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Assessment of Interactive Virtual Learning Environment to Observe Non-actual Phenomena through Explorative Activities

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Abstract: The purpose of this study was to assess an Interactive Virtual Learning Environment of Space (IVLES) which was developed to cultivate mental rotation skills in STEM (Science, Technology, Engineering, and Mathematics). In the IVLES, learners can manipulate virtual spheres of the sun, the earth, and the moon, and can observe not only actual phenomena, but also non-actual phenomena of the lunar phases. 16 participants assessed the effectiveness and interface design of IVLES and reported that it might be easy for learners to manipulate virtual objects in the IVLES in STEM classes in middle and high schools.

Keywords: Virtual Learning Environment, Non-actual Phenomena, Explorative Activity, STEM education

1. Introduction

Mental rotation and mental cutting skills are essential in STEM (Science, Technology, Engineering, and Mathematics) subject area. For instance, to imagine the movement of the relative positional relationships of celestial bodies, it is necessary to form a mental model (Tayler et al., 2003; Turk et al., 2016). In the same way, learners need to use a mental model to think about spatial figures in mathematics.

There has been some development of astronomy course materials using computer graphics (CG) simulation and virtual reality (VR) to acquire the mental models. Simulation course materials using CG and VR teaching system presenting 3D images enable learners to observe modified actual phenomena (Morita et al., 2006; Setozaki et al., 2007; Setozaki et al., 2013).

However, the previous studies that formed the basis for celestial body simulations were unable to change the CG model relative positional relationships of the sun, the earth, and the moon. The learners can observe the actual phenomena within the virtual space, but, in many cases, they are unable to interact actively with the CG models.

Therefore, an Interactive Virtual Learning Environment of Space (IVLES) was developed to manipulate CG models interactively, and to observe non-actual phenomena of the lunar phases in various viewpoints to acquiring mental rotation skills (Miyanishi et al. 2018). In this paper, IVLES was assessed effectiveness on exploring learning and interface design, also discussed possibilities to use it in K-12 STEM education.

2. Method

2.1 Interactive Virtual Learning Environment of Space

Figure 1 shows an overview of the IVLES (Miyanishi et al., 2018) which was designed by a game development engine (Unity ver. 2017.2) released by Unity Technologies, and manipulation control functions were implemented using libraries for a head mounted display set (VIVE manufactured by htc Corp.). In the IVLES, learner can observer actual phenomena, for instance, rotation and revolution of the earth and the moon, lunar phases, and solar eclipse. Furthermore, they can grab and move the virtual celestial bodies from actual position to the other non-actual positions. It means the IVLES allows learner's flexible and explorative observations to cultivate mental models.

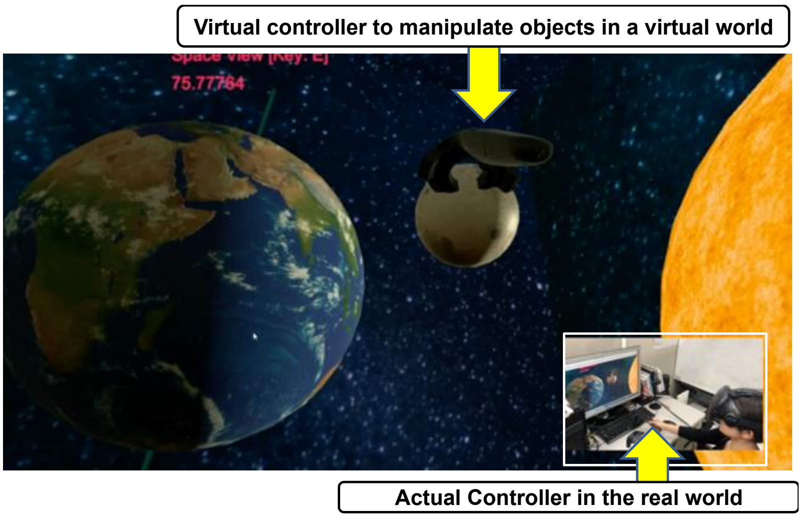

Figure 1. Overview of Interactive Virtual Learning Environment of Space (IVLES)

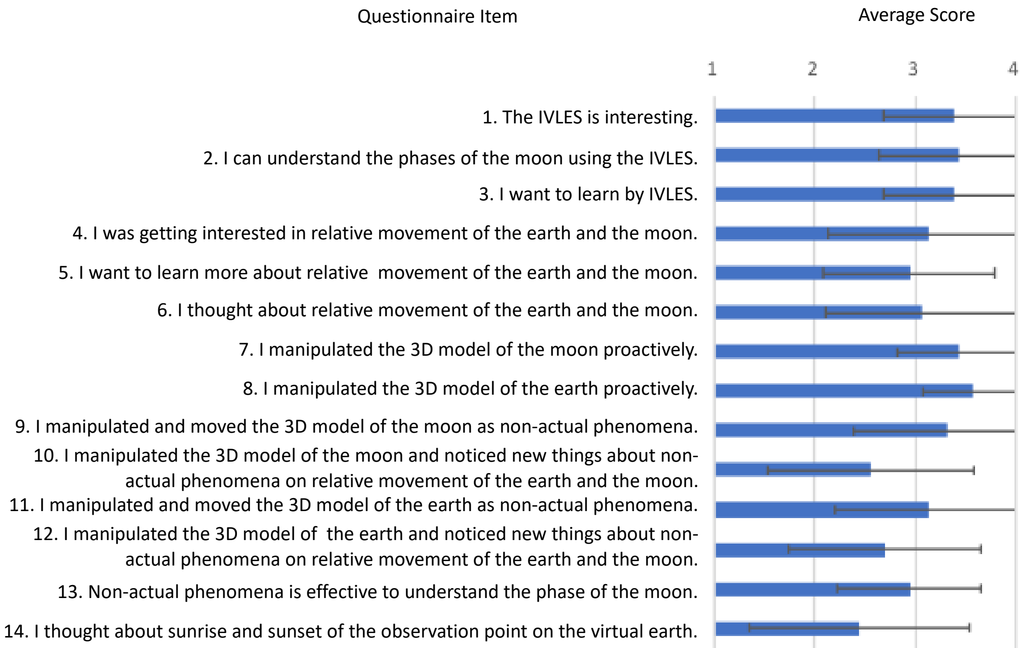

Figure 2. Average scores of each questionnaire item on exploring learning using IVLES

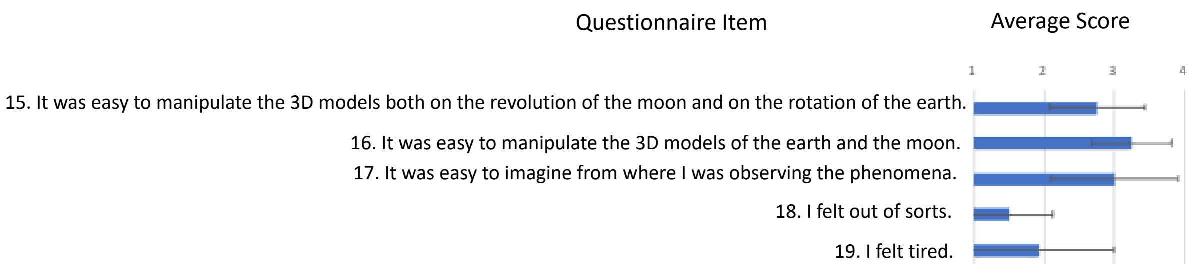

Figure 3. Average scores of each questionnaire item on interface design

2.2 Assessment

16 participants who were in junior and senior university students assessed the IVLES effectiveness on exploring learning and interface design. Each participant manipulated the IVLES for approximately 15 minutes in a seminar room or a classroom, then answered the IVLES by questionnaire including 14 items for exploring learning and five items for interface design. The participants answered each item on the questionnaire using 4-level Likert scale to score as follows: "strongly disagree" was 1, "disagree" was 2, "agree" was 3, and "strongly agree" was 4. The average scores were calculated for each item and compared.

3. Result and Discussion

Figure 2 shows the calculated average scores of each item regarding exploring learning using IVLES. All items scored over intermediate value 2.5, except one question item. It means that there were more than half of participants could move the virtual spheres and observed non-actual phenomena in the virtual environment which allowed learner's exploring activities.

Figure 3 shows the average scores of each item regarding interface design. It means that most of the participants assessed that it might be possible to manipulate the 3D models in the IVLES.

4. Conclusion

This paper reported briefly regarding the virtual learning environment which could support exploring activities to think spatially in STEM subject area. The participants could observe not only actual phenomena of lunar phases, but also non-actual phenomena by manipulating the virtual objects. It might be effective to cultivate mental models, which were essential in STEM subjects, and be possible to use the IVLES in STEM classes in middle and high schools.

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