6%)	0 (0%)	0 (0%)	3.63	0.55	10.886	0.002*
S4	12 (37.5%)	13 (40.6%)	7 (21.9%)	0 (0%)	0 (0%)	4.16	0.77	0 (0%)	16 (50.0%)	15 (46.9%)	1 (3.1%)	0 (0%)	3.47	0.57	16.634	0.000*
S5	12 (37.5%)	18 (56.3%)	2 (6.3%)	0 (0%)	0 (0%)	4.31	0.59	1 (3.1%)	17 (53.1%)	14 (43.8%)	0 (0%)	0 (0%)	3.59	0.56	24.885	0.000*
S6	9 (28.1%)	16 (50.0%)	7 (21.9%)	0 (0%)	0 (0%)	4.06	0.72	1 (3.1%)	18 (56.3%)	13 (40.6%)	0 (0%)	0(0%)	3.66	0.60	6.043	0.017*

$N = 64$; $^{*}p < 0.05$.

with English teachers, and therefore, they lacked confidence when talking with teachers. The HELLO enabled them to talk with a VLT which could encourage them to gain confidence to speak back.

Responses to item S1 indicated that there was a significant difference in students' enjoyment of the 'Campus Environment' activity: $F = 12.003$, $Sig. = 0.001 < 0.05$. Students in the experimental group stated that the game was interesting compared with a textbook and they could practice listening through rich multi-media English learning resources, such as conversations, songs, and movies. Some students in the experimental group stated that they would like to rent English movies to learn from following this learning activity. Responses to item S2 indicated that there was a significant difference in students' enjoyment of the 'Campus Life' activity: $F = 23.250$, $Sig. = 0.000 < 0.05$. Most of the students in experimental group felt that the 'Campus Life' ubiquitous game was interesting, and they seemed to be immersed in the learning situation during the activity. One student in the experimental group stated that he enjoyed the 'Campus Life' ubiquitous game because the virtual tutor and the real context made learning interesting. Responses to item S3 indicated that there was a significant difference in students' enjoyment of the 'Campus Story' activity: $F = 10.886$, $Sig. = 0.002 < 0.05$. Most of the students in experimental group enjoyed the TBLL game because they could complete a common task collaboratively in the story relay game in the real context, which was an interesting experience. Responses to item S4 indicated that there was a significant difference in being satisfied by students' achievement in the 'Campus Environment' activity: $F = 16.634$, $Sig. = 0.000 < 0.05$. Responses to item S5 indicated that there was a significant difference in being satisfied with students' achievement in the 'Campus Life' activity: $F = 24.885$, $Sig. = 0.000 < 0.05$. Many students in the experimental group stated that they could practice the same conversation repeatedly until they were familiar with the learning content. Responses to item S6 indicated that there was a significant difference in being satisfied with students' learning achievement in the 'Campus Story' activity: $F = 6.043$, $Sig. = 0.017 < 0.05$. Numerous students in the experimental group stated that practicing speaking in the real context could encourage them to speak out in public, which further facilitated their learning, although several students felt nervous about speaking in public because of their poor English.

Moreover, the statistical results of the survey also demonstrate that for the experimental group, using context-aware ubiquitous games in the learning process produced better learning outcomes and learning motivation than using the other two learning games. During the interview, many students in the experimental group stated that they enjoyed and were more satisfied with the ubiquitous game called "Campus Life" than the other two ubiquitous games, because they could talk with the VLT, which they found very interesting. Many students in the experimental group also thought that "Campus Life" was more useful than the other two ubiquitous games because HELLO provided opportunities for practicing speaking in an actual context. Although students in the experimental group welcomed these ubiquitous games, they still recognized the value of non-gaming learning modes. They pointed out that ubiquitous game-based learning is motivating, but the non-gaming learning style is still very important. They thought that ubiquitous learning games could not be used alone without traditional teaching, and believed that ubiquitous game-based learning would be widely adopted in the future.

3.3. Relationship between the learning outcomes and motivation

Table 9 reports the score averages of the learning outcomes and learning motivation for both groups. The evaluation results of learning outcomes and learning motivation demonstrate that using ubiquitous games in learning could achieve a better learning performance and motivation than non-gaming learning. Most of the students in experimental group stated that they were afraid of talking with English teachers but were not at all afraid of talking to the VLT. Even if they made a mistake, the VLT only told them the correct sentence without laughing at them openly. Therefore, they felt satisfied with their achievement in the ubiquitous games.

4. Conclusions and future work

This study aimed at investigating how ubiquitous games affects the learning outcomes and motivation of English listening and speaking. To enhance English learning, this work proposes a context-aware ubiquitous learning environment − HELLO based on sensor, augmented reality, the Internet, ubiquitous computing, and information technologies. HELLO helps students to engage in learning activities based on the ARCS motivation theory, involving various educational strategies, including ubiquitous game-based learning, collaborative learning, and context-aware learning. A case study was performed with the participation of three high school teachers and 64 high school juniors. A survey and interviews were administered to the students following the tests.

The experimental results show that the use of ubiquitous games in learning can produce better learning outcomes than the non-gaming method, further demonstrating the effectiveness of HELLO. The survey results indicate that the experimental group students gained better learning motivation for attention, relevance, confidence and satisfaction, further demonstrating the positive relationship between learning outcomes and motivation. According to the interviews, students in the experimental group thought the ubiquitous games interesting and useful for assisting them to learn, so they felt satisfied with the ULGs. Moreover, students pointed out that using the HELLO to conduct context-aware u-learning can not only provide opportunities to practice, but also to engage in enjoyable experiences for assisting listening and speaking. Students were excited and gained a feeling for the interesting context-aware ubiquitous games when talking to the VLT or playing with classmates. Therefore, the students had a positive learning motivation toward using HELLO to aid language learning and were also satisfied with its effectiveness.

Table 9
Score average of learning outcome and learning motivation.

Score average	Experimental group	Control group
Tests	86.00	78.47
Attention	4.16	3.52
Relevance	4.16	3.79
Confidence	4.11	3.75
Satisfaction	4.17	3.54

This work also demonstrates that sensor, AR, and ubiquitous technologies are useful in providing ubiquitous game-based English learning. This paper analyzes and discusses the effectiveness of ubiquitous games used in English speaking and listening, which has implications for current and future developments in pedagogy.

In future research, we will continue to work with high school English teachers in order to conduct further studies. We will set up multiple interactive touch screens at learning zones in campuses; thus, students can communicate with the virtual characters on the touch screens in English and further increase their opportunities to learn English. Moreover, we will continue to develop more efficient and interesting ULGs to improve English learning for students.

Acknowledgments

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financially supporting this research under NSC 98-2511-S-262-004.

References

Bremner, S. (1999). Language learning strategies and proficiency: investigating the relationship in Hong Kong. *Canadian Modern Language Review, 55*(4), 490–514.
Canale, M., & Swain, M. (1980). Theoretical bases of communicative approaches to second language teaching and testing. *Applied Linguistics, 1*(1), 1–47.
Chang, C. K., Chan, T. W., & Yang, J. C. (2007). Learning activity design on mobile learning device: Using ESL reading comprehension as example. *Paper presented at the 13th International Study Association on Teachers and Teaching (ISATT 2007)*, 6–9 July 2007, St. Catharines, Ontario, Canada.
Chamot, A. U. (1987). The learning strategies of ESL students. In A. Wendenin, & J. Rubin (Eds.), *Learner strategies in language learning* (pp. 71–83). Englewood Cliffs, NJ: Prentice-Hall.
Chen, C. M., & Chung, C. J. (2008). Personalized mobile English vocabulary learning system based on item response theory and learning memory cycle. *Computers & Education, 51*(2), 624–645.
Chen, C. M., & Hsu, S. H. (2008). Personalized intelligent mobile learning system for supporting effective English learning. *Educational Technology & Society, 11*(3), 153–180.
Chen, N. S., Hsieh, S. W., & Kinshuk. (2008). Effects of short-term memory and content representation type on mobile language learning. *Language Learning & Technology, 12*(3), 93–113.
Collins, T. G. (2005). English class on the air: mobile language learning with cell phones. *Paper presented at the Fifth IEEE International Conference on Advanced Learning Technologies*, July 5–8, 2005, Kaohsiung, Taiwan.
Ericsson, K. A., Krampe, R. Th., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100*, 363–406.
Eow, Y. L., Ali, W. Z.b. W., Mahmud, R.b., & Baki, R. (2009). Form one students' engagement with computer games and its effect on their academic achievement in a Malaysian secondary school. *Computers & Education, 53*(4), 1082–1091.
Ehrman, M., & Oxford, R. (1989). Effects of sex differences, career choice, and psychological type on adult language learning strategies. *Modern Language Journal, 73*, 1–13.
Ferdinand, P., Müller, S., Ritschel, T., & Wechselberger, U. (2005, September). The Eduventure – a new approach of digital game based learning combining virtual and mobile augmented reality games episodes. *Paper presented at the Pre-Conference Workshop "Game based Learning" of DeLFI 2005 and GMW 2005 Conference*, Rostock, Germany.
Green, J. M., & Oxford, R. L. (1995). A closer look at learning strategies, L2 proficiency, and gender. *TESOL Quarterly, 29*, 287–307.
Hartup, W. W. (1992). *Having friends, making friends, and keeping friends: Relationships as educational contexts*. (ERIC Document Reproduction Service No. ED 345 854).
Henderson, L. (2005). Video games: A significant cognitive artifact of contemporary youth culture. In: Proceedings of DiGRA 2005 conference. Changing views – Worlds in play. http://www.diagra.org/dl/db/06276.11341.pdf. Accessed 19.12.08.
Jones, V., & Jo, J. H. (2004). Ubiquitous learning environment: An adaptive teaching system using ubiquitous technology. In R. Atkinson, C. McBeath, D. Jonas-Dwyer, & R. Phillips (Eds.), *Proceedings of the 21st ASCILITE (Australasian Society for Computers in Learning in Tertiary Education) Conference* (pp. 468–474). Perth, Australia: ASCILITE.
Keller, J. M. (1987). Development and use of the ARCS model of motivational design. *Journal of Instructional Development, 10*(3), 2–10.
Keller, J. M., & Suzuki, K. (2004, October). Learner motivation and E-learning design: A multinationally validated process. *Journal of Educational Media, 29*(3), 229–239.
Kiernan, P. J., & Aizawa, K. (2004). Cell phones in task based learning-are cell phones useful language learning tools? *ReCALL, 16*(1), 71–84.
Kukulska-Hulme, A. (2005). *The mobile language learner – now and in the future. Fran Vision till Praktik*. Language Learning Symposium, Umea University, Sweden. Retrieved on September 11, 2008, from http://oro.open.ac.uk/9542/
Lan, Y. J., Sung, Y. T., & Chang, K. E. (2007). A mobile-device-supported peer assited learning system for collaborative early EFL reading. *Language Learning & Technology, 11*(3), 130–151.
Lepper, M. R., Iyenger, S. S., & Corpus, J. H. (2005). Intrinsic and extrinsic motivational orientations in the classroom: age difference and academic correlates. *Journal of Educational Psychology, 97*(2), 184–196.
Liu, T. Y., Tan, T. H., & Chu, Y. L. (2009). Outdoor natural science learning with an RFID-supported immersive ubiquitous learning environment. *Educational Technology and Society, 12*(4), 124–140.
Luchini, K., Quintana, C., Krajcik, J., Farah, C., Nandihalli, N., Reese, K., Wieczorek, A., & Soloway, E. (2002, April). Scaffolding in the small: designing educational supports for concept mapping on handheld computers. *Paper presented at the ACM conference on Human Factors in Computing Systems: CHI 2002 Extended Abstracts*, Minneapolis, Minnesota, USA.
Marshall, C., & Rossman, G. B. (1989). *Designing qualitative research*. Newbury Park, CA: Sage.
Merrill, M. D. (1994). *Instructional design theory*. Englewood Cliffs, NJ: Educational Technology Publications.
McFarlance, A., Sparrowhawk, A., & Heald, Y. (2002). *Report on the educational use of games: An exploration by TEEM of the contribution which games can make to education process*. Cambridge: TEEM.
McMahon, T. (2006). Teaching for more affective learning: seven maxims for practice. *Radiography, 12*(1), 34–44.
Noels, K. A., Pelletier, L. G., Clément, R., & Vallerand, R. J. (2000). Why are you learning a second language? Motivational orientations and self-determination theory. *Language Learning, 50*, 57–85.
Nunan, D. (1992). *Research methods in language learning*. Cambridge: Cambridge University Press.
Nunnaly, J. (1978). *Psychometric theory*. New York: McGraw-Hill.
Ogata, H., & Yano, Y. (2004). Knowledge awareness for a computer-assisted language learning using handhelds. *International Journal of Continuous Engineering Education and Lifelong Learning, 14*(4/5), 435–449.
Olson, C. K., Kutner, L. A., Warner, D. E., Almerigi, J. B., Baer, L., Nicholi, A. M., Jr., et al. (2007). Factors correlated with violent video games use by adolescent boys and girls. *Journal of Adolescence Health, 41*(1), 77–83.
Omaggio, A. C. (1986). *Teaching language in context: Proficiency-oriented instruction*. Boston: Heinli.
Oxford, R. L. (1990). *Language learning strategies: What every teacher should know*. New York: Newbury House/Harper & Row.
Papastergiou, M. (2008). Digital game-based learning in high school computer science education: impact on educational effectiveness and student motivation. *Computers & Education, 52*(1), 1–12.
Prensky, M. (2001). *Digital game-based learning*. New York: McGraw-Hill.
Ranalli, J. (2008). Learning English with The Sims: exploiting authentic computer simulation games for L2 learning. *Computer Assisted Language Learning, 21*(5), 441–455.
Reiss, M. (1983). Helping the unsuccessful language learner. *Forum, 21*(2), 1–8.
Rigney, J. W. (1978). Learning Strategies: A theoretical perspective. In H. F. O'Neil, Jr. (Ed.), *Learning strategies*. New York: Academic Press.
Rubin, J. (1987). Learner strategies: Theoretical assumptions, research history and 62 typology. In A. L. Wenden, & J. Rubin (Eds.), *Learner strategies in language learning* (pp. 15–30). Englewood Cliffs, NJ: Prentice-Hall.
Schwabe, G., & Göth, C. (2005). Mobile learning with a mobile game: design and motivational effects. *Journal of Computer Assisted Learning, 21*(3), 204–216.
Segler, T. M., Pain, H., & Sorace, A. (2002). Second language vocabulary acquisition and learning strategies in ICALL environment. *Computer Assisted Language Learning, 15*(4), 409–422.

Stanton, D., Neale, H., & Bayon, V. (2002). Interfaces to support children's co-present collaboration: multiple mice and tangible technologies. In G. Stahl (Ed.), *Computer Support for Collaborative Learning (CSCL)* (pp. 342–352). New Jersey: Lawrence Erlbaum Associates.
Thornton, P., & Houser, C. (2005). Using mobile phones in English education in Japan. *Journal of Computer Assisted Learning, 21*, 217–228.
Tüzün, H., Yilmaz-Soylu, M., Karakus, T., İnal, Y., & Kizilkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education, 52*(1), 68–77.
Ushioda, E. (1996). *Learner autonomy 5: The role of motivation*. Dublin, Ireland: Authentik.
Virvou, M., Katsionis, G., & Manos, K. (2005). Combining software games with education: evaluation of its educational effectiveness. *Educational Technology & Society, 8*(2), 54–65.
Whiteside, A. J. (2002). Beyond interactivity: immersive web-based learning experiences. *The e-Learning Developers' Journal, 283*, 1–10, Retrieved January 12, 2008, from. http://www.elearningguild.com.
Willis, J. (1996). *A framework for task-based learning*. London: Longman.
Yu, F. Y., Chang, L. J., Liu, Y. H., & Chan, T. W. (2002). Learning preferences towards computerised competitive modes. *Journal of Computer Assisted Learning, 18*(3), 341–350.