A Mobile Augmented Reality Based Scaffolding Platform for Outdoor Fieldtrip Learning

Chung-Hsien Tsai
Computer Science and Information Engineering
National Defense University
Tauyuan County, Taiwan, R.O.C.
chtsai@ndu.edu.tw

Jiung-Yao Huang
Computer Science and Information Engineering
National Taipei University
New Taipei City, Taiwan, R.O.C.
jyhuang@mail.ntpu.edu.tw

***Abstract*—Mobile learning provides learners with the capability to assimilate courses anywhere in any time. However, most of the existing Mobile learning systems only allows learners to passively receive knowledge without considering the temporal and spatial information of the learners. The paper proposed a context-aware mobile augmented reality learning platform, called Historical Time Tunnel(HTT), as scaffolding platform for outdoor field learning. The location-based nature of Augmented Reality(AR) technology, AR-based Mobile learning systems could enable learners to acquire the historical interactive knowledge that are related to the specific geographical location. Through such direct interaction with location-based information provided by AR-based M-learning technology, the knowledge acquisition efficiency can be significantly boosted. The designed HTT system not only focuses on student learning management module but also provides teaching material management module for teachers. The conducted experiments on the elementary school student successfully prove that HTT system is an effective scaffolding tool for the novice teachers as well as a helpful assistant to the experienced teachers.**

Keywords—Scaffolding; Mobile Augmented Reality; Outdoor Fieldtrip Learning; Local Culture

I. INTRODUCTION

Although E-learning is an excellent platform for the students to work and learn at their own paces and places without the restriction of time and location compare to the traditional learning. However, there are some problems with E-learning. For examples: How to build their self-learning skills? How to avoid distraction from information overflow or isolation? How to maintain students' interest and persistence? Hence, E-learning requires support and structure to assist the students. Different approaches of Scaffolding[1] in E-learning are then proposed over the years. Furthermore, with advance of mobile technology has promoted the utilization of smart devices application in our daily life. In recent years, E-learning researchers notices that the process of mobile technologies have changed with portability and interactivity. The objective of M-learning is to provide the learner with the ability to assimilate learning anywhere at any time. M-learning technology focuses on the mobility of the learner and interaction.

A scaffold is a temporary framework that is put up for supporting and assisting students in learning. The framework would be gradually faded away after the students completing the assigned tasks to gain the enough knowledge. It was first introduced in the late 1950 and was promoted by Vygotsky since 1978.[2] There are three categories of scaffolds, including cognitive, meta-cognitive, and affective or motivational scaffolds. Cognitive and meta-cognitive scaffolds provide assistance, support, hints, prompts, and suggestions regarding the content, resources, and strategies relevant to the problem solving and learning management. Motivational scaffolds involve techniques designed to maintain or improve the learner's motivational state, such as attribution or encouragement.

Local culture courses are the lessons teaching students regarding the historical events or geography of an area. The courses mostly emphasize the history and nature of an area. Since the local culture course is the lecture of time, space and event of local features and era background, traditionally, the teacher lectures in the classroom first; then a field trip to the spot of monument or historical event for further exploration would be followed. However, there are several problems of this ordinary approach. First of all, local cultures are the knowledge of past. Hence, the learning performance is dominated by teacher's personal experiences. Secondly, local cultures take place in specific locations. Such monuments may not be well preserved due to the society evolution and generations' variation. Students may not comprehend what the teacher tries hard to explain if the original monument doesn't exist anymore. Furthermore, since the field trip is completely guided by the teacher, the knowledge of the teacher will significantly affect the learning outcomes. Students may also overlook the geographical location of the monument if they are interfered by the surroundings, such as noise or passerby. Students may not concentrate on teacher's instruction during walking or self-guided trip. Teacher can't ensure if individual student indeed fully understands his interpretation. To ensure the learning efficiency, teacher can quiz students, but not all students have the chance or the capability to answer during the interactive atmosphere. Finally, the exploration is not so appealing that students may lose their interests to further explore by themselves. Based on the above issues, it has been the educators' striving target on how to advance students' learning interests and results for local culture courses. Field trip is a way to promote students' learning aspiration but should be supported with proper scaffolds. According to the essence of local culture courses, the scaffold for local culture courses belongs to cognitive type.

This paper proposes a M-learning platform that integrates the interactive and convenient nature of mobile platform and

978-1-4799-4173-5/14 $31.00 © 2014 IEEE
DOI 10.1109/IIAI-AAI.2014.70

enhances with AR technology and scaffolding theory to support the field trip of local culture course. A prototype system called the Historical Time Tunnel (HTT) system was then designed and implemented for an elementary school in Taiwan for their local culture courses.

II. Related Work

To develop context aware location-based learning system, a variety of new techniques and products concerning M-learning system has three distinct features as following:

A. *Location-aware learning*

Location-aware learning enables the learning activities to integrate the physical environment and learning contents for the purpose of empowering learners to obtain the best relevant learning information with their physical location. Location-aware learning system usually needs to be equipped with the features of positioning, guiding and context push.[3]

- Positioning: Among the positioning devices, GPS receiver is one of the most regular outdoor positioning sensors. It majorly acquires the satellite signals to determine the position of the GPS receiver. GPS receiver nowadays spreads over various outdoor location-aware learning systems. Whereas WiFi determines the position of the receiver through the radio signal strength broadcasted from IEEE 802.11 wireless base stations. However, limited by the environmental interference and other factors, there are more than ten meters errors existing in the current WiFi positioning technology. For the requirement of closer observation during learning process, the stationary positioning technology, including RFID, QR Code and 2D barcode, etc., is often adopted to provide the additional positioning service.
- Guiding: With accurate positioning data, the system could guide learners through the trail of attractions to conduct their learning behavior according to their positions. Such guiding trail is named as Learning Path. The learning path could be either pre-defined or be generated randomly. For the beginners, because they don't have any prior background knowledge, they should be guided with the pre-defined learning path to establish their background knowledge. After having owned the basic knowledge, learners could start to set up their individual interested learning subjects to dynamically create their personalized learning paths.
- Context Push: Context Push is the most important function of location-aware learning system. It automatically pushes the location related learning contents to the learners based on their current locations and learning path. Hence, the required functions include (a) estimate learners' current locations; (b) take the position data as the index to extract the location-related learning contents from the learning contents database; (c) personalize learning contents based on learner's location and learning history; (d) push learning contents to learners through wireless network.

B. *Context-aware ubiquitous learning*

The well-known definition of ubiquitous learning is to permit learners to perform their anywhere and anytime learning by means of wireless networks, mobile devices or sensing technology to retrieve various learning context in any locations at any time. Nevertheless, such definition only expresses the learning with ubiquitous computing technology instead of actual ubiquitous learning. For example, the context-aware ubiquitous learning system (CAULS), proposed by Chen and Huang[4], is equipped with radio-frequency identification(RFID), wireless network, embedded handheld device and database to promptly detect students' learning behaviors.

C. *Augmented reality mobile learning*

Azuma[5] considers AR has the following three features: (1) To integrate virtual and real objects in the same interface space; (2) Promptly interactive mode; (3) To interact with users in three-dimensional physical space. Consequently, an AR M-Learning System should contain three distinct characteristics: Interaction, Extension and Experience. Interaction emphasizes the interaction between learners and environment. Extension indicates the appropriate transition and extension of sensory information; then users could manipulate the virtual information or objects on the screen through environmental sensors. Finally, it could enhance learners' experiences by means of virtual information or objects without the constraints of time and space. For example, [Design and evaluation of a virtual mobile time machine in education] use GPS as the position sensor and integrated with timeline to display historical pictures using AR technique. It allows users to aware historical events at that spots and to increase the learning motivation accordingly.

In order to intensify the efficiency of context in teaching and learning, Abas & Zaman[6] further integrates scaffolding learning theory into AR teaching. Scaffolding learning theory was derived from cognitive study and was based on the concept regarding the learning differences between learner autonomy and peer cooperation.[2] It emphasizes dynamic teaching assessment and learners' learning interaction together with exploration process. Such temporary supporting scaffold could be some kind of teaching tool or teaching strategies. Teachers could gradually transfer the learning responsibility to students with the advancement of their learning capability. Through the learning environment constructed by location-aware detection, behavior perception and augmented reality technologies, it not only could empower students to manage their own learning pace under teachers' assistance, but also could properly adjust their learning behaviors accordingly. Besides, teachers could further provide the additional respective learning assistance based on individual student's learning progress. Students could also actively search their interested learning subjects on Internet. Though each student has different progress and priority of learning; yet, they finally could actively organize what they have learned. It just satisfies the spirits of active learning designed by scaffolding learning theory.

Based upon the above surveys, this paper proposes an AR-based M-learning system for local cultural teaching called

Historical Time Tunnel system (HTT). HTT integrates three distinct features of M-learning with AR technology and scaffolding learning theory to provide location-aware mobile learning environment. It is equipped with three key functions of positioning, guiding and spontaneous pushing to provide context-aware ubiquitous learning platform.

III. THE HISTORICAL TIME TUNNEL SYSTEM

HTT intends to lead the students back to those disappeared or damaged historic attractions to rekindle the ancient memories. Therefore, HTT must be able to provide the immersive, interactive and self-learning functions. The immersion is to reconstruct the visiting disappeared monument on its remaining or spot by means of sounds, images, 3D virtual objects, or video clips on mobile device. However, the immersion should not just one-way passively receive the information provided by the system. Instead, it should inspire students to deal in thorough exploration, and could permit students to interact with those reappeared monuments. Through the immersion and interaction, it should further promote students' learning interests and even to promote their self-learning willingness. The interdependence of those functions is the significant basis of constructing scaffolding learning environment. In order to implement those functions, the system has to know users' locations to orientate the geographical relationship between users and the monument. The system then requires users to register to the environment, and next reconstructs the monuments by means of sounds, images, 3D virtual objects, or video clips on mobile device.

Based upon the above requirements, HTT system aims to solve the problems of traditional field trip exploration, it adopts GPS to locate user's position and to register user to the environment accordingly. HTT system uses GPS to register the student to the space of the visiting monument while QR Code allows student to register to the monument in time. After successful registration, the historical contents of monument are then retrieved wirelessly from the server. In order to ensure the learning outcomes, a set of quiz is designed for each monument. In addition, in order to further enhance student's cognition of geographical location of each monument, AR interface is added for student to browse during the field trip.

The entire system is designed into three layers as illustrated in Fig. 1. The web layer is for the teachers to manage learning material and organize courses from the bank of monuments material. The Data Base layer contains all the required information, such as students' data and various learning materials, for the entire system. The Mobile Device App refers to the APP on student's mobile device.

Since HTT system also allows teachers to organize teaching material and to set up field trip agenda, the operation of the entire system flow can be viewed from the student's perspective or teacher's viewpoint.

Fig. 2 illustrates the system flow from the student perspective. The APP will download the field trip agenda along with the respective quiz once he successfully logins. He then begins to explore the monuments assigned by the course. Whenever the student finishes exploring a monument, he would be asked to answer several quizzes to reinforce his cognition. The answers are then wirelessly uploaded to the server for later retrieved by the teacher.

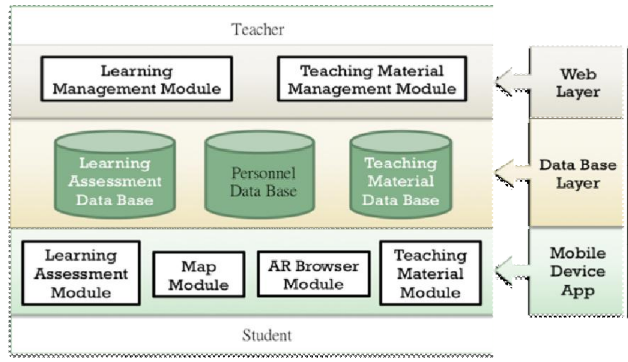

Fig. 1. HTT System Architecture

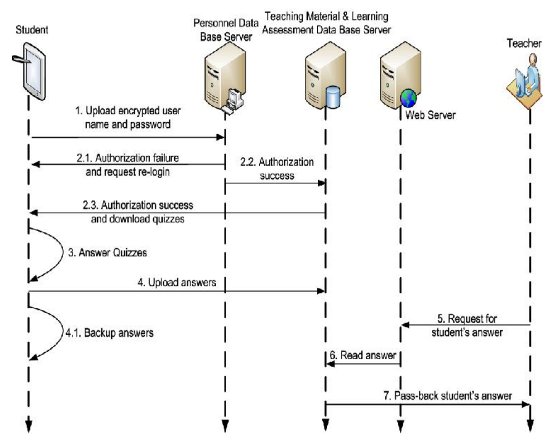

Fig. 2. Student's Flow

Fig. 3 shows the system flow from the teacher viewpoint. The teacher can create course material and organize field trip agenda from the teacher's web page, which is in turn to access monuments from the material database.

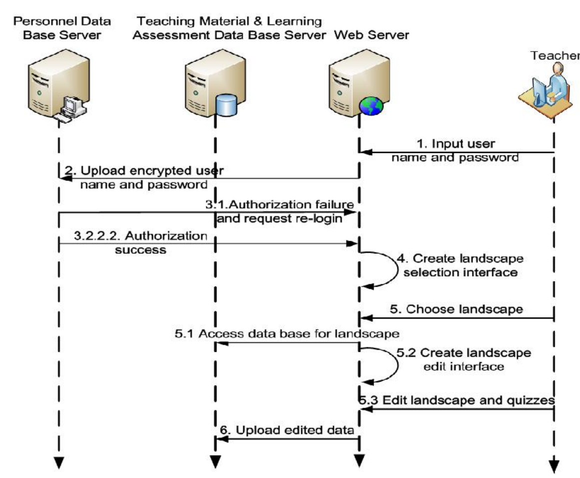

Fig. 3. Teacher's Flow

IV. THE IMPLEMENTATION

HTT system was a joint project with Taipei Yong-Le Elementary school, Taiwan, and implemented on Omniguider platform. Omniguider is a mobile augmented reality browser, which is available on both iOS and Android platforms and was designed by our lab in 2010.

From the teacher perspective, the teaching material management module allows teachers to manage field trip teaching material through the web browser. As illustrated in Fig. 4(a), other than enable teacher to set up the scenic spots for the field trip, the multimedia contents can also be uploaded and managed online as illustrated in Fig. 4(b). Fig 4(c) shows that a QR code is then created for each multimedia content web page for the students to point and access the teaching material wirelessly on a scenic spot. Finally, the finished web page will be as shown in Fig.4(d).

Fig. 5 is the snapshot of AR View User Interface on the mobile device. The radar illustration in the upper screen denotes the scatter of attractions whose distances to the user are within 100 meters. The system achieves AR effect by overlaying attractions' 2D icons with live video captured from users' viewpoint. The tagging of attractions' 2D icons will constantly updated according to the change of users' viewpoint. When an attraction is right in front of the view of users, the system would then draw an arrow directing to the attraction's 2D icon to remind users.

(a) The field trip map

(b) Manage multimedia content online

(c) QR code for each teaching web page

(d) The teaching material web page

Fig. 4. Teaching material management module function diagram

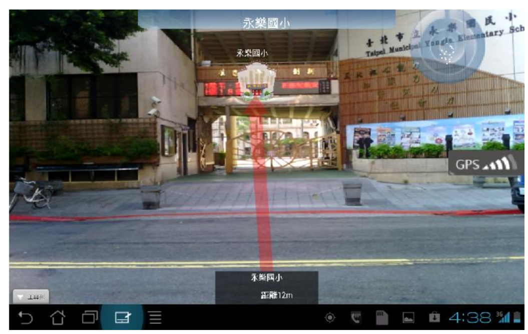

Fig. 5. AR View User Interface

In AR View user interface, a QR Code scanner button is implemented in the popup Toolbox menu on the lower left corner. If QR Codes appear near the spot of monument, then, just press QR Code scanner button on Toolbox menu to connect the website to retrieve the relevant multimedia context description as shown in Fig. 6. According to the course requirement, there are two types of QR Codes at each spot of monument. One for downloading the graphic description context of monument; and the other is to download pre-recorded video clips. Within the permitted time, students could repeatedly view the multimedia contents according their personal interests. Hereafter, the system would automatically download online quiz to enhance students' knowledge of respective monument, shown as Fig. 7. Upon completing the quizzes, other than displaying the outcomes on the mobile device's screen, the answers would be also uploaded to the website server for teachers to assess students' learning outcomes and adjust the course's scaffolding accordingly.

Besides, when the quiz is completed, system would automatically activate the camera module embedded in mobile device. Students could utilize the camera to take photographs or video of monument for future sharing with classmates.

Fig. 6. Multimedia Contents User Interface

Fig. 7. Online Quiz User Interface

V. Experiments and Discussion

In order to testify if HTT system could achieve the expected Scaffolding learning results, the study performs experiments on the sixth graders for two weeks. Experimental study architecture employs the process proposed by [7], shown as Fig. 8. Regarding the field trip teaching context, five famous monuments of Dadaocheng area, as shown in Fig. 9, in New Taipei City, Taiwan, were scheduled into the agenda of the course. The experiments are conducted in fixed POI attractions with variation on visiting routes.

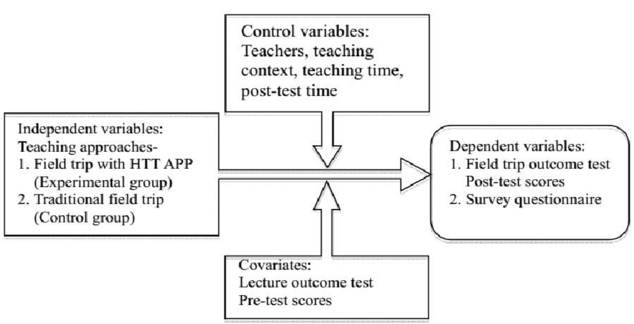

Fig. 8. The architecture of experiment

Fig. 9. Illustration of field-trip route

A class of 19 students participate in the experiment. Students are divided into two groups A and B to play the experimental group and control group in turn. Group A has 10 students while B has 9. The procedure of experiment is started with teacher lectures to all students in class, followed with a pre-test for 10 minutes. Field trip is then taking place with group B playing as the control group that uses the traditional approach while group A uses HTT system as the experimental group. Both groups are visiting the same monuments but with different routes to avoid the mutual interference during the field trip. Post-test is immediately taken place after the trip. The above procedure is repeated in the following week. This time, group B uses HTT system and group A is led by the traditional method. Finally, a survey questionnaire is taken to understand students' affection by different teaching approaches. Paired-sample t-test is conducted to further investigate the scores on pre-tests and post-tests and the analyzed results are shown in Table I.

Table I(a). Result of paired-sample t-test analysis for Week 1 test

Week 1 Test	Group A	Group B
Pre-test	(HTT) 14.20	(Trad.) 14.13
Post-test	(HTT) 16.80	(Trad.)16.38
Correlation Coefficient	0.439	0.951

Table I(b). Result of paired-sample t-test analysis for Week 2 test

Week 2 Test	Group A	Group B
Pre-test	(Trad.) 12.60	(HTT) 8.50
Post-test	(Trad.) 17.20	(HTT) 16.12
Correlation Coefficient	0.926	0.940

The experimental scenario of Table I(a) is, group A is led by an experienced teacher but HTT system is used for the field trip, while the guiding teacher of group B is a young and novice teacher who is responsible for narrating the whole trip. According to Table I(a), the average scores of group A are just promoted to 16.80 from 14.20 with correlation coefficient value 0.439. The lower correlation coefficient value implies students of group A do not rely too much on the HTT system during the trip. On the other hands, although the average scores of group B has similar increased rate to group A, its correlation coefficient value has climbed up to 0.951 which means students all depend upon the teacher to explain the history of each monument.

The experimental scenario of Table I(b) is to switch the field trip methods between groups A and B. This time, group A uses traditional narrating approach while group B adopts HTT system. Table I(b) shows that, after recovering back to the traditional field trip from HTT system, the correlation coefficient value of group A has climbed up to 0.926 in Table I(b) from 0.439 of Table I(a). Furthermore, its average scores increased rate in week 2 is also larger than week 1. It reveals that an experienced teacher can also play an effective role of learning scaffolding without the help of HTT system. On the contrary, although group B's correlation coefficient values of week 1 and week 2 are very similar, its average score is significantly increased from 8.5 to 16.12 in week 2. Compared with week 1, the result of group B shows that HTT system is a very helpful scaffolding tool for the novice young teacher.

After completing the experiments, each student is asked to fill out the survey questionnaire. It majorly asks students to express their subjective feeling about the traditional field trip teaching and HTT system individually. There are total 10 quizzes as:

- Questions No. 1-4 & No. 5-8 are control questions to check students' subjective learning experiences between the traditional narrating method and HTT system.
- Students then are asked to express their own preferred teaching method at Question No. 9.
- Question No. 10 is to check if students' self-learning intention could be promoted by HTT system.
- Questionnaire analysis results reveal that students all agree multimedia contents can attract their attention and stimulate their learning interests, and even further promote their self-learning desire after class. In addition, all students agree that HTT system positively can solve the problems which teacher can't meet individual student's curiosity during the group teaching.

Over the repeated discussions, the final conclusions are then made. First, the HTT system has limited help for the experienced teacher, but, on the other hand, it has significant assistance to the novice teacher. The second is the network environment will also affect the result of the experiments. 3G wireless bandwidth is insufficient during the week 1 experiment. However, the problem is solved before the week 2 experiment was conducted. Hence, students have more enjoyable experiences of viewing the multimedia contents during week 2. The third is multimedia contents shouldn't increase student's learning burden; especially during the outside-campus field trip noisy surroundings. Therefore, each multimedia video should be no longer than couple minutes for students' quick glance.

VI. Conclusion and Future Works

The paper presents an attempt of designing an AR-based M-learning platform for the local culture courses. Its design tries to match the main technology trends of M-learning, including location-aware learning, context-aware ubiquitous learning, and AR technology on mobile devices. It also explores the possibility to combine scaffolding learning with AR technique for M-learning system. Experiments show that, HTT system has obviously significant assistance to novice teachers on the field trip of local culture course. Students can more enjoy the video clips and multimedia contents of monuments during the field trip exploration.

However, the multimedia contents for AR interface is 2D icons at this moment. It is strongly believed that, if the 3D model of monuments can be recreated and overlaid at their original spots, the learning outcome and scaffolding effect can be further boosted. Hence, the next step of HTT system is to add image processing technique to register user to the landscape so that the disappeared monuments can be reconstructed by 3D graphical model.

In all, the HTT system achieves the effect of learning through play. HTT system also achieves one-to-one tutoring result. It solves the problem of preventing from the distraction in the traditional group teaching and field trip exploration. The experiments validate that HTT system can effectively boost students' interest for further self-learning to meet the goal of scaffolding learning.

Acknowledgment

The work is sponsored by Nation Science Council, Taiwan, at the contract number NSC 102-2221-E-606-009.

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