The Learning Effectiveness of Pervasive Game Integrated with Inquiry-Based Navigation System

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Abstract: Recently, the application of information technology on the local history teaching has become a most important research topic for the researchers. With information technology, we can bring teaching outside of the classroom, and students can be involved in the situation themselves. But teachers have to design a proper learning content to let students absorb the whole information. This study applied two teaching methods to compare the teaching effectiveness; one is the traditional web-based learning in which teachers provide complete information to the learners; the other is to implement pervasive game into inquiry-based navigation system with which students focus on the leaning contents allocated in routes .provided in the mobile device. In the research, smart phones were used with Open Data Kit (ODK) system and web integration system to let the teachers to extend the teaching environment to outside the classroom. By comparing these two teaching methods, we found out that the learning effectiveness of pervasive game integrated with inquiry-based navigation system is significantly better than traditional teaching method.

Keywords: Mobile learning, Inquiry-based learning, ODK, Pervasive Gaming

Introduction

People's lifestyles are gradually affected by the advancement of information technology from supercomputer to laptops and smart phones. From the perspective of education, traditional learning environment is limited in weather, time, and space. However, the advances of technology have brought digital learning into the era of mobile learning, and ubiquitous learning. Today, ubiquitous learning has been widely applied to all levels of education. The content of this study focused on local history and culture, and aimed to enhance students' learning achievement with the concept of pervasive game which use mobile device to help students to learn in the context both in the virtual and real world. We integrated inquiry-based navigation system to allow students to explore the learning environment individually.

1. Literature Review

1.1 Mobile learning

Mobile learning enables learning anytime and anywhere using mobile devices with learning content in it. The learning content was designed by teacher or experts for the demand of learners. The characteristics of mobile devices, including convenience and portability, allow

learning activities to be extended from the classrooms to the outdoor. It goes beyond the restrictions of time and space, and makes learning more flexible. Students could enjoy the learning process anytime and anywhere [1]. Therefore, the main purpose of mobile learning is build a flexible learning environment, and support it to be a joyful learning environment in the real-world at the right time at the place [2].

Learning activity could extend from classroom to the outdoor through mobile learning. Therefore, it could provide practical benefits in local culture course in which the learning experience is needed to be enhanced by field exploration. Chuang, Shih, and Hwang (2008) used mobile device with context-aware computing to support historic exploration activities with cooperative learning [3]. It guides the student to conduct independent learning and to enhance their cognition on local culture. Akkerman et al. (2009) used mobile device with GPS positioning function to teach students to learn the history of Amsterdam and organize the collected data to write stories [4]. It is beneficial for learners to learn the local history and culture.

1.2 Inquiry-based learning

Inquiry-based learning helps students learning with a proactive attitude and constructs their own knowledge structures. It could train students' inquiry, thinking, and communication skills, and also promote their lifelong learning ability. It enables learners to become self-directed independent learners. In the Inquiry-based learning, students are the active constructor of knowledge, and teachers are the enabler of learning. Teachers explore the issues raised and provide relevant information to support students to predict, explore, validate, summarize, explain, and discuss [5].

1.3 Pervasive Gaming

Pervasive gaming refers to play games which combine reality and virtual environments. Comparing with the virtual reality game, pervasive gaming puts emphasis on the user interaction with the reality. Its main concept includes three aspects [6]. (1) Movable: People could play games at any place not limited to the stationary PC or TV. When they play the games, they are moving the whole body instead of just the fingers. The game is played both in virtual and real environment. (2) Interactive: The core of pervasive gaming is the social interaction between players. The game only provides the main goals or tasks to the players, and the players need to use a variety of tools to communicate or interact with each other in order to reach the goals. (3) Integration of virtual and real environments: The main characteristic of pervasive gaming is combining with reality and virtual environments. It extends the games on the original PC Game and Console Game, and allows players play games through the mobile devices. Players could play games anytime and anywhere, and they would not be limited in certain space.

The core technology of pervasive gaming contains three parts [7]: (1) Mobile Display Devices: It can transmit the digital content to users by mobile phones, handheld computers, and wearable computers. (2) Sensing Technologies: It can detect the user's location by GPS sensor, camera, microphone, and other physical sensors. (3) Wireless Technologies: It allows user to communicate with remote users. It contains 3G, GPRS, GSM, and Bluetooth technology.

2. System Design and Content

The system is divided into the experimental group and control group. The control group is taught using web-based materials built by MediaWiki. History related information is provided online. The experimental group used mobile devices with Google Open Data Kit to upload cloud data that were provided on consolidated web page. Users could upload collected data to the website to share and discuss with classmates. It is the realization of Inquiry-based learning and Pervasive Gaming.

2.1 MediaWiki

MediaWiki is an open source content management system (CMS) for Wikipedia in the beginning. It is implemented with MySQL database, Apache Server, and PHP. Most of the wiki-websites were built by it.

Before building the MedieWiki teaching website, we collected history materials and place them into the database with instructional design methods. The learning materials include books, Web pages, and textbook content. The learning content in the system includes the introduction of Fort Zeelandia, the architectural features, history (before and after Koxinga entered), Guo Huaiyi Rebellion, museum of Fort Zeelandia, and related links.

MediaWiki does not only have simple web page text, but also have functions such as directories, search, and extended reading.. The directory function allows users to jump tocertain sections quickly. The search function uses keyword search to retrieve related information. The extended reading function (Figure 1) was a design that automatically compares page titles and keywords in the text and generate hyperlinks between the matches. Therefore, the users could follow the hyperlinks of the keywords to read further information. It could establish the information chain to enhance readers' reading effectiveness.

Figure 1. The extended reading function of MediaWiki

2.2 Open Data Kit

Open Data Kit (ODK) system is an open source tool which was built by Google. It provided a form to assist users to collect data, so it could be an Inquiry-based learning tool. The tool is implemented in the Android mobile device and allows users to upload data to the cloud server. The server could integrate the data and then output into other formats. The data type collected could be text, location information, images, videos, sounds, and bar codes.

Therefore, the ODK system is a tool that should not be underestimated. It can be used to fulfill a variety of purposes such as data integration, decision-making, and data mining. This study assisted students to collect texts, images, and location information through the ODK forms, and become the basic data source for the instructional website. First, learning tasks and data types should be decided (Figure 2). This study expected students to write down their observations, collect images and location information in specific locations. Then, students uploaded the data they collected to the cloud server. These data would be saved in the database and be exported to the Excel files for the consolidated web page.

Figure 2. Data type chosen for learning tasks

2.3 Forum

The forum is implemented with Apache Server, PHP, and MySQL database (Figure 3). It could save and classify a variety of information. Students could get information they want quickly. In addition, every member had personal data including the number of published and reply articles, points, and GP. All these records were the proof of the activities they did on the system. These values could give them a sense of achievement and become the grading reference for the teachers.

Figure 3. Discussion board for user interaction

2.4 Consolidated Web Page

In order to allow the students to easily view the collected data, the students' collected data were transformed into Google Docs. Related research data were also collected through the web page for subsequent analysis. The tables on the web page were created by Google Visualization API. Google Map API was used to show the landmarks. Records of each

group of students would be shown with the images collected from the ODK server (Figure 4). The web page provides detailed data each group of students collected including the location information and images. Such information presentation supports both researchers and teachers for post-analysis and discussions.

Figure 4. Consolidated Web Page provides the index of data, images, and location information.

3. Method

3.1 Experiment Design

This study was conducted with experimental group and control group. The students in the experimental group were guided to learning by inquiries with tasks, and the students in the control group were learning with MediaWiki. The learning activity was conducted in Fort Zeelandia in Tainan County.

The experiment design is shown in Figure 5. Before conducting the learning activity, each group of students received the basic instruction about the learning activities and learn to use the mobile devices; at the same time, a pre-test was conducted to analyze the students' pre-knowledge of Fort Zeelandia.

There are four stages in each group. In the first stage of the learning activity, the students in the control group can tour around Fort Zeelandia freely and they could access the relevant information from the mobile devices as they feel needed. In the second stage, they were guided by a tour guide in the museum before they go free for exploration. In the last stage, students discussed and shared their experiences in the classroom, and the teacher would give feedbacks. Finally, the post-test was conducted after the learning activity.

The students in the experimental group were learning with Inquiry-based learning and Pervasive Gaming. They were guided to learning by tasks with ODK system in the first stage. After listening to the museum guide by the tour guide, they should answer the questions in the mobile device in the second stage. When they finished this stage, all of the data they collected would be uploaded unto the cloud server. In the third stage, the students could discuss in the online forum when they go home. There was a class discussion in the fourth stage. The data the students collected in the ODK system were presented on the consolidated web page, and they could compare and discuss their data in the class

discussions. The teacher gave as many feedbacks as in the control group. Then, the post-test was conducted.
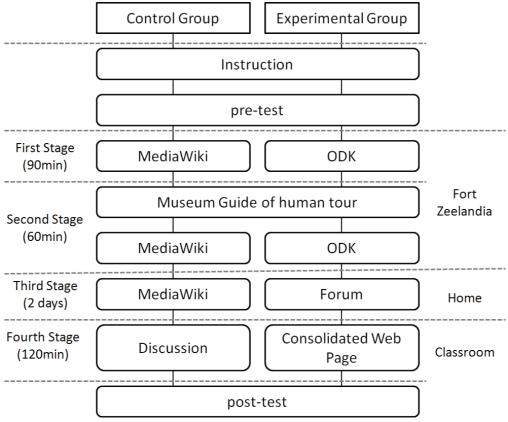

Figure 5. Research design

3.2 Participants

The learning content in this study was designed according to the seventh grade students' local culture course. We hoped they could identify the culture and history of Fort Zeelandia. The participants were the seventh grade students in Tainan City. Their average age was sixteen years. Eighteen students are assigned to the control group and 15 students are assigned to the experimental group. They were divided into small groups of two or three people. They would conduct the learning activity together. Most of them had the experience of using mobile devices, but only a few had used the mobile device for tour guide.

3.3 Experiment Environment

The learning activity was conducted in Fort Zeelandia in Tainan County (Figure 6). There were many monuments in Tainan. Fort Zeelandia is one of distinctive monuments and there is a wealth of historical knowledge in it. The teaching resources in Fort Zeelandia were related to local culture course of middle-high school, so it was selected to be the experiment environment.

Figure 6. Experiment Environment

4. Results

The t-test was performed for the pre-test results. There was no significant difference between the pre-test results of the students between the two groups. After conducting the learning activity, an analysis of Covariance (ANCOVA) was performed on the post-test results, in which the pre-test was the covariance, and the post-test results were the dependent variable. The ANCOVA results are given in Table 1, and show that the learning achievements of the experimental group students were significantly better than the control groups students. Accordingly, it was found that the pervasive game design with inquiry-based learning was helpful to improve student's learning outcomes.

Table 1. Analysis of ANCOVA of the learning achievement test

	N	Mean	SD	Adjusted Mean	F
experimental group	15	82.67	11.18	80.52	15.20**
control group	18	63.44	11.43	65.24	

**$p<0.01$

5. Conclusions

In recent years, the local cultures content was included in the compulsory education. The students in the elementary school start to learn about the local culture of Taiwan.

This study tried to find the effect on learning achievements with web-based teaching and inquiry-based learning. The web-based teaching could provide a large amount of information, but was easy to lose students' attentions. Although the inquiry-based learning system can provided only limited information, the advantage is to create an individualistic learning environment that can hold up to students' attention. This shows that information overload does not improve students' learning effectiveness and can reduce the students'

learning motivation. In contrast, if the teacher could guide students' learning with goals or tasks which are accompanied with a small amount of information, and provide appropriate teaching methods such as gaming, the students' learning outcomes would be improved significantly.

In order to compare the two teaching methods, two learning systems were designed and used in the research. The research results show that the learning achievement of inquiry-based learning was better than the web-based teaching. Besides, adding pervasive gaming design into the inquiry-based learning system has brought learning into a new dimension. Both the real and virtual learning materials were integrated into the learning tasks so that the students can experience what the textbook describes in person. The gaming elements have added more fun into learning so that students have more interests in learning. In this study, we only tested students' learning achievements. In the future, learning motivations, learning behaviors especially when students in the outdoor learning environment with mobile devices, and their cooperation patterns can be analyzed and described in details to provide more information for research.

Acknowledgements

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