APPLYING AN AR TECHNIQUE TO ENHANCE SITUATED HERITAGE LEARNING IN A UBIQUITOUS LEARNING ENVIRONMENT

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ABSTRACT
Since AR can display 3D materials and learner motivation is enhanced in a situated learning environment, this study explores the learning effectiveness of learners when combining AR technology and the situation learning theory. Based on the concept of embedding the characteristics of augmented reality and situated learning into a real situation to enhance learning interest and effectiveness, a ubiquitous learning system is therefore proposed. The features of the system include: the learning activities and contents are planned and designed using the key factors of situated learning; combining virtual objects with a real environment using the techniques of augmented reality to provide a story-based learning situation for learners. To assess the acceptance of the proposed system, we first conducted a questionnaire analysis based on the technology acceptance model. An independent samples t-test was then applied to evaluate the learning achievement of learners. The results show that the research scale is highly reliable and that all assumptions made are valid. In addition, participants were attracted to and willing to use the system, which directly enhances their incentive to actively learn and promotes learning achievement.
Keywords: Augmented reality, Ubiquitous learning, Situated learning, Technology acceptance model

INTRODUCTION

Ubiquitous learning has been developed in recent years, owing to the rapid development of Internet communication technology. With the development of mobile computing and wireless networks, students can learn outdoors and interact with the learning environment (Hwang, Tsai, & Yang, 2008). Hwang et al. (2010) pointed out that when facing a class with a large number of students, the teacher cannot give every student the right guidance. Shih, Chuang & Hwang (2010) also pointed that instructors need to carefully arrange the learning environment and design an interactive learning model, along with meaningful learning content provided in time to prevent the students from aimlessly wandering around.

In Taiwan, leisure and tourism has become a popular field of employment, because of the two days off per week policy. Heritage tourism also offers intellectual depth. However, when visiting monuments general visitors often just consider the appearances of monuments, rather than really understanding their rich histories. In many cases, guides are hired to lead groups and to explain the history of monuments. However, due to the noise associated with a large number of tourists, tourists are easily distracted and the guide is slowed. Thus, most tourists cannot really understand the history and value of monuments. Monuments are merely considered to be old buildings with a pleasing appearance. Therefore, increasing tourists' interests in monuments, enhancing the desire of understand the history of monuments, avoiding situations where tourists aimlessly wandering around, decreasing the learning pressure and acquiring knowledge of history of monuments are the research objectives of the study.

The Technology Accept Model (TAM) introduced by Davis (1986) continues to be one of the most influential research models in studies of the determinants of information systems/information technology (IS/IT) acceptance. In TAM, perceived usefulness and perceived ease of use are hypothesized and empirically supported as fundamental determinants of user acceptance of a given IS/IT. In addition, a revised TAM was also proposed by researchers according to different research topics.

Therefore, to achieve the research objectives, this study aims to apply an AR technique to enhance situated heritage learning in a ubiquitous learning environment. The tourists are situated in a learning scenario with AR technology to extend their learning interest. A situated learning based approach is proposed for developing the mobile learning system to facilitate and guide the learning of tourists. That is, by integrating information technology and wireless communications services, RFID tags and AR identification marks can be placed on learning objects and learning resources can be connected through links to the tags. As long as tourists have

mobile devices equipped with an RFID reader, guided learning can be digitized. Tourists engage in a story scene and can find meaning and answers through AR and situation learning, thereby enhancing learning motivation and interest in the content. Furthermore, a TAM and t-test are used to evaluate the acceptance of the learning method and the learning performance of the tourists.

LITERATURE REVIEW

AR in E-Learning

In recent years, AR has been applied in various fields, such as E-learning, monument tour guides, and so on. Billinghurst et al. (2001) first used augmented reality technology to establish 3D books, allowing readers to see the figures and animation in books through a hand held AR display (HHD). Miyashita et al. (2008) used AR in museum tours, where the tourists were guided through their visit by animated floating balloons. When the tourists reached the target objects, the exhibition objects' glass displayed the functions of AR. Lee et al. (2009) directly identified images for teaching materials and then displayed the corresponding 3D materials using AR technologies. Learners could then use their fingers to interact with these 3D objects, for interactive learning. Kim et al. (2009) proposed an augmented reality system for an immersive experience for tourists at a cultural heritage site. With images captured by a lens, the four corners of the scenes were detected to allow the tracking and recognition of pictures. When the historical figures from the scene appeared in the screen, 3D virtual objects were rendered on the image of the target scene in real time, depending on the position of the camera. Correa et al. (2007) presented an augmented reality musical game to help people with learning disabilities develop the following skills: creativity, attention, memory, planning, concentration, ready-response, hearing and visual perception and motor coordination. The experimental result showed that the system had the potential to improve the lives of people with special needs. Kirer et al. (2006) introduced augmented reality and investigated ARToolKit software, pointing out its interactive processes. The use of augmented reality in the development of games was illustrated by five case studies of games. The results showed that augmented reality contributes in a significant way to games, providing the user with attractive visualization and natural interaction. El Sayed et al. (2011) presented the Augmented Reality Student Card (ARSC) as an application of AR in the field of education. ARSC can represent any lesson in a 3D format, helping students to visualize different learning objects, interact with theories and deal with information. AR-based digital artwork which presents interactive poems was designed and evaluated by Lin et al. (2012). This artwork was created following a rigorous design flow, including a visual poem generator and an AR system. Chen (2012) developed a 3D virtual reality course suitable for helping high school students to develop basic technological implementation techniques. In addition, quasi-experimental design was used to rule out pre-test effects and examine the influence of the course on the various constructs. Haydar et al. (2011) pointed that virtual reality (VR) technology can provide us with the possibility of immersion within multimodal interactions to enhance user presence in digitalized culture.

The research results from the above studies show that learning motivation and enthusiasm in learners can be engendered by the integration of augmented reality technology into learning. AR technology enhances learning effectiveness.

Situated learning

Situated learning was first proposed by Dewey (1938). Instead of just referring to the object itself, Dewey proposed that knowledge is related to social situations and that people must continuously interact with situations to gradually obtain useful knowledge. Situated learning has been gradually incorporated into mainstream teaching, with a variety of scientific field theories and research results. Situated learning is used in many fields such as language learning (Yang, 2011; Wu, et al., 2010; Piirainen-Marsh & Tainio, 2009; Shih & Yang, 2008), science education (Sadler, 2009), etc. For example, to engage college students who are learning English as a foreign language in the context of a big class, Yang (2011) developed a system, which was an online situated language learning environment, to support the students, the teachers, and the teaching assistants to communicate synchronously and asynchronously in and after class. The experimental results showed students' language learning progress was also revealed through a questionnaire and the pre- and post-tests. Huang et al. (2012) also pointed out that the students in situated learning environment demonstrated sophisticated problem-solving skills, exhibited metacognitive awareness, produced coherent artifacts, and showed high levels of motivation.

Real-life situations are an important factor in the teaching field. Learners are placed in an environment, which is important to motivation and interest. An effective situated learning environment uses appropriate teaching content, methods, sequences and real situations. Many scholars have proposed various definitions of the necessary conditions for situated learning. McLellan (1996) proposed that situated learning should contain the following eight types of key compositional factors: stories, reflection, cognitive apprenticeship, collaboration, coaching, multiple practices, articulation of learning skills and technology. This study will use these eight key learning factors for its situated learning design.

Mobile learning and ubiquitous learning

Owing to the progress of wireless communication and sensor technologies, research issues have progressed from web-based learning to mobile learning (Chen, Chang, & Wang, 2008), and from mobile learning to context-aware ubiquitous learning. In the field of ubiquitous learning, many researchers have begun to design context-aware ubiquitous learning environments by combining context awareness. Huang et al. (2012) developed a ubiquitous English vocabulary learning system to assist students in experiencing a systematic vocabulary learning process in which ubiquitous technology is used to develop the system. One of the results showed that the system characteristics positively and significantly influence the perspectives of all students using the system. Hwang (2009) presented context-aware ubiquitous learning as an innovative way of learning, combined with sensor networks, mobile devices and context-aware devices, which allow learners to interact with the real environment. Ogata (2008) also proposed context-aware language learning support systems for learning vocabularies, mimicry and onomatopoeia, polite expressions and conversational expressions. He mentioned that contextual awareness helps students interact with the real world anytime and anywhere and that this technology can integrate the learning environment into daily life. This study establishes a ubiquitous learning system using AR technology to enhance active and effective learning.

The Developed AR Ubiquitous Learning System

The architecture of the ubiquitous learning system proposed in the study is illustrated in Figure 1. It consists of the following three parts: front-end, back-end and database.

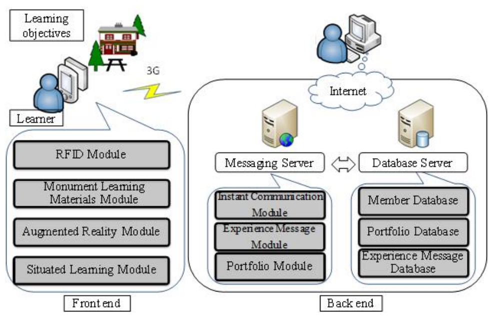

Figure 1: System framework

Front-end

The core functions of the system are contained in the front-end. Learners carry out learning activities in the wireless network space using smart phones equipped with a camera and a Bluetooth RFID Reader. The front end comprises the following four modules:

1. RFID Module: The module receives and analyzes the information in the tag read from the front-end device. It then communicates with the monument learning materials module to transfer relevant learning content to the learners.
2. Monument Learning Materials Module: This module provides the relevant learning materials when it receives a request from a RFID module. It first provides the corresponding leading story, comprising texts and the AR animation from the augmented reality module, to lead the learners into the learning situation. The corresponding learning materials are then displayed to the learners for further learning.
3. Augmented Reality Module: When the learners use the AR function to learn, they aim the lens at the AR MARK. The module compares the identified pictures with the learners' courses. After that, the 3D animation of the figures or objects in the story described in the course is combined with the real environment and displayed on the screen of the smart phone.
4. Situated Learning Module: This module was designed according to the situated learning elements proposed by McLellan. The module provides the related learning situation to learners during the learning process.

Back-end

The following three modules are contained in the back-end to assist the learners:

1. Instant Communication Module: The instant communication module provides instant messaging to on-site learners for help and chat. In addition, the other users can also use the instant messaging via the Internet to discuss and chat with other on-site learners.
2. Experience Message Module: After a learner completes the learning phase, they provide related experience messages using this module. These experience messages can be watched and shared by other learners.
3. Portfolio Module: Information relevant to the learner’s learning process is recorded by this module, including the date of use of ubiquitous learning, scores, progress and learning reflections. These records are

directly uploaded to the learning process profile webpage so that learners can directly connect to the web to observe their own process.

Databases
1. Member Database: The information for the learner, such as accounts and passwords, are stored here.
2. Experience Message Database: The related experience messages of learners are stored in this database.
3. Portfolio Database: This stores the date of learning, scores, learning progress and reflections during learning.

Design of Situated Learning and Learning Materials
Design of situated learning
The design of situated learning is based on situated learning elements proposed by McLellan, including stories, reflection, cognitive apprenticeship, collaboration, coaching, multiple practices, articulation of learning skills and technology, as shown in Table 1.

Table 1: *The design of the situated learning*

Key elements	Functions
Story	Providing the leading story situations relevant to the learning objectives selected by the learners and allowing learners to become more easily embedded in the environment.
Reflection	After a learner completes the learning part of a course, the module reminds the learner to write down the learning experience, providing the learners with space for reflection at this time.
Cognitive apprenticeship	Before a learner begins to learn, the module reminds the learner to follow the directions in completing a course. After that, the learner can use the system independently.
Collaboration	The modules are equipped with an instant messaging function. If the leading story is given for a period of time and the learners do not discover learning objectives, they are reminded to enter the interactive area and to interact with other learners to ask for advice.
Coaching	The learning sequence of the courses depends on the learners. The static 3D maps supported by the system provide the location cues for learning objects and the researchers assist the learners if necessary.
Multiple practice	After a learner completes a course, the module provides a relevant test so that the learner can understand the result of their learning. After scoring, the learner can rapidly return to the questions and take the test again.
Articulation of learning skills	The 3D animation, images, audio, stories, tests and other content are provided successively for the learners. Therefore, the learners know in what ways they have obtained knowledge and all the functions presented to the users at one time.
Technology	The learning tools for the augmented reality are provided to enhance the learners' telepresence.

Design of learning materials
Taking Tainan City Government Department of Culture and Tourism (2011) and Tainan cultural tourism (2011) as references, four learning units, including the Horse Statue with Broken Legs, the Weight Training Stone, the Zheng Chenggong Story and the Architecture, containing 12 learning objectives, were selected as the teaching materials, as shown in Figure 2. Each teaching material contains leading stories and the learning content. The following illustrates the related leading stories and learning content of the two teaching materials.

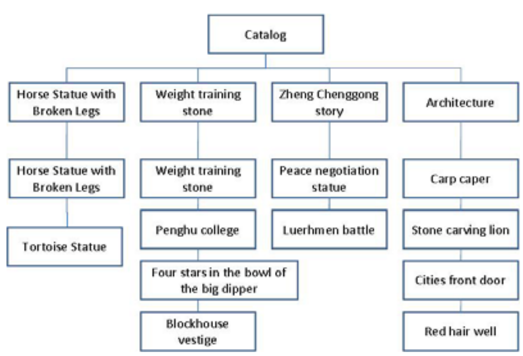

Figure 2: Teaching materials framework

1. Horse Statue with Broken Legs:
   (1) Leading story: According to the villagers around Chihkan Tower, a horse often appeared and reared

in Chihkan Tower at midnight. The reason why the horse reared must be discovered.

(2) The learning content:

- Originally, the stone horse acted as the grave keeper of General Zheng Qiren. At the time, the local farmers often saw the ghost of a white horse damaging and trampling grain in the fields at night. The farmers guessed that it was because this stone horse did not want to be the grave keeper. The stone horse's legs were broken by the farmers and the ghost has not since appeared.
- The length and width of the monument "Mrs. Huang Granted in Longevity Field" are approximately one meter and twenty centimeters, respectively. Mrs. Huang was the concubine of Zheng Qiren and was buried here after she died.
- In 1977, Mr. Wan-Shou Shi and Mr. Tai-Hong Zhou worked together to explore the layers of the white horse grave, using the four-pole approach of Wenner. They excavated at the right side of the door at No. 10, Lane 41, Chau Mei Street, Yan Village, Yongkang City and at Zheng Qiren's tomb another stone horse and Cheng's Longevity Field and pencil were excavated.

2. Tortoise Statue:

(1) The leading story: It is said that there were ten stone tortoises in the Great South Gate City. One windy and rainy night, one of these stone tortoises crashed against the city wall and escaped into the sea. Ask the other tortoises if such a thing really happened.

(2) The learning content: Tainan has ten tortoise statues that were donated by Emperor Qianlong in the Qing Dynasty in praise of the suppression of Shuang-Wen Lin by Kang-An Fu. When they were shipped to Tainan, one of them fell into the sea. One hundred years ago, it was found and enshrined in Bao-An Temple. The remaining nine statues are now stored in Chihkan Tower.

Design of the leading story

The flow of leading story design contains the following four parts, as shown in Figure 3:

1. Leading story: The leading story is designed according to the contents of reference books.
2. Situation elements: The keywords such as persons, things, objects and verbs are retrieved from the leading story.
3. Teaching material design: To display animation of the learning materials, related AR images are designed according to the situation elements.
4. Animation establishment: The animation is established by AR technology.

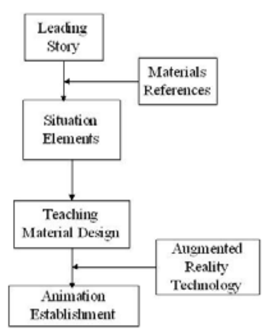

Figure 3: The Flow of leading story design

Taking Redhair Well as an example:

1. Leading story: According to the contents of the book, "Tainan History Walking", Redhair Well was dug by the Dutch for the purpose of drinking water. Provintia and Zeelandia were separated by the Taijiang Bay and they were visible to each other from afar. To enable communication between these two cities, a secret passage was dug by the Dutch. The Dutch ran away through the secret passage when Provintia was besieged by Zheng Chenggong.
2. Situation elements: Redhair Well, explore the secret passage, run away
3. Teaching material design: Design a situation where the residents run away to Redhair Well, and are ready to enter the secret passage using VR technology.
4. Animation establishment: After the animation is constructed, it will be displayed to learners and let the learners to explore whether or not the Redhair Well exists.

Snapshot of the ubiquitous learning system

As shown in the learning screen in Figure 4, after a learner enters a course, the system first provides the leading story and images to describe the story in the course. In addition, corresponding audio is provided. When the learner begins the augmented reality learning, the corresponding 3D animation of the figures or objects in the story described in the course are then displayed, as shown in the AR screen in Figure 4. Once the entire story is understood, the learner starts to search for the learning objectives to obtain complete knowledge of the history. When the learning objectives are not discovered by the learner, the map guide can be opened and a 3D map is provided to the learner, as shown in the 3D map screen in Figure 4. The message board screen in Figure 4 shows the experience messages written on the doodle wall in the interactive area.

Figure 4: Snapshot of the ubiquitous learning system

Experiment Design

Learning environment

Chihkan Tower, a first-class protected historical site in Tainan City, Taiwan, served as the research environment for this study.

Twelve learning objectives acted as the subject matter for learners, as shown in Figure 5. The RFID tags were placed on these learning objectives, in order to preserve the monument. In addition, researchers guarded the RFID tags.

Figure 5: Research environment: Chihkan Tower

Experimental procedure

This research was designed as shown in Figure 6. 60 visitors participated in this study. The 60 visitors were randomly divided into an experimental group and a control group. The 30 visitors in the experimental group learned through the ubiquitous system by smart phone and the other 30 visitors learned by way of traditional guided learning. The main purpose was to investigate the performance of the proposed system and the differences of learning achievement between the two groups. For the expert interview, a Mr. Chen, the CEO of an action learning technology company in Tainan was invited to provide recommendations and advice for the ubiquitous system.

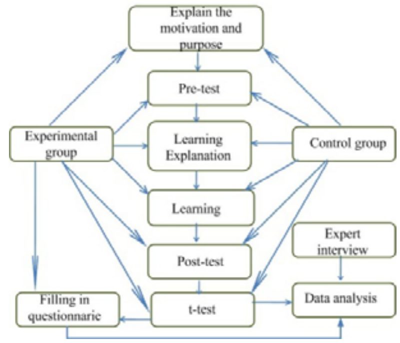

Figure 6: Research process

The research process comprised the following six phases.
Phase 1: The motivation and purpose of this study was explained to each group. This phase took 10 minutes for each group.

Phase 2: Each group completed the pre-test. This phase took 15 minutes for each group.
Phase 3: For the experimental group: the learners were taught how to use the ubiquitous system, which took approximately 10 minutes.

For the control group: the basic information for the guided tour was explained to the learners, which took approximately 10 minutes.

Phase 4: For the experimental group: the learners learned using the ubiquitous system, which took approximately 60 minutes.

For the control group: the learners learned in the traditional manner, which took approximately 60 minutes.

Phase 5: Each group completed the post-test, which took approximately 15 minutes for each group.
Phase 6: For the experimental group: The learners completed the questionnaire, which took approximately 10 minutes.

For the control group: The learners shared their learning experiences, which took approximately 10 minutes.

Learning tools
The following is a list of the hardware and software used in the development of the system:
1. Hardware: Smart phones with camera functions that can be used as ubiquitous learning tools, with a Bluetooth RFID Reader to read the RFID Tag.
    - HTC Touch Diamond smart phone
    - A Bluetooth handheld RFID reader with the pattern: SYRDBT-M1
    - AR identification mark
    - RFID Tag, Mifare card with 13.56MHz
2. Software:
    - Development Application: Visual Studio 2008 VB mobile, ASP.NET.
    - Database: SQL Server.
    - The augmented reality software: NyARToolkit.
    - The operating system for the mobile device: Microsoft Mobile 6.5.
    - Statistical software: SPSS 12.0 - Chinese version.

Acceptance Evaluation
An evaluation model based on TAM is used to estimate the acceptance of the proposed system. For external variables, this study uses the following three dimensions: augmented reality, content quality and environmental interaction. The research hypothesis consists of 9 assumptions, numbered H1 to H9, as shown in Table 2. The basic infrastructure takes the question items of the TAM as a reference and modifies the questionnaire of Liu (2007) to produce the questionnaires for this study. There are a total of 25 question items in the questionnaire. The agreement level for each dimension is based on the five-point Likert scale: strongly agree, agree, no opinion, disagree and strongly disagree, with corresponding scores from 5 points to 1 point.

Table 2: The research hypotheses

No.	Hypotheses
H1	There is a positive correlation between augmented reality and perceived usefulness.
H2	There is a positive correlation between augmented reality and perceived ease of use.
H3	There is a positive correlation between content quality and perceived usefulness.
H4	There is a positive correlation between content quality and perceived ease of use.
H5	There is a positive correlation between environmental interaction and perceived usefulness.
H6	There is a positive correlation between environmental interaction and perceived ease of use.
H7	There is a positive correlation between perceived ease of use and perceived usefulness.
H8	There is a positive correlation between perceived usefulness and user intention to use.
H9	There is a positive correlation between perceived ease of use and user intention to use.

Learning Achievement

An independent samples t-test was used to assess the learning achievement of learners.

RESULTS

Sample Data Analysis

The basic data of the 60 visitors were first analyzed. The visitors were made up of graduate students and master students, and their ages were between 18 and 26. Therefore, they had the basic ability to use mobile equipment.

Acceptance Evaluation for the Proposed System

Validity of the questionnaire

The study distributed 30 questionnaires to the learners in the experimental group and these questionnaires were all returned. The validity of the questionnaire is based on expert validity and the findings of relevant studies. In other words, experts were asked to offer suggestions and advice about the content of the scale and the removal of unnecessary words. Finally, 6 dimensions, including augmented reality functions, content quality, environment interaction, perceived usefulness, perceived ease of use and user's intention to learn were examined. The agreement level for each dimension used the five-point Likert scale: strongly agree, agree, no opinion, disagree and strongly disagree, with corresponding scores from 5 points to 1 point.

The reliability of the questionnaire was tested. Cronbach's α coefficient was used to test the scale's internal consistency. If the α coefficient is above 0.7, a high confidence is assumed (Wagner, 2010). The reliability analysis for the dimensions in Table 3 shows that α coefficients are all larger than 0.7. In addition, the scale's α coefficient is 0.960. Therefore, the scale is highly reliable.

Table 3: Reliability coefficients statistic

Variable	Number of item	alpha(α)
AR function	5	.936
Content quality	6	.873
Environment interaction	3	.751
Perceived usefulness	3	.768
Perceived ease of use	5	.889
User intention to use	3	.781

Path analysis

Path Analysis was the statistical technique used to analyze the relationship between variables during modeling. Then, through a series of regression analysis and hypothetical structures, permutation and combination formulas were used to form a structured model and continuous regression analysis was performed by statistical software to complete the calculation of model parameters. This was a return-oriented path analysis. In addition to the aforementioned path analysis, path analysis of the structural equation modeling orientation was performed. However, as suggested by Hoelter (1983), the threshold sample number for structural equation modeling orientation must be greater than 200. As a result, due to the low sample number, we could not use this analysis.

In this study, recursive-orientation was used for path analysis. The one-way arrows show the causal relationship: the variable at the beginning of an arrow is the cause and the variable at the end of an arrow is the effect. In path analysis, the variance that is explained by the independent variable's effect on the dependent variable is called the coefficient of determination (R2).

From the analysis results shown in Figure 7, H1 ~ H9 all show significant results. That is, these hypotheses are all valid. In the path of user's intention to learn, all of the path coefficients attained a significant effect, as evidenced by the values for the path analysis coefficient. The augmented reality functions, content quality and environmental interaction have some influence on the learners, increasing perceived ease of use, improving perceived usefulness, directly increasing learners' intentions to learn, and encouraging active learning.

Besides, consider the following four paths, where path coefficient reaches 0.6 or more, and R2 is higher than 50%.

Path 1: AR function→ Perceived usefulness → User intention to use
Path 2: AR function → Perceived ease of use → User intention to use
Path 3: Content quality → Perceived usefulness → User intention to use
Path 4: Perceived ease of use →Perceived usefulness → User intention to use

The results show that the learners in experimental group very approve the AR function and content quality of the proposed system. That is, improving the planning of AR function and providing good content quality will enhance the perceived ease of use and promote the user intention to use for the learners.

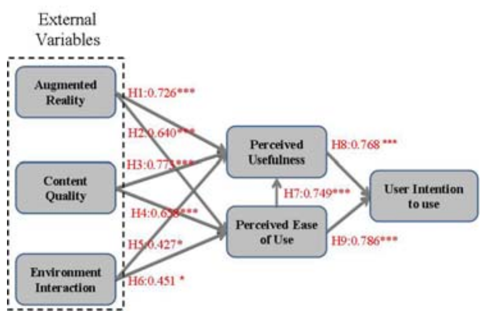

Figure 7: The results of hypothesized path analysis

Learning Achievement

As follows, an independent samples t-test is used to assess the learning achievement of the experimental group and control group, respectively.

Table 4: Independent samples t-test results of pre-test for the visitors in the experimental group and the control group.

Group	n	Mean	SD	t
Experiment group	30	36.26	6.469	-0.719
Control group	30	37.60	7.832	

Table 4 shows the t-test results of the pre-test scores for the experimental group and the control group, from which it can be seen that there was no significant difference between the scores of the students in the two groups ($t = -0.719$, $p = 0.475 > 0.05$).

Table 5 presents the t-test results of the post-test, showing that the students in the experimental group had significantly better achievement than those in the control group ($t = .5.037$, $p = 0.000 < 0.05$). This shows that the difference of scores between these two groups is quite obvious. That is, the performance of learners in the experimental group is better than that of learners in the control group.

Table 5: Independent samples t-test results of post-test for the visitors in the experimental group and the control group.

Group	n	Mean	SD	T-value
Experiment group	30	79.06	12.635	5.037
Control group	30	63.06	11.962	

*p < 0.05.

Expert interview

Mr. Chen, the CEO of an action learning technology company in Tainan was invited for an interview, on May 31, 2011. The interview firstly involved a demonstration of the system. Mr. Chen then tried out the system. The relevant parts of the ensuing interview were recorded. The interview revealed the following two results:

1. From the aspect of the teacher:
   - It is difficult for teachers to obtain 3D modules, because the establishment of 3D modules is not the professional domain of general teachers.
   - The augmented reality functions are less suitable for exam-oriented courses. They are more suitable for courses with higher interaction with an outdoor environment.
2. From the aspect of the learner:
   - The augmented reality functions of the system are interesting and augmented reality is a new technology for the general public.
   - It was emphasized that the operation should not be too complicated in use, or the characteristics of augmented reality will be lost. In addition, the key aspects that make learners use this system should be improved.

CONCLUSIONS AND DISCUSSIONS

In this study, we search the learning effectiveness of learners by combining AR technology and situation learning theory. Since a story is one of the situated learning elements proposed by Mclellan, the AR technology was then applied to design animation related to a story. From the analysis results of TAM, our hypotheses are all valid. In the path of user's intention to learn, all of the path coefficients attained a significant effect, as evidenced by the values for the path analysis coefficient.

From the statistical analysis of each dimension, the three items with the highest average scores of the overall question items are "The animation of learning material content is very interesting.", "It is very interesting to see the combination of virtual and real environments in the smart phone and this makes me want to use the system.", and "Using the ubiquitous learning system of Augmented Reality and Situated Learning improves my learning efficiency. " and their corresponding scores are 4.27, 4.23, and 4.17. That is, the learners agree that using the AR functions combining virtualization with reality to learn is novel and interesting. In addition, learning efficiency is improved by ubiquitous and situated learning.

Therefore, the results show that learners appreciated the overall quality of the content provided by this system and gave a good evaluation of this learning approach. The learners also agreed that combining AR with situated learning made learning interesting.

In addition, the results of the analysis of the independent samples t-test for the pre-test and the post-test scores of the experimental group and the control group show that the learning achievement of the experimental group was significantly greater than that of the control group. Furthermore, the questionnaire survey also demonstrates that the learners in the experimental group had a positive opinion of each dimension of this system. This study shows that this is because the learners felt that the system was novel and they had a high degree of certainty after using it. Since the users liked this method of learning, it indirectly increases the difference in learning effectiveness between the experimental group and the control group.

Nevertheless, the overall average for the system's ease of use is 3.887, this was the lowest satisfaction level of all 6 dimensions, where the average is 3.70 for item "Using the system makes it easy for me to learn." and is the lowest of all question items. Through experimental observation, it is speculated that since the learners had to hold the smart phone, the stylus, the RFID reader, and the identification patterns for AR when they were learning, they may have felt burdened. Therefore, the term for system ease of use requires improvement and strengthening.

In addition, based on interviews with experts and the results of the questionnaire, there are several areas in which there is room for improvement in the use of augmented reality for learning in the future.

The main suggestions for improvements are as follows:
The 3D animation must be more complete. It is necessary to improve the convenience of the acquisition of 3D objects. However, it is difficult for general teachers to produce 3D animation by themselves in the preparation of teaching materials and thus a more convenient way to produce 3D objects is needed.

Courses with relatively no pressure are more suitable for such a system. Such learning systems may be unsuitable for higher learning objectives in schools.

The motion tools that are popular nowadays can be used. The users could understand the operation of this system more quickly and the degree of acceptance would be higher.

In order not to confuse users, the number of overall learning tools should be restricted. It is suggested that the system should be easy for users to operate with both hands, or even with one hand.

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