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Poster

Improvement of VR science teaching materials that visualize invisible elements and Evaluation as a self-study use

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Abstract

Teaching materials using virtual reality (VR) technology are expected to further improve learners' understanding. However, it is assumed that the instructor's engineering knowledge may be insufficient to introduce these materials in the classroom, and that it will take time to educate the instructors. Therefore, we improved VR science teaching materials that visualize electric currents and magnetic fields for self-study at home, and reviewed their self-study use. Experiments were conducted with university students, and we found that our modifications improved usability and VR sickness.

CCS Concepts

• ***Human-centered computing*** $\rightarrow$ ***Virtual reality;***

1. Instructions

The use of VR technology is expected to help achieve these goals and improve learners' comprehension. In particular, in the field of science, there is research on teaching materials for learning electromagnetism using AR [IVD14]. However, to date there are not many examples of the implementation of VR educational systems targeting elementary and secondary education in japan, nor of research on such systems. This is thought to be due to the problem that, when introducing the system in school education, a lack of engineering knowledge on the part of instructors is assumed in the construction of instructional curriculum knowledge and discussion and trainings must therefore be provided [Yam19]. It will take time to educate instructors to improve their engineering knowledge.

In the past, we constructed VR science teaching materials that allowed students to experience experiments visualizing electric currents and magnetic fields, and compared self-study using the VR science teaching materials with self-study using a textbook [FTSC23]. Due to the shorter self-study time, the results of the post-study test were lower on average in the VR science materials group than in the textbook group. In addition, it had low usability and was easy to get VR sickness. In this paper, we report on the results of an experiment conducted on university students using a modified version of these VR science teaching materials, in which the self-study time was extended to twelve minutes.

2. VR science teaching materials

The content that can be studied with these VR science teaching materials is the unit of "electric current and magnetic field" studied in the second year of junior high school in Japan. Figure 1 shows the virtual space of the VR science teaching materials. Until now, it was possible to move within the virtual space by operating the controller, but this movement caused a difference from the body in real space, resulting in VR sickness. Therefore, we redesigned the system so that movement by controller operation is not possible. In addition, to suppress VR sickness, we changed the rotation method of the viewpoint using the controller from guardian-centered to player-centered.

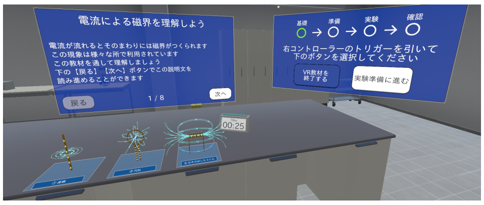

Figure 1: *Virtual space within VR science materials.*

For the purposes of the present experiment, we fixed the self-study time. We added a clock-type object that displays the self-study time for the learner, and we also added a graphical user interface (GUI) to show the progress of the study.

3. Evaluation metrics

3.1. Pre-study test

This test was designed to test the basic knowledge presented in the unit. The test consisted of eight questions to be answered usings

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words and terms, and two questions to be answered with reference to diagrams, for a total of ten questions (one point each, for a total of ten points). The test was administered to reduce bias in the academic ability of the subjects assigned to each group when comparing the scores of the post-study test.

3.2. Post-study test

This test focused on the part of the unit regarding the visualization of invisible elements. The test consisted of ten questions, eight to be answered with reference to diagrams and two to be answered after reading short passages (one point each, for a total of ten points). By comparing the scores of the textbook group and the VR group, we can determine the degree of improvement in understanding and the effectiveness of the VR science materials for self-study.

3.2.1. VR-related questionnaire

The SUS [Bro95] was used to determine the user's feelings about operating VR science materials, and the SSQ [RSKL93] was used to measure the degree of VR sickness. In addition, we presented six statements regarding learning effectiveness and motivation. The statements using a Likert scale from 1 to 5(1 is Poor, 5 is Excellent). we also conducted a questionnaire in which participants freely described impressions they had when they studied by themselves using these materials.

3.3. Experimental Methods

Our subjects were twelve university students two groups of six students each. First, a five-minute pre-study test was administered and the students were assigned to the textbook group or the VR group such that the difference between the groups in average scores on the pre-study test was small. The textbook group carried out a twelve-minute self-study session using a textbook. This was followed by the seven-minute post-study test and the test-related questionnaire. The VR group carried out a twelve-minute self-study session using the VR science teaching materials. After that, they completed the seven-minute post-study test, the test-related questionnaire, and the VR-related questionnaire.

4. Results and discussion

Pre-study test scores were used to assign subjects to the two groups with the least possible difference between mean scores. The mean score of the textbook groups were 7.67, and the VR groups were 7.50. Figure 2 shows the results of the post-study test. Since there was no significant difference between the two groups in the mean score of the post-study test, it can be said that the VR science teaching materials created for this experiment were as effective as the textbook for self-study.

The SUS and SSQ scores of the VR materials before improvement were 60.0 and 47.69, respectively, while they improved to 72.50 and 8.73 after improvement. Indicating that usability was improved, and VR sickness was reduced by our modifications.

Table 1 shows the results of the questionnaire regarding learning effectiveness and motivation. The mean scores for all questions were 3 or higher. In particular, Question 4 was highly rated.

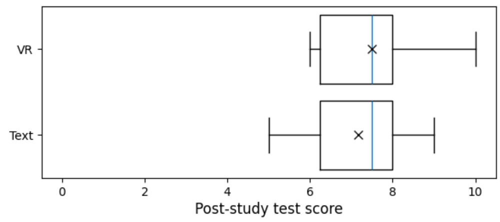

Figure 2: *Results of the post-study test*

Table 1: *Results of the questionnaire regarding learning effectiveness and motivation.*

Statement	1	2	3	4	5	6
Mean	3.67	3.17	3.00	4.17	4.00	4.00

Some subjects answered, "I felt it was easy to understand". It is thought that the visualization of invisible elements facilitates understanding. Some subjects answered that "the weight of the HMD made my glasses shift". Depending on the shape and size of the glasses they usually wear, it may be difficult to wear the HMD. In order to enable the use of VR materials regardless of whether the user wears glasses, it is necessary to develop an application that can work other HMDs.

5. Conclusions

We improved VR science teaching material that visualize invisible elements and conducted an experiment with university students. The VR materials were as effective for learning as self-study using a textbook. Usability was improved and VR sickness was reduced. It is necessary to conduct further experiments to determine whether the positive effects of self-study using the improved VR materials can be obtained by junior high school students.

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