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The Instructional Application of Augmented Reality in Local History Pervasive Game

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Abstract: Pervasive game is a new type of mobile learning, which adds game mechanism into the traditional mobile learning. It increases the interactions of the players with both the learning environment and mobile technology. In this research, Tainan historical monuments are used to be the activity sites of the game. Markerless augmented reality and social community website are used to sustain gaming collaboration and learning motivation. Pre and post tests, system logs, interviews, and questionnaires are analyzed to investigate the influence and effectiveness of pervasive game in learning Tainan culture.

Keywords: Pervasive game, Augmented Reality, Collaborative Learning, Mobile Learning, Social Community Website

1. Introduction

There is a great deal of research work on pervasive game in the past decade. Barkhuus et al. (2005) designed "Treasure" to make player collect or snatch coins to earn game points. According to players' game experience, they investigated the influence to game strategy and game identification. Benford et al. (2005) made players play games such as lion hunting on the virtual savannah, and investigated their interaction and cooperation. Bell et al. (2006) designed "Feeding Yoshi", a game last for a week in three cities, to reveal the impact and change of players during the procedure.

The term "pervasive game" is popularly considered to be an extension of mobile learning game which emphasizes more on the creation, use, and manipulation of the learning content. Learning content used for mobile learning is mostly pre-designed; whereas, in pervasive game, it requires users to interact with the learning content or retrieve more learning materials both in the real world and the virtual world. Participants can reach various explanations to the learning content since everyone has different perspectives. With the addition of game mechanism, it is more interesting and intriguing than the current practices of mobile learning.

Until recently, few studies have provided microanalyses of pervasive game on local history. In this research, a role play historical game about Tainan monuments is designed by applying principles described in the literature review. Players interact with historical spots to explore the events happened in the past and search for the connections between the events. In this paper, we re-examine the notion of pervasive game and explore the implementation of augmented reality (AR) technology into the local history learning. Smart phones were used as supplement devices in which hints to the investigation are provided with AR. Players' learning condition, gaming strategy, and teamwork styles would be analyzed by behavioral observations and questionnaires. The goal is to encourage students to have self-development and self-directed learning.

2. Literature Review

2.1 Mobile Game

The improvement of mobile technology is not only driving mobile-commerce, but also coming up with mobile game. Okazaki, Skapa, and Grande (2008) said that the attraction of mobile game to players is convenience. Game can be played anytime and anywhere. For the past few years, many research presented positive results in all aspects in mobile game, especially on education. For instance, Schwabe

and Goth (2005) grouped students in the mobile game. Different teams were assigned different missions and related geographical locations. Students used Geographic Positioning System (GPS) to complete missions, and then sent answers back to the server by mobile devices. The fastest team won the game. The type of mobile game-based learning is usually called geocaching. Huizenga, Admiraal, Akkerman, and Dam (2009) thought that educational mobile game should integrate situated and active learning. They divided students into mobile game team and traditional team to learn the culture of Amsterdam in Middle Ages. Learning achievement showed that game team is much higher than the traditional one.

2.2 Pervasive game and Design Elements

Pervasive game (PG) is a mobile game combining with physical environment and virtual scenarios. Walther (2005) stated that pervasive game establishes a real and virtual situation for players to play by means of software information system, mobile devices, real objects in the environment, and other assistances. Players are typically equipped with handheld or mobile devices. Wifi or 3G connections are common technologies used for the players to communicate with the virtual environment. To be more precise, location tracking and orientation sensors are usually based on GPS. AR is also used to increase the gamification of gameplay. Laine, Sedano, Joy, and Sutinen (2010) commented that PG is an extension of M-learning. The interaction between the player and environment is the key point. Another annotation about PG was raised by Montola (2011). He stated that "magic circle of play" created by online game is an invisible fence keeping game from real life. Players are also separated. However, PG breaks the circle and bridges real and virtual environment to surge more interaction.

In recent years, many researchers have different thoughts about pervasive game design elements. Walther (2005) offered a constructional framework called "four axes of PG", which includes: 1) Distribution, refers to the gaming information which can widely and effectively distribute through network; 2) Mobility, refers to user mobility, computing mobility, network mobility, and context-aware and cross platform services.; 3) Persistence, refers to total availability all along; and 4) Transmediality, refers to a media circle that multi-link the world of virtual social networks. Upon the constructional framework, he further introduced three critical units of PG: 1) Game rules: All games must be rule-based and clear defined; 2) Game entities: Abstract class of an object that can be moved and drawn over a game map; it can further shape into three categories, game object, human agent, and physical object; 3) Game mechanics: An input-output engine that monitoring and modifying the physical and virtual linkage to ensure a fluent game flow.

Gentes, Guyot-Mbodji, and Demeure (2010) recognized local culture to be a part of PG, especially Instructional Pervasive Game (IPG). For a cultural-rich PG, they suggested three key features to be included. They are: 1) Collaborative contents: The contents should be designed by people with qualified knowledge or actually living on the premises, therefore, scholars, neighbors, and respectable alike are all contributors of the content; 2) Team exploration: The gameplay either relies on solitary errands or on collective sharing, strategies can be more "group oriented"; 3) Cultural narrative: unlike traditional computer games which always open with a virtual scenario, PG's are based on urban-cultural representations. There is always first narrative that sufficiently describes the culture of the city therefore game players are able to have a clear idea of the fashionable places, the living or working areas, and the cultural spots.

2.3 Collaborative Learning in Pervasive Game

As mentioned above, Gentes, Guyot-Mbodji, and Demeure (2010) particularly pointed out that recognition of local culture must accompany with co-create content and team exploration. It also strengthened the importance of cooperation learning in pervasive game. Generally speaking, cooperation learning is considered to be an educational strategy, which encourages team member to help, rely on, and share learning resources with each other. Beside reaching the team goal, players can also improve personal learning effectiveness and positive interpersonal relationship (Pragnell, Roselli & Rossano, 2006).

Dyson, Griffin, and Hastie (2004) pointed out that integrating cooperative learning mechanism into games can enhance students to finish the missions more effectively. Huang, Shih, and Lai (2011) also indicated that group competitions can increase learning motivations and working efficiencies since

group competition is the dynamic of cooperation. Edwards (2003) had similar thought that teamwork and competition are the key elements of game, and so as the use of cooperative learning strategies. To this research, game development will take cooperative learning and competition as the major learning strategies.

2.4 The application of Augmented Reality in Pervasive Game

Augmented Reality (AR), also known as Extended Reality, is a computer graphics interactive technology originating from Virtual Reality (VR). Azuma (1997) believed the interactive technology can apply to military, medicine, industrial design, maintenance, commercial activity, learning, and entertainment. To pervasive games or mobile edutainment applications, AR seems to be essential. For instance, Cheok et al. (2002) brought classical arcade game "Pacman" into the real world which is called "Human Pacman" (Figure 1). Players collected cookies made by AR and avoided to be caught by the ghosts. Ghosts in the game are enacted by other players so it is also a multiplayer game. The application of AR in ARQuake (Piekarski & Thomas, 2002) and Treasure (Barkhuus et al., 2005) were used for the players to collect objects. Ballagas, Kuntze, and Walz (2008) designed REXplorer as a historical exploration guide for tourists in Regensburg. Tourists visited landmarks and find the virtual magical spirits and treasures using detectors on their way. Herbst, Braun, McCall, and Broll (2008) presented an interactive time travel game, TimeWarp, which guides the users to explore historic buildings with a AR virtual tour guide (Figure 2).

Figure 1. Human Pacman first-person perspective.

Figure 2. TimeWarp virtual tour guide.

Based on the experiences of previous studies, the application of AR in this research adopts markerless AR to make the overall activity more intuitive and natural. Gaming content includes story clues, mission hints, and event keys. Content are presented in the way of websites, animations, or images.

3. Research Methods

Research Process is divided into three phases (Figure 3). The first phase is game design and development stage which maps out the game structure (Figure 4). The research is designed based on the research purposes, PG definitions, and GNS game theory. Game script is designed with Tainan historical events which happened in period of Koxinga and also some folklore stories to increase the fun. The activity space is the historical monuments including Five Concubines Temple, Tainan Grand Matsu Temple, and Tainan Confucius Temple. AR presentations on the players' mobile phones can increase players' gaming motivation and interest. With the instructional pervasive game design, players can have more interactions with the environment.

Social network service, Facebook, is used in the game as a communication platform which can allow players interact with each other. It is not only a communication bridge to players, but also a terminal to researchers (Figure 5). Players' gaming conditions can be monitored. In the experimental

phase, college students are invited as the research subjects. Smart phones are used as the mobile learning tools which are equipped with wireless Internet connections. The phones are installed with ARUSMA and Facebook apps to read AR and to communicate. Before the game, players are divided into groups and Facebook group spaces are installed for interactions. Then, pre-test about the history are conducted to know players' prior knowledge.

In the gaming process, all interactions are recorded as the behavior observations (Figure 6). After the game, historical knowledge post-test are conducted. At the same time, game satisfactions questionnaire and focus group interviews are done to evaluate the learning effectiveness. Behavior observations and interactive course records are used for cross-analysis of the evaluations at the end.

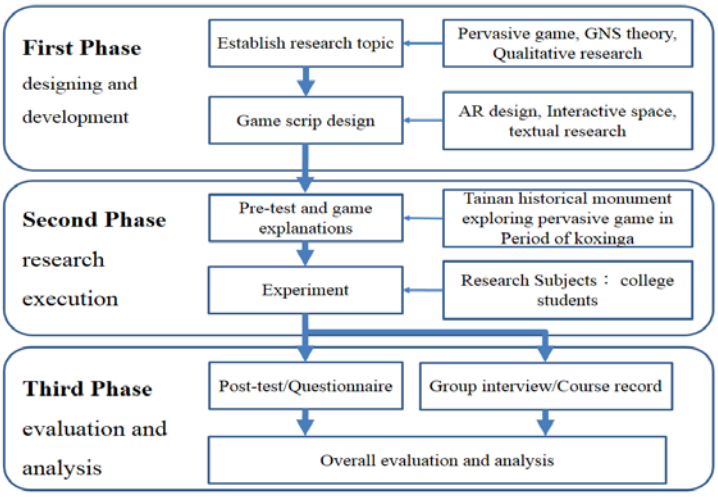

Figure 3. Research Process

Figure 4. Game Structure.

Figure 5. Game message publication.

Figure 6. Behavioral observations.

4. Game Design

4.1 Script Design

In accordance with the contribution during Period of Koxinga, the game is divided into four sections in terms of content: Battle, Construction, Education, and Sentiment. Players in the game may be soldiers, architects, civilian, or students.

In 1661, Zheng Chenggong landed on Luerhmen in Taiwan, and marched to Provintia where is today's Chihkan Tower. In the game, when players were soldiers, each team competes with others to occupy markers in the tower, and then report the information and situation to their team members as soon as possible. After attacking and occupying Provintia, the next mission is to take down another military base, Zeelandia.

Players are then brought to the year 1666 when they play the role of architects to build Tainan Confucius Temple. Players have to find out the original blueprint and construction list in Tainan Confucius Temple to begin with. There are about thirty architectural elements on the list. After finding the elements, the players should take a picture and post it on the Facebook as a proof. Other players can use the "comment" function to introduce the architectural element's function or hidden meaning, and use "like" to vote for the best description.

As Tainan Confucius Temple was built, the imperial examination was implemented formally. Confucianism started to flourish rapidly. There were two lessons for the players to attend. One is for the players to act as students attending the Great Learning in Ming Lun Tang where was used as the classroom. Another lesson for the player is to learn and record Six-Row dance in front of Dacheng Palace and then uploaded the video to the Facebook.

As Zheng Chenggong took Taiwan as the revival base, he still could not overcome the illness and the arrival of Qing Dynasty. Before surrender, Prince of Ningjing's concubines died for the loyalty of their husband and country. The story became a taboo during Qing Dynasty. People gradually forgot about the tragedy except an old tree in Five Concubines Temple. The tree knew everything and turned this memory into pieces hidden in the temple. Players have to look for the old tree and put the pieces together to retrieve the lost memory.

4.2 Technology Implementation

The game is designed to encourage players to actively explore the information as they really need them rather than guide them to the learning materials they aren't interested in. In order to make the exploration more intuitive, markerless AR is employed. Learning contents embedded in the AR are in the forms of game props, stories, and map hints.

Game props are objects used for gaining game points. Stories are told by the historical relics unlike TimeWarp using a virtual spirit to guide the exploration. In this game, the narrators of the stories are those existed in the history. For example, when the player comes to the stone statue (Figure 7), he uses the smart phone to scan it to retrieve the AR information. The learning content includes the name and the stories about the statue. Another example is when the player reaches the temple door (as Figure 8), the door gods will explain the meaning of the objects they hold and stories about what happened during their guidance. Map hints are those when the player scans the map, it will reveal the hidden objects and locations (as Figure 9). Players then have to find out the blueprint.

. Figure 7. Stone statue of Tainan Confucius Temple.

Figure 8. Five Concubines Temple door gods

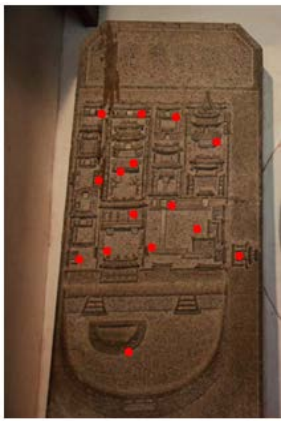

Figure 9. Tainan Confucius Temple blueprint and virtual tag

5. Research analysis

The pretest and posttest are used to estimate the learning effectiveness. Questionnaire is used to collect data. The questionnaire includes three parts. The first part is the learners' prior experience including the experience of using AR and Facebook to see whether players' game experience and technology

application use would influence the effectiveness of the pervasive game activity. The second part is considering the AR application, presentation, and content in the game. The third part is the influence of pervasive game to the exploration of Tainan historical monuments. The questionnaire is divided into three aspects, Technology, Culture, and Gameplay. Last, focus group interviews and community website records are used to assess students' feelings and behaviors toward the game.

6. Conclusion

E-learning is a modern and unavoidable learning method. Along with mobile technology, learners can approach the learning content and environment more directly outside of the classroom. In problem-based mobile learning activities, learners are mostly guided passively through the activities. Some learners do not immerse themselves in the learning environment and have low learning motivations.

In this research, players are guided to explore the historical monuments actively through the pervasive game and use AR technology to experience more interactions. Players will have an in-depth knowledge of the history of Zheng Family Dynasty as well as the Tainan monumental architecture. Through the game, players interact with the monuments and other players. With the application of markerless AR, getting information from the environment is more easily and intuitive. Using Facebook for social interactions can dispense the time to learn new tools. Not only players' game play process can be recorded on the server, their personal output of game experiences can also be shared to their family and friends to achieve knowledge dissemination.

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