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Paper:

Experience-Based Training in Earthquake Evacuation for School Teachers

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This study proposes experience-based training in evacuation due to earthquakes for school teachers. The purpose is for school teachers to develop their practical disaster response capabilities to save lives. Although disaster reduction education is important, conventional disaster reduction education in schools in Japan has been delivered in accordance with procedures from the education manual for disaster reduction. Conventional education materials may provide knowledge and skills in disaster reduction, but in order to take appropriate action as a disaster unfolds, it is important to develop practical capabilities by using the knowledge and skills acquired. In this study, we propose a method of training aimed at developing practical disaster response capabilities. We propose experience-based evacuation training to raise the response capabilities of school teachers. The proposed method employs a training simulator that reproduces disaster situations through a mixture of real and virtual space. An example of the training is provided to demonstrate its usefulness and that of the training simulator.

Keywords: training system, virtual reality, disaster reduction education, school disaster reduction, earthquake

1. Introduction

The Great East Japan Earthquake caused large-scale damage across a wide area. The disaster unfolded in an unexpected way, and many children, teachers, parents, and local residents died [1]. About 40% schools reported that the disaster was beyond what they had prepared for and school organizations did not function effectively [2]. The main reasons for this were that teachers themselves were injured, teachers were not able to communicate with each other, and incidents occurred that were outside the scope of the manual.

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has reconsidered disaster risk reduction education and disaster prevention management in school since the Great East Japan Earthquake [3]. Each school proactively implemented disaster measures. In terms of structural measures, the earthquake resistance rate in elementary and junior high schools increased from 73.3% in 2011 to 95.6% in 2015 [4]. In terms of non-structural measures, in March 2012, MEXT published its School Disaster Prevention Manual Creation Guide (Earthquake and Tsunami Disaster) [5], which included lessons learned from the Great East Japan Earthquake.

These disaster prevention measures may help to reduce the damage incurred in future disasters. However, even if disaster prevention measures are enhanced, unexpected situations may arise. In order to take appropriate actions during a disaster, it is important to develop practical disaster response capabilities that use acquired knowledge and skills. Teachers need to be trained in disaster response capabilities, including the ability to predict what might happen, make quick decisions, and act immediately.

In this study, in order for people to gain practical capabilities, we propose experience-based evacuation training that can enable trainees to experience the sequence of actions to be taken during a disaster. The proposed training employs a training simulator [6] that reproduces disaster situations through a mixture of real and virtual space. In our course, trainees experience various disaster situations and learn through making physical responses. We have developed an initial earthquake response and secondary evacuation training course for school teachers. We present examples of lessons to demonstrate the training simulator and discuss the usefulness of our experience-based evacuation training.

2. Current Issues in Disaster Risk Reduction Education

2.1. Disaster Risk Reduction Education in Schools

Disaster reduction experts have noted that promoting the ability of students themselves to predict and avoid risks in times of disaster is an important part of disaster prevention education [3]. Guidelines for educating teachers did not list, however, that teachers have to acquire similar abilities. In a disaster, teachers need to properly judge the situation, give appropriate instructions, and take

measures to ensure the safety of students. Therefore, it is necessary to improve teacher quality by enhancing their training.

However, conventional disaster reduction education in schools in Japan has been delivered in accordance with procedures from the disaster reduction education manual. Although conventional education materials provide disaster reduction knowledge and skills, they do not provide guidelines for the development of practical response capabilities during disasters. For example, the evacuation drills practiced in many schools proceed as follows. An earthquake occurs during the class, the students hide under their desks, and then the students gather in the schoolyard, which is the evacuation place. Unexpected situations do not occur in evacuation drills. Therefore, the teachers and students do not acquire the ability to respond in unexpected situations.

Hada et al. [7] have mentioned the problem of conventional evacuation drills as well. They have pointed out that conventional evacuation drills focus on ensuring the safety of students through basic behavior patterns. This type of training does not cause any failures, and it does not lead to any new awareness, either. To promote proactive attitudes that would lead to the prediction and avoidance of risks, Hada et al. [7] have proposed using the earthquake early warning system to provoke unannounced emergency evacuation drills.

Boards of Education in Japan have conducted disaster reduction leadership training programs for school teachers; however, as these training programs are largely lectures and workshops led by disaster prevention experts, they involve mostly passive learning, so the teachers do not acquire any practical capabilities. Furthermore, most disaster evacuation training programs are conducted in accordance with procedures contained in the manual. Although conventional education may be useful in terms of acquiring disaster reduction knowledge and skills, it does not develop practical disaster response capabilities.

In this study, we propose training that is aimed at the acquisition of response capabilities and that uses a computer system. Our approach is different from in Hada et al. [7] devising actual disaster prevention drills.

2.2. Related Work

2.2.1. Disaster Reduction Education Materials

Japan has experienced many disasters, and various disaster reduction education programs and materials have been developed in response to the lessons learned in these disasters [8]. For example, many disaster reduction centers operating in prefectural administrations in Japan provide experience-based study facilities, such as earthquake experiences using earthquake simulation vehicles, storm experiences, or smoke evacuation experiences. Better disaster reduction plans and the actions of active local groups, schools, and individuals can be found on the website of the Disaster Management Education Challenge Plan (DMECP) [9]. It is easy to reference disaster programs to launch further educational work.

In the research field, Nouchi et al. [10] have developed game-books for children. The stories in the game-books promote decision making in disaster situations. Nouchi et al. [11] have developed pocket notebooks and quizzes for elementary school students to study earthquake disasters. They have demonstrated that their materials significantly improve risk cognition, protective actions, and preventative actions in disaster situations.

Almost all previous disaster reduction education programs were designed to raise disaster reduction awareness. Our study developed a learning environment that would improve practical response capabilities in preparation for disasters. However, there are few existing teaching materials for teachers. Our training has teachers as its main target.

2.2.2. Computer-Based Disaster Reduction Education

In previous studies, computer-based simulations have been actively used in disaster reduction education. For example, Kuwasawa et al. [12] have developed a tsunami disaster scenario simulator to support the tsunami evacuation of local residents. This simulator displays residents' activities during a tsunami disaster on a computer-display map. A user of this system can examine and create effective disaster prevention measures.

Recently, virtual reality (VR) techniques have been used in education and training [13]. Tsubota and Ohno [14] have developed a portable VR system and conducted earthquake disaster prevention training. This system, employing three sets of projectors and screens 6.0 m wide and 1.8 m high, can present a real-time simulation of what occurs in an earthquake. Gong et al. [15] have developed an earthquake drill simulation system based on VR and using a head-mounted display and body motion sensor, Kinect. These systems can be utilized as disaster visualization tools. Disaster reduction education increases the awareness of disaster reduction and risk perception. Kawai et al. [16] have developed a tsunami evacuation drill system. They have used augmented reality (AR) and smart glasses to improve the visual reality.

In previous studies, our training simulator used VR techniques to easily represent a disaster situation. In addition, unlike in a conventional disaster reduction education system, the aim of our training program is for the trainees to acquire response capabilities through their own physical movements in disaster situations reproduced through VR techniques.

Training to improve practical capabilities has been developed for the medical field. Lapland University in Finland has developed a Virtual Center of Wellness Campus, "ENVI" [17], which is a virtual and simulation-based learning environment that can simulate practical health and social care situations. The basic concept of our training simulator references the concept of ENVI but targets school teachers as opposed to health and social care personnel.

3. Training Simulator for the Reproduction of Disaster Situations

3.1. The Concept of a Training Simulator

In this study, we develop an experience-based evacuation training program that enables the trainees to experience the sequence of actions to take during a disaster. Conventional disaster reduction education focuses on knowledge and skills related to disasters. However, to respond to disasters, knowledge and skills are not sufficient; the ability to respond when facing a disaster by utilizing learned knowledge and skills is also required. The training simulator promotes one's ability to respond by reproducing disaster situations through a mixture of real and virtual space. The concept of the training simulator has three main aims:

1) The trainee gets a sense of how disasters really unfold.

2) The trainee experiences situation prediction, decision-making, and physical movement.

3) The trainee can repeatedly experience a situation in order to learn to make better decisions.

These three requirements are described in detail below.

3.1.1. A Sense of How Disasters Really Unfold

Actual evacuation training in schools enhances the sense of disaster realism by using various real-life props. Specifically, the sound of an earthquake is played through a school's public address system, individuals play the role of injured persons, and smoke-generating equipment is used to simulate a fire. However, this takes time to prepare and money for supplies. Furthermore, certain situations are difficult to reproduce, such as the shaking of a building in an earthquake or a seriously injured child.

The training simulator can reproduce disaster situations by mixing the real and virtual world. The training simulator presents a disaster environment through VR images projected on large screens, and it combines these images with objects such as school tables, chairs, and textbooks. Although a head-mounted display can be used to enhance realism when VR is used, the training simulator uses real objects, such as desks to hide teachers and children, and doors that open in an evacuation. We selected this configuration because we think that the trainee's physical response is important to the effective development of disaster response capabilities.

3.1.2. Situation Prediction, Decision Making and Physical Movement

Evacuation training conducted at school is intended to confirm whether children can act according to a predetermined training scenario, so unexpected situations are not presented. However, actual disasters do not progress in the same way as expected scenarios. For example, a student may be injured during an evacuation, or the primary evacuation area may not be available for use due to liquefaction. When faced with unexpected situations, teachers must deal with them. They must acquire the disaster response ability to make correct judgments using only the information available, make quick decisions, and act immediately.

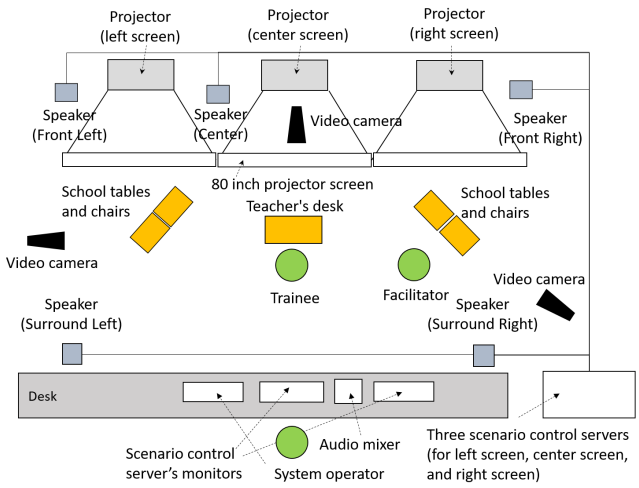

Fig. 1. Configuration of the training system.

Training that employs various unexpected situations and where optimal actions must be selected serves to develop these abilities. The training simulator presents a dynamic branching training scenario according to the behavior of the trainee. The trainee experiences motion physically while watching disaster situations projected on screens. Changing the scenes according to the behavior of the trainee can strengthen the judgment and the response of the trainee.

3.1.3. Repeatedly Experiencing a Situation

Repeated training is necessary to improve and maintain an individual's ability to respond. If training is conducted using the same training scenario, the trainee is able to predict the next situation, so it may not be an effective tool for improving and maintaining response capability. To train for practical response capability, trainees must experience a variety of situations. Therefore, it must be possible to add and update training scenarios easily.

The training simulator includes a feature that enables a training scenario to be updated easily. A new realization obtained through training can lead to the creation of a new training scenario. These functions amount to the continuous management of the system.

3.2. Configuration of the Training Simulator

The training simulator was developed to realize the concept presented in section 3.1. The configuration of the training simulator is demonstrated in **Fig. 1**. The simulator is installed in a room 8 m wide and 6 m long. It is comprised of three screens each 80 inches wide (W: 1,628 mm $\times$ H: 1,220 mm), 5.1 channel surround sound, real-life props (such as textbooks, school tables and chairs, and the

Fig. 2. Overview of the training system.

door of the classroom), and scenario control servers. The three screens are arranged side by side. To enhance the immersion training, a dark curtain covers the perimeter of the room, and the interior lighting is darkened.

Scenario control servers control the playing and alternation of images projected on screens. The training simulator can show photographs, video, and VR. The scenario control server in the center screen shows images that synchronize with other servers.

An operator and a facilitator support the progress of the training. The operator manages the progress of the training by operating the scenario control servers and the volume of environmental sounds using an audio mixer. The operator observes the trainee and alters the scene in response to the trainee's behavior. It is possible to produce a range of unexpected situations by altering scenes in response to trainee behavior. The facilitator helps the trainee feel the reality of the training. Trainees experience disasters and learn physical responses. If the trainee does not actively move, the facilitator assists the trainee by explaining the situation.

Figure 2 shows the classroom as appears from the position of the teacher. A teacher's desk and student desks and chairs are placed in front of the screen. The training system reproduces disaster situations through a virtual image on the screen and real props. The purpose of this training system is for trainees to experience disasters and learn to move around in response. Disaster situations are reproduced using not only computer images but also real-life props, such as the teacher's desk and textbooks.

4. Development of an Evacuation Training Scenario for School Teachers

4.1. Composition of Training Scenario

The training simulator scenario is made up of flowchart forms. The operator observes the trainee's behavior and selects a scene from a flowchart branch. Each scene has a photograph, a video, and VR. The VR scene is composed of five text-based setting files. The VR image can be altered by editing portions of the setting files using the text editor. The placement and movement of 3D objects in scenes can be edited in a few hours using basic computer skills.

Table 1. Outline of the initial earthquake response training scenario.

Training Purpose	a) To find the places where things are not coming down or falling in the classroom b) To protect students in the classroom c) To evacuate students to the evacuation place
Training Goal	a) To predict the action needed after an earthquake occurs b) To act immediately on this prediction c) To give students appropriate instructions
Training Main Target	School teacher (a class teacher at an elementary school)
Training Main Target	A trainee is a second grade class teacher of 32 children (16 boys and 16 girls). An earthquake occurred on a winter afternoon. The trainee has to protect both themselves and the students from danger The trainee has to effectively and efficiently lead students to the evacuation station in the schoolyard.

4.2. Initial Earthquake Response Training Scenario

The training simulator presents disaster situations according to trainee actions. The operator observes the action of the training experience and selects a scene from the flowchart branch. To implement this dynamically changing scenario, scenes of response actions of the trainee are created in advance. A scene is created with a change in situation as a unit. The scene includes feedback not only on the passage of time but also on the trainee's behaviors and remarks. A training flowchart combining these scenes is created.

For this study, an initial earthquake response training scenario was created to develop school teachers' response capacities. The outline of the training scenario is shown in **Table 1**. The procedure for developing a training scenario is outlined below.

First, the basic scenario referencing conventional evacuation training was developed. Specifically, in this scenario, a teacher and children evacuate from a classroom to the schoolyard after an earthquake. The scenario was developed using examples from the School Disaster Prevention Manual Creation Guide (Earthquake and Tsunami Disaster) [5] and reports of the Great East Japan Earthquake. Next, we conducted interviews with disaster prevention experts to add unexpected events designed to be checkpoints in the evacuation training [18]. The specific contents of which are shown below.

- Does the teacher instruct the children to hold the legs of the desk when the children get under their desks?
- Does the teacher secure an escape exit?

In addition, there are several alternatives that determine the difficulty of the scenario. A scenario flowchart is

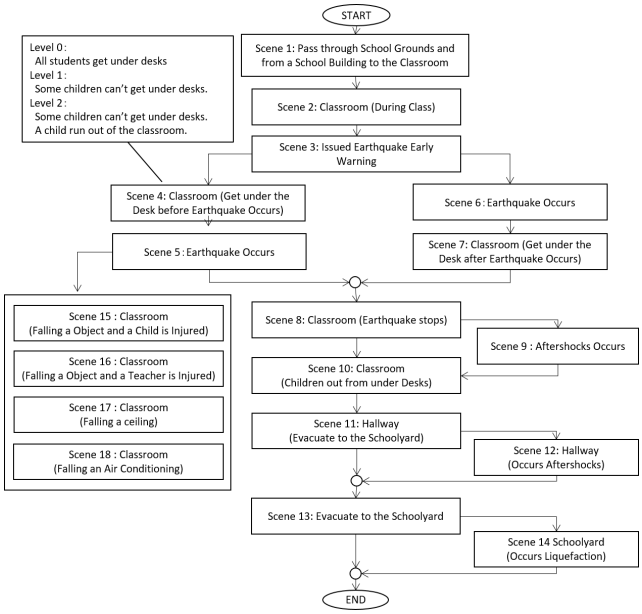

Fig. 3. Flowchart overview of the initial earthquake response training scenario.

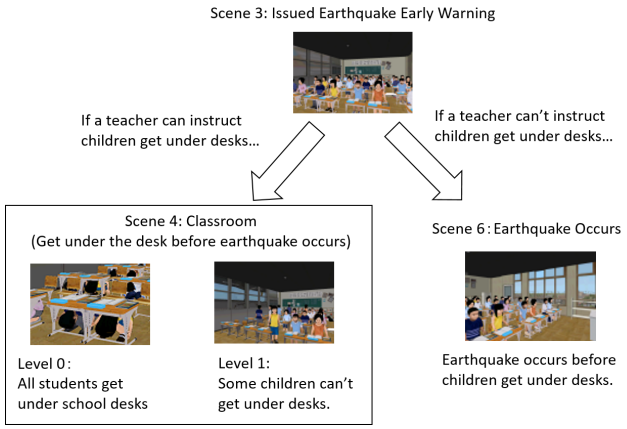

Fig. 4. An example of a scene transition.

shown in **Fig. 3**. The scenario alternatives are at a basic level and a high level, and they vary if the trainee does not perform any behavior or does not perform the expected behavior. The training simulator has functions to add and update scenarios as described in section 3.3. We are able to develop training scenarios systematically from comments by disaster prevention experts as well as from opinions of trainees.

An example of a scene transition is shown in **Fig. 4**. The branching conditions of the scene are the difficulty of the training scenario and the trainee's actions or words. The scene transition is selected by the operator observing the behavior of the trainee. **Fig. 4** shows the selection of "Scene 3: Issues Earthquake Early Warning" of the flowchart in **Fig. 3**. "Scene 3" has two branches, according to the teacher trainee's instructions. If the teacher trainee says "Drop and hide under your desk," "Scene 3" transition to "Scene 4," in which the children on the screens drop and hide under their desks. If the teacher trainee does not say anything, the earthquake occurs while the children are sitting in their chairs. "Scene 4" also has difficulty levels, including an alternative in which all children get under their desks, as well as one in which some children cannot get under their desks. If the scenes are switched according to the behaviors of the teacher trainee, the trainee can experience situational changes according to their own actions. When the trainee takes action in scenes that are not prepared in advance, the facilitator assists with supplementary explanations.

4.3. Secondary Evacuation Training Scenario and Evacuation Simulation Game

A secondary evacuation-training scenario is an evacuation from the schoolyard of a primary evacuation site to the high ground of an evacuation site. The training simulator presents VR disaster image scenes, such as town areas, crossroads, and railway crossings. In secondary evacuation training, while viewing images of a disaster, the trainee determines what he or she should be aware of in an evacuation with another trainee and the facilitator. We developed a map showing an evacuation route, shown in **Fig. 5**. The flowchart overview of the secondary evacuation-training scenario is shown in **Fig. 6**. The scenario contains the selection of an evacuation route.

An example scene from a secondary evacuation is shown in **Fig. 7**. This scene shows a railroad crossing. The gate of a railroad crossing may remain closed after an earthquake. In such an occurrence, a teacher would have to confirm the safety of the surroundings. The teacher then lifts the gate and continues the evacuation.

After the trainee experiences the secondary evacuation training scenario, a secondary evacuation simulation game [19] is conducted. The evacuation simulation game demonstrates the difficulty of evacuation through a course containing obstacles. Artificial turf is used to represent the ground scattered with window glass, and cushions and cones are used to represent debris.

5. Example of Ecacuation Training

5.1. Usage of the Training Simulator

The training simulator has been in operation since October 2014. 91 training sessions were conducted between October 2014 and November 2016. There have been 1,565 trainees, including visitors, with 188 in the teacher role. The main participants have been common citizens, school officials, participants in local events, and inspectors of disaster-related organizations. School officials have undergone 16 training sessions. There have been many group training sessions, but few individual ones. Operation has been continuous.

5.2. Example of a Training Session

In this section, an example training session is described to demonstrate the usefulness of the training simulator. A

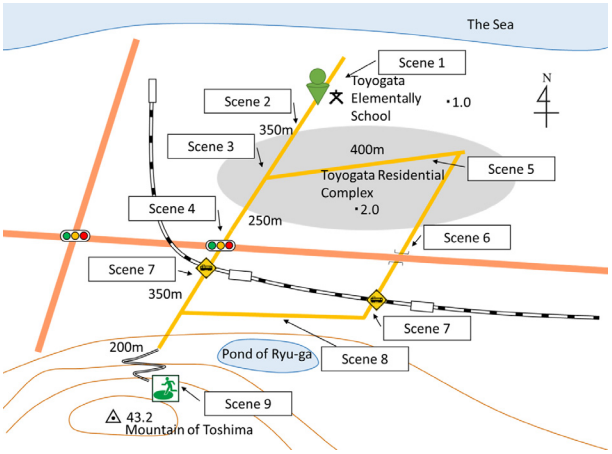

Fig. 5. Secondary evacuation map.

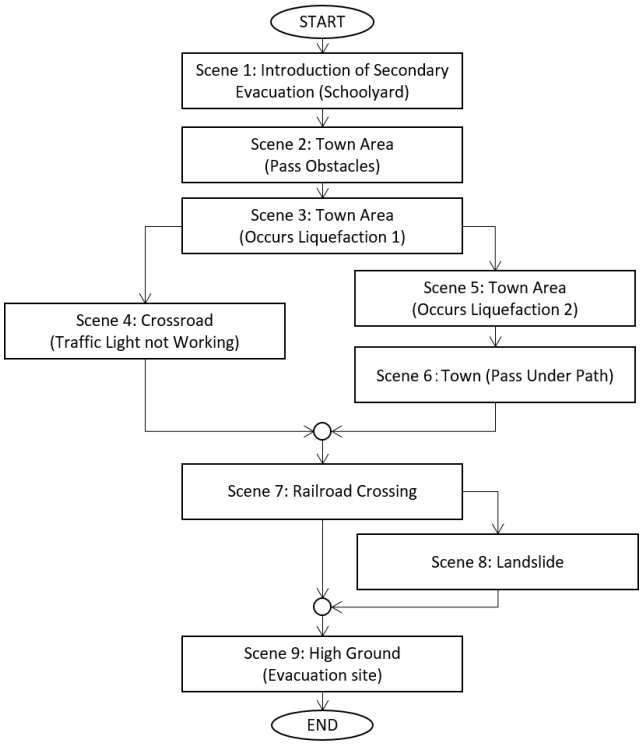

Fig. 6. Flowchart overview of the secondary evacuation training scenario.

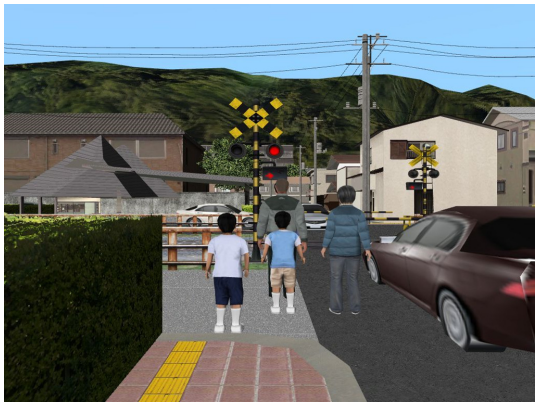

Fig. 7. An example of a scene (Scene 7: Railroad Crossing).

training session was conducted for teachers at a school for the visually impaired in August 2015. The trainees were nine teachers working at this school. Initial response training and secondary evacuation training were conducted.

5.2.1. Initial Response Training

In the initial response training, one person adopted the role of the school teacher, four people acted as students, and the remaining people observed. The training time, which included an explanation of the proposed system and discussion time, was approximately 30 minutes. There were two training sessions on the same day, with the first one using the basic-level scenario and the second using the high-level scenario. The training sessions were video recorded; after the session, the trainees watched the video and discussed the performances. The flow of training session that day is explained below.

1) Introduction of training

At the beginning of the training, the facilitator explained the training preconditions to all trainees. The facilitator explained the use of the training simulator, the environment of the school, the age of the school building, the date and time, and the number of children cared for. The school is located in an urban area. The school building is a three-story reinforced concrete structure, and earthquake resistance is ensured. In addition, there is little risk of tsunami or landslides immediately after the earthquake.

2) Initial response training (first training session)

Every trainee filled out a prior review sheet in order to be reminded of appropriate actions in the earthquake, before the training experience. The sheet included the question, "What actions should be taken in the following five scenes when an earthquake occurs in the classroom?" The five scenes were the following: (1) as the earthquake early warning sounds, (2) while the earthquake tremors are occurring, (3) when the shaking has subsided, (4) while guiding the children to the evacuation site (in this scenario, the schoolyard is set as the site), (5) at the evacuation site after all the children are gathered.

The scenario of the first training session confirmed the basic responses at the time of the earthquake, and unexpected events were rarely generated.

3) Discussion of the first training session

After the session, the trainees, while watching the recorded video, discussed the behaviors of the teachers and children. The facilitator gave explanations and advice. All trainees discussed which actions were good and what might have been done difficulty. They discussed the good and bad points of their actions.

4) Initial response training (second training session)

Fig. 8. Initial response training (first training session).

Fig. 9. Initial response training (second training session).

The training was performed using a second training scenario. In the second training session, unexpected scenes were presented more often than in the first one. Furthermore, the facilitator warned the participants that trainees in the children's role may behave unexpectedly during the disaster.

5) Discussion of the second training session

The trainees discussed the behaviors of the teachers and children while watching the recorded video, as in the first discussion. Trainees filled out a review sheet, as was done previously.

The initial response training is shown in **Figs. 8** and **9**. In the first training session, all the children hide under their desks when instructed to do so by the trainee in the teacher role (**Fig. 8**). However, in the second training session, some children cannot get under their desks (**Fig. 9**). In this way, by generating different situations even within the same scene, the training simulator can reproduce unexpected situations in a disaster.

5.2.2. Secondary Evacuation Training

In the secondary evacuation training, the trainees watched images of disasters on the screens and discussed what should be done. The trainees then walked the evacuation obstacle course. The training time was approximately 45 minutes, with the flow of the training explained below.

1) Secondary evacuation training

Fig. 10. Evacuation simulation game (a).

Fig. 11. Evacuation simulation game (b).

Table 2. Results of the questionnaire on the training content.

Questions	Evaluation Value
Q1) Were you satisfied with the training?	4.25
Q2) Did you feel the disaster was realistic?	4.00
Q3) Did you think you could get the response capabilities?	3.88

The trainees watched images of disasters on screens. Trainees discussed with other trainees and the facilitator what they should be aware of in an evacuation.

2) Evacuation simulation game

As a specialized training session for the school for the visually impaired, we set up an evacuation in the dark. The trainees got into pairs and walked the evacuation course. In each pair, one trainee wore a mask over the eyes and the other guided him/her to the evacuation spot. In the training, an evacuation target time was set and measured. The evacuation simulation game is shown in **Figs. 10** and **11**.

3) Discussion

The trainees discussed what was learned through the training.

5.2.3. Results and Discussion

After the session, a questionnaire was distributed regarding the usefulness of the training. The responses were given on a rating scheme, with 1 being the lowest and 5 the highest. The results of the questionnaire are shown in **Table 2**. As shown in **Table 2**, the training was evaluated as being highly satisfactory. Because the training simulator worked effectively, it appears that the disaster simulation felt real to the trainees.

The trainee in the teacher role commented, "I was only able to repeat the same things, such as 'It's okay,' or 'Be careful of broken glass.' I should have given more instructions, such as advising the students to hold the handrail while evacuating down the stairs." Another trainee in the child role commented, "I realized that there may be not enough teachers to guide students with visual impairments." These concrete opinions were obtained from the experience-based training session.

5.3. Discussion of the Effectiveness of the Training

In this section, we discuss the effects of our training system, including other training examples we have conducted.

5.3.1. Effectiveness of the Training

This training system has two effects. First, the trainees develop new awareness through their own behavior when experiencing a simulated disaster. Second, a common image of disaster is constructed among the trainees. The following comments have been obtained from the surveys conducted so far.

- I realized the importance of experiencing and participating.
- Evacuation drills are done every year at school, but even though I somehow know in my head about issues such as falling objects and evacuation routes, I realized that other things could happen.

These comments indicate that understanding and acting together leads to the creation of a new awareness. In the discussion of initial response training, a number of comments were made, such as "I go to help even though I am being shaken," or "I was in trouble in an unavoidable circumstance." These were obtained in the scene where there was an injured child. A trainee said, "It was difficult to continue giving instructions to children as the tremors continued for a long time."

The training outlined in section 5.2 was based on the Nankai Trough earthquake, and it is predicted that the tremors will continue for about three minutes in the training target area. The first training session contained tremors lasting one minute; those in the second session lasted two minutes. The teacher must keep giving instructions and calm the children down while the shaking continues. By experiencing the duration of the tremor through the training simulator, the trainee noticed the difficulty of continuing to speak to the children.

The environment containing a realistic disaster simulation and a training scenario that changes in response to the behavior of the trainees worked effectively. Experiencing disaster in simulation resulted in high scores for Q1 and Q2 in **Table 2**. The lower score for Q3 shows that it is necessary to conduct repeated sessions. Some trainees recommended "not only one session" and mentioned "the necessity of repeated sessions." This suggests that multiple sessions may be necessary for trainees to feel that they are able to respond.

Trainees discussed how to respond when a child is injured and when a child does not follow instructions. The training simulator helps the trainees to identify new problems. In the future, it will be necessary to develop a method of quantitatively evaluating the effects of the training and to develop a curriculum for systematic learning.

One trainee commented, "Trainees can experience the same disaster situations by viewing VR images. This encourages the discussion of countermeasures among trainees." This comment indicates an advantage of simulation training over the evacuation training given at schools. In the training simulator, trainees can discuss how they should act in a situation based on their sharing images of a disaster. The training system decreases the possibility of misunderstanding among teachers.

5.3.2. Usefulness of the Training Simulator

VR images can present disaster situations visually and aurally so those trainees can easily understand disaster situations. Some trainees expressed opinions such as "The screens and sounds made the disaster situation feel real." This testifies to the usefulness of the system configuration, which consists of three wide screens and environmental sound equipment. Other comments, such as "Seeing the VR image made it feel real. The children's movements were also real," indicate the ease of understanding of the disaster situation provided by the VR images.

Still images and movie images only present the situation, but with VR trainees interact with the situation. The trainees highly value that the situation will change according to the instructions and behavior of the trainee in the teacher role. Opinions from trainees, such as "It was good the students reacted according to the instructions from the teacher" and "The reactions of the students were different depending on the instructions from the teacher," indicate the trainees' valued the interactivity provided by VR.

The training proposed in this study may be able to be carried out in actual schools. The facilitator could go to schools, and teachers and students could carry out the simulation training in their actual classrooms by using the flowchart scenario developed in this study. However, our training system has several advantages over the training currently given in schools. Still, the training currently given in schools has the advantage of being practical yet low in cost, because the actual school and corridors, etc. can be used. The disadvantage is that there are situations that come up in disasters that are difficult to simulate

without VR. On the other hand, the advantage of utilizing our training system is that even one person alone can be trained. Above all, the training provided in actual school cannot realize two things, namely, the self-awareness of one's responses and a shared image of a disaster scene.

6. Conclusion

In this study, our experience-based evacuation training was found to develop the disaster-response capabilities of school teachers. The training simulator reproduced disaster situations through a mixture of reality and virtual reality. Trainees experienced various disaster simulations and learned through their physical responses to them. We also developed an initial earthquake response and secondary evacuation training scenario for school teachers.

In all, 1,565 people, including visitors, experienced our training over about two years of simulator operations. In a test, our training proved its ability to reproduce disaster situations and provide new and valuable information to trainees. It was confirmed that this training had two effects. First, trainees can become newly aware through their own behavior while experiencing a simulated disaster. Second, a common image of a disaster can be constructed among trainees.

This study effectively provided experience-based evacuation training, with trainees experiencing a series of actions taken as disaster strikes. In the future, we plan to develop an extensive training scenario and training curriculum to increase school teacher's response capacities. A qualitative evaluation was presented to demonstrate the effectiveness of the training. However, an assessment with a quantitative evaluation methodology is also required to clarify the effects of our method of training.

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