The Effect of Using Head-mounted Virtual Reality to Improve Learning

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Abstract
In the current class, the limitation of location, season, and presence of insects eliminate students to observe the insects closely. The students usually are confused with insects' appearance and growing process. Virtual reality (VR) removes the limitation of time and space and facilitates students to learn and explore more actively. The head-mounted devices provide a more immersive environment for students to enhance their learning motivation. Studies found appropriate pedagogy should be integrated into virtual reality. In this study, the head-mounted virtual reality were used to improve insect education and further compared their learning experiences.

Keywords: Virtual reality, head-mounted devices, insect education

Introduction

Due to the limitation of season and size, students usually have little chance to observe insects closely and they could only learn by watching pictures, video clips, and specimens. Students are usually confused with insects' appearance and learning process. Virtual reality eliminates the boundary of time and space, and provides students with interactive learning environments. VR holds students' engagement because it provides exciting experiences and it is challenging to interact in the virtual environment (Kuei-Shu, Jinn-Feng, Hung-Yuan, & Tsung-Han, 2016). The rapid development of information technology facilitates the application of VR to wider fields. The head-mounted devices provide students with more immersive experiences and improve their learning motivation. Virtual technologies promote autonomous exploration and decision-making so VR has the potential to encourage students to become active learners (Gutiérrez, Domínguez, & González, 2015). However, appropriate instructional designs should be integrated when learning in a VR environment (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, Davis, 2014). Inquiry-based learning supports students to discover new causal relations by identifying questions, proposing hypotheses, finding possible solutions, conducting experiments, making observations, and obtaining conclusions (Pedaste, Maeots, Leijen, & Sarapuu, 2012). The learning model encourages learners to participate actively and discover new knowledge to improve learning (de Jong & van Joolingen, 1998). The learners not only obtain knowledge from the learning process but experience the process to think critically. The students become the center of learning and increase their learning motivation. Studies have supported the effectiveness of applying inquiry-based learning to improve learning (de Jong, Sotiriou, & Gillet, 2014). The focus of the inquiry-based learning model may be consistent with what VR could bring to our students.

In sum, because of the importance of elementary students' insect knowledge improvement and the importance of taking appropriate pedagogy into consideration, this study developed a virtual reality environment designed according to inquiry-based learning and tried to enhance the performance of elementary students' insect knowledge developing. The research questions were listed below:

1. Whether the students in the virtual reality environment that was designed based on the inquiry-based learning model (ILM-VR) will improve their learning?
2. Is there a significant difference in the learning outcome between the students using ILM-VR or not?
3. Is there a significant difference in learning motivation, perceived usefulness, perceived ease of use, and satisfaction in students using ILM-VR or not?
4. What are students' learning experiences in the ILM-VR learning environment?

Methodology

The research was conducted in two elementary classes in Taiwan and 27 students participated. A total of 54% of them were male and 46% were female. One class was randomly assigned as experimental (ILM-VR) group (N=13), which used virtual reality technology based on inquiry-based learning model in the class. The other class was named as a control group (N=14), and the course was taught by PowerPoint and video clips. The entire treatment lasted for two weeks. In the study, quantitative data consisted of a questionnaire, pre-test, and post-test scores, and qualitative data came from semi-structured interviews. The participants were asked to take the pre-test before the treatment. After the treatment, they were asked to take post-test, a questionnaire, and the in-depth interviews were conducted. To determine the validity of the questionnaire, the principal component analysis was performed on the 10 questions. Four factors were yielded by factor analysis. The total variance accounted for by two factors was 83.49%. Respondent ratings of students' perceptions in the learning motivation of using virtual reality obtained from the questionnaire were judged to be fairly reliable with an internal consistency reliability coefficient of 0.86. Respondent ratings of students' perception of perceived usefulness obtained from the questionnaire were judged to be fairly reliable with an internal consistency reliability coefficient of 0.89. Respondent ratings of students' perception of perceived ease of use obtained from the questionnaire were judged to be fairly reliable with an internal consistency reliability coefficient of 0.93. Respondent ratings of students' perception of satisfaction obtained from the questionnaire were judged to be fairly reliable with an internal consistency reliability coefficient of 0.92.

Results

A dependent t-test was used to answer research question one "Whether the students in the virtual reality environment that was designed based on the Inquiry-based learning model (ILM-VR) will improve their learning? " The pre-test and post-test were administered to the students in the experimental group at the end of the two weeks of study in order to answer this research question. There is a statistically significant mean difference ($t= -12.73$, $df=12$, $p<.01$) between pre-test and post-test in the ILM-VR group. The posttest score (mean= 86.59, s= 11.72) was higher than the pre-test score (mean= 56.42, s=12.48). The 95% confidence interval suggests the true mean difference is included in $-32.14<\mu<-24.57$.

An independent t-test was used to answer research question two "Is there a significant difference in the learning outcome between the students using ILM-VR or not?" The pre-test and post-test scores were administered to the students at the end of the two weeks of study in order to answer this research question. The results from the pre-test showed that there was no statistically significant difference in the pre-test between the ILM-VR and the control groups ($t=.76$, $df=35$, $p=.48$). The 95% confidence interval indicates the true mean difference (-.27) may range from $-2.73<\mu<6.42$. On average, participants in the ILM-VR group (M=56.42, SD=12.48) had a similar level of prior knowledge before the treatment (M=58.14, SD=11.83). The results are shown below in Table 1.

Table 1. Scores of the Pre-test

Groups	Mean	Std. Deviation	N
ILM-VR	56.42	12.48	13
Control	58.14	11.83	14
Total	59.27	11.64	27

The results from the post-test showed that there was no statistically significant difference in the post-test between the ILM-VR and the control groups ($t=-.24$, $df=25$, $p=.27$). The 95% confidence interval indicates the true mean difference (-3.81) may range from -7.62<μ<-2.04. On average, participants in the ILM-VR group (M=86.59, SD=11.72) had similar academic performance with the control group (M=84.38, SD=13.69). The results are shown below in Table 2.

Table 2. Scores of the Post-test

Groups	Mean	Std. Deviation	N
ILM-VR	86.39	11.72	13
Control	84.38	13.69	14
Total	85.59	15.86	27

Motivation

A composite score from questions 1-4 was used to determine students' perception of motivation towards learning through virtual reality. The composite score ranged between 4 and 12. The results from the survey showed that there was a statistically significant difference between the ILM-VR and the control groups (t=5.86, df =25, p<0.01). The 95% confidence interval indicates the true mean difference (-4.77) may range from -5.46<μ<-4.09. On average, participants in the ILM-VR group (M=6.19, SD=1.83) had more motivation towards learning through ILM-VR than the control group (M=10.24, SD=1.76). The results are shown below in Table 3.

Table 3. Scores of Motivation

Groups	Mean	Std. Deviation	N
ILM-VR	10.24	1.76	13
Control	6.19	1.83	14
Total	8.14	2.43	27

Perceived usefulness

A composite score from questions 5-7 was used to determine students' perception of perceived usefulness towards learning through virtual reality. The composite score ranged between 3 and 9. The results from the survey showed that there was no statistically significant difference between the ILM-VR and the control groups (t=9.64, df =25, p=.08). The 95% confidence interval indicates the true mean difference (-2.47) may range from -3.28<μ<-2.09. On average, participants in the ILM-VR group (M=7.85, SD=1.64) felt the VR system to be as useful as the learning environment in the control group (M=6.42, SD=1.53). The results are shown below in Table 4.

Table 4. Scores of Perceived Usefulness

Groups	Mean	Std. Deviation	N
ILM-VR	7.85	1.64	13
Control	6.42	1.53	14
Total	7.11	1.62	27

Perceived ease of use

A composite score from questions 8-10 was used to determine students' perception of perceived ease of use towards learning through virtual reality. The composite score ranged between 3 and 9. The results from the survey showed that there was no statistically significant difference between the ILM-VR and the control groups (t=6.32, df =25, p=.06). The 95% confidence interval indicates the true mean difference (-2.39) may range from -3.31<μ<-2.02. On average, participants in the ILM-VR group (M=8.19, SD=1.73) felt the VR system to be as easy to use as the learning environment in the control group (M=7.58, SD=1.86). The results are shown below in Table 5.

Table 5. Scores of Perceived Ease of Use

Groups	Mean	Std. Deviation	N
ILM-VR	8.19	1.73	13
Control	7.58	1.86	14
Total	7.87	1.79	27

Satisfaction

A composite score from questions 11-13 was used to determine students' perception of confidence. The composite score ranged between 3 and 9. The results from the survey showed that there was a statistically significant difference between ILM-VR and the groups (t=3.16, df =125, p<0.01). The 95% confidence interval indicates the true mean difference (-4.83) may range from -5.96<μ<-3.62. On average, participants in the ILM-VR group (M=8.59, SD=1.63) had a more positive attitude toward learning satisfaction than the control group (M=3.41, SD=1.27). The results are shown below in Table 6.

Table 6. Scores of Satisfaction

Groups	Mean	Std. Deviation	N
ILM-VR	8.59	1.63	13
Control	3.41	1.27	14
Total	5.90	3.28	27

From the semi-structured interviews, most of the students found using ILM-VR to be fun and interesting. They agreed the system helped them sustain their attention and motivation to learn about the topic. However, few students got lost in the VR environment and needed more time and guidance.

Conclusions

The purpose of this study was to investigate the effect of using ILM-VR in insect learning. The findings of this study showed that ILM-VR facilitates students' learning motivation and interest. However, there showed no improvement in insect learning in primary education. In the ILM-VR group, the post-test scores demonstrated tremendous improvement from the pretest. From the pre-test scores in this study, there was no statistically significant difference in test scores between the ILM-VR and the control groups. However, the ILM-VR group had a similar knowledge post-test score with the control group. Integrating ILM-VR in learning did not help improve participants' academic performance although ILM-VR was interesting and help them get involved in the learning process. More guidance and clear instructions should be given during learning.

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