Effects of interactively virtual reality on achievements and attitudes of pupils- a case study on a natural science course

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Abstract: This study aimed at investigating the effects of interactively virtual reality on learning achievements and attitudes of elementary school pupils to natural science. A quasi-experiment with unequal class pre-post evaluations was carried out. Within the 136 participants from four Grade 5 classes in an elementary school, 68 pupils from two classes were randomly assigned as the experimental group, while another 68 pupils from other two classes were the control group. Within the 80 minutes experimental teaching, the experimental group was instructed with interactively virtual reality, and the control group was taught with multimedia presentations. Regarding the process of experimental teaching, both groups received pretest, experiment, and post-test; and, the data were tested with covariance analyses. The findings showed that the learning achievement of the students in the experimental group was significantly better than that in the control group, indicating that interactively virtual reality could effectively enhance the learning achievement of pupils. Regarding the learning achievement of different genders, both males and females did not present remarkable difference in learning with the virtual reality approach. Moreover, the average of questionnaire analyses on the attitudes to the application of actively virtual reality into the instruction was 4.46, showing that pupils affirmed the instruction with actively virtual reality.

Key-Words: Virtual reality, natural science, mosquito, dengue fever, information technology

1 Introduction

In recent years, governments in various countries often remind people of preventing dengue fever in summers which has become a common problem in the world that various governments try to teach their citizens the prevention and cure of dengue fever through the mass media. World Health Organization (WHO) indicated that mosquitoes are the primary source of infecting dengue fever, which mostly occurs in cities and peri-urban areas in tropical and subtropical climates, as well as the outbreak of dengue fever has been greatly increased. Presently, there is about two-fifths world population facing the threats of dengue fever which even becomes one of the primary factors of children death in some Asian countries. In this case, how to effectively implement health education has become the major problem, in addition to enhance health-care standard [35].

Researchers have indicated that good health habits should be established as earlier as better [1]. For this reason, the prevention and cure of high contagious and high risk diseases, like dengue fever, should be started from elementary education. Meanwhile, from the aspects of natural science, pupils should be taught the principle of the incident, mosquitoes, and further pay attention to environmental sanitation to block the source of disease. Regarding the lesson plan, teaching materials integrated with the life can result in learning interests of students more easily and further enhance their learning desire as well as coordinated with current events can blend social values in the lessons [11]. Regarding the instruction, researchers believed that computer simulations could effectively help the learners understand abstract knowledge and enhance their motivation to learn, with active

participations of the learners [20]. Moreover, with the diverse teaching of virtual reality, the learning interests and achievements of students would remarkably increase [21]. For this reason, applying virtual reality in natural science is a worth trying strategy.

In recent years, the technology of virtual reality has been rapidly improved and applied to education [9][26]. It was found that instructions with virtual reality could enhance the motivation of learning and achievements [15]; moreover, the models created by computers could make students see and understand the changes of astronomical events more clearly so that the achievements were better than traditional teachings [2]. Researchers have reported, in the study on leaning in computer presentations with virtualized characters, that the research subjects had reached significance in the test of space visualization [36]. From the above studies, the application of virtual reality indeed presented good learning effects on instructions. Furthermore, virtual reality has been considered as an animation instructor that the virtual 3D environment could vitalize animation as well as the lifelike quality could make the learners more comfortable and enhance their learning effects [17]. Nonetheless, the concept of human-machine interactions was of the prime importance to design a successful and feasible virtual reality [14] [29].

Researchers have indicated that instructions with the virtual reality approach would motivate learners [30] [32]. Virtual reality could effectively help students experience unreachable or dangerous environments in daily life as the practices of formal activities. Furthermore, the situation-assisted learning allowed learners to randomly change locations in the virtual space and observe objects in the space [31]. Baron and Sternberg have stated that, to cultivate students with independent thinking and problem solving, they had to learn in the real situation for effective knowledge and experiences. In this case, the arrangements of teaching activities should consider the scenario design and the application of virtual reality technology [3].

Hosticka, Schriver, Bedell and Clark found, in the study on computer-based virtual reality, that teaching methods were the key of promoting achievements and teaching activities were the combination of contents and teaching methods that should be designed with students' cognition to reach the teaching goals [13]. For this reason, this study established an interactive virtual reality situation based on the content of "mosquitoes and the prevention and cure of dengue fever" in natural science in elementary school as the teaching goal. With the virtual reality as the experimental teaching, this study aimed to understand the achievement of Grade 5 pupils in elementary schools in natural science with interactively virtual reality based on the virtual reality.

The research objectives are as follows:

I. Investigating the effect of interactively virtual reality on the achievement of students in natural science,

II. Investigating the effect of interactively virtual reality on the achievement of male and female students in natural science, and

III. Investigating the perceptions and attitudes of students toward the application of interactive virtual reality into the learning activities of the natural science course.

2 Relevant studies

2.1 Virtual reality

In 1965, Ivan E. Sutherland proposed 'the Ultimate Display' to present the concept of 3D special images with computers that the 3D virtual environments were generated with computer-related software and hardware technologies [16]. Virtual reality provided the users with the design of direct experiences and communications [4] as well as became the interactive interface between the users and the information [28]. Pratt, Zyda and Kelleher indicated that virtual reality allowed the users to instantaneously interact with the 3D environments created by computers [27].

Virtual reality is a computer-simulate-reality or fictitious environment with which the users interact through human-computer interface so that the users experience the immersion. Dennis and Kansky believed that computer simulations provided virtual scene with fabricated reality that the users could observe and learn with judgments in the fabricated situations [10]. On the other hand, Heinich, Molenda and Russell considered that computer simulations should simplify the reality and extract the essence [12].

Bricken regarded traditional computer-assisted trainings being the trainings focusing on symbols and the learners being "observers", while virtual reality trainings created real situations and emphasized the experiences of the learners that the learners were "participants" so that the application of virtual reality could teach students to think and judge [5]. Taylor and Disinger found that virtual reality could help students get in touch with the environments which they were unable to experience

in reality as well as advantage to environmental education [33].

This study drew up 3D objects, film shooting, as well as daily scenes related to mosquitoes and the prevention and cure of dengue fever and placed agents. The operators could randomly rotate and zoom in/out 3D objects and select films that the characters in the scenes were randomly controlled to walk and run. With the familiar living environments, the experimental group was existed in the immersion.

2.2 Situated learning Theory

Brown, Collins and Duguid believed that, in the process of knowledge acquisition, people had to interact with the environment [6]. McLellan considered that the situated learning could be both in real or virtual situations that learners could learn in the situation created by computer multimedia. Virtual reality provided interactive virtual situations and offered learners with the opportunities of actively operation and repeated practices, with visual effects presenting abstract questions [23].

"Situation", essential for learning, provides real experiences and makes learning become social reference. In this case, situated teaching and learning focuses on the examples or problems occurred in reality, help learners understand how to solve problems with knowledge in reality, and provides real experiences with real activities to learn knowledge and skills. Winn indicated that knowledge was constructed contents which learners received in reality and merely presented meanings in the generation and application of situations, so that knowledge could not be separated from social contexts. Only with the participation in living situations could learners know well of knowledge [34].

The learning of knowledge and skills should be completed with actual activities so that learners could regard knowledge as a tool and apply it flexibly [6] [7]. Effective learning should allow learners getting into the social culture and meaningful situations so that learners could actively interpret and comprehend knowledge [24].

Cognitive psychologists interpreted learning activities in schools from the aspect of anthropology and proposed the theory of "situated cognition" emphasizing that learning should be proceeded in authentic activities that students searched for reasonable explanations of knowledge in the process of interactions in reality and established complete knowledge system [7] [19] [22].

Situated learning theory emphasizes that learners should actively explore and operate in real or virtual environments, establish meaningful knowledge, and apply the knowledge and skills to the real or virtual situations.

3 Research methods

In order to match with the real instructions, this study applied quasi-experimental nonequivalent-control group design, instead of randomized equivalent-control true experimental design. The independent variable was different teaching media integrated into courses. Pupils in the experimental group operated the interactively virtual reality instruction of mosquitoes and the prevention and cure of dengue fever, while the control group was taught with multimedia presentations. The dependent variable was the achievement in natural science.

3.1 Participants

The participants contained 136 pupils from four Grade 5 classes in an elementary school in southern Taiwan that two classes were the experimental group and another two classes were the control group. To prevent the experiment results from being affected by various control variables from different instructors, the four classes were taught by the same instructor. Both 68 pupils (34 males and 34 females) in experimental group and 68 pupils (34 males and 34 females) in control group were taught "mosquitoes and the prevention and cure of dengue" for 80 minutes in 2 sessions.

3.2 System implementation

Based on situational learning, this study implements "mosquitoes and the prevention and cure of dengue fever virtual reality learning system" and applies 3ds max, Cult3D and Virtoolds as the primary development tool in virtual reality, where 3dxMax is the modeling tool for 3D objects, Cult3D can display, browse, control zoom in/out, and rotate according to the 3D objects, and Virtools provides the integration of real-time interactive virtual reality scenes. With PHP program language and MySQL database, "achievement test record" is developed. Having installed Cult3D player and 3DVIA player, the system users can process interactive virtual reality learning with browsers on the Internet, including wireless network, at any time. The system structure is shown as Fig. 1.

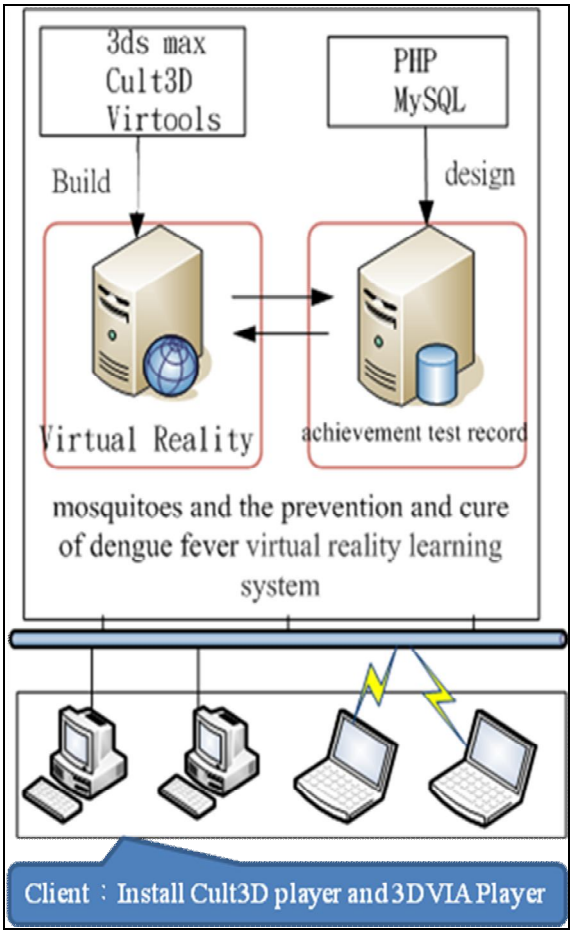

Fig.1 System implementation

3.3 Research tool

Based on the course objectives, the achievement test was made with 32 single-choice questions in which there were four options and one point was given for a correct question. 106 Grade 5 pupils were pre-tested for 40 minutes with discrimination above 0.25 and difficulty between 0.20-0.80. With discrimination and difficulty analysis system, questions were selected from the trial test and automatically transformed into 25 formal questions of pretest with one point each, total 25 points. Cronbach's α value of content consistency was 0.86 showing the appropriate content consistency. Furthermore, 10 well-educated and experienced teachers were invited to examine the test contents, themes, meanings, number of questions, and dictions conforming to the evaluation of natural science. The results presented the contents being with certain validity.

Based on the research purpose, this study drew up the questionnaire on the application attitudes as the evaluation and improvement reference of virtual reality instruction. Sixteen questions were contained in the questionnaire. With Likert-type five scale, the highest score 5 stood for positive attitudes pupils presented to the application of virtual reality into natural science, while the lowest score 1 represented unacceptable.

3.4 Learning activities

This study, based on "mosquitoes and the prevention and cure of dengue fever", designed the teaching activities, including the eggs of mosquitoes, wigglers, pupae, mosquitoes, and the prevention and cure of dengue fever, with the teaching period of 80 minutes. The instructional contents for the test and the control groups were identical. The students in the experimental group learned with the virtual reality system in an interactive manner. On the other hand, the ones in the control group learned with the multimedia instructional approach; that is, the teacher presented the multimedia content to them, asked them to complete a learning sheet, and gave feedback to them.

The applied interactively virtual reality contained four parts, as Fig. 2 Animation of wiggler, Fig. 3 Animation of pupa, Fig. 4 Animation of mosquito, and Fig. 5 Interactive virtual reality of the prevention and cure of dengue fever.

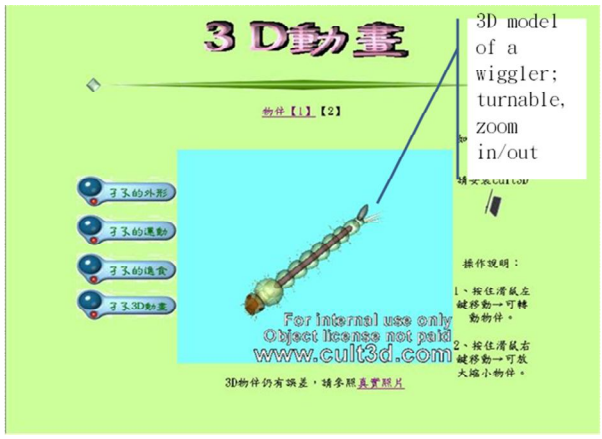

Fig.2 Animation of wiggler

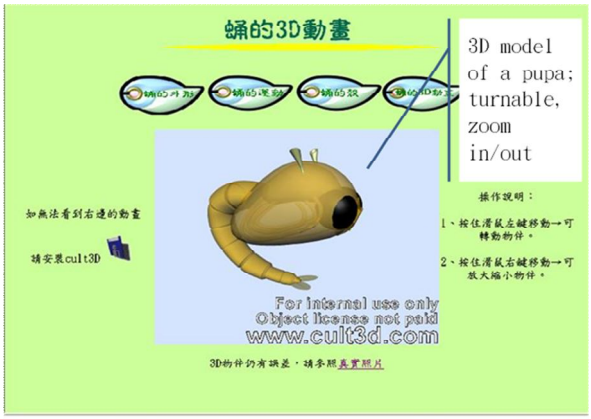

Fig.3 Animation of pupa

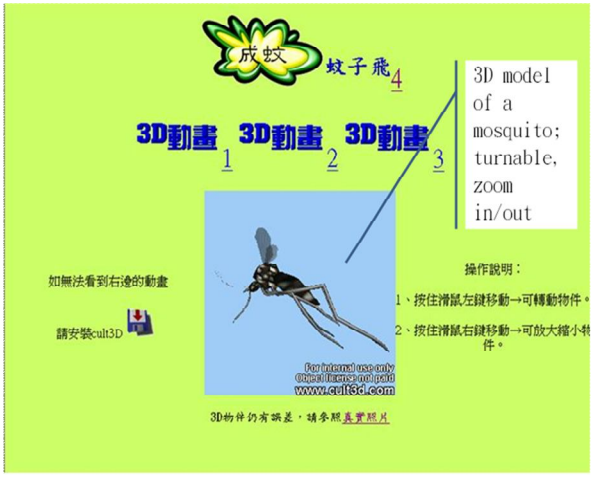

Fig.4 Animation of mosquito

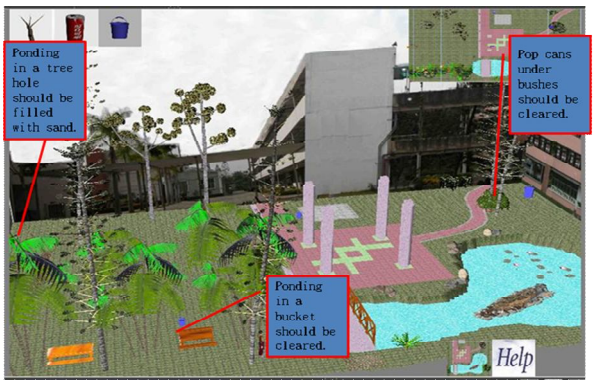

Fig.5 Interactive virtual reality of the prevention and cure of dengue fever

Figures 6 to 9 show the corresponding instructional materials for the control group, including videos, photos and graphs. Such an instructional approach has been widely adopted by school teachers in Taiwan.

Fig.6 Video of wiggler

Fig.7 Video of pupa

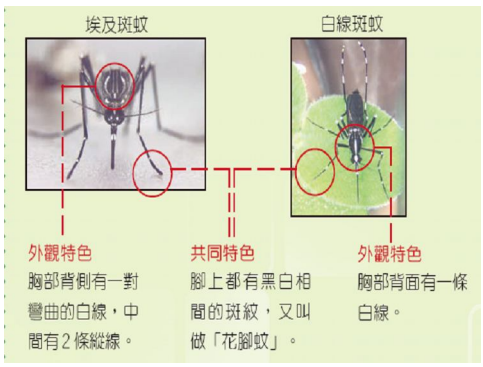

Fig.8 Photo of mosquito

Fig.9 Graph of the prevention and cure of dengue fever

3.5 Experiment procedure

Fig.10 shows the experiment procedure. In the first phase, to ensure the appropriateness of the operation design of variables in the experiment, 106 pupils from three Grade 5 classes in an elementary school in southern Taiwan were arranged for the trial test. Having analyzed the trial test, formal questions were transformed.

In the Second phase (the formal experiment), the pretest of natural science achievement was conducted, and then the two groups of students were guided to learn with different approaches.

Both learning activities lasted for 80 minutes in two sessions. After completing the experiment, all pupils received the natural science achievement

post-test. Moreover, the control group were then arranged to experience the virtual reality system. Participants were further required of the questionnaire about applying interactively virtual reality in the instruction.

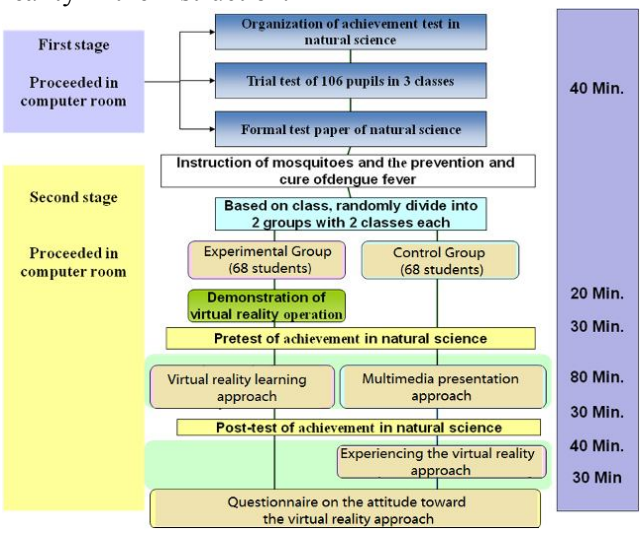

Fig.10 Implementation procedure

3.6 Data analyses

The data in this study was analyzed with SPSS for Window 12.0 Chinese version. Since the experimental teaching was processed with "class" as the unit, and in order to remain the completeness, random samples of individual participants could not be selected. The pretest scores were treated as the covariance, while the post-test scores were the dependent variables. With the analysis of covariance, the differences between the two groups were analyzed.

4 Results

4.1 The effects of virtual reality on student achievement in natural science

In this study, the pretest score of the achievement in natural science was the covariance which was processed with analysis of covariance (ANCOVA) for deleting the effects of pretest on natural science. Since the analysis of covariance referred to regression coefficient and regression line, there was a basic hypothesis of the regression coefficient in regression line of each group being homogenous (Lin, 1992). Having the independent variables and covariance of the achievement in natural science interacted with each other, F=2.575 (p=.111, p>.05) did not reach the significant standard of .05, showing that the relation between the covariance (pretest score) and the dependent variable (post-test score) would not change with the different standards of independent variables so that the analysis of covariance would be continued.

As table 1, after deleting the effect of the scores in natural science achievement test on the post-test score, the variance, resulted from groups, F = 17.85 ($p < 0.01$) achieved significant standard, meaning that the post-test scores would present significant difference with the distinct experimental treatments of the participants. In comparison with the experimental group whose adjusted average was 19.759, the adjusted average of the control group was 18.144 showing that the experimental group was superior to the control group. It demonstrated that interactively virtual reality instructions could effectively advance the achievement in natural science.

Table 1 The descriptive data and ANCOVA of the post-test of achievement test in natural science

Group	N	Mean	S.D.	Adjusted Mean	*F*
Experimental group	68	19.63	2.764	19.759	17.85***
Control group	68	18.31	3.699	18.144	

***$p<.001$

4.2 The effects of virtual reality on male and female achievement in natural science

With the pretest score of the achievement in natural science as the covariance, the analysis of covariance was performed. Having the independent variables interacted with the covariance, F=.772 (p>0.05) did not reach the significant standard of 0.05, showing that the relation between the covariance (pretest score) and dependent variables (post-test score) would not change with the different standards of independent variables, meaning that the slope obtained from the regression analyses with the covariance to the dependent variables was the same so that the analysis of covariance could be continued.

From Table 2, after deleting the effects of pretest score of the achievement in natural science on the post-test score, the variance, resulted from male and female groups, F=.312 (p>0.05) did not achieve significant standard. Regarding the achievement in natural science, the adjusted average in male group was 19.508 and in female group 19.757 that the score in female group was higher than it in male group, but not significant.

Table 2 The descriptive data and ANCOVA of the post-test of achievement test in natural science between males and females

Group	N	Mean	S.D.	Adjusted Mean	*F*
Male	34	19.56	3.047	19.508	.312
Female	34	19.71	2.493	19.757	

4.3 Understanding the points of view and reactions of pupils on virtual reality applying to natural science

Table 3 shows the descriptive statistics of the questionnaire feedback from the students. It was found that most of the students showed positive attitude toward the virtual reality instructions; in particular, they highly appreciated learning with the 3D objects, which enabled them to more easily observe and learn from different angles (4.65). Moreover, they believed that the operation of 3D objects is help to them in learning the natural science course (4.61).

Table 3 Questionnaire of Attitudes to applying virtual reality instructions

Question	N	Mean	S.D.
I like 3D objects which are more easily to observe and learn from different angles.	136	4.65	.493
I think the operation of 3D objects easy and understandable.	136	4.44	.686
I like learning with the operation of 3D objects.	136	4.61	.623
I think the operation of 3D objects is help to the learning of natural science.	136	4.60	.670
I prefer teachers utilizing 3D objects to teach us.	136	4.54	.759
I consider the contents suitable for applying computer 3D objects to learn.	136	4.48	.677
I think all courses suitable for applying 3D objects to learn.	136	4.24	.890
Learning with 3D objects, I will be more attentive.	136	4.39	.771
I agree with "this virtual reality instructional system" being helpful to learning.	136	4.43	.717
I agree with the virtual situations in "this virtual reality instructional system" being real.	136	4.35	.764
I agree with the operation interface of "this virtual reality instructional system" not difficult.	136	4.26	.837
With "this virtual reality instructional system", my learning willingness will be promoted.	136	4.42	.756
I think "this virtual reality instructional system" is a worth trying method of learning.	136	4.41	.793
I will try similar instructional systems if there are chances.	136	4.51	.740
I have known better about mosquitoes with the assistance of "this virtual reality instructional system".	136	4.50	.699
I will really inspect the living surroundings and clean the sources of mosquito breeding after the assisted learning of "this virtual reality instructional system".	136	4.51	.750
Total	136	4.46	.455

5 Conclusions and suggestions

5.1 Conclusions

This study, based on the natural science course "mosquitoes and the prevention and cure of dengue fever" in the elementary school, applied the technology of interactively virtual reality and established virtual life situation to understand the effect of the interactively virtual reality instruction on the achievement in natural science in an elementary school. The findings showed that the interactively virtual reality instruction presented significant effect that future natural science teaching in schools could attempt virtual reality instructions. The findings of this study are concluded as follows.

I. Regarding the learning achievement of the interactively virtual reality and multimedia presentation instructions, the post-test outperformed the pretest, showing that both interactively virtual reality and multimedia presentation instructions reached favorable achievement in natural science.

II. From the ANCOVA on the test scores of the students, it was found that the learning achievement in natural science with the virtual reality approach was significantly superior to that with the multimedia presentation instruction. Such a finding conforms to what was reported by Chiou in 2009 [8].

III. The interactively virtual reality instruction could help the promotion of the learning achievement in natural science for both males and females. Regarding the achievement of both males and females in natural science, the post-test outperformed the pretest. Besides, the superior

performance of females to males was not significant, showing that the interactively virtual reality instruction presented same achievement on the two genders. This result conforms to the study of Piburn et al. in 2005 [36].

IV. Regarding the application of interactively virtual reality into the instruction of natural science, pupils showed definite and positive attitudes. From the questionnaire on attitudes, most pupils presented positive and definite attitudes on the interactively virtual reality instruction, with the average affirmation of 4.46. Pupils further expected interactively virtual reality being applied into the instruction of natural science, which conformed to the study of Lai, Huang, Liaw, and Huang in 2009 on the acceptance of applying 3D virtual reality into medical education that the application of interactively computerized virtual reality was mostly accepted by users [18]. Moreover, with the interactively computerized virtual reality instruction, pupils did inspect the living surroundings and clear the breeding sites of mosquitoes, expecting to effectively reduce dengue fever.

5.2 Suggestions

This study discovered the achievement in natural science with the application of interactively virtual reality. Regarding the theoretical aspects and empirical findings, interactively virtual reality was an instruction with application value. For this reason, in future instructions of natural science in elementary schools, if teachers could nicely apply interactively virtual reality to the lessons, the teaching effects should be advanced. Based on the findings, several suggestions are provided as follows.

I. In spite that interactively virtual reality presented significant achievement in natural science, instructors should understand the contents of the interactively virtual reality being suitable for the learning objectives before the lesson and further apply the interactively virtual reality into the instruction, so that the situation in the interactively virtual reality planned in the lesson is meaningful and students do not neglect the learning effects due to curiosity.

II. In the process of this study, pupils were found extremely active in the interactively virtual reality instruction and the achievement in natural science was noticeable that the instructional strategy was worth applying and promoting. Nonetheless, such relevant virtual reality is not popular in elementary schools at present. In this case, instructions related to interactively virtual reality should be designed with the cooperation of education professionals and virtual reality designers in the future so as to help pupils' learning in elementary stage.

III. Pupils showed high interests on operating the 3D animations and the virtual reality system. Moreover, the experimental group had better learning achievement than the control group after the learning activity. However, the effectiveness of the present approach could be due to the 3D animations, the virtual reality system, or both. It is worth investigating the roles of these two technologies in improving the learning achievements of the students in the future.

IV. With the rapid development on computer software and hardware technologies, interactively virtual reality-related software requires higher level computers. Nevertheless, the renewal of computer equipment in elementary schools is rather slow that in the process of interactively virtual reality instruction, the waiting time becomes longer or the computers are sometimes crashed. In this case, the experimental environment needs to be pre-arranged as well as backup computers are required.

V. Although the scenes in interactively virtual reality are made as real and lively as possible, they are still considered as teaching aids, not being able to replace the object observation. Regarding the teaching activities in elementary schools, the real living situation is the priority for object observations, except with special considerations.

VI. Presently, elementary teachers are generally lack of the knowledge and concepts of virtual reality, which should be taken into the professional development of teachers so that teachers could receive the basic concepts of virtual reality for the preparation for future instructions.

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