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Basic Research on the Use of XR Technology to Support Science Education

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***Abstract:** As a result of conducting a questionnaire about science classes to high school students in 2016, the percentage of high school students who answered "I like science" and "Science is important" is lower than other subjects. However, more than 80% of elementary and junior high school students said they like experiments and observations. In addition, the 2019 smartphone penetration rate survey found that it is popular among about 90% of students. In addition, VR technology has recently made remarkable progress. From the above, I researched the idea that creating a simulation application using VR technology using smartphones would change the way high school students think about science classes. In this paper, we have developed a simulation application for science experiments. Subjects were asked to experience the newly created app and complete a questionnaire. As a result, the average score is 4 out of 5 and it is not bad. But at the same time, a problem was found. The problem was that this app was a simulation app, so there wasn't much user operability, so I wanted a little more operability. I want to make apps in other fields while improving the problem.*

***Keywords:** Education, science, chemistry, physics, experiment / observation, virtual reality, simulation app.*

I. INTRODUCTION

In the materials related to science surveyed by the Science Working Group in 2016, it was found that the percentage of high school students who answered "I like studying science" and "It is important to study science" is lower than other subjects [1]. However, the percentage of elementary and junior high school students who answered "I like experiments and observations" exceeds 80% [2]. However, not enough science experiments are being conducted. The main reasons for not conducting science experiments are lack of time, equipment, and space for preparation and cleanup [3]. In addition, a survey of smartphone penetration in 2019 showed that about 90% of students have one [4]. Most schools have PC classrooms. In addition, each classroom is equipped with a computer for teachers. Under these circumstances, it is believed that the educational effects can be further enhanced in various classes.

In light of the above, the purpose of this research is to contribute to education by creating a science simulation application using VR technology to solve the current situation where science experiments are not sufficiently conducted.

Fig. 1. Example of an English conversation learning app that supports VR [5].

II. PHYSICS EXPERIMENT APP

In this study, we attempted to simulate the physics of "projectile motion" and "falling body motion".

In the initial state, the selection screen shown in the figure below is displayed, and by selecting a button object, you can move to the "Projectile Motion" and "Falling Body Motion" screens. After transitioning to each screen, the screen transition to the selection screen is made by selecting "Return to Selection Screen".

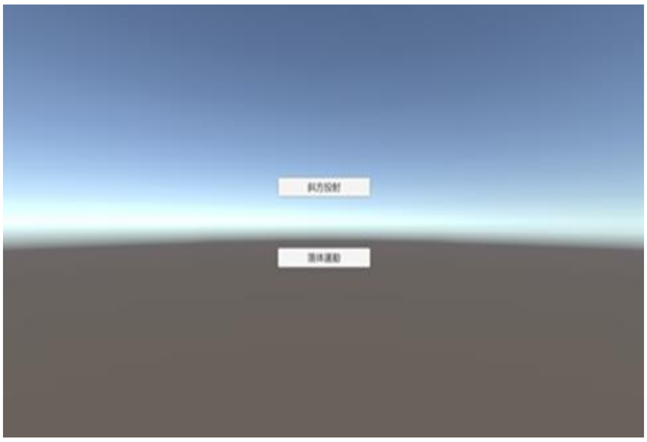

Fig. 2. The start screen I created.

Since these experiments require large experimental tools and it is sometimes difficult to obtain accurate values, we thought it would be suitable to conduct them in a virtual environment.

A. Development environment

This survey was conducted in the environment shown in Table-I.

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Table- Ⅰ : Development environment

operating system	Windows10
Programming language	C#
software	Unity 2019.2.15f1

B. Projectile motion

Projectile motion moves from the initial position. After deciding the angle and speed and pressing Start Button, the object will be fired and the distance will be displayed. If it is difficult to check the current situation, you can zoom in and out on the ball with the zoom below.

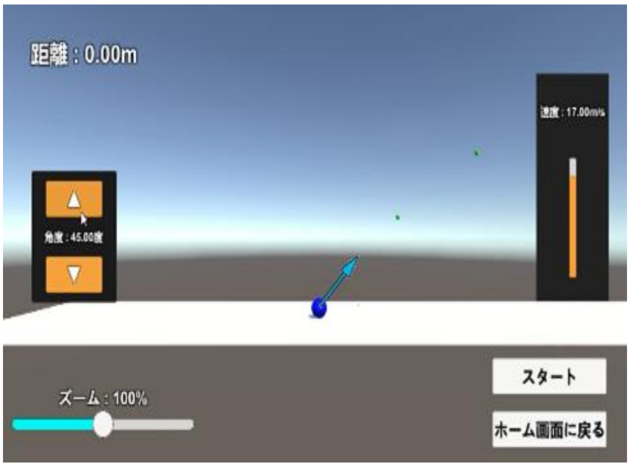

Fig. 3. Created projectile motion app.

C. Falling exercise

I made a slope that controls the falling speed by rolling the ball while changing the angle of the slope. Determine the angle of tilt and press Start to start spinning the sphere. The tilt angle, ball speed, and ball position are displayed.

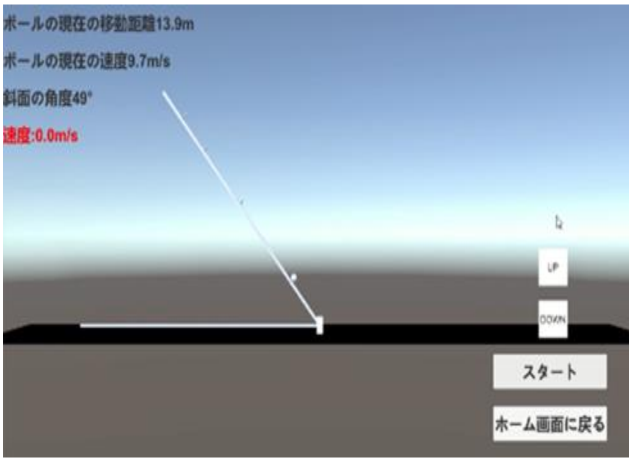

Fig. 4. Created falling exercise app.

III. CHEMISTRY EXPERIMENT APP

In this study, we tried to create a prototype chemical experiment simulation of the "flame color reaction" and the "silver mirror reaction".

In the initial state, the selection screen shown below is displayed, and by selecting the button object, you can move to the "Flame Color Reaction" and "Silver Mirror Reaction" screens. After moving to each screen, selecting "Back" will move the screen to the previous screen.

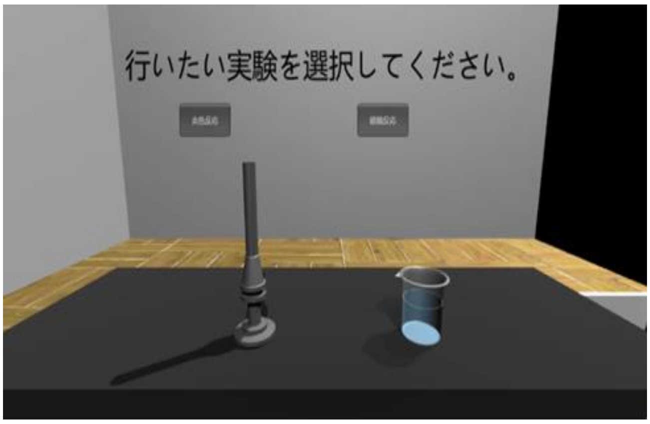

Fig. 5. The start screen I created.

These experiments require a lot of solutions and experimental tools, which can be difficult to prepare and clean up, and the experiments take a long time, so we thought this would be a good solution to the lack of class time.

A. Development environment

This survey was conducted in the environment shown in Table-II.

Table- Ⅱ : Development environment.

operating system	Windows10
Programming language	C#
software	Unity 2019.2.15f1
	Blender 2.81

B. Flame color reaction

First, select an aqueous solution. There are seven types of aqueous solutions. From left to right: lithium chloride solution, sodium chloride solution, potassium chloride solution, calcium chloride solution, strontium chloride solution, barium chloride solution, and copper (II) chloride solution.

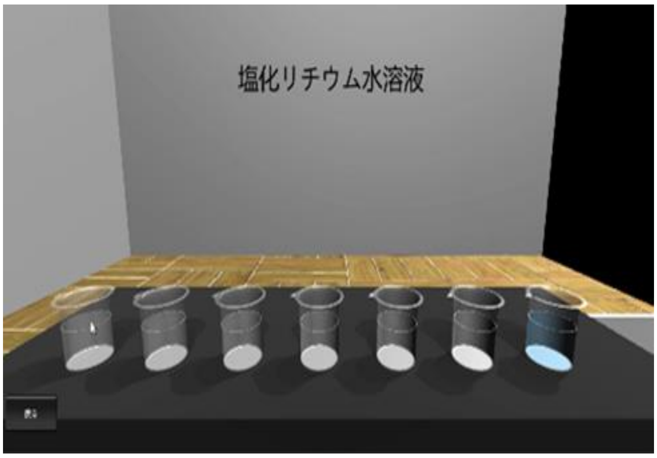

Fig. 6. Created flame color reaction app.

When you select an aqueous solution, a flame color reaction occurs. Lithium chloride aqueous solution is red, sodium chloride aqueous solution is yellow, potassium chloride aqueous solution is purple, calcium chloride aqueous solution is orange, strontium chloride aqueous solution is beni, barium chloride aqueous solution is yellowish green, and copper(II) chloride aqueous solution is green.

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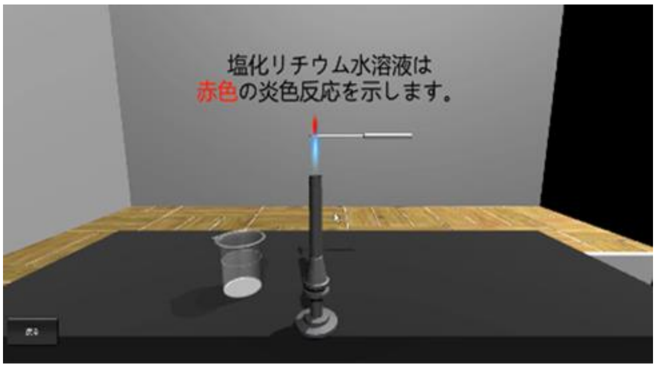

Fig. 7. Created flame color reaction app.

C. Silver mirror reaction

The process of silver precipitation is shown with the chemical reaction equation.

Fig. 8. The first stage of the application of the silver mirror reaction that I made.

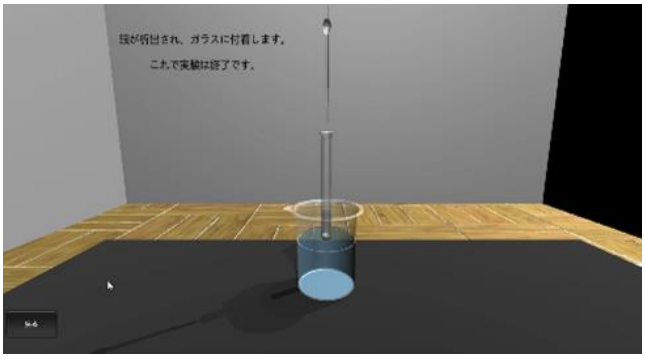

Fig. 9. The final stage of the application of the silver mirror reaction made.

IV. EVALUATION EXPERIMENT

An evaluation experiment was conducted to verify whether the developed science experiment simulation app was useful. We conducted a questionnaire to 10 people, including students in the laboratory, and evaluated the usefulness and usability of the system. The contents of the questionnaire are the following four points.

Evaluation item 1: Was it easy to operate?

Evaluation item 2: Was the result of the experiment easy to understand?

Evaluation item 3: Was it easy to imagine a physical phenomenon?

Evaluation item 4: Opinions and points to be improved (free description)

Evaluation items 1 to 3 will be evaluated on a scale of 1 to 5 points, and evaluation item 4 will be freely described.

A. Experimental result

The average of the evaluation results for evaluation items 1 to 3 is shown in the figure.

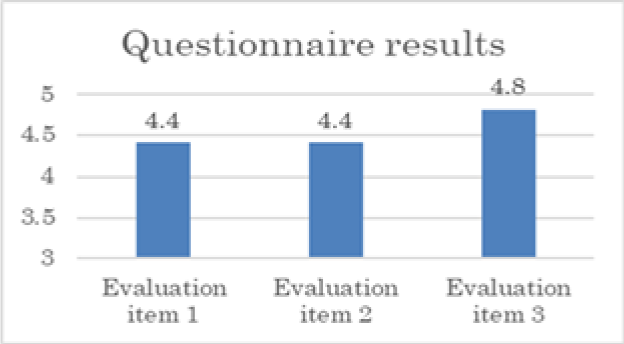

Fig. 10. Questionnaire average score.

The average score of 4.4 was obtained for the evaluation items 1: Was it easy to operate? and 2: Was the result of the experiment easy to understand? from this result, we can say that the application is easy for anyone to use.

For the third question, " Was it easy to imagine a physical phenomenon?", the average score was 4.8. From this result, we can say that it is easy to visualize the phenomena in science. In response to evaluation item 4, " Opinions and points to be improved (free description)", the following comments were given as good points: "It was good that the sound showed that the gravitational acceleration is constant in the vertical direction," and "It was easy to understand the trajectory of the sphere. On the other hand, the following comments were made as "improvements": "It would be easier to understand the difference between the new object and the previous one if the distance of the previous object is displayed," "It would be easier to operate if the speed and angle can be input by the experimenter," "It would be easier to understand if the trajectory of the ball is connected with a line," and "It would be easier to understand how far the object actually flew if there is a memory in the background.

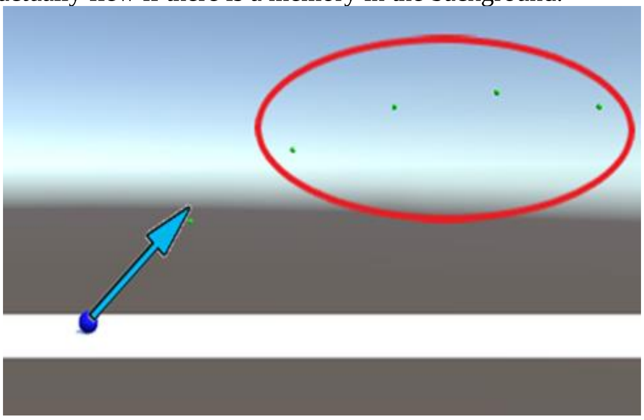

Fig. 11. Examples of questionnaire improvement points.

V. CONSIDERATION

We asked five people to help us evaluate the application through a questionnaire, and the results show that the application was useful. The results show that the app is useful, but there are a few things that could be improved.

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First of all, the distance measurement was done when the object was completely stopped. However, the problem of oblique projection in high school physics often involves finding the distance to the part of the object that lands on the ground, so I think we need to devise a way to make a physics experiment simulation application that is closer to the kind of material that students actually use on a regular basis. Regarding evaluation item 4, there were many opinions about the expansion of functions. Extension to VR was also mentioned as an extension of the function. With regard to expansion to VR, effects such as immersive feeling and easy image of physical phenomena can be expected. However, since VR-specific equipment is required, I think we must devise ways to make it easy for anyone to use.

VI. FUTURE TASKS

If we can create a simulation app that is similar to the teaching materials that students usually handle, we can support education not only in science but also in various subjects. Also, before creating an app, you need to think about what kind of app can support student education. This time, it could not be expanded to VR. If it is possible to expand to VR, it will be possible to realize a more immersive feeling by actually expressing the sound and science room during the experiment, so this is a future issue.

VII. CONCLUSION

As mentioned at the beginning, VR technology has grown remarkably in recent years. In this research, we tried to create an application that can perform science experiments using virtual reality, but as mentioned in future tasks, special equipment is required to reproduce VR. It has become a trial of only CG images. However, from the results of the evaluation experiment, it was found that a useful application was created. Ultimately, I think it is to create a system that will help support education.

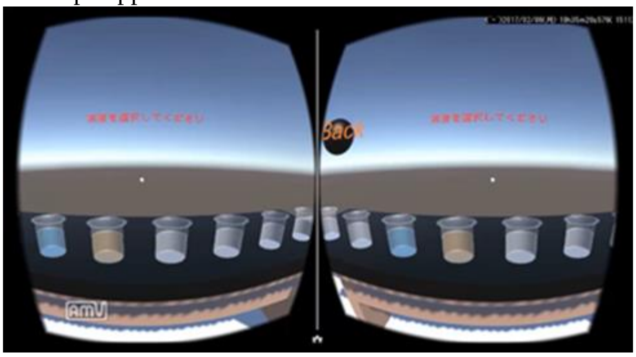

Fig. 12. Extension to VR.

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