A Learning Support Environment for Earthquake Disaster with A Simulation of Furniture Falling by Mobile AR

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Abstract— Learning for earthquake disaster is important in Japan. However, it is rare to experience a big earthquake disaster even in Japan. Therefore, it is difficult to teach the importance of learning for earthquake disaster. We developed a learning support environment that can give a learner simulated experience of earthquake disaster by mobile augmented reality.

Keywords-component; learning; environment; mobile; skill; augmented reality; earthquake disaster

I. INTRODUCTION

Earthquakes occur about 10,000 times per one year in Japan. Therefore, earthquake disaster is well-known disaster in Japan. Every Japanese has experienced it at least once. However, it is rare to experience a heavy earthquake disaster even in Japan. Therefore, there are many people who are not aware of crisis of earthquake disaster [1]. In this situation, learning and training for earthquake disaster is conducted in schools, universities, hospitals and institutes as follows.

Saito, et. al. reported international training system and information network for earthquake disaster mitigation [2]. Takimoto, et. al. developed a web based disaster learning system and learning contents [3]. Kojima, et. al. proposed a disaster-relief training system using the electronic triage tag [4]. Yamori, et. al. proposed and practiced a gaming approach to disaster preparedness learning in a high school [5]. Nakajima developed and practiced teaching materials on disaster prevention education for junior high school students and citizens [6]. Ohara, et. al. developed an E-leaning system for doctors and nurses on emergency responses [7]. Noda, et. al. developed functionally-extended real world edutainment and its application to education for disaster prevention[8].

As just described, the learning for earthquake disaster has been conducted by using textbook, video movie or web based training system (WBT) at most. However, it is difficult for a learner to imagine earthquake disaster in his/her daily life by learning with textbook, video movie or WBT. It is impossible for a learner to cope with earthquake disaster only with static knowledge which is separated from his/her daily life. As a result, victims become an unexpected situation in many cases after an earthquake.

In this background, we have developed a learning support environment that simulates virtual furniture fallings in a real room in case of earthquakes. The goal of the learning environment is to give learners not only static knowledge but also skills to cope with earthquake disasters in real rooms in their daily lives.

The learning support environment used mobile augmented reality. Mobile augmented reality simulates furniture falling during earthquake. This is simulated experience of earthquake disaster. The simulations of the furniture fallings impact learning for earthquake disaster. Additionally, the simulations enhance learners' interests in earthquake disaster.

II. COMPOSITION OF THE LEARNING SUPPORT ENVIRONMENT

The learning environment consists of Android terminals and AR markers. We used "Unity 3" for the development environment. We prepared 4m * 4m area for the simulation by

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AR (Figure. 1).

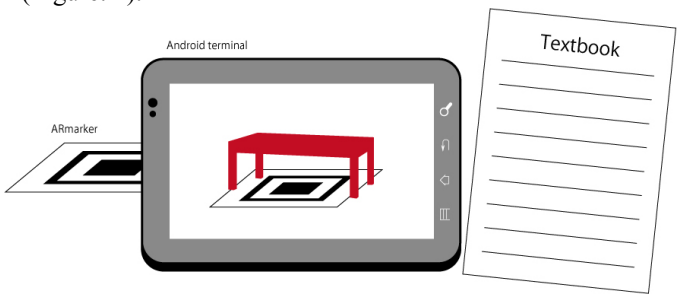

Figure. 1 Composition of the learning support environment

A. Simulation of Earthquake disaster

In this study, the environment displays 3D CG model animation of furniture fallings during an earthquake on an Android terminal. We set the earthquake with level 6.0 on the Japanese seismic scale, frequency 1[Hz], maximal acceleration 320[gal] and the peak of acceleration time 5[s].

B. Simulation of Furniture

In this study, we chose furniture in consideration of general usage in daily life. The number of kinds of the furniture is five. Four pieces of the furniture can be arranged in the assessment experiment (Table Ⅰ)(Figure. 2).

Furniture has rigid body and it consists of rectangular surfaces. Dynamic friction coefficient is 0.5, and static friction coefficient is 0.6 for all furniture.

TABLE I. **SIZE OF FURNITURE**

furniture	width[cm]	depth[cm]	height[cm]
TV set	50	10	50
Table	105	75	50
Book shelf	85	40	150
Bed	100	180	50
Sofa	120	50	60

Figure. 2 Furniture by augmented reality

C. The Learning Support Environment

We put AR makers in an experiment room. Life-size furniture is displayed on the AR makers (Figure. 3). A learner practices looking into an Android terminal. The learner can play, pause and reset the animation of furniture falling simulation.

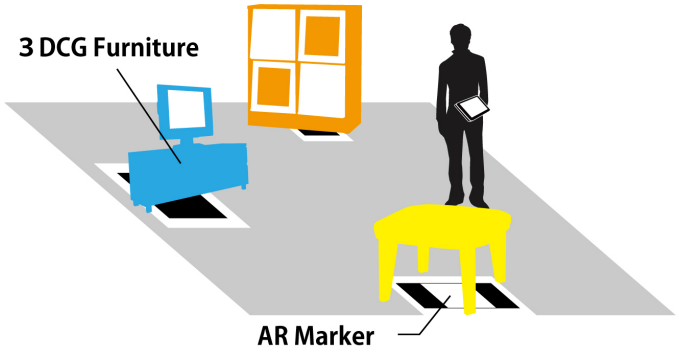

Figure. 3 Experimental room

III. THE ASSESSMENT EXPERIMENT

A. Experiment Objective

The experiment objective is to verify the usefulness of the learning support environment for earthquake disaster.

There are two abilities to be evaluated. One is the ability to estimate safety zone and danger zone. The other is the ability to prepare for an earthquake and to respond to earthquake disaster.

After the end of the assessment experiment, we conducted questionnaire survey to learners.

B. Experimental Methodology

The number of subjects was 10 persons in the assessment experiment. Subjects were divided into experimental group and control group.

Figure 4 shows the flow chart of the experiment. Experimental group learned the earthquake disaster by using the learning support environment with Android terminals. Control group learned it by using a different system which didn't use AR. We will describe it in detail in the next section.

We calculated the average score of pre-test and post-test respectively in each group, and calculated growth rate in each group. After that, we compared the growth rates between experimental group and control group. After the end of the assessment experiment, we conducted questionnaire survey.

C. A Learning Support Environment of Control Group

A learning support environment of control group is a system which shows a learner CG animation of furniture fallings on a desktop monitor (Figure. 5).

The big difference from our learning support environment is that a learner cannot see the furniture falling simulation by augmented reality. The viewpoint of CG animation of control group is fixed.

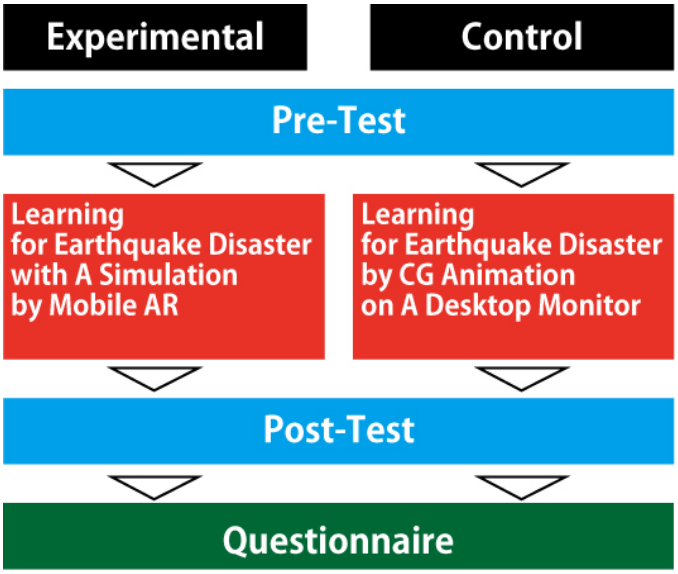

Figure. 4 Flow chart of the experiment

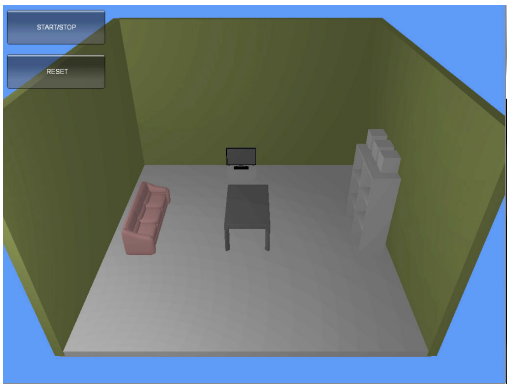

Figure. 5 The learning support environment of control group

D. Test Methodology for pre-test and post-test

In this section, we explain the methodology and purpose of pre-test and post-test. We performed pre-test and post-test in the same way. Furthermore, we performed them in both groups in the same way.

We prepared 4m * 4m experimental room. We put AR markers in the experimental room. The AR markers are captured by a camera of an Android terminal. The display of the Android terminal shows 3D CG model of life-size furniture on the AR markers in the room. Learners answered questions looking at layout of the furniture in the room.

There were two questions. The purpose of 1st question was to measure the ability to estimate safety zone and danger zone. Specifically, the experimenter asked learners to point safety zones and danger zones in case that an earthquake occurred. The learner's answer was written on an answer sheet by the experimenter. In the answer sheet, safety zones were colored in blue, and danger zones were colored in red (Figure.6).

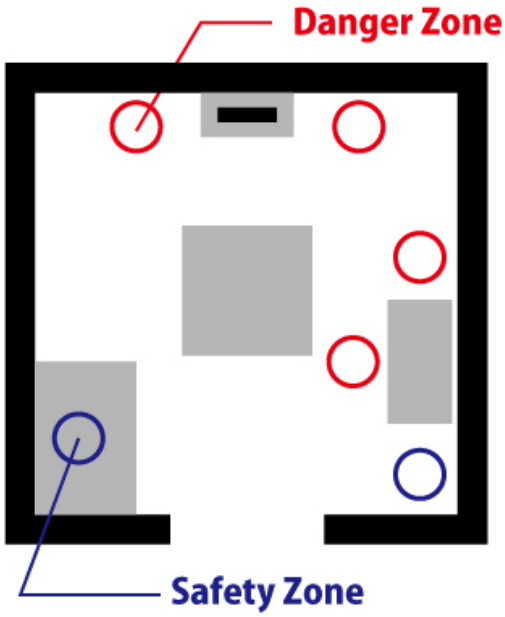

Figure. 6 An answer example for measuring learner's ability to estimate safety zone and danger zone

The purpose of 2nd question was to measure learner's ability to cope with earthquakes and earthquake disasters. Specifically, the experimenter asked learners to answer precautious points and to answer how to cope with earthquakes and earthquake disasters in case that the earthquake occurred. The learners answered the 2nd question with free description.

E. Learning Methodology

In this section, we explain learning method. The learning was conducted between pre-test and post-test. Both groups learned the disaster with the same furniture models and the same room arrangement.

Experimental group experienced the simulation of furniture fallings in an earthquake by mobile AR. Subsequently learners learned general precaution points in case of an earthquake by reading textbook.

On the other hand, control group experienced the simulation of furniture fallings in an earthquake not by mobile AR, but by CG animation on a desktop display monitor instead. Subsequently learners learned general precaution points in case of an earthquake by reading the textbook.

The textbooks of both groups were the same. It was made by referring to technical books and specialist's answers.

F. Questionnaire

After the end of the assessment experiment, we conducted questionnaire survey. Learners answered each question by 5-point scale. The contents of questions were about satisfaction rating on a learning support environment. The number of the questions of the questionnaire survey was five. They were as follows.

Q1—"Do you think that your ability to imagine earthquake disaster is improved?"

Q2—"Do you think that your skill to cope with earthquake disaster is improved?"

Q3—"Do you think that your knowledge on earthquake disaster is improved? "

Q4—"Do you think that your interest in learning on earthquake disaster is enhanced?"

Q5—"Do you think that you would like to use again the learning support environment that you used in the experiment when you will learn earthquake disaster?"

IV. ANALYSIS METHOD AND RESULTS

A. Analysis Method

We performed pre-test and post-test to measure knowledge level before and after learning. Subsequently, we compared the knowledge levels. Difference between the levels indicates learning effect.

We tried to measure two kinds of enhancements of abilities as learning effect by the tests. One is the enhancement of the ability to estimate safety zone and danger zone. The average of the number of correct answers, incorrect answers and no answer were calculated. Rate of correct answer was also calculated. We compared them later.

The other is the enhancement of the ability to prepare for an earthquake and to respond to earthquake disaster. The average of the number of correct answers, incorrect answers, and no answer and bonus (Bonus is unanticipated correct answer in free description) were calculated. We compared them later.

B. Results

1) The ability to estimate safety zone and danger zone:

Table Ⅱ shows the result of the answers that indicate learners' ability to estimate safety zone and danger zone. Rate of correct answers in control group was degraded. Experimental group was improved greatly. However, the number of "no answer" was almost same between pre-test and post-test in the experimental group.

TABLE II. **RESULTS OF MEASURING LEARNERS' ABILITIES TO ESTIMATE SAFETY ZONE AND DANGER ZONE**

(Pre = Pre-test, Post = Post-test)

	Correct(%)		Incorrect(%)		No answer(%)	
Test	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Exp.	**37**	**51**	**20**	**5**	**43**	**44**
Cont.	**48**	**40**	**24**	**10**	**28**	**50**

2) The ability to prepare for an earthquake and to respond to earthquake disaster:

Table Ⅲ shows the result of the average numbers of answers that indicate learners' ability to prepare for an earthquake and to respond to earthquake disaster. Both groups were improved. Especially, experimental group was improved greatly. However, the number of "no answer" was same between pre-test and post-test.

TABLE III. **RESULTS OF MEASURING LEARNERS' ABILITIES TO PREPARE FOR AN EARTHQUAKE AND TO RESPOND TO EARTHQUAKE DISASTER**

(Pre = Pre-test, Post = Post-test)

	Correct		Incorrect		No answer		Bonus	
Test	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Exp.	**2.4**	**3.4**	**2.2**	**0.0**	**2.0**	**2.0**	**0.4**	**1.6**
Cont.	**2.2**	**2.4**	**1.6**	**1.2**	**2.2**	**2.2**	**0.6**	**0.8**

3) Results of Questionnaire

TableⅣ shows the results of the questionnaire survey. The scores in the table represent average scores on 5-point scale by learners' answers in each group.

TABLE IV. **RESULTS OF QUESTIONNAIRE SURVEY**

	Exp.	Cont.
Q1. Ability to imagine earthquake disaster	4.4	4.2
Q2. Skill to cope with earthquake disaster	3.4	3.6
Q3. Knowledge on earthquake disaster	4.0	4.0
Q4. Interest in learning on earthquake disaster	4.0	3.6
Q5. Hope to learn again with the environment	4.2	3.6

Discontent points by free descriptions were "Narrow view in the display of an Android terminal", "Delay of the animation by slow speed of processor" and so on.

V. CONSIDERATION

A. The ability to estimate safety zone and danger zone

Comparing experimental group with control group, the results of the ability to estimate safety zone and danger zone showed a great enhancement in experimental group.

In table Ⅱ, especially, the number of correct answers by experimental group was improved greatly compared with control group. It turned out that this learning support environment is useful compared with the learning support environment of control group.

However, the number of "no answer" of experimental group was not improved. The number of "no answer" of control group was increased. The number of "no answer" is a parameter which represents that the learner does not find out safety zones or danger zones by himself/herself. If the number of "no answer" decreases, it means that the learner's ability to find out safety zones or danger zones by himself/herself is enhanced.

However, the number of "no answer" did not decrease in both groups. It means that learning environments of both groups were not helpful for learners to enhance their abilities to find out safety zones or danger zones by themselves.

B. The ability to prepare for an earthquake and to respond to earthquake disaster

Comparing experimental group with control group, the results of the ability to prepare for an earthquake and to respond to earthquake disaster showed a great enhancement in experimental group.

The number of incorrect answers by experimental group decreased greatly compared with control group especially. It turned out that this learning support environment is useful compared with the learning support environment of control group.

However, the number of "no answer" by experimental group was not improved. This result shows that the learning environment was not helpful for learners to find out answers by themselves. However, the number of "bonus" was improved greatly in experimental group. The number of "bonus" is the parameter which represents that the learner found out original answer to prepare for an earthquake and to respond to earthquake disaster by himself / herself. Therefore, this result shows that learner's ability to imagine earthquake disaster was improved. Furthermore, the results shows that the learning environment was helpful for learners to find out original answer to prepare for an earthquake and to respond to earthquake disaster by themselves, however, learners didn't find out proper answers by themselves.

VI. CONCLUTIONS

In this paper, we designed and developed a learning support environment that can give a learner simulated experience of earthquake disaster by mobile augmented reality. Through the assessment experiment, we verified learning effect by the learning support environment.

Especially the ability to estimate safety zone and danger zone were improved greatly. Probably, this is because a learner can see an earthquake disaster close at hand through an android terminal with virtual experience, and he/she can see the disaster from any viewpoint in a real room. Therefore, the learner can check safety zone and danger zone effectively.

However, the number of "no answer" was not improved for both questions. On the other hand, the number of "bonus" was improved. This result shows that ability to imagine earthquake disaster was improved. Therefore, the learning environment is helpful for learners to find out answers by themselves, however, learners could not find out proper answers by themselves.

Through the questionnaire survey, it turned out that learners did not think that they mastered skill to cope with earthquake disaster easily, although the results of post-test showed that they mastered some skills. Therefore, for the future, we are going to improve the interface, and implement feedback system which will satisfy learners.

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