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A Pilot Study on the Effects of a Tangible Learning System for Pre-Service Teacher Training

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Abstract: The purpose of this pilot study was to discuss a possibility of a tangible learning system for pre-service teacher training. For the purpose of this pilot study, the tangible learning system was implemented and demonstrated in a science teacher training class. Then, comprehension test scores before and after the class and a mental rotation test (MRT) score were compared. 23 college students were divided into three groups based on the pre- and post-comprehension test scores; HH (12 High-High students), LH (7 Low-High students), and LL (4 Low-Low students). According to the ANOVA on the MRT, the LH students received an average score on the post comprehension test, however the LL students scored lower due to their lack of spatial thinking ability. The results of our study imply that the tangible learning system is effective for college students to understand the phases of the Moon. Meanwhile, the results also imply that there are some students who do not have enough spatial thinking ability. These findings stress the importance of taking students' spatial ability into account especially in science teacher training.

Keywords: Tangible Learning System, Spatial Thinking Ability, Teacher Training, STEM education

1. Introduction

In recent years, Science, Technology, Engineering, and Mathematics (STEM) education has become a government policy in the United States and other countries (Baran *et al.* 2016). Spatial thinking is one of the key abilities to understanding STEM's contents. Astronomy has some of the most difficult content because it requires spatial thinking ability to comprehend the phenomena (Nasboum *et al.* 1983, Vosniadou 1991). The positional relationships among celestial bodies that exhibit relative rotational movement are difficult to understand not only for students but also teachers. Spatial thinking ability will allow teachers to understand and as a result more effectively teach the phenomena. Therefore, it is important to implement spatial thinking training in STEM teacher education.

Tangible User Interface (TUI: Ishii *et al.* 1997) is one solution to cultivate students' and teachers' spatial thinking ability (Hawes *et al.* 2015). Schneider et al. (2013) developed and implemented a tabletop TUI to study content regarding neuroscience and reported the usefulness of the learning environment because it could be fundamental for improving student performance. Morita *et al.* (2010) also developed a tabletop tangible learning system that facilitates viewpoint changing applying TUI. The user can manipulate models of the Sun, Earth, and Moon as visible tangible bodies and the real objects are on the tabletop to operate CG models.

Figure 1. Tangible Learning System

The tangible learning system was also tested in a science classroom (Morita *et al.* 2012). The previous research reported the usefulness of the tangible learning system through its implementation in an elementary science class. The results clearly show that active exploratory learning using the tangible learning system supports the understanding of students with comparatively high spatial ability. Although, the results suggest that teachers need to consider how to facilitate the understanding of students with comparatively low spatial thinking ability.

The purpose of this pilot study was to discuss the possibility of the tangible learning system for learning the phases of the Moon in science teacher training. In this research, the tangible learning system was implemented in a teacher training class for future elementary school teachers.

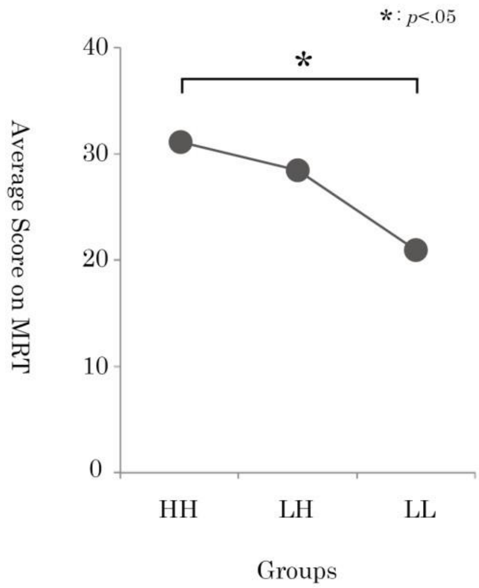

Figure 2. Comparison of MRT Score

2. Method

2.1 Participants and Procedure

Twenty three college students in the Tokyo area participated in this practical study. The practical study was conducted in a 90 minute period. The class was taught by a guest professor from another university.

Figure 1 shows the tangible learning system illustrating the phases of the Moon. In the beginning of the class, the students were divided into two groups at random. First, one group used the tangible learning system set in another classroom, and the other group worked with application software in their lecture room. Once the first group completed their activity using the tangible learning system, they then went back to their lecture room. Similarly, once the other group completed an exploratory activity using tablet application software, they then went to the tangible learning system classroom.

2.2 Measurement and Analysis

Measurement was performed using a pre- and a post-comprehension test, a questionnaire, and a mental rotation test (MRT). The comprehension tests comprised 8 questions in the following four categories: the shadow on the ball (Earth's viewpoint), the shadow on the Earth (overhead viewpoint), the shadows on the models (Earth's viewpoint and spaceship's viewpoint), and the shadow on the Moon (the phases of the Moon). The questionnaire comprised 6 items related to interest, understanding, and teaching capability. The Mental Rotation Test (MRT) had twenty sets of quizzes.

In this study, the participating college students were divided into three groups based on their comprehension test scores. Students who scored high (5-8 points) on both pre- and post-test were in HH, students who scored low (0-4 points) on pre-test and scored high on post-test were LH, students who scored high on pre-test and scored low on post-test were HL, and the others who scored low on both the pre- and post-tests were LL. Then, the differences among MRT scores and questionnaire scores were examined using one-way analysis of variance (ANOVA).

3. Results and Discussion

Figure 2 shows the average scores of the MRT. The results indicate that the 23 college students were divided into three groups using the pre- and post-comprehension test scores; HH (12 High-High students), LH (7 Low-High students), and LL (4 Low-Low students). It deserves special mention that no students fell within the HL category. According to the result of ANOVA, the main effect indicates a significant difference (F[2,20]=3.96, p<.05). Multiple comparisons using the Bonferroni method show a significant difference between HH and LL students' scores. This indicates that the LL students could not receive a high score on the comprehension tests because of their lack of spatial thinking ability.

Figure 2 shows average scores of the questionnaire items and the results of ANOVA at the 5% level. On the item Q1, interest in astronomy, there is no significant difference (F[2,20]=0.74, *n.s.*). On the item Q2, understanding in astronomy, the main effect indicates a significant difference (F[2,20]=10.36, p<.01) and multiple comparisons using the Bonferroni method shows a significant difference between HH and LL students' scores, also between LH and LL students' score. On the item

Q3, teaching capability in astronomy, there is no significant difference (*F*[2,20]=3.02, *n.s.*). On the item Q4, interest in phases of the Moon, the main effect indicates a significant difference (*F*[2,20]=10.20, *p*<.01). Multiple comparisons using the Bonferroni method show significant differences between HH and LL students' scores, also between LH and LL students' scores. On the item Q5, understanding the phases of the Moon, the main effect indicates a significant difference (F[2,20]=10.15, *p*<.01). Multiple comparisons using the Bonferroni method show significant differences between HH and LL students' scores, also between HH and LH students' scores. On the item Q6, teaching capability of the phase of the Moon, the main effect indicates a significant difference (*F*[2,20]=3.32, *n.s.*). It suggests that the tangible learning system is effective for college students to understand the phases of the Moon. Meanwhile, there are some students who lack adequate spatial thinking ability. It might be suggested that professors consider how to support their learning.

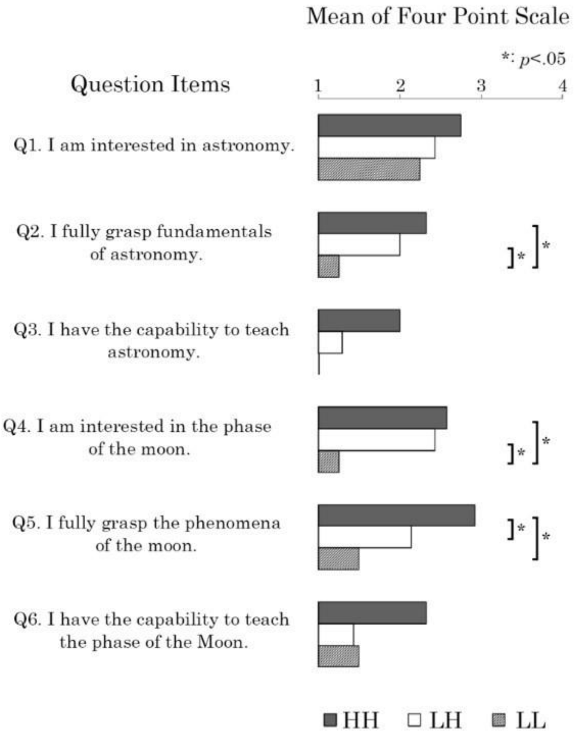

Figure 3. Comparison of Questionnaire items

4. Conclusion

In this research, the tangible learning system was implemented in a college teacher training class for predictive elementary school teachers. The results imply that tangible learning system has a possibility of effectively explaining the phases of the Moon in science teacher training.

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References

Baran, E., Bilici, S. C., Mesutoglu, C., Ocak, C. (2016). Moving STEM beyond Schools: Students' Perceptions about an Out-of-School STEM Education Program. *International Journal of Education in Mathematics, Science and Technology*, *4*(1), 9-19.

Hawes, Z., LeFevre, J., Xu, C., Bruce, C., (2015). Mental Rotation with Tangible Three-Dimensional Objects: A New Measure Sensitive to Developmental Differences in 4- to 8-year-old Children. *Mind, Brain, and Education*, *9*(1), 10-18.

Ishii, H. & Ullmer, B. (1997). Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms, *Proceedings of CHI*, 234-241.

Morita, Y., Setozaki, N., Iwasaki, T. (2010). Development and Evaluation of a Tangible Learning System for Astronomy Education: A Pilot Study. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications*, 3666-3671.

Morita, Y., Setozaki, N. (2012) Practical Evaluation of Tangible Learning System: Lunar Phase Class Case Study. *Proceedings of Society for Information Technology & Teacher Education International Conference*, 3718-3722.

Nussbaum, J., Sharoni-Dagan, N. (1983). Changes in Second Grade Children's Preconceptions about the Earth as a Cosmic Body Resulting from a Short Series of Audio-Tutorial Lessons. *Science Education*, *67*(1), 99-114.

Schneider, B.; Wallace, J.; Blikstein, P.; Pea, R. (2013). Preparing for Future Learning with a Tangible User Interface: The Case of Neuroscience. *IEEE Transactions on Learning Technologies*, *6*(2), 117-129.

Vandenberg, S.G., Kuse, A.R. (1978). Mental Rotations, a Group Test of Three-Dimensional Spatial Visualization. *Perceptual and motor skills*, *47*(2), 599-604.

Vosniadou, S. (1991). Conceptual Development in Astronomy, *The Psychology of Learning Science*, 149-177, LEA.