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Study on Learning Effect by Active Manipulation using Tangible Solar System Teaching Equipment

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Abstract: This study aimed to clarify the learning effect through an active manipulation of tangible solar system teaching equipment that was synchronized with a model manipulation. A teaching practice using the tangible solar system teaching equipment was carried out with high school students who had previously been taught using multi-view VR teaching equipment. As a result, an improvement in the understanding levels of students with low proficiency was observed. It is suggested that active manipulation of the teaching equipment may contribute to the improvement of students' levels of understanding.

Keywords: Tangible, Human interface, Active manipulation, Teaching practice

Introduction

It is not easy for children and students to understand the position of the heavenly bodies as they revolve around the sun at different speeds and also rotate at their own axis. It is necessary to switch freely between aspects of Ptolemaic theory and Copernican theory to solve problems of the astronomical field.

Recently, VR technology that supports spatial perception by visual presentation has received attention. Kubota et al. [1] did a study of the filling lack of the moon using a solar system simulation. Moreover, Setozaki et al. [2] developed multi-view VR teaching equipment related to the solar system based on an investigation of the needs of teachers, and examined an effective use method. However, these studies did not employ the interactivity that the VR teaching equipment originally had, and the learner learned passively.

Setozaki et al. [3] instructed classes using VR teaching equipment and models. As a result, the students showed an interest and a desire to learn by actively operating the models. As for tangible [4], it is known as a concept of human–computer interface that creates a computer that touches, and practicing research is performed on an educational site. Yamashita et al. [5] developed tangible teaching equipment that synchronized the globe with a PC, and examined its utility. Moreover, Morita et al. [6] developed tangible solar system teaching equipment that was synchronized with models. In addition, the group study that used the tangible teaching equipment revealed communication between learners. However, the learning effect through active manipulation that uses tangible teaching equipment has not been examined in an individual study.

Therefore, this research aimed to present a teaching practice using tangible solar system teaching equipment, and to examine the learning effect through of active manipulation.

1. Tangible solar system teaching equipment

This research used teaching equipment that had improved graphics accuracy and virtual space of the tangible teaching equipment that Morita et al. [6] had developed.
Figure 1 shows a diagram of the tangible solar system teaching equipment. Because the cameras set up under the table recognize the marker shown in the models, the CG model corresponding to each model can be displayed on monitors. The model synchronizes with the CG model so that the system functions in real time, processed using an AR tool kit (metaio Unifeye SDK) and an interactive manipulation.

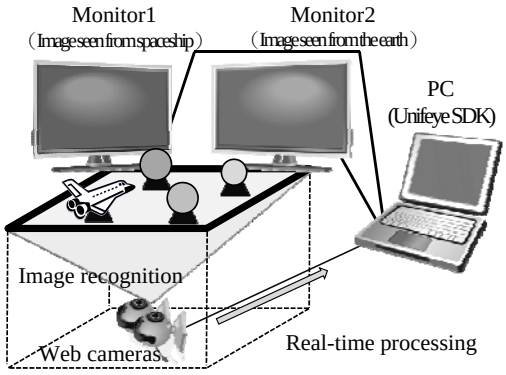

Figure 1: Tangible teaching equipment

2. Procedure

For the teaching practice set up, a high school class of 26 students (15 males and 11 females) whose science lectures materials included VR teaching equipment related to the solar system was considered. Students were organized into groups of three or four and the class practiced for about 15 minutes. First, the lecturer taught the "The reason why the moon waxes and wanes" using the tangible solar system teaching equipment. Next, the students learned actively by taking turn to individually manipulate the teaching equipment.
To investigate students' understanding levels, a pretest and a posttest were conducted before and after the class. Each test involved the same problem. A score scale from 0 to 10 points was considered to evaluate students' understanding levels. Students who scored from 0 to 4 points on the pretest were classified into the "low group" (13 students); students who scored from 5 to 9 points on the pretest were classified "high group" (13 students).In addition, as a subjective assessment investigation, a questionnaire was administered.

3. Results and Discussion

Figure 2 shows the results of the comprehension test. In addition, an analysis of variance was done with two factors, "proficiency" and "score of the test". The result was not significant for the interaction ($F(1,24) = 0.36$, n.s.). However, there was a significant difference in the factor of proficiency as a result of analyzing the main effect ($F(1,24)= 39.70$, $p < .01$). Moreover, there was a significant difference for the factor of score of the test ($F(1,24) = 12.19, p<.01$). Based on the results, it was clear that both the "high group" and the "low group" similarly improved their scores of the test after the class used the tangible solar system teaching equipment. The low group could locate it with students who did not understand the content of learn from the class used the VR teaching equipment. Therefore, we postulated that the score of the low group improved by active manipulation through using

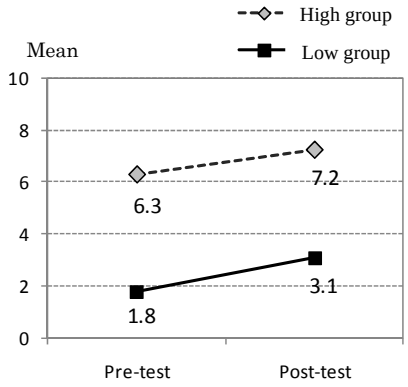

Figure 2: Result of comprehension test

the tangible teaching equipment.

Table 1 shows the results of the subjective assessment. The results of the survey were classified into an affirmative answer and a negative answer, and they were analyzed by the exact probability test. It was confirmed that there were numerous affirmative answers to 9 questions. We hence can conclude that the students' interest and understanding had improved by an active manipulation.

Table 1: Results of subjective assessment

Question item	Affirmative	Negative	proportion
Active manipulation			
The tangible operations expanded my understanding of astronomy.	26	0	0.00
I could easily understand because I could mamipulate the models while watching phenomena from the celestial bodies.	26	0	0.00
Phases of the moon were easy to understand because of the real objects.	25	1	0.00
Operation was easy.	25	1	0.00
I enjoyed maniulating the real models.	24	2	0.00
I wanted to use the system more.	16	9	0.23(n.s.)
I couldn't figure out how to operate the system.	4	22	0.00
Comparison with other teaching materials			
The system made astronomy easier to understand than the VR teaching equipment.	25	1	0.00
The system was more interesting than the VR teaching equipment.	24	2	0.00
The system made astronomy easier to understand than texts and handouts.	26	0	0.00
The system was more interesting than texts and handouts in science class.	25	1	0.00

4. Conclusion

This study aimed to clarify the learning effect through the active manipulation of tangible solar system teaching equipment that was synchronized with a model manipulation. A teaching practice using the tangible teaching equipment was carried out in a high school class whose students had already been taught with multi-view VR teaching equipment. It was found that the low proficiency students' understanding levels improved when they were taught using the tangible teaching equipment. The research results suggest that an active manipulation of the tangible teaching equipment may be one factor in improving their level of understanding.

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