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# VR Learning System to Support Active Locomoting Viewpoint for Astronomy Education

**Norio SETOZAKI[a*], Yuya TOMINAGA[a] & Yusuke MORITA[b]**
[a]*Faculty of Education, Nagasaki University, Japan*
[b]*Faculty of Human Sciences, Waseda University, Japan*
*setozaki@nagasaki-u.ac.jp

**Abstract:** In the field of astronomy, it has proved challenging for students undergoing elementary school teacher training to understand the moon phasing mechanism. Therefore, in this study, we developed an astronomical VR learning system that supports active locomoting viewpoint through explorative learning in a virtual environment. To evaluate the effectiveness of the proposed system, the degree of comprehension of students undergoing teacher training was evaluated. The results show that the proposed system is effective for students with low comprehension about the phases of the moon.

**Keywords:** Virtual Reality, Locomoting Viewpoint, Teacher Training, Astronomy Education

## 1. Introduction

In the field of astronomy, children interested in studying the phases of the moon have difficulty understanding the phases of the moon (Miyawaki *et al*., 1992). Trumper (2001), in his study, reported that several junior high school students find it difficult to distinguish between the moon phasing mechanism and the lunar eclipse mechanism. Further, almost half of the university students do not have a scientific understanding about the phases of the moon (Trumper, 2000).

Such problems, particularly in the field of astronomy, are no exception for students training to be elementary school teachers. Matsumori *et al.* (2015) reported that students undergoing teacher training face challenges in recognizing the apparent position of the moon and observable time. In addition, students who did not major in science suggested that they were underconfident when teaching about astronomy (Shimoikura *et al.*, 2014). Therefore, it is meaningful for teacher training students to examine concrete measures for issues in the astronomy field.

To conceptualize the phases of the moon, it is necessary to understand the relative positions and motions of objects in synchronous rotation, and to shift from a geocentric to a heliocentric perspective. Therefore, to comprehend moon phases, the learner must exhibit the spatial ability associated with locomoting viewpoint. The learner's ability associated with the locomoting viewpoint depends on both the "operation" and the "relative positional relationship between the target to be recognized and the learner". In addition, Okada (2009) reported that the correct answer rate when using "active locomoting viewpoint", wherein the observer moves with the position of the observation object fixed is high. In this study, we develop an explorative learning tool that supports active locomoting viewpoint.

In general, learning by direct observation is challenging in astronomy considering the temporal constraints and weather. Therefore, use of virtual reality (VR) technology for such application is a promising solution. As regards the use of VR for learning equipment in the field of astronomy education, several types of systems have been developed, including multi-view type solar system VR learning equipment (Setozaki *et al.*, 2009) and tangible solar system learning equipment linked with model operation (Morita *et al.*, 2010). However, these learning systems provide limited support to the learner's active locomoting viewpoint.

Therefore, in this study, we develop an astronomical VR learning system that supports active locomoting viewpoint through the use of explorative learning in a virtual environment. In addition, an evaluation study was conducted to assess the comprehension of students undergoing teacher training.

## 2. Development of Explorative VR Learning System

Figure 1 presents an overview of the proposed Explorative VR Learning system. The system was constructed in a VR environment using the Unity 5 cross-platform game engine. In the VR environment, the CG models of the Earth, the moon, and the sun were placed, with the texture of the universe as the background. In addition, the parallel rays from the sun's CG model were irradiated. The animation of the rotation movement was set for the Earth's CG model. For the moon's CG model, the animation of the moon's revolution and rotation (rotating around the Earth) were also configured. In addition, an animation playback/stop function and speed change function was implemented, such that the learner could use these function via two controllers.

In addition, the exploration area was confined to a 2 m × 3 m area. This enabled the learner to observe the phases of the moon while freely exploring outer space within the VR environment. In this study, HTC Vive was used as the head mounted display (HMD).

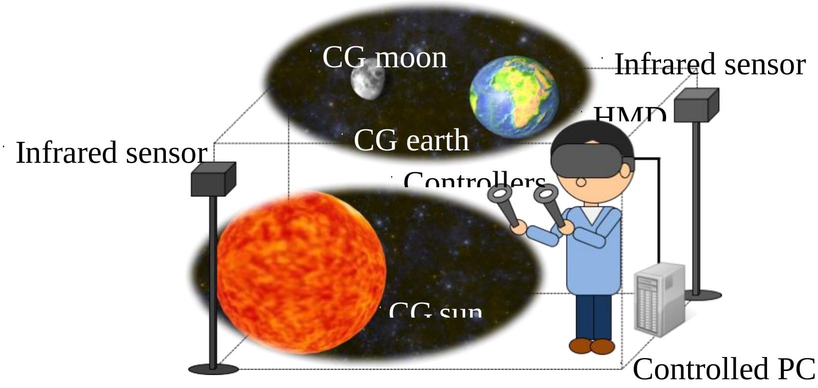


*Figure 1*. Overview of the astronomical VR learning system

## 3. Experimental Procedure

We evaluated the proposed system through experiments, wherein 16 teacher training course students were recruited as participants. The students were given approximately 45 minutes to acclimatize themselves with the VR learning system. The participants were instructed to observe the celestial bodies while moving actively around the VR environment.

To investigate the effectiveness of the system in aiding the students' understanding, a pre-test and a post-test were conducted, before and after the experiment. Both tests used the same questionnaire. The participants were scored on a scale from 0 to 20 points for the evaluation. The average scores for the comprehension pre-test was 11.1 points. Therefore, students who scored 11 points or less on the pre-test were grouped into the "low group" (8 students); students who scored more than 12 points on the pre-test were classified as "high group" (8 students). In addition, an analysis of variance was done using two factors, namely "proficiency" and "changes in test score."

## 4. Result and Discussion

Figure 2 illustrates the results of the comprehension test. The results showed significant difference for the interaction between the two factors ($F(1,14) = 13.31$, $p<.01$). Therefore, when analyzing the simple main effect of “proficiency”, a significant difference was observed in the pre-test average points ($F(1,14) = 25.12$, $p < .01$). On the other hand, the simple main effect of “proficiency” showed no significant difference in either the post-test results ($F(1,14) = 1.07$, *n.s.*). The findings of the analysis of the simple main effect of "changes in test score" showed a significant difference between the pre- and post-test scores for the “low group” ($F(1,14) = 50.86$, $p<.01$), and corresponding significant tendencies were observed between the pre- and post-test scores for “high group” ($F(1,14) = 3.59$, $.05<p<.10$).

Therefore, by using the explorative VR learning system, it was demonstrated that the score of “low group” was improved, and the average score attained in the post-test was equal to that of “high group.”

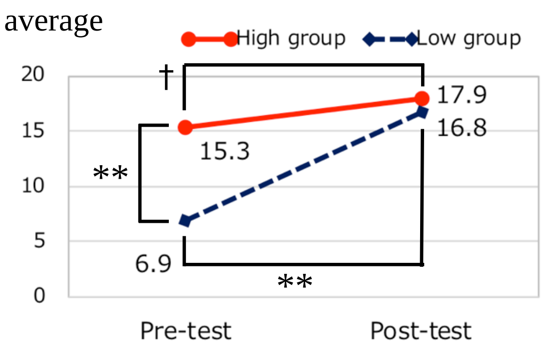

*Figure 2*. Results of the comprehension test

## 5. Conclusion

In this study, we developed an astronomical VR learning system that supports active locomoting viewpoint through explorative learning in a virtual environment. We evaluated the degree of comprehension of students undergoing teacher training course students. The results showed that the proposed VR learning system is effective for students who had low comprehension about the phases of the moon.

In our future work, we intend to improve the credibility of the analysis results by increasing the sample size as well as analyzing, in detail, other factors associated with the learning effect.

## Acknowledgements


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