



Development of a Virtual Wetland Ecological System Using VR 360 for Applications in Environmental Education

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Abstract

The purpose of this study is to develop the “Cardboard VR Game-based Virtual Wetland Ecology System” learning software using virtual reality technology, displaying the image of the real wetland environment, designing the exploratory missions and challenging level stages by adding the digital game-based learning concept, to initiate students’ interest and motivation. Finally, the effectiveness of the students’ learning achievement and motivation in environmental education was investigated. This system used the wetland ecology of Hsinchu as the environmental educational teaching theme. The learning contents of the wetland ecologies and creatures of the “Chin Cheng Hu watching bird area”, “Hsiang Shan wetland” and “Shin Feng mangrove forest area” provided students with the knowledge of the wetland creatures and importance of the wetland environment. This study adopted 42 students from 1st grade of county junior high school in Pingtung County as the research participants. The quasi-experiment design was employed. They were divided into two groups. A half of students in the experimental group used this system to conduct learning activities with exploratory missions, and the other half of students in the control group received regular teaching materials. The teaching time was 135 minutes covering three lessons. The measuring tools of this study included: (1) the questionnaire of satisfaction towards this system, (2) the wetland ecology environmental education learning achievement test, and (3) the questionnaire of wetland ecology learning motivation.

The experimental results in this study indicated: (1) Using “Cardboard VR Game-based Virtual Wetland Ecology System”, the learners showed a high degree of satisfaction of the overall experience perception (2) Using “Cardboard VR Game-based Virtual Wetland Ecology System”, the students’ learning achievement in environmental education was significantly higher than that of regular teaching. (3) Using “Cardboard VR Game-based Virtual Wetland Ecology System”, the students’ learning motivation in environmental education was significantly higher than that of regular teaching.

Keywords: Cardboard VR, wetland ecology, environmental education, digital game-based learning, learning achievement, learning motivation

1. Introduction

With the development of science and technology, the mobile technology and wearable devices such as AR (Augmented Reality) and VR (Virtual Reality), and they have been widely applied in learning activities. The students are not restricted by time or space when immersed in the VR environment [1]. The VR technology is often referred to as an immersive multimedia, and the objective is to recreate human sensory experiences to create a computer-generated environment that simulate physical presence in virtual world [2].

This study adopted simple headset mounted VR device, it provides panoramic images in real world to make students can watch around the environment through Cardboard VR viewer and smartphone. Therefore, the students are not limited by time, space, traffic cost, and the problem of the personal safety will not happen either. Oigara [3] indicated that students considered Google Cardboard VR device as an effective tool which provided an immersive and active experience for learning, and they agreed that Cardboard VR could provide a new way of learning helping them to clearly understand the complicated concepts and increased their interest and concentration. In this study, we developed the “Cardboard VR Game-based Virtual Wetland Ecology System” using virtual reality technology, and the related research indicated the students used the VR learning tools to learn and operate and it could help students to establish their spatial perception [4].

Furthermore, we introduced the digital game-based learning conception to integrate wetland ecology learning contents into this system, making students complete effectively the learning targets and initiate their interest and motivation [5], understanding knowledge of the wetland beings and importance of wetland environments. Finally, we investigated the effectiveness of the students’ learning achievement and motivation in environmental education.



2. Cardboard VR Game-based Virtual Wetland Ecology System

This study adopted the Google's Cardboard VR headset where the smartphone is inserted into the cardboard viewer. It is a mobile, inexpensive, and convenient device and the whole system is referred to as "Cardboard VR" [2]. Cardboard VR Game-based Virtual Wetland Ecology System is a smart phone application. It contains the learning contents of the wetland ecologies and creatures of the "Chin Cheng Hu watching bird area", "Hsiang Shan wetland" and "Shin Feng mangrove forest area". Students can use the application to explore and observe real wetland ecology environment and beings via the cardboard viewer headset by themselves, as shown in Fig.1.

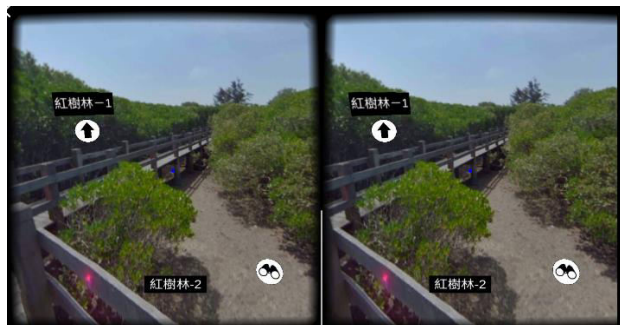


Fig.1. Screen view of the smartphone application

In addition, this system is developed by Unity 3D game engine software, introducing digital game-based learning conception to design wetland ecology exploratory missions and challenging level stages, so they can initiate students' learning motivation and enable them acquire the sense of accomplishment, and it can also enhance their learning achievement.

3. Experimental design and results

In order to analyze the effectiveness of the students' learning achievement, motivation and the satisfaction by using the Cardboard VR Game-based Virtual Wetland Ecology System after the VR learning activity, a teaching experiment was conducted.

3.1 Participants

A total of 42 students from 1th grade of junior high school were used as the research participants. Among them, 21 students were in the experimental group using the system to receive teaching with exploring mission worksheet, and the other 21 students were in the control group receiving regular teaching materials. Both groups were taught by the same teacher in the teaching activities to avoid the impact of the different instructors on the experimental results.

3.2 Experimental process

Before teaching activity of the wetland ecology environmental education was started, both groups were required to complete the pre-test of wetland ecology environmental education achievement test. The instructor spent 20 minutes explaining the function and operation of the Cardboard VR Game-based Virtual Wetland Ecology System to the students in the experimental group. They were guided sequentially via the instructor to use this system and then explored and learned the wetland ecology by themselves. After that they were asked to complete the wetland ecology game-based exploratory mission with the worksheet, as shown in Fig. 2 and Fig. 3.



Fig. 2. Student using the Cardboard VR to explore Hsinchu Wetland ecology



Fig. 3. Student completing the wetland ecology exploratory mission worksheet

On the other hand, the students in the control group had received regular teaching materials with the PowerPoint learning contents, and they were guided sequentially by the instructor to learn knowledge of the wetland ecological environment and creatures. After the 135-minute teaching activity, both groups had taken the post-test and filled out the questionnaire of learning motivation, and the students in experimental group were requested to complete the questionnaire of satisfaction toward this system. The experimental procedure is as shown in Fig. 4.

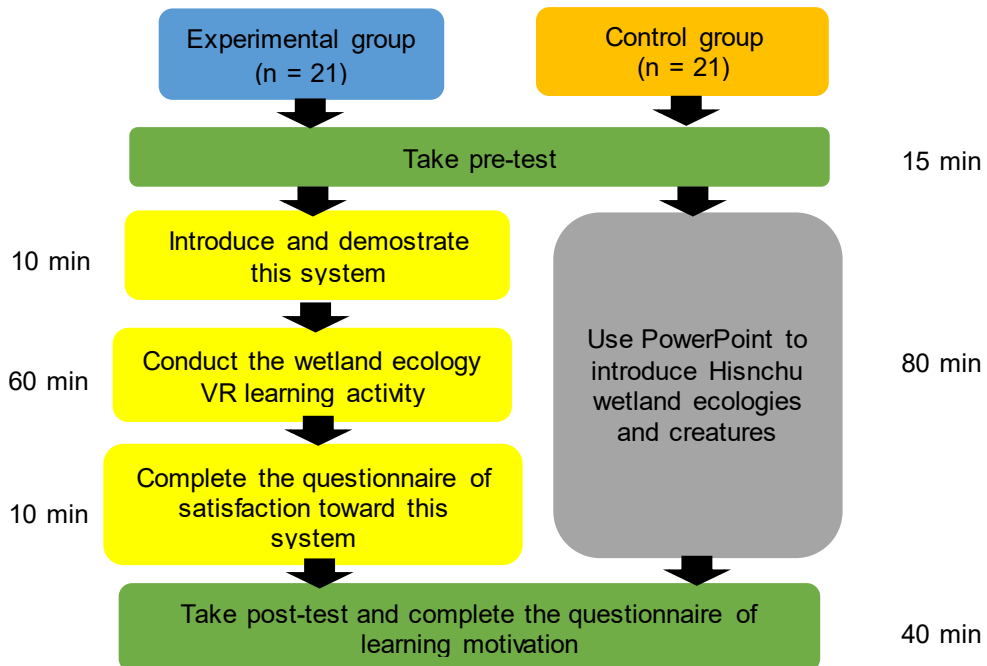


Fig. 4. Experimental procedure of the wetland ecology learning activity



3.3 Measuring tools

The measuring tools of this study include: questionnaire of satisfaction towards this system, learning achievement test of the wetland ecology environmental education, and questionnaire of wetland ecology learning motivation. The questionnaire of satisfaction for this system was designed by the advised professor, and it contains fifteen items (e.g., “I can clearly observe the outline and feature of the wetland animals and plants”), divided into three dimension, “VR system interface design”, “VR system learning contents”, and “VR system operating sensibility”. The questionnaire used 5-point Likert scale ranging from 1 (very disagree) to 5 (very agree), and the Cronbach’s alpha value of this questionnaire was 0.88, implying this questionnaire is reliable.

The questions of wetland ecology environmental education learning achievement test in both pre- and post-test were designed by three experienced natural science teachers. The purpose of this test was to understand the students’ knowledge of the wetland ecology environment. The test consists of twenty items, adopted from three Hsinchu wetland ecology contents.

The questionnaire of wetland ecology learning motivation was designed by the advisor, and it was used to measure the students’ learning motivation about learning wetland ecology contents. It consists of thirteen items (e.g., “I am very curious about wetland animals and plants, and want to learn more”) and uses 5-point Likert scale ranging from 1 (very disagree) to 5 (very agree), and the value of Cronbach’s alpha for this questionnaire is 0.93, implying this questionnaire is reliable.

3.4 Results

This study used descriptive statistics to analyze learners’ overall and three dimensions satisfaction toward this system, adopting one-way ANCOVA to analyze the learning achievement, and applying independent sample t-test to evaluate the learning motivation.

First, the analysis of the satisfaction toward this system indicates: (1) the mean value and standard error of the overall satisfaction are 4.27 and 0.96, (2) the mean value and standard error of the “VR system interface design” satisfaction are 4.36 and 0.95, (3) the mean value and standard error of the “VR system learning content” satisfaction are 4.31 and 0.93, (4) the mean value and standard error of the “VR system operating sensibility” satisfaction are 4.15 and 1.01. Therefore, the learners showed a high degree satisfaction by using this system.

Secondly, we performed the homogeneity test before analyzing the learning achievement of both groups. The homogeneity test result showed that ANCOVA ($F=0.70$ and $p>0.05$). Therefore, we can analyze the post-learning achievement scores of the both group students. As shown in Table 1, the adjusted mean value of the learning achievement were 88.04 for the experimental group and 73.85 for the control group. According to the one-way ANCOVA result ($F=14.448$ and $p<0.001$), which shows the students’ learning achievement in experimental group was significantly higher than control group.

Table 1. The ANCOVA result of the students’ learning achievement.

| Group | n | mean | SD | Adjusted mean | F | η^2 |
|--------------------|----|-------|-------|---------------|--------|----------|
| Experimental group | 21 | 87.14 | 10.79 | 88.04 | 14.448 | 0.27 |
| Control group | 21 | 74.76 | 13.46 | 73.85 | | |

* $p<.05$, ** $p<.01$, *** $p<.001$

Third, the analysis of the wetland ecology learning motivation was performed by independent sample t-test, the mean value were 53.24 for the experimental group and 43.24 for control group ($t = -3.209$, $p < 0.01$), as shown in Table 2. Therefore, it indicated the students’ learning motivation in experimental group was significantly higher than control group.

Table 2. The independent sample t-test result of the learning motivation.

| Group | n | mean | SD | t-test | p |
|--------------------|----|-------|-------|--------|---------|
| Experimental group | 21 | 53.24 | 9.85 | -3.209 | 0.003** |
| Control group | 21 | 43.24 | 10.33 | | |

* $p<.05$, ** $p<.01$, *** $p<.001$



4. Conclusions

From the analysis of the experimental results, it was found that the students using the Cardboard VR Game-based Virtual Wetland Ecology System could enhance students' learning achievement and initiate students' learning motivation significantly. In addition, the students showed high degree of satisfaction toward this system, and they thought it was a good and effective learning tool to learn the knowledge of wetland ecology in environmental education.

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