

Development of a plant growing experience application for physically challenged children using VR

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Abstract

In 2016, the “first year of VR,” many VR platforms emerged, making VR technology more accessible. Currently, technology is expected to be applied and utilized in various fields. Application to the education sector is being promoted as part of the educational use of ICT. However, it is difficult to get the benefits of implementing VR due to lack of technology and equipment for teachers. Therefore, it is necessary to limit the scope of coverage. This research will focus on limb-challenged children and develop a VR application that allows them to experience plant growing. We believe that this will solve the problems that have been a concern for children with physical disabilities, such as the inability to perform exercises using soil and the lack of opportunities for trial-and-error. In this study, we also asked men and women in their teens to 40s to experience the apps we developed and obtained their evaluations through questionnaires. Within the survey, we received certain evaluations in areas such as trial and error. As for future issues, the application will be improved based on the feedback received from the survey. In addition, we believe it is necessary to evaluate the long-term effects of the application by having children with physical disabilities use it.

Keywords: VR, physically handicapped child, education, plant breeding

1. Introduction

1.1. What is a physically challenged child?

The term “physically handicapped children” refers to “children who are born or born with impairments, or who have motor disabilities in their hands, feet, or spine due to illness or accident at an early age” [1].

According to the Ministry of Health, Labor and Welfare, there were 50,100 physically handicapped children in Japan in 2006[2]. In the Children's Charter established by the Ministry of Education, Culture, Sports, Science and Technology, it is stated that “every child shall be given the protection of proper treatment and education in case of physical incapacity or inadequate mental functioning.

1.2. Background

Many physically handicapped children spend time in hospitals. This makes it difficult for them to participate in out-of-school learning and experiential learning. In addition, when students go on field trips or experience learning, teachers and others around them help them to experience success because it is a valuable opportunity, and as a result, there are few opportunities for them to make mistakes and trial-and-error experiences. Other problems include the difficulty of long-term experiential learning due to physical condition and other issues, and the limited activities that can be experienced because of the hospitalization. The impact of these problems has made it difficult to achieve the Children's Charter established by the Ministry of Education, Culture, Sports, Science and Technology. In this study, we will develop a VR application that can simulate off-campus learning,

which is difficult to do in hospitals, in order to solve the above problems.

1.3. Virtual Reality (VR)

VR is a technology that creates a virtual environment on a computer and gives the illusion of an actual experience. In 2016, VR equipment became more readily available to the public, and it has been called the “first year of VR”. VR technology is expected to play an active role in the field of education. Examples of actual use of VR technology in the field of education will be presented.

1.3.1. Google for education

A comprehensive solution offered by Google Inc. for educational institutions that, with the Expeditions app and a head-mounted display (HMD), allows students to experience natural phenomena and other experiences while in the classroom.

1.3.2. Science experiment simulation application [3]

This application allows users to simulate four fields: “oblique projection,” “how to use a gas burner,” “the moon and the sun,” and “all-sky planetarium. Experiments on events that are difficult to conduct with large experimental equipment or experiments can be conducted in a virtual environment.

2. Methodology

2.1. Development environment

The applications developed in this study were developed in the environment shown in Table 1.

Table 1 Development environment

OS	Windows 10 Pro
Unity	2021.3.0f1
VR Devices	Meta Quest 2
CG Model Creation	Blender 3.1.2

2.2. Prior research

In order to understand what functions are actually needed in the development process, we conducted a survey of teachers working at Kiyotake Seiryu Support School.

The following issues were identified within the research.

- Practical training using soil and other materials is not possible due to the long time spent in the hospital.
- During the training, there is a lot of help, and the individual is not able to experience trial-and-error.
- Difficulty in conducting long-term practical training

2.3. Preliminary experiment

In addition to the problems identified in the preliminary survey, a VR trial session was held as a preliminary experiment for students enrolled in the Kiyotake Seiryu Support School in order to confirm the problems when the target students use the system.

The following problems were identified as a result of the implementation.

- Difficult to perform complex operations
- Difficulty in securing VR equipment to the head

2.4. Development objectives

The application to be developed in this study will implement the following functions to solve the problems identified in the preliminary survey and preliminary experiments.

- Plant growth status changes depending on the behavior of the experimenter.
- Short experience and can quickly move on to the next experience.
- Simple operation, no need to move the body significantly

2.5. VR application

The newly developed application allows users to experience growing mini tomatoes. The experience can be divided into four growing stages, and the growing stage changes depending on the actions taken. The following is a summary of each stage of development and the actions that can be taken. In all phases, a condition is imposed that the water be done once or twice. Other conditions exist for each stage. A start screen is displayed at the beginning of each stage, and a failure screen is displayed when a failure occurs.

2.5.1. Growing stage

2.5.1.1. Seeding period

The stage of sowing mini-tomato seeds. Failure will occur if the condition is not achieved. An additional condition is that the seeds must be sown (Fig 1).

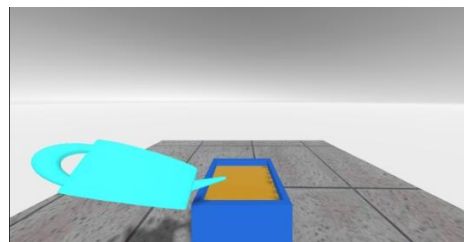


Fig 1 Seeding period

2.5.1.2. Germination period

The stage when mini tomatoes have germinated (Table 2). Failure occurs when conditions are not met. The stage of growth that is transferred changes depending on the percentage of weeds remaining (Fig 2).

Table 2 Germination period transition destination

watering	Weed cutting	Transition Destination
1~2	pull out everything	highest growth period
1~2	pull out a little	middle growth period
1~2	Not pulling out at all.	least growth period
0,3~	All conditions	failure

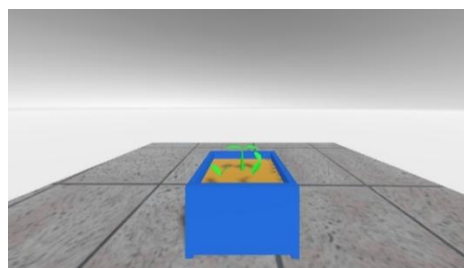


Fig 2 Germination period

2.5.1.3. Growth period

The stage in which mini tomatoes grow and flowers. It is divided into three stages depending on its behavior during the germination stage.

2.5.1.3.1. Highest growth period

The stage of greatest growth during the growth phase (Table 3). Failure to achieve the conditions will result in failure. The growth stage to be transitioned changes depending on the percentage of weeds remaining (Fig 3).

Table 3 Highest growth period transition destination

watering	Weed cutting	Transition Destination
1~2	pull out everything	highest harvesting period
1~2	pull out a little	middle harvesting period
1~2	Not pulling out at all.	least harvesting period
0,3~	All conditions	failure



Fig 3 Highest growth period

2.5.1.3.2. Middle growth period

The second largest growth stage in the growing season. Failure occurs if the conditions are not met or if all the weeds remain unexcluded. The percentage of weeds remaining changes the stage of growth to which the weeds are transferred (Table 4).

Table 4 Middle growth period transition destination

watering	Weed cutting	Transition Destination
1~2	pull out everything	middle harvesting period
1~2	pull out a little	least harvesting period
1~2	Not pulling out at all.	Failure
0,3~	All conditions	Failure

2.5.1.3.3. Least growth period

The smallest growing stage of the growing season. Failure occurs when conditions are not achieved or weeds remain (Table 5).

Table 5 Least growth period transition destination

watering	Weed cutting	Transition Destination
1~2	pull out everything	least harvesting period
1~2	Not pulling out at all. pull out a little	Failure
0,3~	All conditions	Failure

2.5.1.4. Harvesting period

The stage at which mini tomatoes have grown and are ready to be harvested. The number of mini tomatoes that can be harvested varies depending on the stage of growth (Table 6, Fig 4).

Table 6 Harvesting period transition destination

growth stage	Number of harvestable
Highest	10
Middle	5
Least	3

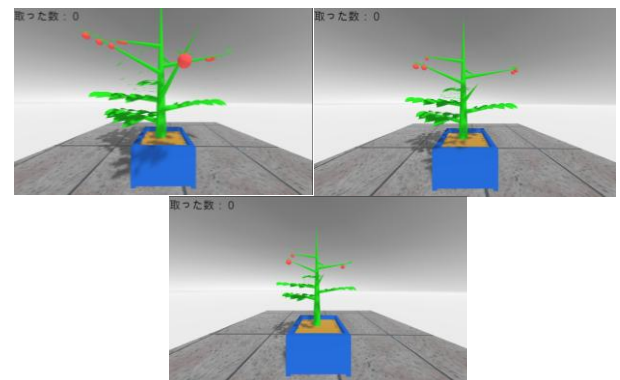


Fig 4 Germination period (upper right: highest, upper left: middle, under: least)

2.5.2. Method of operation

Actions in the application are performed with the controller that comes with Meta Quest2. All operations are performed with buttons, and the tilt function and other functions of the controller are not used.

3. Evaluation experiment

To confirm the effectiveness of the application developed this time, an evaluation experiment was conducted with men and women in their teens to 40s.

After the two trials, the subjects were asked to answer a questionnaire to evaluate the effectiveness of the application.

3.1. Questionnaire content

The questionnaire has eight items, and in addition to age and gender, the respondents are asked to answer on a five-point scale about the feeling of operation (i), whether it was enjoyable (ii), whether it could be considered an alternative to the experience of growing mini-tomatoes (iii), and screen sickness (iv). They were also asked to respond to the results of the first and second growing experience.

3.2. experimental results

We asked 19 men and women, ranging in age from under 10 to 40, to use the application and answer a questionnaire (Table 7).

Table 7 Questionnaire results

age	sex	i	ii	iii	iv	1st	2nd
20	M	4	4	5	2	0	10
10	M	3	3	2	5	0	0
40	M	2	2	2	5	0	3
20	M	2	4	2	5	0	5
20	M	5	2	3	4	0	0
20	M	4	4	4	5	0	0
U10	W	5	5	5	3	0	10
10	M	3	5	5	5	0	3
U10	M	2	5	5	5	5	10
U10	W	2	5	5	5	5	10
10	W	5	5	5	5	0	10
10	W	5	5	5	5	0	3
10	M	4	5	3	5	0	3
U10	W	5	5	5	3	0	3
20	M	5	5	5	5	10	10
10	M	2	4	1	4	0	10
10	M	4	5	2	5	0	10
10	M	4	5	5	5	0	10
20	M	3	4	3	5	0	10

4. Consideration

The results of the second run were better than the results of the first run for all ages. Question 3, which asked whether the program would be a substitute for the actual mini tomato growing experience, also received many favorable responses. Based on the above, we believe it is possible to develop an application that meets the objectives.

5. Conclusion

In this study, a plant growing experience application was developed with the goal of providing educational

support to children with physical disabilities. Based on the results of the questionnaire, we believe that the goal was achieved. As a future issue, it is necessary to investigate the long-term effect of the art collection using limb-challenged children as subjects.

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References

1. Japanese Association for the Physically Handicapped. <https://www.nishikyoo.or.jp/about/index.html>
2. Cabinet Office “white paper on disability Appendix 8 Number of children and persons with disabilities 2013 Edition https://www8.cao.go.jp/shougai/whitepaper/h25hakusho/zenbun/furoku_08.html
3. Kouta Miyamoto, バーチャル技術による小学生向け教育支援に関する基礎的研究, 2022 <https://cir.nii.ac.jp/crid/1050015520409327616>

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