

Evaluation of AR Learning Equipment for Astronomy Education

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Abstract: Various fields of education have focused on augmented reality (AR), which can synthetically present virtual objects in real environments. This study examines the effects of utilizing AR learning equipment for synchronized model operation in astronomy education. The findings show that AR enhances the learning experience of students by synthetically presenting a Computer Graphic (CG) shadow on a Moon model as well as creating a CG Sun and background.

Keywords: Augmented reality, tangible user interface, astronomy education

1. Introduction

It is sometimes difficult for students to understand the position of heavenly bodies as they revolve around the Sun at different speeds and rotate on their individual axes (Masuda, 2007; Vandenberg, 1978). Thus, it has become necessary to switch freely between the aspects of Ptolemaic theory and Copernican theory to solve problems in the astronomical field. Morita et al. (2010) developed multi-view astronomical learning equipment and showed that active learning was useful for understanding the presented information (Setozaki et al., 2010).

On the other hand, various fields of education have studied augmented reality (AR), which can synthetically present virtual objects in real environments (Yuen, 2011). Moreover, synthetically presenting three-dimensional information in real environments can enhance effective learning in the astronomical field (Setozaki et al., 2012). Therefore, this study examines the effects of utilizing AR learning equipment for synchronized model operation in astronomy education.

2. Procedure

2.1 Development of the AR Learning Equipment for Astronomy Education

Figure 1 illustrates the AR learning equipment used for astronomy education. Regarding this learning equipment, the operation of astronomical models and the AR system was synchronized for learners to observe the phenomenon in which the Moon waxes and wanes. The orbital plate was attached to the table so that each model could easily operate, and markers were attached to the bottom of the Earth and Moon models. The top plate of the table was created from translucent acrylics and a web camera was placed underneath the table to clearly recognize the markers. By recognizing the image of the markers, the position information of both the Earth and Moon models was acquired. A small wireless camera was built into the Earth model and the image viewed from the Earth model was shown on a monitor.

The Computer Graphic (CG) models were synthetically presented by using AR authoring software (Unifeye SDK). The CG model of the Sun was synthetically presented as an image viewed from the Earth model, while the phenomenon in which the Moon waxes and wanes was shown by synthetically presenting a shadow on the Moon model. Furthermore, to show the day/night rotation of the Earth model, a CG of the gradation from black to colorlessness was

created in the background of the Moon model. As a result, when the observation from the Earth model was in the opposite direction of the CG Sun, the background (except for the Moon model) became dark.

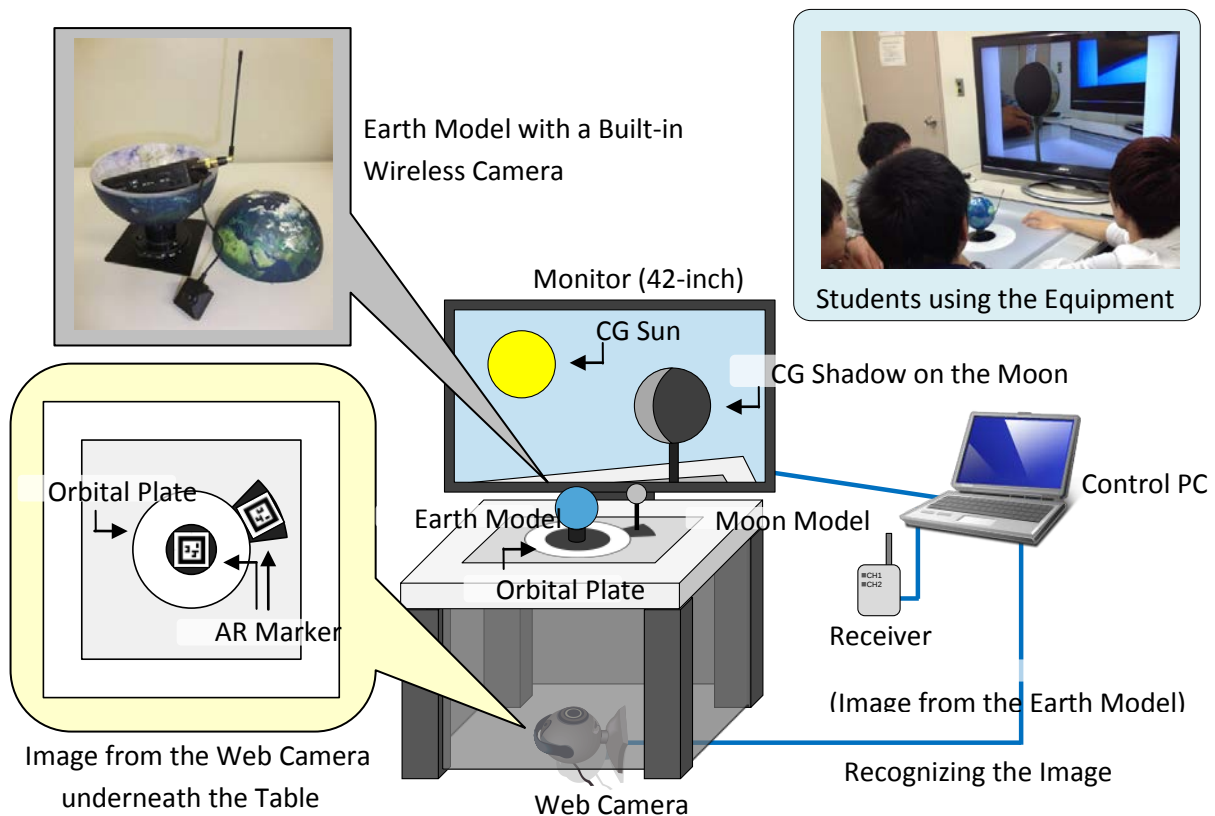


Figure 1. AR Learning Equipment for Astronomy Education.

2.2 Subjective Assessment by Survey

A total of 47 undergraduate university students participated in the study. After operating the learning equipment, the students responded to eight questions by selecting from the following four responses: Strongly Agree, Agree, Disagree, and Strongly Disagree. The positive (Strongly Agree and Agree) and negative (Disagree and Strongly Disagree) responses were totaled for each item and compared using Fisher's exact test.

3. Results and Discussion

Table 1 shows the results of Fisher's exact test. All of the students responded in the affirmative to the question item of "The synthetically presented CG shadow on the Moon model enhances my understanding" and "Synthetically presenting CG models in real environments is effective for learning." Moreover, there were many affirmative replies for the item, "conscious of the day and night," "conscious of the sunrise and sunset," and "conscious of the sunlight." These responses show that the use of AR equipment was effective for learning about the Sun's diurnal motion and sunlight as well as understanding "the phenomenon in which the Moon waxes and wanes."

Conversely, there were a number of negative replies regarding "the consciousness of the observation time." Therefore, the observation time of the information presentation needs to be improved in the future.

Table 1: Results of the subjective assessment.

Question Categories	Positive		Negative		Fisher's Exact Test
	Strongly Agree	Agree	Disagree	Strongly Disagree	
The synthetically presented CG shadow on the Moon model enhances my understanding.	35	11	0	0	**
Synthetically presenting CG models in real environments is effective for learning.	25	21	0	0	**
This learning equipment makes me conscious of the day and night.	23	18	5	0	**
This learning equipment makes me conscious of the sunrise and sunset.	14	20	10	2	**
This learning equipment makes me conscious of the sunlight.	15	18	13	0	**
This learning equipment makes me conscious of the phenomenon in which the Moon waxes and wanes.	8	21	12	5	n.s.
The gap between the shadow and the model of the Moon was not a problem.	7	20	18	1	n.s.
This equipment makes me conscious of the observation time.	5	11	23	7	+

**: $p < 0.01$, *: $p < 0.05$, † : $p < 0.10$, n. s.: not significant.

4. Conclusion

This study examined the effects of utilizing AR learning equipment for synchronized model operation in astronomy education. The findings show that the use of such equipment enhanced the learning experience of students by synthetically presenting a CD shadow on the Moon model as well creating a CG Sun and background. However, it became clear that the information presentation should be more conscious of the observation time. Using data from this study, future research should focus on improving AR learning equipment and examining effective practical uses of the AR learning equipment in elementary schools and junior high schools.

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