Paper:

Proposing A Multi-Hazard Approach to Disaster Management Education to Enhance Children's "Zest for Life": Development of Disaster Management Education Programs to Be Practiced by Teachers

Toshimitsu Nagata[*,†] **and Reo Kimura**[**]

[*]Utsunomiya Local Meteorological Office of Meteorological Agency
1-4 Akebono-cho, Utsunomiya, Tochigi 320-0845, Japan
[†]Corresponding author, E-mail: nagata@met.kishou.go.jp
[**]School of Human Science and Environment, University of Hyogo, Hyogo, Japan
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This study reviews the current situation and problems in disaster management education in schools in Japan, proposes systematic programs for elementary and junior high school students, and the proposed programs are verified and evaluated in different schools. The programs aim to educate the students of the correct knowledge on various natural disasters and enhance their capacities to forecast and avoid the risks on their own initiatives.

The programs have an advantage that it can be implemented by teachers who can practice disaster management education in the ordinary learning process for elementary and junior high school students in schools; disaster management specialists are not needed for its implementation.

Prior to the development of the programs, an awareness survey was conducted to both elementary and junior high school students and teachers regarding their level of "consciousness of the crisis of school safety caused by natural disasters, among others." The results of the survey revealed that "the disaster management education based on earthquake disaster is effective for students and teachers as a starting point of the learning, since they have already experienced an earthquake and a disaster drill targeting earthquake in their lives." Thus, the proposed education programs have been designed that earthquake and other natural hazards disaster management education are practiced not separately but jointly to foster children's "zest for life" at a time of natural disasters. The proposed two programs correspond to earthquake and tornado, and each program consists of three parts. The teaching materials, such as the proposed guidance and worksheet, have been prepared using editable files to allow teachers to edit the content by themselves.

A survey method based on the ADDIE process of instructional design is adopted. In the ADDIE process, effectiveness of the proposed education programs is measured through the students' self-assessment on the extent to which the programs' learning objectives have been attained. Consequently, the proposed programs are evaluated by measuring the degree of attainment several times: before, during, and after the implementations. As a result of the evaluation, the earthquake and tornado disaster management education programs proved to be highly effective for education. Findings also proved that the knowledge acquired and capabilities improved through the proposed programs can be maintained by repeating the practice of the programs.

In carrying out this study, cooperation with disaster prevention organizations and educational institutions was indispensable. To further realize such cooperation, this study proposes that the specific educational institutions, Prefectural Board of Education, Municipal Board of Education, and model schools that are willing to implement the programs must cooperate with one another.

Keywords: Earthquake Early Warning, tornado disaster, general policies regarding curriculum formulation, package of decision-making process, disaster response exercise

1. Introduction

1.1. Natural Disaster in Japan in Recent Years

Japan is vulnerable to various natural disasters deriving from its geographical, topographical, and meteorological conditions. It is located on the circum-Pacific mobile belt, a region where volcanos are active and the earth's crust is moving at geographically rapid rate causing frequent earthquakes. Although it covers only 0.25% of the world's land area, the occurrence of an earthquake and the number of distribution of active volcanos in the country are extremely high.

The March 2011 earthquake off the Pacific coast of Tohoku was a magnitude of 9.0, the highest ever recorded in Japan. Seismic intensity of 7 was observed in Miyagi Prefecture and strong shake in most areas in the eastern

part of Japan. This earthquake caused a huge tsunami resulting in the immense and wide-area damage around the Pacific coast of the eastern part of Japan. For the first time in Japan, in the Kumamoto Earthquake that occurred in April 2016, a series of magnitude-7 earthquakes struck the same area twice. This earthquake caused a tremendous damage, including loss of lives and the destruction of about 160,000 houses. Other kinds of natural disasters also result in loss of lives and properties every year because of Japan's unique characteristics. Examples of these are the tornado disasters in Ibaragi and Tochigi Prefectures in September 2012 and Saitama Prefecture in September 2013, a large-scale sediment disaster triggered by the heavy rain in Hiroshima Prefecture in August 2014, and the Mount Ontake eruption in September 2014, which is thus far the worst volcanic eruption after the war.

Japan has taken measures against these major natural disasters. For example, the disaster prevention and mitigation measures for the immense and wide-area damage following the Nankai Trough Earthquake or any earthquake that hits Tokyo area directly were planned in cooperation with the central and local governments and research institutions. The disaster response exercises have been promoted actively in the areas where such damage supposedly occurs. However, according to the "White Paper on Disaster Management 2016" published by the Cabinet Office of the Japanese Government [1], the disaster management measures for a maximum level of damage have not yet been completed since the Great East Japan Earthquake in 2011. The White Paper argued that citizens and companies still lack sufficient knowledge on disaster preparedness, including ways to address disaster risks based on their own initiatives. Thus, intangible measures, such as disaster management education and response exercises, are deemed equally important as tangible ones, such as strengthening of infrastructures for disaster prevention and mitigation, in enhancing disaster awareness and preparedness in everyday life. Intangible measures, in particular, lead to raising of awareness of "self-help," which means one's own life must be protected by oneself.

1.2. Current Status and Problems in Disaster Management Education

Disaster management education is defined as the education aiming at prevention of disaster and minimization of damage through a swift and an appropriate response to disaster when the disaster already occurred [2].

After the Great East Japan Earthquake, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) founded "the Council on Disaster Education and Disaster Management after the Great East Japan Earthquake" [3], indicating a "promotion of the disaster management education to enhance the capacities to forecast the risk and avoid it" as an orientation for the policies on disaster management education in schools in the future. The "Development of Disaster Management Education to Foster 'Zest for Life'" [4] and "Guidelines for Disaster Management in Schools in Preparation for Earthquakes and Tsunami Disasters," [5] which contain information on disaster preparedness and reference examples of evacuation drill, have been developed and distributed among schools. Since 2004, a number of experts on disaster management education have been operating the website on "Disaster Management Education Challenge Plan" [6], in cooperation with the MEXT, Fire Defense Agency, and National Institute for Educational Policy Research, among others. This website introduces several examples of highly motivated activities on disaster management education in schools, where disasters have already been experienced or the risk of disaster is imminent. Nishira et al. [7] and Fujioka et al. [8] proposed practical studies in schools, including the development of materials and games for disaster management education. Ichii [9] provided summaries of the books and picture books to be used as reference materials in carrying out disaster management education in schools and guides on ways to use these materials, such as games for disaster management education that have been developed by other researchers. Moreover, Kimura et al. [10] presented various methods of implementing "disaster management literacy."

The author has also supported the disaster management education in schools, such as elementary, junior high, and high schools in the Kanto Region, especially since the Great East Japan Earthquake. The author has undertaken the disaster management education and drills in certain schools to learn not only the attitudes toward disaster but also the appropriate knowledge on disaster and capabilities to respond to potential risks for schoolchildren to protect themselves from various natural disasters (for examples, see [11–13]). However, in essence, schoolteachers do not develop disaster management expertise in teacher training course, as they are only trained with respect to the challenges on schoolchildren's psychological and physical health, such as bullying and refusal to go to school, and school safety, such as bicycle accident and problems caused by SNS. Accordingly, schoolteachers find it difficult to teach systematically the mechanism of occurrence of natural disaster and the appropriate behaviors to respond to it in their classes [14, 15].

For example, several schools in Tochigi Prefecture, which is the focus of this study, carry out evacuation drills regularly as part of disaster management education, but they do not consider specific local conditions, such as the natural environment surrounding each school.

1.3. Objectives of this Study

This study reviews the current situation and problems in disaster management education programs in schools, and then proposes a systematic one for students to learn the correct knowledge on various natural disasters and enhance their capacities to forecast the risk and avoid it on their own initiatives. The availability of such programs is verified in schools. This study is based on the above findings indicating that disaster management specialists, including teachers, do not necessarily study to be qualified in implementing such programs. Nevertheless, they

carry out such programs that build on the regular curriculum for students in a school.

This study focuses on earthquake and tornado, and proposes disaster education programs on both disasters that are designed to be practiced not separately but jointly to foster "zest for life" of students at a time of natural disasters. How disaster experts cooperate with educational institutions under these proposed programs is also examined in this study.

This study covers Tochigi Prefecture in the northern part of the Kanto Region in Japan. Tochigi Prefecture is under the jurisdiction of the Utsunomiya Local Meteorological Office of the Meteorological Agency with which the author is affiliated. The prefecture is among the seven prefectures in the Kanto Region, which includes Tokyo Metropolis, and has 1.98 million people. The prefectural capital is Utsunomiya City, a core city located at the center of the prefecture. It is an inland prefecture without seashore along its boundary. The Nikko National Park is located in Tochigi Prefecture and has famous tourist resorts, such as Nikko and Nasu. As regards the natural disasters from which Tochigi Prefecture suffered in recent years, a strong tremor with a seismic intensity of more than 6 was recorded during the 2011 Tohoku Earthquake, resulting in physical damage (e.g., completely destroyed houses) and loss of lives. Other natural disasters that caused similar damage are the yearly tornado in recent years and the Kanto and Tohoku Heavy Rain in September 2015, which triggered a sediment disaster and severe flooding.

1.4. Instructional Design

The ADDIE process (hereafter referred to as "ADDIE") [17], a systematic instructional design model, has been adopted to develop the proposed disaster management education programs for earthquake and tornado. Instructional design is a learning theory in the fields of pedagogy, psychology, and educational technology and is defined as "the model or research field synthesizing the methods to enhance effectiveness, efficiency, and attractiveness of educational activities and the processes to realize the learning environment, such as teaching materials and classes, by adopting such model or research field" (Suzuki, 2006) [16].

Instructional design is focused not on teaching itself but on support of the learning process. It builds the framework necessary to promote the intentional learning of leaners effectively, that is, the question of "how" "who" learns "what" and how learning is supported. This is a method aiming at designing a better learning environment comprehensively. By adopting this method, a concrete plan can be made to achieve an optimal learning effect in school while recognizing the intention of the leaner. In this study, the ADDIE process in the proposed educational programs involves a review of the objectives and requirements in implementing classes and trainings, such as those for the leaners, purpose of learning, problems in schools, and contents of disaster management education. The ADDIE contributes to the efforts in creating effective teaching materials by following the cycle of Analysis, Design, Develop, Implementation, and Evaluation.

Kimura and Tamura et al. [18] and Tamura [19] are among the previous studies that employ instructional design for the development of educational programs. They designed the drill and training programs based on the framework of ADDIE, verified the effectiveness of the proposed guidance and trainings with their learning objectives, and argued the efficacy of such programs.

2. Current Status of Risk Consciousness

2.1. Objective of the Survey

The author observed the following while participating in the activities in Tochigi Prefecture: although earthquake trainings are planned systematically for a span of one year, those on other natural disasters are mentioned simply in science classes and no curriculum guidelines have been developed to protect students from these natural disasters. Among the concerns raised by the teachers is that they guide their students only based on the knowledge they have acquired from their own experiences, and thus they lack the knowledge on how disaster management education is practiced in a concrete way.

Therefore, the author hypothesizes that a multi-hazard approach to disaster management education is an effective method. First, earthquake is selected as an introduction theme of the disaster management education to be carried out and continued in schools, and then the appropriate knowledge and behaviors to respond to other natural disasters are taught expansively. After these two procedures, the students are expected to respond to various natural disasters appropriately.

Thus, in May 2016, a "questionnaire on risks in the surroundings" was conducted to elementary students and teachers in Tochigi Prefecture to identify their risk consciousness of school safety at a time of natural disaster. The aim of the questionnaire was to know whether the proposal mentioned above would be accepted by the students and teachers and determine the current situation with respect to their risk consciousness. On the basis of the findings of the questionnaire survey, the author would like to know whether the hypothesis of this study is adequate for the promotion of the proposed disaster management education in all areas in Tochigi Prefecture.

2.2. Outline of the Survey

This study analyzed the completed questionnaires obtained from 266 students from the second to the sixth grade in two elementary schools in Tochigi Prefecture. Although an exhaustive survey or a sampling targeting all the elementary schools in the prefecture is ideal, coordination among schools in advance is required in such situation. Hence, only the elementary schools recommended by the Board of Education were selected in this survey.

Questionnaire on Risks in the Surroundings

1. ( ) Grade Gender : Male / Female

*(Please write your grade inside the bracket and circle your gender either male or female.)

2. If you have encountered the following events in your daily life, can you imagine the situation vividly? What kind of damage would it cause and how would you be inconvenient by it?

Please circle the applicable number.

Situation	1 I can imagine vividly and clearly	2 I can imagine moderately	3 I can imagine slightly	4 I can hardly imagine
Example: Fall ill because of food intoxication	1	(2)	3	4
1. Fire occurs.	1	2	3	4
2. An earthquake occurs.	1	2	3	4
3. A tsunami strikes.	1	2	3	4
4. A volcano erupts.	1	2	3	4
5. It rains heavily suddenly.	1	2	3	4
6. Lightning strikes.	1	2	3	4
7. A tornado appears.	1	2	3	4
8. River flooding.	1	2	3	4
9. A road or a building is inundated.	1	2	3	4
10. A mountain or a cliff collapses.	1	2	3	4
11. A typhoon strikes.	1	2	3	4
12. It snows heavily.	1	2	3	4
13. Injured seriously at school.	1	2	3	4
14. Encounters an accident or is injured during an off-campus learning.	1	2	3	4
15. A suspicious person enters the school.	1	2	3	4
16. A stranger talks to or asks me about something on my way home from school.	1	2	3	4
17. Encounters an accident while walking on a school road or a sidewalk.	1	2	3	4
18. Encounters an accident while riding a bicycle.	1	2	3	4
19. Encounters an accident while riding on a bus or in a train.	1	2	3	4
20. Encounters a minor collision with a motorcycle or a car.	1	2	3	4

This is the end of the questionnaire. Please check again to make sure you have answered all items.

Fig. 1. Questionnaire on risks in the surroundings.

The survey asked how vivid the students' and teachers' impressions are of each risk mentioned in the 20 question items regarding school safety, including disaster, traffic, and school life safety, and crime prevention. Referring to the "Development of Disaster Management Education to Foster 'Zest for Life'," which the MEXT developed, the risks mentioned in the 20 question items were selected from the "Miyagi Basic Guidelines for Disaster Management Education," [20] which the Board of Education in Miyagi Prefecture formulated; such guidelines outline the concrete direction on school safety. Moreover, the 20 question items were selected based on whether the students could answer them within the reasonable time without excessive burden, according to the opinions of the concerned schools. These 20 question items were classified into 12 items on disaster safety and 4 each on traffic and school life safety (**Fig. 1**).

The following instruction is provided at the beginning of the questionnaire: "If you have encountered the following events in your daily life and could imagine the situation vividly, what kind of damage would such situation cause and how you would be inconvenient by it? Please mark the applicable number with a circle." After the instruction, the 20 risk items to which the students respond

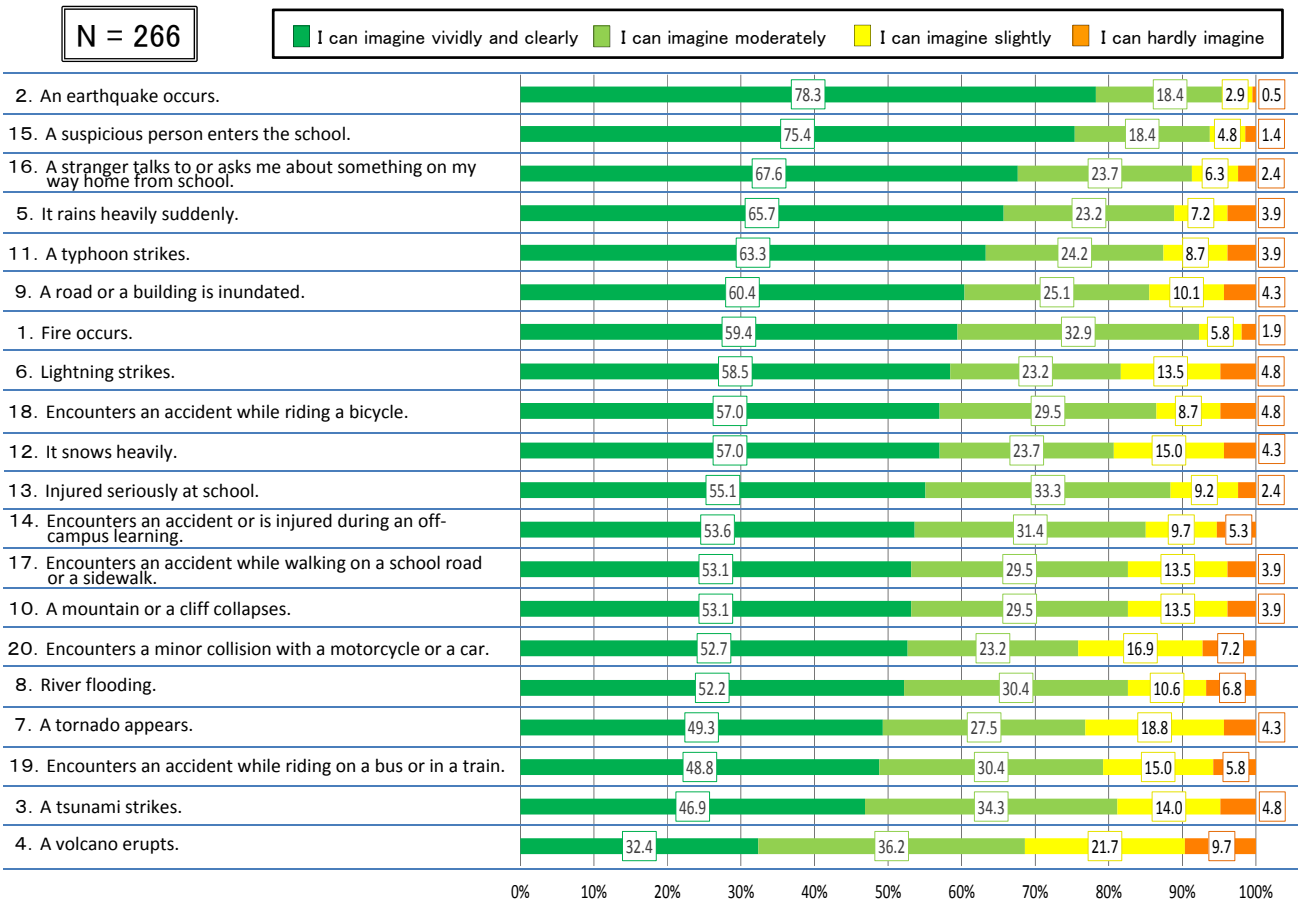


Fig. 2. Questionnaire on risks in the surroundings/aggregated answers of students by item.

on a four-stage quantitative evaluation (i.e., "I can imagine vividly and clearly, I can imagine moderately, I can imagine slightly, I can hardly imagine.").

In addition, a questionnaire survey was conducted to teachers, who are mainly in charge of school safety, in selected public schools in Tochigi Prefecture. The questionnaires were distributed at the reception desk of the disaster management training for teachers, and then retrieved when the training ended by placing them into a box. The questionnaires distributed to the teachers also contain the same 20 items.

2.3. Concrete Image of Risk

The extent of how each risk is imagined was derived based on the findings of the survey. The scores were calculated and arranged in descending order; the option "imagine vividly and clearly" was assigned with the highest score.

Reviewing the findings on the students ($n = 266$), the risk that was marked mostly with "imagine vividly and clearly" is "2. Earthquake" (78.3%). Hence, an earthquake is supposedly imagined vividly because it is experienced frequently in Japan, and thus evacuation drills for earthquakes are exercised regularly in schools. The risks with the next highest scores are "15. Intrusion of a suspicious person" (75.4%) and "16. Talked to or asked by a stranger about something" (67.6%). Such high results could be attributed to the schools being located in the residential areas and the regular implementation of education that targets suspicious person. The following other risks are listed in decreasing order of scores: "5. Sudden heavy rain" (65.7%), "11. Typhoon" (63.3%), "9. Flooding" (60.4%), "1. Fire" (59.4%), "6. Thunder" (58.5%), "18. Bicycle accident" (57.0%), "12. Heavy snow" (57.0%), "13. Injury at school" (55.1%), "14. Injury outside the school" (53.6 %), "17. Accident on school road" (53.6%), "10. Landslide" (53.1 %), "20. Minor collision" (52.7%), "8. River flooding" (52.2 %), "7. Tornado" (49.3%), "19. Accident while riding a vehicle" (48.8%), "3. Tsunami" (46.9%), and "4. Volcanic eruption" (32.4 %) (**Fig. 2**).

As regards findings on the teachers ($n = 573$), the risk with the highest score of "imagine vividly and clearly" is "2. Earthquake" (46.4%). The following other risks are listed in decreasing order of scores: "11. Typhoon" (45.7%), "13. Injury at school" (45.2%), "5. Sudden heavy rain" (42.9%), "20. Minor collision" (40.3%), "18. Bicycle accident" (40.0%), "12. Heavy snow" (38.4%), "17. Accident on school road" (38.0%), "1. Fire" (37.5%), "14. Injury outside the school" (36.0%), "16. Talked to or asked by a stranger about something" (30.7%), "15. Intrusion of a suspicious person" (26.5 %), "8. River flooding" (26.2%), "6. Thunder" (24.3%), "9. Flooding" (23.7%), "19. Accident while riding a vehicle"

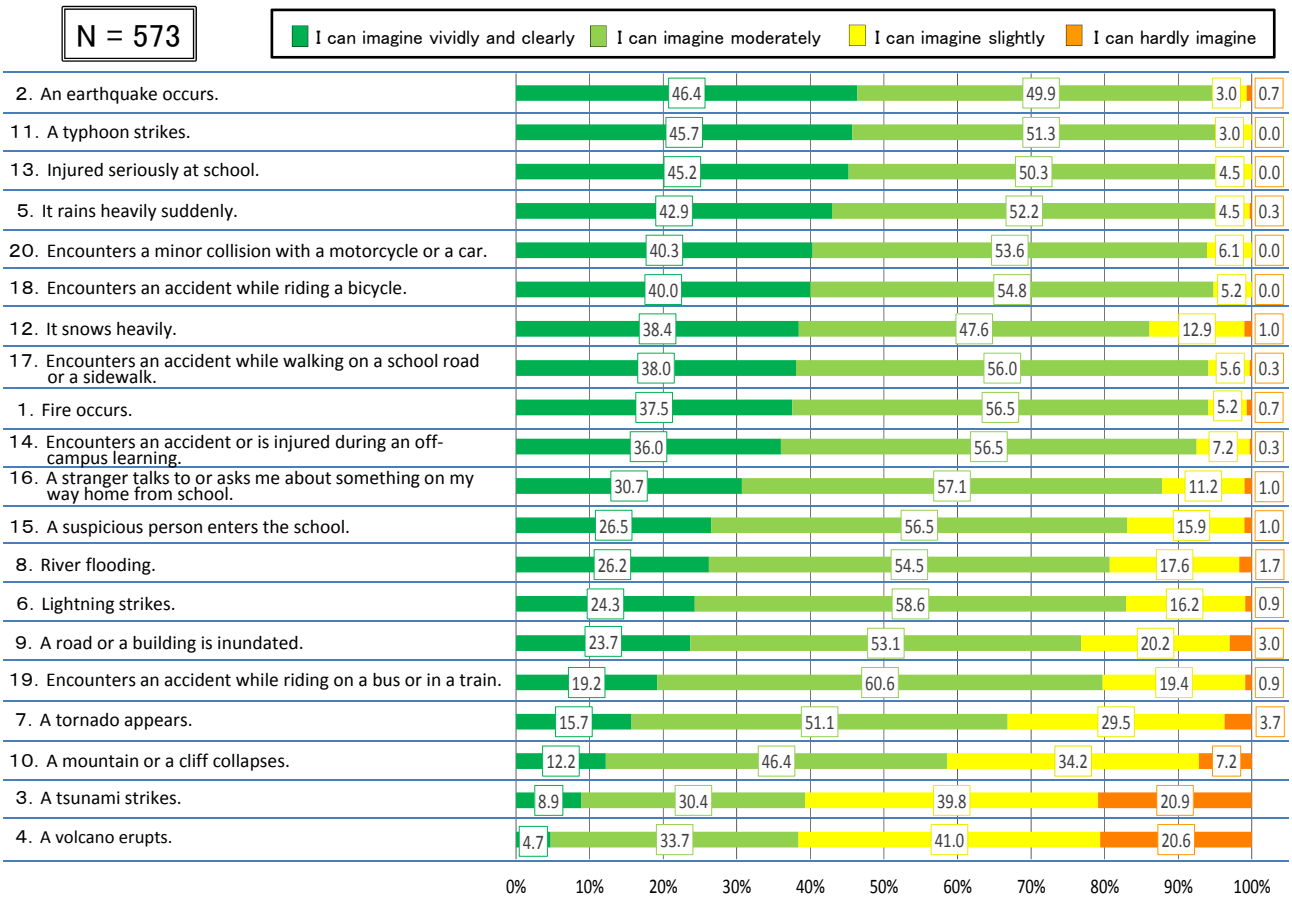


Fig. 3. Questionnaire on risks in the surroundings/aggregated answers of teachers by item.

(19.2%), "7. Tornado" (15.7%), "10. Landslide" (12.2%), "3. Tsunami" (8.9%), and "4. Volcanic eruption" (4.7%) (**Fig. 3**).

In summary, an earthquake is the risk that can be imagined most vividly among all the 20 items, as both students and teachers have experienced it in their lives and evacuation drills for earthquakes are exercised regularly in schools. Other risks, which have high incidence and are highlighted frequently inside and outside the school, can also be imagined vividly to a certain extent. These other risks include the storm, flooding caused by heavy rain and typhoon, suspicious persons, and injuries. However, the risks, such as tornado, flooding, sediment disaster, and volcanic eruption, which has occurred in Tochigi Prefecture in recent years, can be imagined relatively less than the others.

2.4. Factor Analysis of Risk Image

Factor analysis (maximum likelihood method with Promax rotation), which is a kind of multivariate analysis and often used to search the relation among multiple variables, was performed to determine the relation among the risks based on the findings of the survey conducted to students and teachers.

The following four factors were extracted as a result of the analysis of the students ($n = 266$) (**Fig. 4**). The first factor represented by traffic accident and suspicious persons is termed "Risks coming from the world outside of home and school, such as traffic accident and suspicious persons." The second is represented by tornado and volcanic eruption; it is termed "Risk of the natural disaster that is not clearly considered as 'my concerns'." The third one represented by earthquake and sudden heavy rain is termed "Risk of the natural disaster that is often observed and experienced in the surroundings." The fourth one is termed "Risk of injury," which occurs in daily life. Taking the findings of the analysis into consideration, the following guidance is regarded as effective to raise students' and teachers' risk consciousness in a comprehensive way. That is to say, the risk of an earthquake, which is classified under the third factor and has been experienced by the students in their lives including the evacuation drills in schools, is set as a starting point of learning. Then, the risk of tornado and volcano, which is classified into second factor and is not so familiar for the schoolchildren, is associated as the possible risk in their surroundings.

On the other hand, a similar survey was conducted with schoolteachers ($n = 573$) and the following 4 factors were extracted (**Fig. 5**). The first factor, represented by traffic accident and suspicious persons, is termed "Risk for traffic safety and school safety." The second one, represented by typhoon and flood, is termed "Risk of storm and flood disaster caused by typhoon, etc." The third one,

Elementary students
N = 266

Items to be observed (risk in the surroundings)	Factor loading				
	Factor 1	Factor 2	Factor 3	Factor 4	Communality
【Factor 1】 Risk coming from the world outside of home and school (traffic accident and suspicious persons, etc.) "Traffic and community safety"					
15. A suspicious person enters the school.	**.765**	-.174	-.033	.089	.447
17. Encounters an accident while walking on a school road or a sidewalk.	**.722**	-.146	.004	.214	.554
18. Encounters an accident while riding a bicycle.	**.654**	-.016	-.012	.044	.431
20. Encounters a minor collision with a motorcycle or a car.	**.537**	.343	-.020	-.118	.582
19. Encounters an accident while riding on a bus or in a train.	**.516**	.222	.033	.102	.608
16. A stranger talks to or asks me about something on my way home from school.	**.510**	.136	-.116	.134	.389
12. It snows heavily.	**.296**	.270	.019	.125	.381
【Factor 2】 Risk of natural disaster that is not considered clearly as "my concerns" "Disaster safety based on basic knowledge"					
10. A mountain or a cliff collapses.	-.132	**.938**	-.201	.046	.553
3. A tsunami strikes.	-.096	**.622**	.097	.196	.527
4. A volcano erupts.	.198	**.538**	.059	-.052	-.519
7. A tornado appears.	.007	**.440**	.144	.167	.418
8. River flooding.	.045	**.373**	.364	-.193	.430
9. A road or a building is inundated.	.111	**.364**	.111	.191	.424
【Factor 3】 Risk of natural disaster that is often observed and experienced in the surroundings "Disaster safety learnt from disaster response exercise, etc."					
5. It rains heavily suddenly.	-.019	-.306	**.817**	.123	.446
2. An earthquake occurs.	-.224	.063	**.597**	.158	.323
1. Fire occurs.	.036	.207	**.489**	-.086	.419
11. A typhoon strikes.	.327	.063	**.395**	-.214	.417
6. Lightning strikes.	.116	.121	**.370**	.109	.365
【Factor 4】 Risk of injury "School and community safety (First-aid treatment)"					
14. Encounters an accident or is injured during an off-campus learning.	.161	.222	.014	**.612**	.734
13. Injured seriously at school.	.237	-.040	.050	**.545**	.479
Factor contribution	6.5	6.4	5.1	3.3	21.3
Contribution ratio (%)	37.6	4.3	2.7	2.6	47.2

Method of extraction of factor: maximum likelihood method
Rotation method: Promax rotation with Kaiser normalization
a. Rotation is converged by repeating 8 times.

Fig. 4. Questionnaire on risks in the surroundings/factor analysis on students.

represented by tornado and volcanic eruption, is termed "Risk of natural disasters that are unfamiliar and cannot be imagined easily." The fourth one, consisting of earthquake and fire, is termed "Risk of natural disasters that can be imagined, including how to respond to it." Although the construction of the factors is different from the case of the students, the following guidance is regarded as effective to raise teachers' risk consciousness in a comprehensive way. The disaster response exercise, which can be imagined easily and has already been targeted frequently for evacuation drills, is first practiced for earthquake and fire. Next, the volcanic and tornado disasters, which are difficult to be imagined, are associated as part of disaster management education.

2.5. Applicability of the Survey Findings to Tochigi Prefecture in Particular and Japan in General

According to the "Opinion Poll on Tochigi Prefectural Government 2014" (covering the whole prefecture, two-stage stratified random sampling, selection, $n = 1,318$) as regards consciousness of disaster prevention of the residents of Tochigi Prefecture who seldom suffer from large-scale disasters, the answers to the question "What kind of disaster do you feel most uneasy about in your daily life" are as follows: "Earthquake" (66.2%), "Damage caused by a tornado, etc." (9.7%), "Fire" (8.5%), "Typhoon and flood" (5.6%), "Lightning damage" (4.4%), "Snow damage" (0.8%), "Volcanic eruption" (0.7%), and "Others or no answer" (4.0%) [21].

Although the questionnaire was not answered by multiple answers, less than 70 percent of all the residents of Tochigi Prefecture are conscious of the risk of an earthquake, but they are less conscious of that of a tornado disaster, a storm, and flooding.

Meanwhile, according to the "Opinion Poll on Disaster Management 2013" (covering the entire country, multiple answers are allowed, $n = 3,110$), which was conducted by Japan's Cabinet Office, the answers to the question "Have you ever imagined vividly that you would suffer from natural disaster" are as follows: "Earthquake" (80.4%), "Damage caused by a tornado, gust of wind, and typhoon, etc." (48.1%), "River flooding" (19.6%), "Tsunami" (17.8%), "Landslide" (13.2%), "Heavy snow," (9.7%), "Volcanic eruption" (5.9%), "High tide," (3.5%) and "Others" (9.4%) [22]. The level of consciousness of the risk of a storm, flooding, and a tornado across the

Teachers
N = 573

	Items to be observed (risk in the surroundings)	Factor loading				
		Factor 1	Factor 2	Factor 3	Factor 4	Communality
【Factor 1】 Risk of traffic and school safety "Traffic and community safety"	18. Encounters an accident while riding a bicycle.	**.953**	-.035	-.100	-.056	.736
	17. Encounters an accident while walking on a school road or a sidewalk.	**.926**	-.073	-.014	-.003	.761
	20. Encounters a minor collision with a motorcycle or a car .	**.811**	.079	-.082	-.058	.624
	16. A stranger talks to or asks me about something on my way home from school.	**.746**	-.065	.027	.008	.393
	19. Encounters an accident while riding on a bus or in a train.	**.646**	.101	.112	-.166	.473
	14. Encounters an accident or is injured during an off-campus learning.	**.608**	.090	.034	.068	.536
	15. A suspicious person enters the school.	**.491**	-.057	.238	.035	.393
	13. Injured seriously at school.	**.467**	.110	-.060	.237	.466
【Factor 2】 Risk of a storm and flood disaster caused by a typhoon, etc. (Flood disaster and inundation) "Disaster safety, Plan and drill for a storm and flood disaster"	8. River flooding.	-.041	**.874**	.055	-.107	.669
	9. A road or a building is inundated.	.004	**.834**	.025	-.099	.628
	5. It rains heavily suddenly.	-.018	**.618**	-.102	.196	.476
	6. Lightning strikes.	.108	**.426**	.113	.109	.427
	11. A typhoon strikes.	.172	**.353**	-.097	.305	.446
	12. It snows heavily.	.110	**.291**	.063	.172	.294
【Factor 3】 Risk of natural disaster that is unfamiliar and cannot be imagined easily "Disaster safety, Raise awareness of volcanic eruption, tsunami, landslide, and tornado hazards"	4. A volcano erupts.	-.032	-.020	**.919**	-.079	.736
	3. A tsunami strikes.	-.020	-.099	**.728**	.154	.556
	10. A mountain or a cliff collapses.	.021	.208	**.574**	-.064	.477
	7. A tornado appears.	.036	.229	**.355**	.100	.375
【Factor 4】 Risk of natural disaster that can be imaged, including how to respond to it "School and community safety (earthquake and fire)"	2. An earthquake occurs.	-.162	.073	-.039	**.890**	.695
	1. Fire occurs.	.151	-.129	.170	**.618**	.536
	Factor contribution	6.7	6.0	4.6	4.8	22.1
	Contribution ratio (%)	39.3	7.2	4.6	3.2	54.3

Method of extraction of factor: maximum likelihood method
Rotation method: Promax rotation with Kaiser normalization
a. Rotation is converged by repeating 8 times.

Fig. 5. Questionnaire on risks in the surroundings/factor analysis on teachers.

country is higher than that of the Tochigi Prefecture.

The findings of the two polls indicate that earthquake crosses most Japanese's minds when they hear the word "disaster." Thus, setting earthquake as a starting point of learning to understand other natural disasters eventually is assumed to be an effective and a comprehensive way of raising risk consciousness in not only Tochigi Prefecture but also other parts of Japan.

3. Development of Disaster Management Education Programs

3.1. Outline of the Programs

The disaster management education programs developed in this study correspond to two kinds of natural hazards, namely, earthquake and tornado. The programs were developed based on the ADDIE process of instructional design, a learning theory. It was designed so that each educational program is not necessarily conducted by disaster management specialists, as the teachers themselves can teach the lessons in the regular learning process for students.

The objective of the educational programs is to teach students of the correct knowledge on natural disasters and enhance their capacities to forecast the risks and avoid them; in other words, the programs aim to foster "zest for life" among the students. Moreover, the students can learn the "package of recognition, judgment, and action" through disaster response exercises. The intension of learning, ways on how to proceed in class and apply the educational materials, and notes on guidance are mentioned understandably. Word and PowerPoint files, with high versatility, are provided to incorporate teachers' originality and ingenuity into the programs in accordance to the characteristics of the school and the students' developmental stage. The programs allow much flexibility to be reproduced and redirected.

3.2. The Proposed Earthquake Disaster Management Education Programs

The "Earthquake Disaster Management Education Programs" developed in this study aim for students to learn the correct knowledge on Earthquake Early Warning and the voluntary and appropriate behaviors after an issuance

Step 1: Prior Learning/A Teacher's Guide (45 minutes)

Utsunomiya Local Meteorological Office Ver.1

■Basic Data

Title	Let us learn the "correct behaviors" when hearing the Earthquake Early Warning
Learning Objective	1. Know the basic knowledge on the Earthquake Early Warning. 2. Know the movements of the objects caused by an earthquake and consider how to respond when hearing the Earthquake Early Warning. 3. Learn the rules on the movement to a safe place.
Grades to be covered	All elementary students
Subject	Response to the Earthquake Early Warning and an evacuation drill, including prior learning
Learning Style	All members (lessons)→individuals (worksheet)→all members (checking answers)→all members (lessons): 45 minutes in all
Preparation	Worksheet, Supplement for Classes 1 (Answers to worksheet), Supplement for Classes 2 (Leaflet for Earthquake Early Warning), Supplement for Classes 3 (Illustration of the evacuation), Sound Source for Exercise of Earthquake Early Warning (Prepared for tsunami disaster) *Homepage of Utsunomiya Local Meteorological Office

■Flow of Learning

Structure	Contents of learning	Notes in the guide (Main questions and assistance to children)
1 Introduction (5 minutes)	1 Know the fear of earthquake	"Today, let us think of what to do to protect ourselves if an earthquake occurs." * Let the students recall previous earthquakes, such as the Great East Japan Earthquake and the Great Hanshin-Awaji Earthquake, by showing photos of the disaster, etc.
	2 Know the basic knowledge on Earthquake Early Warning	"First, are you familiar with 'Earthquake Early Warning'? The message of 'This is Earthquake Early Warning. Please be cautious about a strong shake' is broadcasted on television or radio after the sound of chime. The same message can be heard from mobile phones, too." "The Earthquake Early Warning is the sound of chime that sends us a message of 'be cautious!' before the arrival of strong shake. It takes only several seconds to tens of several seconds between the Earthquake Early Warning and the arrival of a strong shake." *It is better to let the students confirm the sound of chime through playing it on mobile phone or a radio cassette player. *Let the students understand the meaning of the double-underlined sentence well.
2 Development 1 (35 minutes)	3 Know the movements of the objects caused by an earthquake and consider how to respond when hearing the Earthquake Early Warning/	"Now, think of how you can protect yourself when you hear the Earthquake Early Warning" or feel a strong shake. Take time to fill in the worksheet. Please write your opinions on how you can protect yourself at the places listed at 1 of the worksheet." □Set the time for about 10 minutes to fill in the worksheet. *Explain that only the sound of chime is broadcasted at the exercise, if the terminal to receive the Earthquake Early Warning is not set at school.
	(1) Confirm the best way by instructing students to create mutual presentations.	"Please create a presentation of your own opinion. First, how do you respond when you are in a classroom?" *Create a presentation item by item and confirm the results through discussions. *It is also possible to discuss the items by group and create a presentation on what was discussed to confirm the results. *It is also possible to write down the presented opinions on the blackboard for an arrangement and a confirmation of the results. *The teacher should not suggest any answer at the beginning of the exercise.

Utsunomiya Local Meteorological Office Ver.1

	(2) Summarize the "movements of objects" caused by an earthquake	"In summary, it is important to drop your body low, cover your head and body, and hold on until the shake ceases." *This is the basic idea of the disaster drill named "Shake Out." First, drop your body, cover your head, and hold on! *"dangomushi" (pill bug) "Today, we have learned how to protect ourselves while staying at school. An earthquake may occur anywhere at any time. To protect yourself from an earthquake, there are some points that you have to pay attention to at each place. Please write your opinion on what you should pay attention to in number 2 of the worksheet." □Set the time of about 2 minutes to put in number 2 of the worksheet. "Let us confirm the results. The important is to first move to the place where any object does not drop; secondly; move to where any object does not fall down, and third, to where any object does not move." *Let the students understand the meaning of the double-underlined parts well.
3 Development 2 (3 minutes)	4 Learn the rules on the movement to a safe place	"Move to a safer place if the shake ceases. "*OKASHIMOCHI*" (Don't push, don't run, don't return, and don't approach) is the motto. Even if there is no teacher around you, please listen to the broadcast carefully and move to a safer place following the rules." *It is also possible to confirm each evacuation action one by one. *Don't push, don't run, don't return, and don't approach.
4 Conclusions (1 minute)	5 Explain the disaster response and evacuation drill using the Earthquake Early Warning	"Today, we have learned about the disaster response when you hear the Earthquake Early Warning or feel a shake of an earthquake. In the evacuation drill, the Earthquake Early Warning is broadcasted. When you hear the Earthquake Early Warning, please recall what you have learned today, protect yourself, and escape appropriately." *Let the students understand the meaning of the double-underlined parts well. *It can be reviewed from the results of the questionnaire after the exercise whether the students could behave appropriately based on this learning.

*The guide in the parts of "Development" is effective.

■Evaluation Points

1 Whether the students understand what kind of action they should take when they hear the Earthquake Early Warning.
2 Whether the appropriate actions, which were learned in the prior learning, could be practiced also in the exercise.

■Remarks

1 The tendency of the sixth grade in making a self-evaluation: "could not hear quietly" → It is necessary to teach them the meaning of the exercise and urge them to participate in the exercise without being scornfully or ashamed.
2 The tendency of the lower grades in making a self-evaluation: "could not think about what to do by myself" → It is necessary to teach the concrete behaviors understandably to the first and second grades.

■Related Learning

1 With the cycle of learning program of "prior learning→practical exercise→review," it is possible to learn disaster response and evacuation action by using the Earthquake Early Warning.
2 For the upper grades, this can be linked with learning of "Science," for example, taking the mechanism of the Earthquake Early Warning as a theme.

Fig. 6. Earthquake disaster management programs/a teacher's guide (step 1).

of an Earthquake Early Warning.

Earthquake Early Warning is a forecast and warning for seismic motion to be disseminated as quickly as possible. The process involves analyzing the data observed by the nearest seismograph to the epicenter, estimating the epicenter and the magnitude of the earthquake immediately, and forecasting the arrival time of the principal shock and the seismic intensity at each place. The Meteorological Agency issues such warning, which is considered an urgent information that must be gathered every second, and it takes only several seconds to several tens of seconds from its issuance to the arrival of a strong shock. Accordingly, it is required to respond to the Earthquake Early Warning instantly when hearing it. To be able to save one's own life, it is essential that one learns how to respond similar to a conditioned reflex one this warning is issued. In "the Council on Disaster Education and Disaster Management after the Great East Japan Earthquake" and "Plan for Promotion of School Safety" [23], among others, the evacuation drill using Earthquake Early Warning is recommended as a method for disaster management education and drill to learn how to behave based on the initiatives of the learners.

The "Earthquake Disaster Management Education Programs" developed in this study consists of a teacher's guide (**Fig. 6**), a worksheet (**Fig. 7**), a program for disaster response exercise (**Fig. 8**), and a questionnaire for review

Protect yourself from an earthquake!

Step 1 Prior Learning Type A

Grade Class Name ( )

1. Let us consider how you can protect yourself.

Class room		Go under a desk. Hold tight the legs of the table so that the desk cannot move. *Teach the actions that can prevent from the desk to move. *Go under the desk, which is not your own but the one nearby. If there is no desk around you, teach how to protect the head. *Teach that heavy object with casters could move by a strong shake.
Corridor		Keep away from the window. Squat down while protecting your head. (dangomushi) *Teach the students that he/she cannot move to a classroom nearby if a strong shake occurs.
Stairs		Hold on to the rail. Squat down while protecting your head.(dangomushi) *Teach the students that he/she cannot move to a landing or the classroom nearby if a strong shake occurs.
School yard		Escape to the place where any object would not fall down, for example, the center of schoolyard. Keep away from schoolhouse and play equipment and squat down while protecting your head. (dangomushi) *Teach the students that he/she cannot move to the center of a schoolyard if a strong shake occurs.
Library		Keep away from bookshelves. Squat down while protecting your head.(dangomushi) *Teach the students that a heavy object with casters could move by a strong shake.
Toilet		Keep the door open. Squat down with while protecting your head.(dangomushi) *Teach the students that a door could possibly not open because of a strong shake, hence, they would be locked in a toilet room.

2. What you should beware of to protect yourself?

Move to the place where any object "would not drop" from above.

Move to the place where any object "would not fall down" from the side.

Move to the place where any object "would not move" from the side.

Utsunomiya Local Meteorological Office Ver.1

Fig. 7. Earthquake disaster management programs/worksheet (for teachers).

Step 2 Program for Practical Exercise (unannounced)

Utsunomiya Local Meteorological Office Ver.1

*The contents need to be revised according to the situation of each school, because this is the standard program.

■Basic Data

Title	Disaster response exercise using the Earthquake Early Warning (unannounced short exercise)
Learning Objective	1. Making use of prior leaning on the Earthquake Early Warning, learn disaster response exercise to protect own body based on own judgment when the Earthquake Early Warning is heard.
Grades to be covered	All elementary students.
Subject	Disaster response exercise using the Earthquake Early Warning (unannounced short exercise)
Form of learning	Within school (break time) about 5 minutes in total
Preparation	The kit for exercise using the Earthquake Early Warning (sound of chime＋announcement＋sound effect of shake of earthquake) (the Meteorological Agency) Sound source for exercise of the Earthquake Early Warning (prepared for tsunami) (the Meteorological Agency)

■Flow of Learning

Structure	Contents	Behaviors of Teachers	Behaviors of Students
1. Earthquake Early Warning (2 minutes)	Four times of the sound of chime of the Earthquake Early Warning and the following announcement will be made: "Earthquake will occur. Please keep calm and protect yourself."	□ Do not give any instruction on the behaviors of students from the side of teachers. □ Give the instruction to the students who cannot behave to protect themselves.	□Move to a safe place where any object would "never drop, never fall down, and never move" for protection when the Earthquake Early Warning is heard. □As for the students staying outside of classroom, take the appropriate evacuation behaviors according to the situation and wait until the shake ceases. *Complete their evacuation behaviors before broadcasting the sound effect of a shake of an earthquake.
	Sound effect of shake of an earthquake	□ Give the instruction to evacuate to students who are still moving while the sound effect of a shake of an earthquake is announced.	□ Listen to the broadcast well.
2. Broadcast for exercise (3 minutes)	Announcement of broadcast of "Exercise, exercise, exercise. This is the exercise using the Earthquake Early Warning. Did you take the behaviors to protect yourself on the spot? Earthquake may occur outside of classroom, too. Please behave as you did today, wherever you may be. This is the end of the exercise. (If the exercise is reviewed) Please review your behaviors in the classroom."	□ Observe whether the students could behave to protect themselves based on their own judgment after hearing the Earthquake Early Warning. □ Guide where the safe place is to the students who evacuated to a dangerous one. □ Review the exercise (Guide the students in the review).	□ Evacuate on the spot if the Earthquake Early Warning is heard. □ Listen to the instructions given by the teachers and broadcasting calmly. □ Review own behaviors (learn in the review).

■Evaluation Points

1 Whether the students respond appropriately when hearing the Earthquake Early Warning.

■Related Learning

1. By setting the place of the exercise outside "classroom (ordinary classroom)," it is possible to learn the disaster response according to each situation even if there is no teacher nearby.
2. Prevent mannerism of the exercise by performing "unannounced exercise" effectively without noticing time and date.
3. For the upper grades, this can be linked with learning of "Science," for example, taking the principles of the Earthquake Early Warning as a theme.

Fig. 8. Program for disaster response exercise using the earthquake early warning (for short exercise).

on exercise and effectiveness measurement (**Fig. 9**).

This set of programs has the following three steps (structured by units), namely, Step 1: Prior Learning: "Learn the correct behaviors when hearing the Earthquake Early Warning"; Step 2: Disaster Response Exercise: "Disaster response exercise is performed by using the Earthquake Early Warning"; and Step 3: Review: "Review the behaviors when hearing the Earthquake Early Warning." Then, the Teacher's Guide formulates a flow of several guides that shows the ways and sequences on how to guide the learners and how to learn the learning objectives. The Worksheet comprises of teaching materials that contribute to the effective and efficient learning by formulating the contents and points of learning clearly and briefly. The useful ideas can be arranged by "writing" and "summarizing" them on this Worksheet. The Program for Disaster Response Exercise is a plan showing a flow of the exercise performed by using the sound of chime of the Earthquake Early Warning. Two kinds of programs have been prepared; one is a "long exercise" for evacuation to

Let's review the exercise!

Step 3 Review

Grade ___ Class ___ Name (_____)

1. Please circle the applicable answer

① Could you hear the sound of chime and broadcasting of the Earthquake Early Warning quietly?

I could do it well , I could do it , I could not do it well , I could not do it

② Could you think about what to do by yourself when hearing the Earthquake Early Warning?

I could do it well , I could do it , I could not do it well , I could not do it

③ Could do behave swiftly to protect yourself safely?

I could do it well , I could do it , I could not do it well , I could not do it

④ Could you observe the rule of "*O・KA・SHI・MO・CHI*" (don't push, don't run, don't return, and don't approach) when moving to safe place?

I could do it well , I could do it , I could not do it well , I could not do it

2. Where did you stay when the exercise began?

3. How did you protect yourself at that time?

Utsunomiya Local Meteorological Office Ver.1

Questionnaire on Earthquake

Grade ___ Class ___ Name (_____)

1. Please circle the applicable answer.

① Know how to protect yourself correctly if an earthquake occurs.

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

② Know what is the Earthquake Early Warning.

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

③ Know that it takes only a short time between the issuance of Earthquake Early Warning and arrival of a strong shake.

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

④ Know what to do when hearing Earthquake Early Warning (Sound of Chime).

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

⑤ A place where any object would drop, fall down, or move is dangerous if an earthquake occurs.

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

⑥ Drop your body low, cover your head and body, and hold on until the shake ceases if an earthquake occurs.

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

⑦ Protect yourself in the same way as in the case of an earthquake if you hear the Earthquake Early Warning (sound of chime).

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

⑧ Think and behave by yourself to protect you if you hear the Earthquake Early Warning (sound of chime).

I know well , I know a little , I cannot tell either , I slightly don't know , I don't know

Utsunomiya Local Meteorological Office Ver.1

Fig. 9. Questionnaire for review on exercise (left) and effectiveness measurement (right).

a schoolyard, whereas the other is a "short exercise" for quick response in a short period. The Questionnaire has been developed to review the disaster response exercise (qualitative survey) and evaluate the degree of knowledge and behaviors acquired through the implementation of the programs (quantitative one).

Next, the outlines of each step are described below. Prior learning of Step 1 aims to teach the basic knowledge on Earthquake Early Warning and allows the leaners to imagine the movements of the objects caused by an earthquake (or the risks involved), consider the concrete measures to be taken when hearing the Earthquake Early Warning, and understand the rules for evacuation to safe place after an earthquake.

A flow of guidance of Step 1 is described as follows. To begin, in the part of "Introduction," it is intended to understand the fear of earthquake by reviewing previous earthquake disasters and knowing the sound of chime and the mechanism of Earthquake Early Warning. The next step of "Development 1" aims to know the movements of objects caused by an earthquake and consider measures to protect oneself when hearing the Earthquake Early Warning or feeling a strong shake of earthquake. In this step, students must understand the importance of evacuating to a safe place where any object would "never drop, never fall down, and never move," which is a key phrase at a time of an earthquake. In this step, students must also deepen their understanding of the appropriate behaviors in schools by putting their ideas in the worksheet and creating a presentation mutually. In "Development 2," the necessary response in evacuation expressed by the motto of "*OKASHIMOCHI*," an acronym of "*Osanai*, *Kakenai*, *Shaberanai*, *Modoranai*, and *Chikazukanai* (don't push, don't run, don't return, and don't approach)" is learned. Finally, in the "Conclusion" of Step 2, Disaster Response Exercise is prepared by summarizing the contents of the prior learning of Step 1. Step 1 is recommended to be performed in one period of time in school, which corresponds to 45 minutes.

In step 2, the objective of the Disaster Response Exercise is for students to use their prior learning described in Step 1, pay attention to the key phrase for evacuation, "(objects would) never drop, never fall down, and never move," and behave to protect themselves based on their own judgment when hearing the sound of chime of the Earthquake Early Warning. The capabilities to judge on their own and behave as if it is a conditioned reflex action are acquired by practicing the exercise with assumed various situations, such as break time or time for cleaning, at the signal of broadcast of sound of the chime of the Earthquake Early Warning. The disaster response exercise, including the evacuation to a schoolyard and roll call, and review of the exercise are supposed to be performed in one period of time in school corresponding to 45 minutes.

If the school could not allocate an enough time for such exercise, only the disaster response is conducted during break time in a "short exercise." A "short exercise" can be repeated without reducing the school hours and eradicate training with script by performing the exercise without previous notice.

In Step 3, Review, the learning objective is for students to check the appropriate disaster response when hearing the Earthquake Early Warning and understand the importance of protecting themselves based on their own judgment at a time of an earthquake. By using the Questionnaire for Review on Exercise and Effectiveness Measurement, students can evaluate whether they have learned to behave on their own initiatives through prior learning and the practice of a disaster response exercise. A flow of Step 3 can be described as follows. First, in "Introduction," the disaster response exercise is reviewed. In "Development 1," the disaster response that has been practiced in the exercise is filled in the Questionnaire and those to be taken at various places are understood deeply through the mutual presentations of leaners. In "Development 2," the following important key phrase to protect students from an earthquake is reviewed: "(objects would) never drop, never fall down, and never move." In the last part of the learning, "Conclusion" is intended to notice that similar disaster response can be applied to the other places other than school as well and understand the importance for students to behave based on their own initiatives. Step 3 is recommended to be performed in one period of time in school corresponding to 45 minutes. However, it can also be performed in combination with an alternative of Step 2, a "short exercise," in one period of time in school corresponding to 45 minutes.

3.3. The Proposed Tornado Disaster Management Education Programs

The proposed Tornado Disaster Management Education Programs are for the practice of disaster management education to learn the correct knowledge on tornadoes, forecast the risks they cause, and enhance the capabilities of students to avoid them.

The Tornado Disaster Management Education Programs have been developed based on the same educational theory applied to the proposed Earthquake Disaster Management Education Programs. The programs consist of a teacher's Guide, a worksheet (**Fig. 10**), a supplement for the class (**Fig. 11**), a disaster response exercise, and a questionnaire for review on exercise and effectiveness measurement. Each material was developed according to the format of the Earthquake Disaster Management Education Programs mentioned in the previous section.

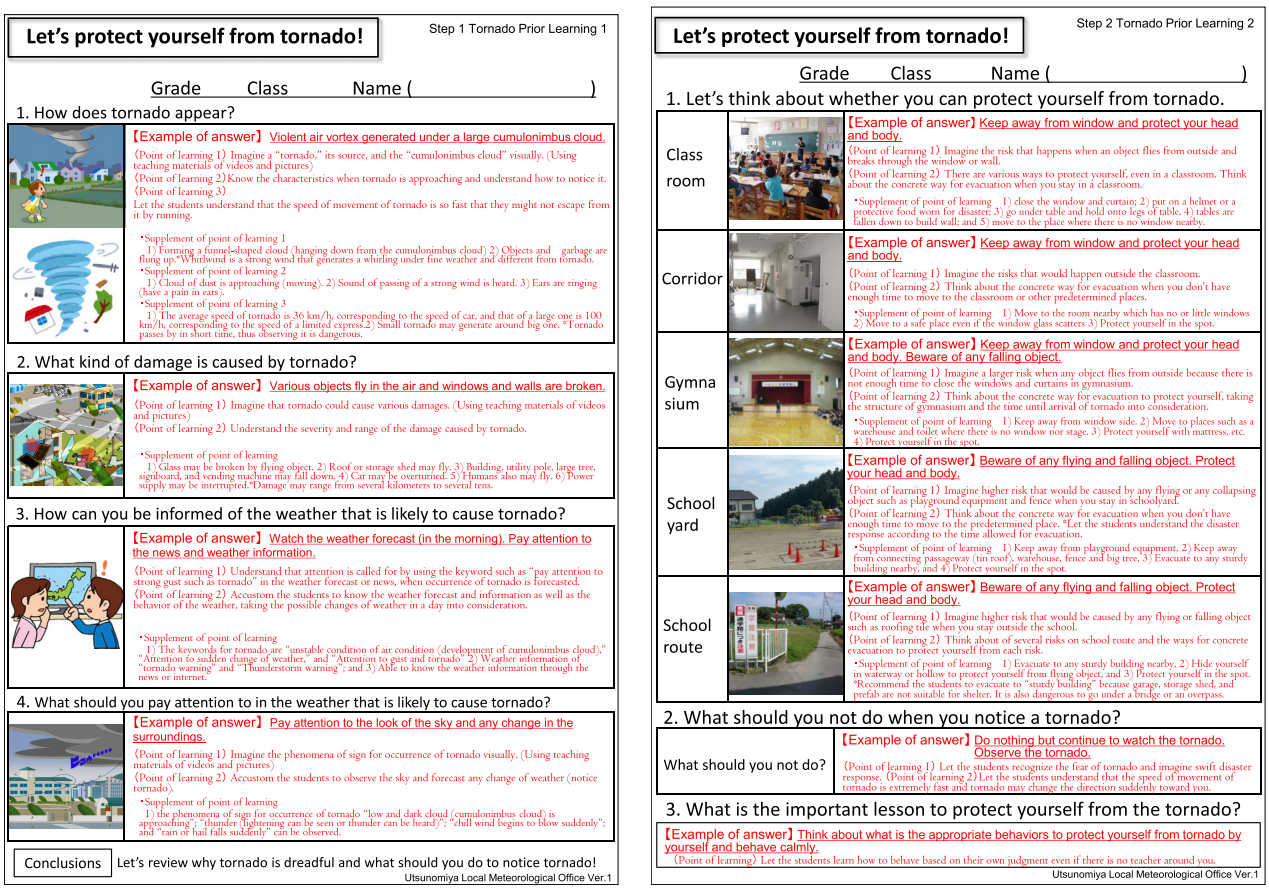
The programs are structured with the following three units, namely, Step 1: Prior Learning 1: "Let us know why a tornado is dreadful"; Step 2: Prior Learning 2: "Let us think of ways to protect yourself from a tornado"; and Step 3: Practical Exercise (a short exercise) and Review: "Let us review the behaviors to protect yourself." A supplement for classes mentioned above means that the knowledge is necessary to put in the Worksheet and the information for the classes to proceed smoothly. In addition to the materials of PowerPoint, many visual materials on tornado such as photo and video are included.

In the prior learning of Step 1, the learning objectives are set to learn the basic knowledge on the characteristics of tornado and the damage and influence caused by it, as well as understand the ways to collect information on its occurrence and the characteristics of the weather phenomena (the sign phenomena) when it occurs. Teachers allows students to imagine the various risks and damages that a tornado could cause and learn the necessary knowledge to observe its occurrence.

The flow of guidance of Step 1 begins with the "Introduction," which defines why tornado is a disaster. In "Development 1," or "Know Tornado," students learn what is tornado. In "Development 2," or "Collection of Information," students learn how to notice a tornado. Finally, in the "Conclusions," the contents of the learning in Step 1 are summarized to lead to Step 2. Step 1 is recommended to be performed in one period of time in school corresponding to 45 minutes.

In the prior learning of Step 2, the learning objectives are set to understand the concrete disaster response when students encounter a tornado or one is approaching toward them, and then think and understand about how to protect themselves appropriately according to the various places at school. In addition of the appropriate disaster response according to each place, the behaviors of "Protect yourself on the spot," which phrase is converted from "Shake Out," the way to protect oneself at a time of an occurrence of an earthquake, are also learned. In the proposed guidance of Step 2, the way of protecting oneself is learned through the same flow of guidance, namely, "Introduction," "Development 1," "Development 2," and "Conclusion," as in Step 1. Step 2 leads to the disaster response exercise in Step 3. Step 2 is recommended to be performed in one period of time in school corresponding to 45 minutes.

In the disaster response exercise of Step 3, the learning objectives are set to acquire the ability to respond to protect oneself based on one's own initiative to make use of the prior learnings of Steps 1 and 2 when hearing the broadcast upon the approach of a tornado. In this disaster response exercise, the settings of time and place are changed, as in the case of an earthquake. Students use the measures to protect themselves on the spot based on their own judgments at the signal of the broadcast upon the approach of a tornado. In the review, after the disaster response exercise, the learning objectives are set to confirm the appropriate behaviors through the review when hearing the broadcast and realizing the importance of protecting themselves by their own judgments when a tornado is approaching. It is evaluated by putting in the Questionnaire for Review on Exercise and Effectiveness Measurement whether each student could acquire the ability to take behaviors on their own initiatives through the exercise or not. A flow of guidance of Step 3 begins with the "Introduction," which reviews the contents of the prior learnings of Steps 1 and 2. In "Development 1," the disas-



Let's protect yourself from tornado! Step 1 Tornado Prior Learning 1

Grade Class Name ( )

1. How does tornado appear?

【Example of answer】Violent air vortex generated under a large cumulonimbus cloud.

(Point of learning 1) Imagine a "tornado," its source, and the "cumulonimbus cloud" visually. (Using teaching materials of videos and pictures)
(Point of learning 2) Know the characteristics when tornado is approaching and understand how to notice it.
(Point of learning 3)
Let the students understand that the speed of movement of tornado is so fast that they might not escape from it by running.

・Supplement of point of learning 1
1) Forming a funnel-shaped cloud (hanging down from the cumulonimbus cloud) 2) Objects and garbage are flung up.*Whirlwind is a strong wind that generates a whirling under fine weather and different from tornado.
・Supplement of point of learning 2
1) Cloud of dust is approaching (moving). 2) Sound of passing of a strong wind is heard. 3) Ears are ringing (have a pain in ears).
・Supplement of point of learning 3
1) The average speed of tornado is 36 km/h, corresponding to the speed of car, and that of a large one is 100 km/h, corresponding to the speed of a limited express.2) Small tornado may generate around big one. *Tornado passes by in short time, thus observing it is dangerous.

2. What kind of damage is caused by tornado?

【Example of answer】Various objects fly in the air and windows and walls are broken.

(Point of learning 1) Imagine that tornado could cause various damages. (Using teaching materials of videos and pictures)
(Point of learning 2) Understand the severity and range of the damage caused by tornado.

・Supplement of point of learning
1) Glass may be broken by flying object. 2) Roof or storage shed may fly. 3) Building, utility pole, large tree, signboard, and vending machine may fall down. 4) Car may be overturned. 5) Humans also may fly. 6) Power supply may be interrupted.*Damage may range from several kilometers to several tens.

3. How can you be informed of the weather that is likely to cause tornado?

【Example of answer】Watch the weather forecast (in the morning). Pay attention to the news and weather information.

(Point of learning 1) Understand that attention is called for by using the keyword such as "pay attention to strong gust such as tornado" in the weather forecast or news, when occurrence of tornado is forecasted.
(Point of learning 2) Accustom the students to know the weather forecast and information as well as the behavior of the weather, taking the possible changes of weather in a day into consideration.

・Supplement of point of learning
1) The keywords for tornado are "unstable condition of air condition (development of cumulonimbus cloud)," "Attention to sudden change of weather," and "Attention to gust and tornado" 2) Weather information of "tornado warning" and "Thunderstorm warning"; and 3) Able to know the weather information through the news or internet.

4. What should you pay attention to in the weather that is likely to cause tornado?

【Example of answer】Pay attention to the look of the sky and any change in the surroundings.

(Point of learning 1) Imagine the phenomena of sign for occurrence of tornado visually. (Using teaching materials of videos and pictures)
(Point of learning 2) Accustom the students to observe the sky and forecast any change of weather (notice tornado).
・Supplement of point of learning
1) the phenomena of sign for occurrence of tornado "low and dark cloud (cumulonimbus cloud) is approaching"; "thunder (lightening can be seen or thunder can be heard)"; "chill wind begins to blow suddenly"; and "rain or hail falls suddenly" can be observed.

Conclusions Let's review why tornado is dreadful and what should you do to notice tornado!

Utsunomiya Local Meteorological Office Ver.1

Let's protect yourself from tornado! Step 2 Tornado Prior Learning 2

Grade Class Name ( )

1. Let's think about whether you can protect yourself from tornado.

Class room		【Example of answer】Keep away from window and protect your head and body. (Point of learning 1) Imagine the risk that happens when an object flies from outside and breaks through the window or wall. (Point of learning 2) There are various ways to protect yourself, even in a classroom. Think about the concrete way for evacuation when you stay in a classroom. ・Supplement of point of learning 1) close the window and curtain; 2) put on a helmet or a protective food worn for disaster; 3) go under table and hold onto legs of table, 4) tables are fallen down to build wall; and 5) move to the place where there is no window nearby.
Corridor		【Example of answer】Keep away from window and protect your head and body. (Point of learning 1) Imagine the risks that would happen outside the classroom. (Point of learning 2) Think about the concrete way for evacuation when you don't have enough time to move to the classroom or other predetermined places. ・Supplement of point of learning 1) Move to the room nearby which has no or little windows 2) Move to a safe place even if the window glass scatters 3) Protect yourself in the spot.
Gymnasium		【Example of answer】Keep away from window and protect your head and body. Beware of any falling object. (Point of learning 1) Imagine a larger risk when any object flies from outside because there is not enough time to close the windows and curtains in gymnasium. (Point of learning 2) Think about the concrete way for evacuation to protect yourself, taking the structure of gymnasium and the time until arrival of tornado into consideration. ・Supplement of point of learning 1) Keep away from window side. 2) Move to places such as a warehouse and toilet where there is no window nor stage. 3) Protect yourself with mattress, etc. 4) Protect yourself in the spot.
School yard		【Example of answer】Beware of any flying and falling object. Protect your head and body. (Point of learning 1) Imagine higher risk that would be caused by any flying or any collapsing object such as playground equipment and fence when you stay in schoolyard. (Point of learning 2) Think about the concrete way for evacuation when you don't have enough time to move to the predetermined place. *Let the students understand the disaster response according to the time allowed for evacuation. ・Supplement of point of learning 1) Keep away from playground equipment, 2) Keep away from connecting passageway (tin roof), warehouse, fence and big tree, 3) Evacuate to any sturdy building nearby, and 4) Protect yourself in the spot.
School route		【Example of answer】Beware of any flying and falling object. Protect your head and body. (Point of learning 1) Imagine higher risk that would be caused by any flying or falling object such as roofing tile when you stay outside the school. (Point of learning 2) Think about of several risks on school route and the ways for concrete evacuation to protect yourself from each risk. ・Supplement of point of learning 1) Evacuate to any sturdy building nearby. 2) Hide yourself in waterway or hollow to protect yourself from flying object, and 3) Protect yourself in the spot. *Recommend the students to evacuate to "sturdy building" because garage, storage shed, and prefab are not suitable for shelter. It is also dangerous to go under a bridge or an overpass.

2. What should you not do when you notice a tornado?

What should you not do?	【Example of answer】Do nothing but continue to watch the tornado. Observe the tornado. (Point of learning 1) Let the students recognize the fear of tornado and imagine swift disaster response. (Point of learning 2) Let the students understand that the speed of movement of tornado is extremely fast and tornado may change the direction suddenly toward you.

3. What is the important lesson to protect yourself from the tornado?

【Example of answer】Think about what is the appropriate behaviors to protect yourself from tornado by yourself and behave calmly.
(Point of learning) Let the students learn how to behave based on their own judgment even if there is no teacher around you.

Utsunomiya Local Meteorological Office Ver.1

Fig. 10. Tornado disaster management education program/worksheet (steps 1 and 2 for teachers).

Fig. 11. Tornado disaster management education programs/supplementary materials for classes (tornado).

Contents of Programs				Name of School		
	Implementation of Programs	Contents	Classification	Niregi Elementary School	Minamioshihara Elementary School	Minamioshihara Junior High School
1	Tornado Questionnaire ①	Effectiveness Measurement	Tornado	June 22, 2015	June 4, 2015	June 17, 2015
2	Tornado Learning "Step 1"	Practice of Class	Tornado	June 23, 2015	June 24, 2015	June 17, 2015
3	Tornado Learning "Step 2"	Practice of Class	Tornado	June 23, 2015	June 26, 2015	June 29, 2015
4	Tornado Disaster Response Exercise ①	Disaster Response Exercise	Tornado	July 9, 2015	July 9, 2015	July 9, 2015
5	Tornado Questionnaire ②	Effectiveness Measurement	Tornado	July 9, 2015	July 9, 2015	July 9, 2015
6	Earthquake Questionnaire ①	Effectiveness Measurement	Earthquake	September 14, 2015	September 25, 2015	September 14, 2015
7	Earthquake Learning "Step 1"	Practice of Class	Earthquake	September 18, 2015	October 2, 2015	September 16, 2015
8	Disaster Response Exercise for Earthquake Early Warning ①	Disaster Response Exercise	Earthquake	September 18, 2015	October 2, 2015	September 18, 2015
9	Earthquake Learning "Step 2"	Practice of Class	Earthquake	September 18, 2015	October 2, 2015	September 18, 2015
10	Earthquake Questionnaire ②	Effectiveness Measurement	Earthquake	September 18, 2015	October 2, 2015	September 18, 2015
11	Tornado Questionnaire ③	Effectiveness Measurement	Tornado	September 18, 2015	October 2, 2015	September 18, 2015
12	Tornado Disaster Response Exercise ②	Disaster Response Exercise	Tornado	November 17, 2015	December 9, 2015	December 9, 2015
13	Tornado Questionnaire ④	Effectiveness Measurement	Tornado	November 17, 2015	December 9, 2015	December 9, 2015
14	Earthquake Questionnaire ③	Effectiveness Measurement	Earthquake	November 17, 2015	December 9, 2015	December 9, 2015
15	Disaster Response Exercise for Earthquake Early Warning ②	Disaster Response Exercise	Earthquake	December 16, 2015	January 12, 2016	January 13, 2016
16	Earthquake Questionnaire ④	Effectiveness Measurement	Earthquake	December 16, 2015	January 12, 2016	January 13, 2016
17	Tornado Questionnaire ⑤	Effectiveness Measurement	Tornado	December 16, 2015	January 12, 2016	January 13, 2016
18	Tornado Questionnaire ⑥	Effectiveness Measurement	Tornado	February 16, 2016	March 8, 2016	February 26, 2016
19	Earthquake Questionnaire ⑤	Effectiveness Measurement	Earthquake	February 16, 2016	March 8, 2016	February 26, 2016

Fig. 12. Dates when programs were implemented at each school.

ter response exercise that assumes a tornado is practiced. In "Development 2," the disaster responses performed in the exercise are placed in the Questionnaire for Review on Exercise and the disaster responses performed at the various places are understood deeply by making mutual presentations by the students. Finally, in the "Conclusions," ways on protecting oneself when there is no place for protection or there is not enough time for evacuation are considered. Then, teachers allow the children to imagine how to protect themselves when they encounter a tornado outside the school. Step 3 is recommended to be performed in one period of time in school, corresponding to 45 minutes.

4. Implementation, Evaluation, and Improvement of the Proposed Programs

4.1. Implementation

In this study, it is verified how the learning objectives could be attained for the teachers who are not the experts on disaster management by practicing the Earthquake and Tornado Disaster Management Education Programs. The teachers distributed the questionnaire to the students before and after the implementation of the programs, and then evaluated their effectiveness in terms of the degree of attainment of the learning objectives, as measured by self-evaluation. The survey was conducted at three schools in Kanuma City, namely, Niregi Elementary School, Minamioshihara Elementary School, and Minamioshihara Junior High School, which have been designated as the model school for disaster management education in the MEXT's Project for Comprehensive Support for Safety [24].

The program's effectiveness was measured in the following order: 1) Tornado Questionnaire no.1 "Effectiveness Measurement" (before the implementation of program), 2) Tornado Learning "Step 1: Let us know about the nature of tornado to understand why it is dreadful"; 3) Tornado Learning "Step 2: Let's think about how to protect yourself from tornado"; 4) Tornado Disaster Response Exercise no.1 "Disaster Response Exercise"; 5) Tornado Questionnaire no.2 "Effectiveness Measurement" (after the implementation of the program); 6) Earthquake Questionnaire no.1 "Effectiveness Measurement" (before the implementation of the program); 7) Earthquake Learning "Step 1: Let us learn the 'correct behaviors' when hearing the Earthquake Early Warning"; 8) Disaster Response Exercise for the Earthquake Early Warning no.1 "Disaster Response Exercise"; 9) Earthquake Learning "Step 2: Review the correct behaviors when hearing the Earthquake Early Warning"; 10) Earthquake Questionnaire no.2 "Effectiveness Measurement" (after the implementation of the program); 11) Tornado Questionnaire no.3 "Effectiveness Measurement" (after the implementation of the program); 12) Tornado Disaster Response Exercise no.2 "Disaster Response Exercise"; 13) Tornado Questionnaire no.4 "Effectiveness Measurement"; 14) Earthquake Questionnaire no.3 "Effectiveness Measurement"; 15) Disaster Response Exercise for the Earthquake Early Warning no.2 "Disaster Response Exercise"; 16) Earthquake Questionnaire no.4 "Effectiveness Measurement"; 17) Tornado Questionnaire no.5 "Effectiveness Measurement"; 18) Tornado Questionnaire no.6 "Effectiveness Measurement"; and 19) Earthquake Questionnaire no.5 "Effectiveness Measurement."

The dates when the programs were implemented at each school are shown in **Fig. 12**. The items from 1) to 10) refer to the implementation of the programs and their effectiveness measurement as well as the analysis on the total practices, including the disaster response exercises. The effectiveness measurement of the disaster response exercises are described in items 11) to 19) and are mentioned in Section 5.

4.2. Evaluation

In this study, to evaluate the Earthquake and Tornado Disaster Management Education Programs implemented by the teachers, effectiveness of the programs is measured by distributing the questionnaire to the students before, during, and after the implementation of the programs. The questionnaires contained questions regarding the extent to which the learning objectives are attained. The effectiveness measurement of the educational program is defined by instructional design researcher M. Gagne [25] as follows, "the evaluation of the program is expressed only by evaluating the performance of the leaners." Kimura and Hayashi [26] and Nagata and Kimura [11–13] argued the implementation and evaluation of the educational programs as well. In this study, the same method of evaluation is adopted to evaluate the availability of the programs.

In "Questionnaire on Earthquake" for effectiveness measurement of the proposed "Earthquake Disaster Management Education Programs," eight questions are set. The first four items, from 1 to 4, ask about the degree of knowledge in terms of earthquake phenomena and Earthquake Early Warning. The other four items, from 5 to 8, ask about the degree of understanding on the disaster response when an earthquake occurs or the Earthquake Early Warning is heard. These items correspond to the learning objectives of the proposed "Earthquake Disaster Management Education Programs." They are also used as criteria for evaluating the educational programs; students evaluate the degree of attainment of the learning objectives in five stages.

As for the concrete contents of the learning objectives in terms of knowledge, the following four items are evaluated by the students themselves in five stages, from "I know well" to "I don't know": "1) Know how to protect yourself correctly if an earthquake occurs," "2) Know what is the Earthquake Early Warning," "3) Know that it takes only a short time between the issuance of the Earthquake Early Warning and the arrival of a strong shake," and "4) Know what to do when hearing the Earthquake Early Warning (sound of chime)." As for understanding the correct behaviors when an earthquake occurs or the Earthquake Early Warning is heard, students evaluate the following four items in five stages, from "I think so" to "I don't think so": "1) Any place where an object would drop, fall down, or move is dangerous if an earthquake occurs," "2) Drop your body low, cover your head and body, and hold on until the shake ceases, in cases when an earthquake occurs," "3) Protect yourself in the same way as in the case of an earthquake if you hear the Earthquake Early Warning (sound of chime)," and "4) Think and act on your own to protect yourself if you hear the Earthquake Early Warning (sound of chime)."

In the "Questionnaire on Tornado" for effectiveness measurement of the proposed "Tornado Disaster Management Education Programs," eight questions are set. The first four items, from 1 to 4, ask about the degree of knowledge in terms of the phenomena, damage of tornado, and response to it. The other four items, from 5 to 8, ask about the degree of understanding on the disaster response when a tornado occurs. These items correspond to the learning objectives of the proposed "Tornado Disaster Management Education Programs." They are used as criteria for evaluating the educational programs; students evaluate the degree of attainment of the learning objectives in five stages.

As for the concrete contents of the learning objectives in terms of knowledge, the following four items are evaluated by the learners themselves in five stages, from "I know well" to "I don't know": "1) Know what is tornado," "2) Know what kind of damage it would cause," "3) Know what to do to notice a tornado," and "4) Know what to do when a tornado is approaching." As for understanding the correct behaviors when a tornado is approaching, students evaluate the following four items in five stages, from "I think so" to "I don't think so": "1) Observe a tornado outside when a tornado is approaching," "2) Go to whatever building when a tornado is approaching," "3) Stay wherever in a building when a tornado is approaching," and "4) You do not need to do anything in a safe place in a building when a tornado is approaching."

4.3. Implementation and Evaluation of the Proposed Programs at Elementary Schools

The Earthquake and Tornado Disaster Management Education Programs were conducted by the teachers to students from the third to the fifth grade of Niregi and Minamioshihara Elementary Schools in Kanuma City ($n = 115 - 116$). The effectiveness of the programs was measured.

As for the degree of knowledge in terms of earthquake phenomena and the Earthquake Early Warning in the first four items of the Earthquake Disaster Management Education Programs, the degree of attainment of the learning objectives is evaluated as the average of evaluation in five stages (where five is the maximum and one is minimum) before the implementation of the programs. The average scores are as follows: 4.10 for the item "1) Know how to protect yourself correctly if an earthquake occurs"; 3.70, "2) Know what is the Earthquake Early Warning"; 3.85, "3) Know that it takes only a short time between the issuance of the Earthquake Early Warning and the arrival of a strong shake"; and 4.03, "4) Know what to do when a tornado is approaching." However, the effectiveness of learning can be confirmed with the higher average of evaluation, from 4.69 to 4.73, after the implementation of the programs. As a result of the t-test analysis, a statistical significant difference is recorded at 1% standard under all the items. As for the other four items on understanding of the correct behaviors when an earthquake occurs or the Earthquake Early Warning is heard, the degree of attainment of the learning objectives expressed as the average of evaluation in five stages (where five is the maximum and one is minimum) is evaluated at 4.46 to 4.83 before the implementation of the programs, and 4.47 to 4.83 after it. It is confirmed that all the four items have attained the learning effectiveness with more than 4 scores. As a result of the t-test analysis, there is no significant difference

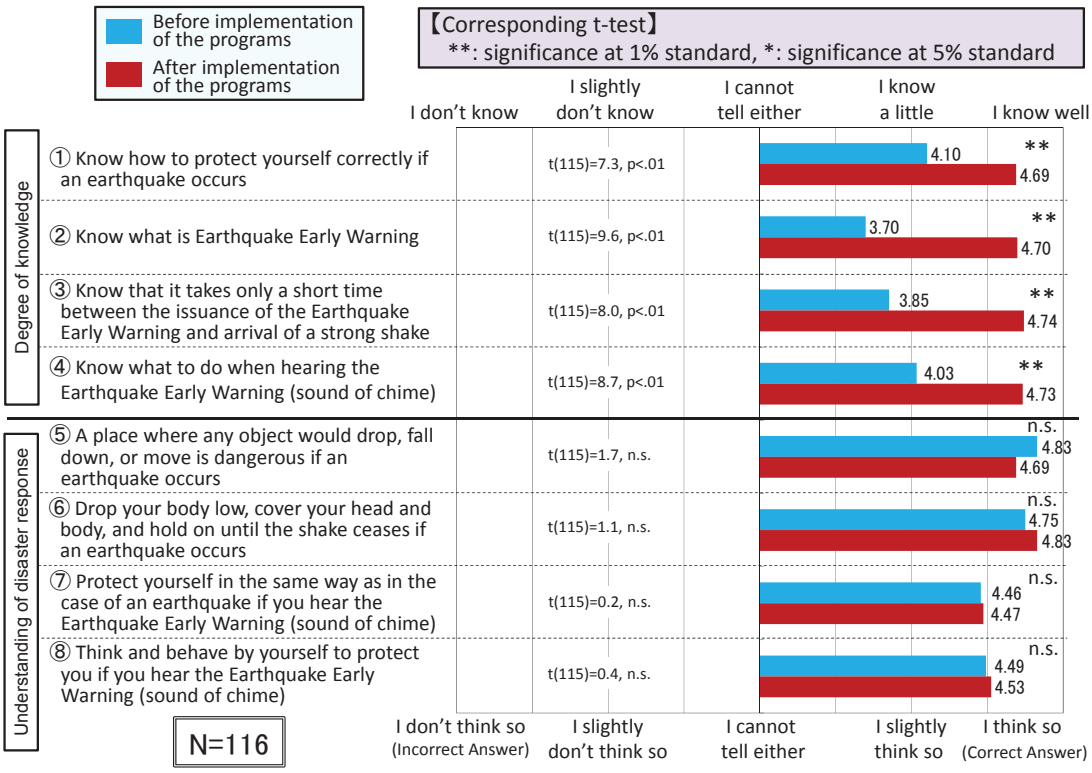


Fig. 13. Earthquake disaster management education at elementary schools.

under all the items (**Fig. 13**). Thus, it is confirmed that the learning effectiveness and the efficacy have been improved by the teachers' implementation of the Earthquake Disaster Management Education Programs. A problem has been revealed that for the 4 items on understanding of the correct behaviors, which had already attained a high score because of the previous evacuation drills, the understanding on this theme needs to be deepen by a continuation and a review of the disaster response exercise.

Next, as for the degree of knowledge on tornado in the Tornado Disaster Management Education Programs, the degree of attainment of the learning objectives is evaluated as the average of evaluation in five stages (where five is the maximum and one is minimum) before the implementation of the programs. The average scores are as follows: 3.90 for the item "1) Know what is tornado"; 4.19, "2) Know what kind of damage it would cause"; 3.25, "3) Know what to do to notice a tornado"; and 3.76, "4) Know what to do when a tornado is approaching." However, the effectiveness of learning can be confirmed with the higher average of evaluation, from 4.01 to 4.51, after the implementation of the programs. As a result of the t-test analysis, a statistical significant difference can be confirmed under all the items. As for the four items on understanding of the correct behaviors when a tornado is approaching, the degree of attainment of the learning objectives expressed as the average of evaluation in five stages (where five is the maximum and one is minimum) is higher, with a score of 3.39 for the item "6) Go to whatever building when a tornado is approaching," which had marked especially low at 3.02 before the implementation of the programs. Under the other three items, the effectiveness of learning can be confirmed similarly, from 3.71 to 4.49 before the implementation of the programs to 4.21 to 4.82 after it. However, there is a room for improvement under one item of 6). As a result of the t-test analysis, a statistical significant difference can be confirmed at 1% standard under the two items of 5) and 8), and at 5% standard under one item of 6). There is no significance under one item of 7) (**Fig. 14**). Thus, it is confirmed that the effectiveness of learning and the efficacy have been improved because of the teachers' implementation of the Tornado Disaster Management Education Programs. A problem has been revealed that as for the item 6) of which the degree of attainment of the learning objectives are still low, the understanding on this item needs to be deepen by the previous learning and review of the disaster response exercise.

4.4. Implementation and Evaluation of the Proposed Programs at a Junior High School

The Earthquake and Tornado Disaster Management Education Programs were implemented by the teachers to students of Minamioshihara Junior High School in Kanuma City ($n = 110$). The effectiveness of the programs was measured.

As for the degree of knowledge in terms of earthquake phenomena and Earthquake Early Warning in the first four items of the Earthquake Disaster Management Education Programs, the degree of attainment of the learning objectives expressed as the average of evaluation in five stages (where five is the maximum and one is minimum) has

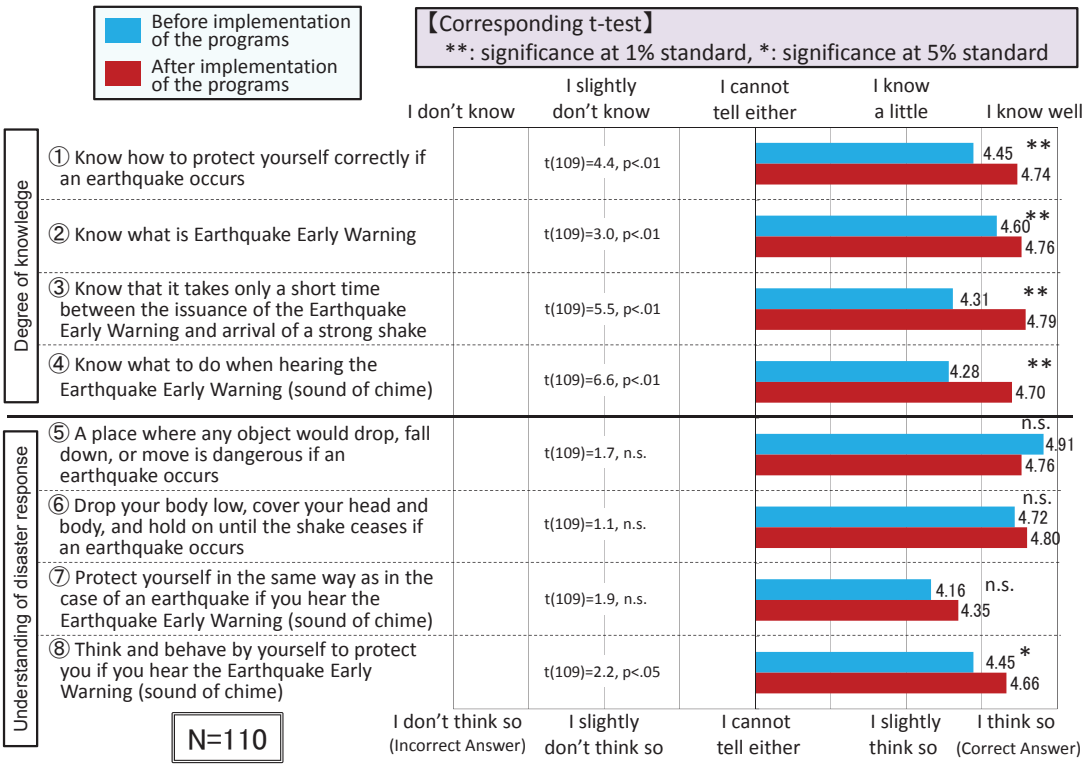


Fig. 14. Earthquake disaster management education at junior high school.

improved, from 4.28 to 4.60 before the implementation of the programs to 4.70 to 4.79 after it. Thus, the effectiveness of learning can be confirmed. As a result of the *t*-test analysis, a statistical significant difference can be recognized under all the items (**Fig. 15**). As for the other four items on understanding of the correct behaviors when an earthquake occurs or the Earthquake Early Warning is heard, the degree of attainment of the learning objectives expressed as the average of evaluation in five stages (where five is the maximum and one is minimum) is evaluated at 4.16 to 4.91 before the implementation of the programs and 4.35 to 4.80 after it. Thus, the effectiveness of learning can be also confirmed generally. As a result of the *t*-test analysis, there is a statistically significant difference under the item 8) at 5% standard, but no significant difference under the other three items. As for the reason why the degree of attainment under the item of "7) Protect yourself in the same way as in the case of an earthquake if you heard the Earthquake Early Warning (sound of chime)" is lower than the other items, the system receiving the Earthquake Early Warning in school is used in the exercise and the arrival time of the principal shock, S wave, is announced after the sound of chime. Accordingly, recognizing more time left than in the case of a sudden shake, students would judge that they could move to a safer place. For this reason, certain students would answer "I don't think so" to the item 6). There is a room for improvement to add a new item to the questionnaire, which ask whether the students recognize more time left in the case of the Earthquake Early Warning or not.

Next, as for the degree of knowledge on tornado in the Tornado Disaster Management Education Programs, the degree of attainment of the learning objectives is evaluated as the average of evaluation in five stages (where five is the maximum and one is minimum) before the implementation of the programs. The average scores are as follows: 4.24 for the item "1) Know what is tornado"; 4.33, "2) Know what kind of damage it would cause"; 3.05, "3) Know what to do to notice a tornado"; and 3.45, "4) Know what to do when a tornado is approaching." However, the effectiveness of learning can be confirmed with the higher average of evaluation from 4.20 to 4.75 after the implementation of the programs. As a result of the *t*-test analysis, a statistical significant difference can be confirmed under all the items. As for the four items on understanding of the correct behaviors when a tornado is approaching, the degree of attainment of the learning objectives of the item "6) Go to whatever building when a tornado is approaching," which had marked especially low at 3.21 before the implementation of the programs, has increased to 3.92. Under the other three items, the average score of their evaluation has risen from 4.10 to 4.44 before the implementation to 4.41 to 4.77 after it. Thus, the effectiveness of learning can be confirmed. As a result of the *t*-test analysis, a statistical significant difference can be confirmed at 5% standard under one item of 8) and at 1% standard under the rest of the other items (**Fig. 16**). In the evaluation of the Earthquake and Tornado Disaster Management Education Programs covering the junior high school students, the efficacy of the programs can be confirmed as well.

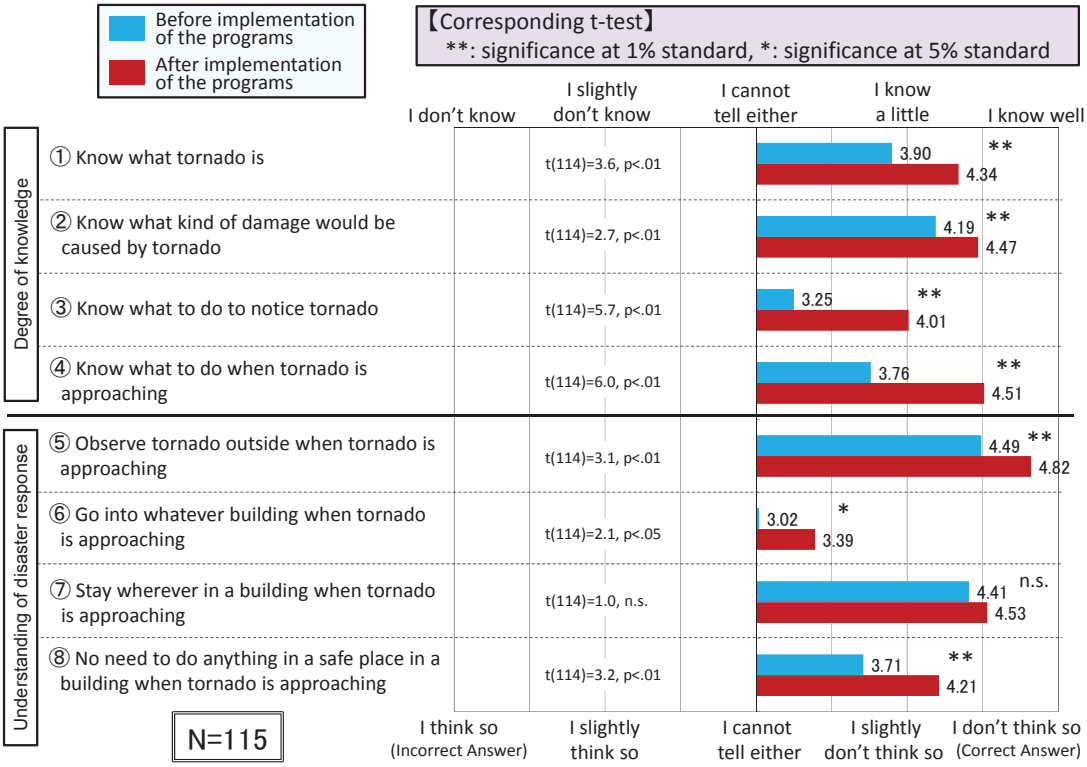


Fig. 15. Tornado disaster management education at elementary schools.

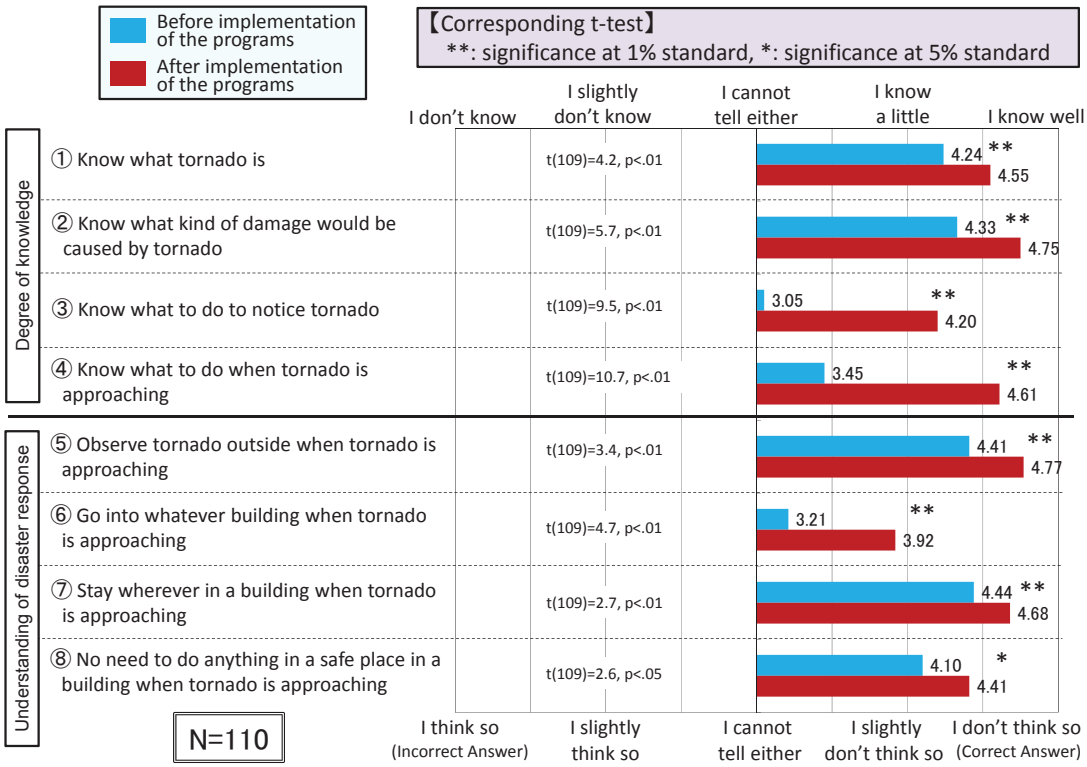


Fig. 16. Tornado disaster management education at a junior high school.

4.5. Verification and Improvement of the Proposed Programs

In this study, the effectiveness of the and Earthquake and Tornado Disaster Management Education Programs was measured through their implementation, and their efficiency was verified. The efficiency of the programs can be confirmed by the improvement in the degree of attainment of the learning objectives from the effectiveness measurement. The results indicate that the proposed programs are effective tools for raising risk awareness among

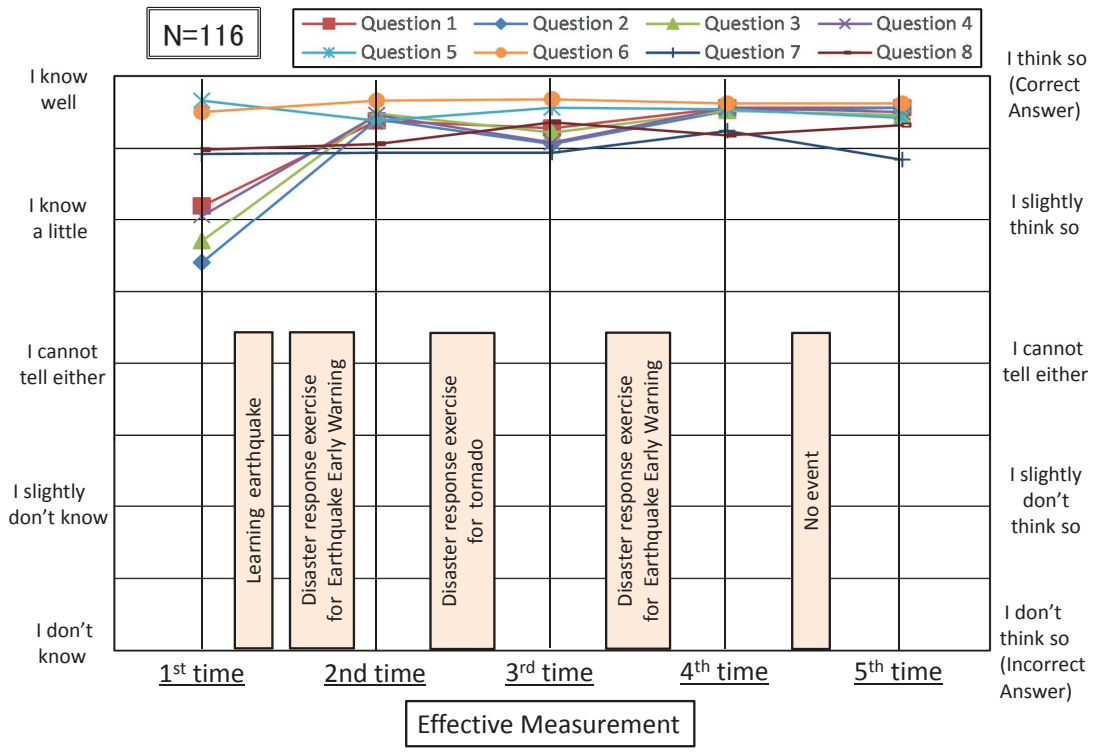


Fig. 17. Repeated measure through earthquake disaster management education programs at elementary schools.

elementary and junior high school students. Moreover, in this study, the classes were practiced according to the developmental stage. The contents of the classes were discussed, a guidance was developed, and the improvement of the programs and methods of the classes were considered by the teachers. To implement the programs in other schools, further improvement must be considered based on the programs improved by the teachers in this study.

5. Maintenance of the Acquired Knowledge and Improved Capabilities through Educational Programs

5.1. Outlines of the Survey

The effectiveness of the Earthquake and Tornado Disaster Management Education Programs is verified through the degree of attainment of the learning objectives for students in the previous chapter. Next, to verify whether the acquired knowledge and improved capabilities through the educational programs for students could be maintained, the effectiveness is measured repeatedly. The survey was conducted at the three schools, namely, Niregi Elementary School, Minamioshihara Elementary School, and Minamioshihara Junior High School, where the educational programs were implemented for the elementary students from the third to the sixth grade ($n = 115 - 116$) and all junior high school students ($n = 110$).

5.2. Method of the Survey

The dates of the implementation and effectiveness measurement of the programs at each school are listed in **Fig. 12**, which was referred to in Section 4 (1).

To confirm the maintenance of the acquired knowledge and capabilities through each program, the continuous effectiveness measurement is required. For this reason, in this study, the disaster response exercise for the Earthquake Early Warning and that for tornado were performed when about two months had passed since the implementation of the Earthquake and Tornado Disaster Management Education Programs. The questionnaire for effectiveness measurement was distributed among the students before and after the exercise; it was answered in five stages, which can be evaluated quantitatively.

5.3. Verification of Maintenance of Acquired Knowledge and Capabilities

To survey the maintenance of acquired knowledge and capabilities through the implementation of the Earthquake and Tornado Disaster Management Education Programs, the same students conducted a self-evaluation. This is a statistical method to survey how the scores on the degree of attainment of the learning objectives of the students have been changed. An analysis of variance (with correspondence) of repeated measures is conducted.

Reviewing the general tendencies among the elementary school students as for the verification of the maintenance of the acquired knowledge and capabilities through the Earthquake Disaster Management Education Programs, despite of certain increase and decrease, the knowledge and capabilities, which were acquired through the first learning, have been maintained. There is no item in which the degree of attainment of the learning objectives decreases remarkably. After students are allowed to

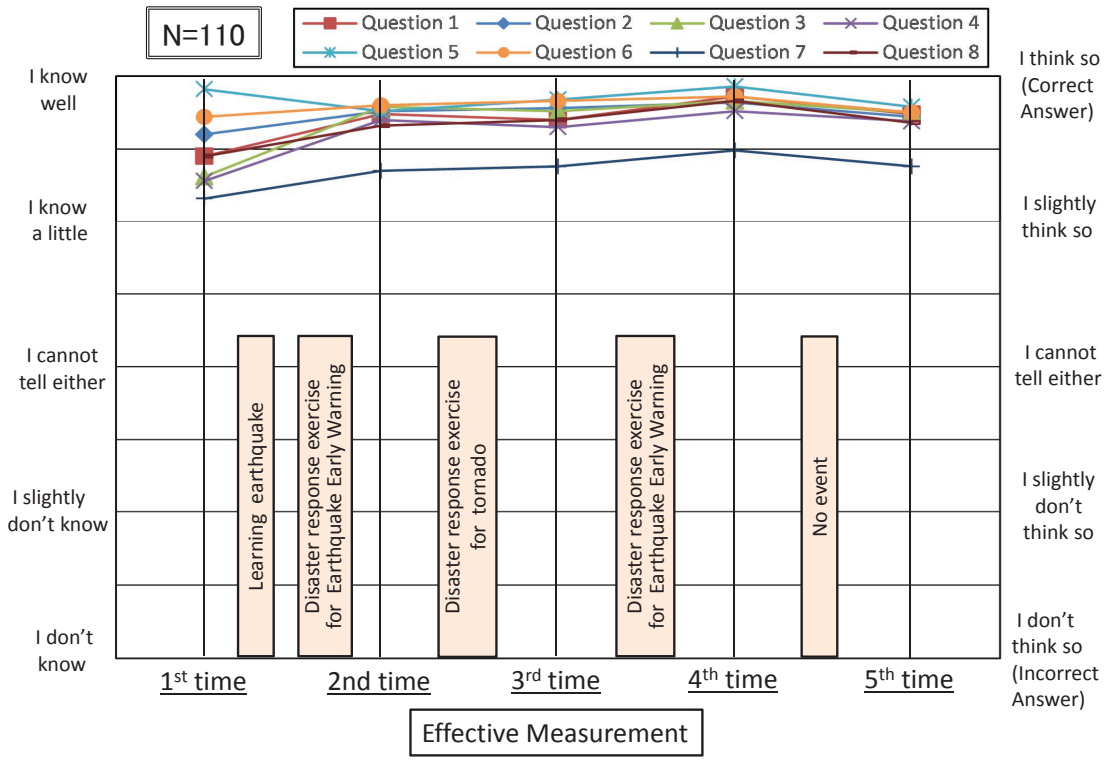


Fig. 18. Repeated measure through earthquake disaster management education programs at a junior high school.

imagine the risk of an earthquake through learning activities, such as a disaster response exercise for the Earthquake Early Warning, the degree of attainment of the learning objectives under four items in terms of knowledge on the phenomena of earthquake and the Earthquake Early Warning has increased with statistical significance. As for the four items on understanding of the correct behaviors, only the degree of attainment of the learning objectives under the item "7) Protect yourself in the same way as in the case of an earthquake if you heard the Earthquake Early Warning (sound of chime)" has increased with statistical significance (**Fig. 17**). Next, reviewing the general tendencies among junior high school students, despite certain increase and decrease, the knowledge and capabilities acquired through the first learning have been maintained. There is no item in which the degree of attainment of the learning objectives decreases remarkably. By implementing the learning to allow the students to imagine the risk of an earthquake, such as a disaster response exercise for the Earthquake Early Warning, the degree of attainment of the learning objectives under all the items has increased (**Fig. 18**). Under all the four items on the degree of knowledge on the phenomena of earthquake and the Earthquake Early Warning, a statistical significance can be recognized in both cases of the elementary and junior high school students. Meanwhile, a statistical significance cannot be recognized under the four items on understanding of the correct behaviors when an earthquake occurs or the Earthquake Early Warning is heard (**Fig. 19**).

Next, reviewing the general tendencies among elementary school students as for the verification of maintenance

	Niregi Elementary School and Minamioshihara Elementary School	Minamioshihara Junior High School
Question 1	F(2.6, 293.8)=36.3, p<.01	F(3.3, 364.7)=15.2, p<.01
Question 2	F(2.2, 249.8)=66.7, p<.01	F(3.6, 396.5)=4.6, p<.01
Question 3	F(2.3,262.0)=47.0, p<.01	F(3.0, 328.9)=17.4, p<.01
Question 4	F(2.9, 329.2)=42.2, p<.01	F(3.6, 388.8)=18.9, p<.01
Question 5	F(3.4, 384.1)=0.9, n.s.	F(3.0, 331.5)=1.7, n.s.
Question 6	F(3.6, 421.4)=0.5, n.s.	F(3.5, 383.9)=1.3, n.s.
Question 7	F(3.7, 436.5)=0.9, n.s.	F(3.6, 389.8)=2.3, n.s.
Question 8	F(3.7, 422.7)=1.7, n.s.	F(3.4, 372.7)=5.1, n.s.
Number of Times	5	5

Fig. 19. Result of one-factor analysis of variance with correspondence (earthquake).

of the knowledge and capabilities acquired through the Tornado Disaster Management Education Programs, despite of certain increase and decrease, the knowledge and capabilities acquired through the first learning have been maintained. Certain items in which the degree of attainment of the learning objectives has not increased through the implementation of the programs follow a similar transition as the other items. There is no item in which the degree of attainment of the learning objectives decreases remarkably. After the learning to allow the students to imagine the risk of a tornado, such as a disaster response exercise for tornado, the degree of attainment of the learning objectives has increased under all the items (**Fig. 20**). Similarly, reviewing the general tendencies among junior high school students, despite certain increase and decrease, the knowledge and capabilities acquired through the first learning have been maintained. There is no item

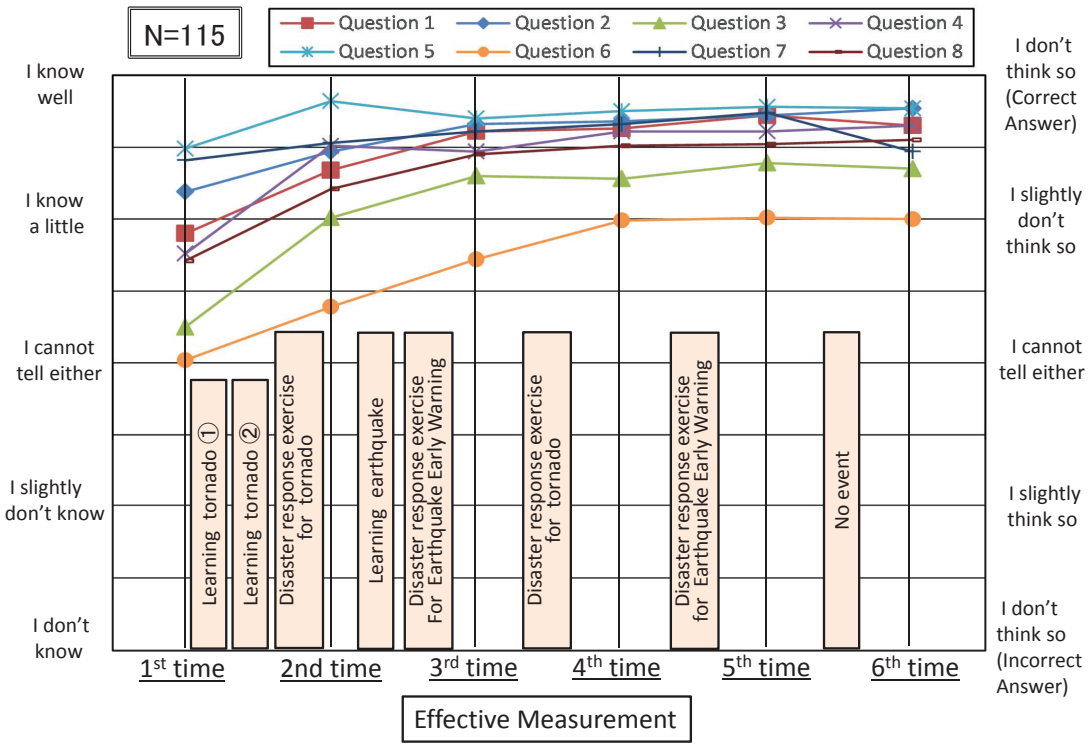


Fig. 20. Repeated measure through tornado disaster management education programs at elementary schools.

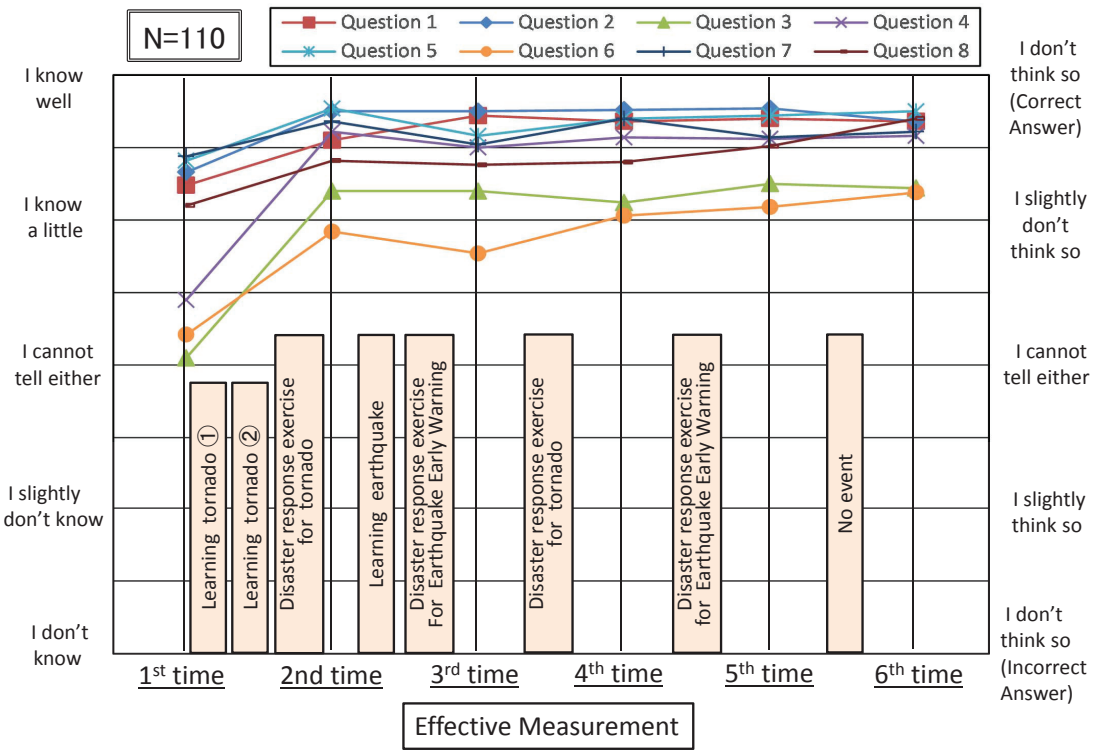


Fig. 21. Repeated measure through tornado disaster management education programs at a junior high school.

in which the degree of attainment of the learning objectives decreases remarkably. After the implementation of the learning to allow the students to imagine the risk of a tornado, such as a disaster response exercise for a tornado, the degree of attainment of the learning objectives has increased under certain items (**Fig. 21**). Under the four items on the degree of knowledge on the phenomena and damage of a tornado and a response to it, a statistical significance can be recognized in both cases of the elementary and junior high school students. As for the four

	Niregi Elementary School and Minamioshihara Elementary School	Minamioshihara Junior High School
Question 1	F(3.3, 371.8)=25.5, p<.01	F(3.1, 337.4)=17.7, p<.01
Question 2	F(3.5, 403.0)=15.0, p<.01	F(3.6, 391.4)=15.5, p<.01
Question 3	F(4.0,458.9)=30.9, p<.01	F(3.6, 397.9)=45.4, p<.01
Question 4	F(3.3, 371.9)=25.9, p<.01	F(3.1, 339.6)=59.6, p<.01
Question 5	F(4.3, 491.5)=3.6, p<.01	F(4.5, 491.0)=3.5, p<.01
Question 6	F(4.3, 489.1)=12.3, p<.01	F(3.5, 403.0)=13.0, p<.01
Question 7	F(4.3, 484.7)=3.2, p<.05	F(4.2, 459.3)=2.5, p<.05
Question 8	F(4.2, 482.3)=12.0, p<.01	F(4.2, 459.0)=6.9, p<.01
Number of Times	6	6

Fig. 22. Result of one-factor analysis of variance with correspondence (tornado).

items on understanding of the correct behaviors when a tornado is approaching, a statistical significance can be recognized under the item of Question 7 at 5% standard and under the other three items at 1% standard in both cases of the elementary and junior high school students (**Fig. 22**).

From the above, it is concluded that the knowledge and capabilities acquired through the Earthquake and Tornado Disaster Management Education Programs can be maintained by incorporating the learning to allow the students to imagine the risks of a disaster into the programs. Moreover, comparing the phenomena of earthquakes and tornadoes, it is recognized that a higher degree of attainment acquired through the learning process can be maintained in the Earthquake and Tornado Disaster Management Education Programs.

6. Desirable Cooperation Between Disaster Management Organizations and Educational Institutions

In this study, the disaster management education programs that has been prepared by disaster management experts are implemented in cooperation with various educational institutions and teachers; the programs are also verified. In the past, "the leaflets or the visual teaching materials, such as DVD, which have been prepared are distributed unilaterally to the schools" and "the experts or the staff of disaster management organizations visit the schools at the request of the schools to give the lessons." However, it is difficult for the teachers without expertise to practice disaster management education only with the help of the teaching materials. The school visit by the experts to give lessons in certain schools cannot easily lead to an improvement in the capabilities of the students in the whole region.

Accordingly, the author has exercised the following method to spread the disaster management education effectively: the disaster management organization, a meteorological observatory in this case, plays a central part, in cooperation with the educational institutions, in implementing the model project for disaster management education at a school and the verified educational model is introduced to other schools, making use of the training course for teachers under the sponsorship of the board of education. In this chapter, "how to spread the disaster management education in school, with the cooperation disaster management experts and educational institutions is considered."

Figure 23 schematizes the cooperation of disaster management organizations and educational institutions. As mentioned in Section 1, only the effort to deliver the lessons to individual schools by experts cannot easily lead to a spread of the disaster management education to other schools. This problem occurs because the educational institutions have a hierarchy from the Prefectural Board of Education, Municipal Board of Education to the schools, and then teachers; each layer has its own independence. Thus, in Tochigi Prefecture, the Meteorological Observatory plays a role of adviser on disaster management, and the mechanism to exercise the disaster management education, according to each level, has been built to take advantage of the schools, Municipal Boards of Education, and Prefectural Board of Education. To spread the disaster management education to all the other prefectures the fruits acquired through the exercises are provided as feedback to the boards of education and the schools by taking the opportunity to train teachers under the sponsorship of the Board of Education.

This mechanism follows the recommendation to "urge the cooperation among schools and their founders, the disaster management departments, the local meteorological observatory, and the fire department in the relevant region to promote especially the disaster management education in schools." This recommendation is referred to in "Plan on Promotion of School Safety," which was submitted by the Central Education Council based on the lessons from the disasters, such as the Great East Japan Earthquake, and endorsed by the Cabinet in 2012.

In Tochigi Prefecture, the disaster management education is now rapidly spreading among schools through the new mechanism, in cooperation with different disaster management organizations and educational institutions. For example, the spread of the disaster management education has been promoted to the teachers through the opportunity of training under the sponsorship of the Board of Education. The Tornado Disaster Management Education Programs are planned to be implemented at all the schools in Utsunomiya City, a core city, and Kanuma City in the fiscal year of 2016. The Earthquake Disaster Management Education Programs are already promoted in Nasu Town, Tochigi City, Sano City, and Nasushiobara City. In summary, to realize a cooperation with disaster prevention organizations and educational institutions, this study proposes that not only specific educational institutions but also three different actors, namely the Prefectural Board of Education, the Municipal Board of Education, and the model schools, which are willing to implement the programs, must be urged to cooperate.

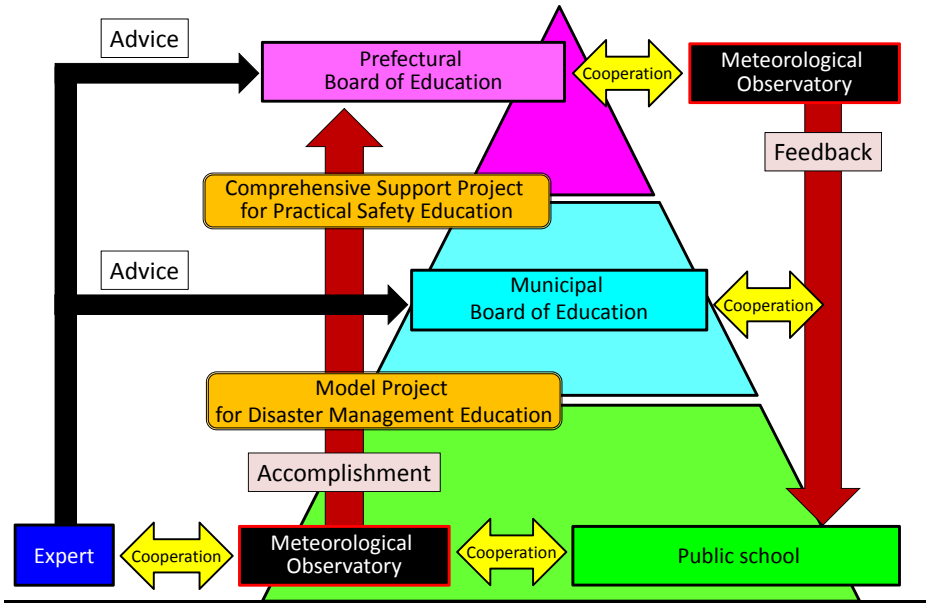


Fig. 23. Cooperation of disaster management organizations and educational institutions.

7. Conclusions and Vision

In this study, the current situation and problems in Japanese schools were reviewed, systematic disaster management education programs were proposed for students to learn the correct knowledge on various natural disasters and enhance their capacities to forecast the risk and avoid it based on their own initiatives, and then the proposed programs were verified and evaluated in these schools.

The proposed programs need not be implemented by disaster management specialists, as teachers can practice the disaster management education as part of the ordinary learning process for elementary and junior high school students.

Prior to the development of the programs, an awareness survey was conducted to both elementary students and teachers regarding "their consciousness of the crisis of school safety caused by natural disasters, among others." The results of the survey indicated that "the disaster management education based on earthquake disaster was effective for students and teachers as a starting point of learning, as they had already experienced an earthquake and a disaster drill targeting an earthquake." Thus, the proposed education programs was designed that the disaster management education for earthquakes and other natural disasters are practiced not separately but jointly to foster children's "zest for life" at a time of natural disasters. The proposed two programs corresponded to earthquake and tornado, and each program consisted of three parts. The teaching materials, such as the proposed guidance and worksheet, were prepared using editable files to allow teachers to edit the content by themselves.

A survey method based on ADDIE process of instructional design, a learning theory, was adopted. In the ADDIE process, effectiveness of the proposed education program was measured through students' self-assessment on the extent to which the learning objectives had been attained. For this reason, the proposed programs in this study was evaluated by measuring the degree of attainment several times, before, during, and after the implementations. As a result of the evaluation, the combination of earthquake and tornado disaster management education programs was proved to be highly effective for education. The results also indicated that the acquired knowledge and improved capabilities could be maintained by repeating the practice of the programs.

In carrying out this study, cooperation with disaster prevention organizations and educational institutions was indispensable. However, to realize such cooperation, it is proposed that not only specific educational institutions but also three the different actors, namely, the Prefectural Board of Education, Municipal Board of Education, and the model schools, which are willing to implement the programs, must be urged to cooperate with one another.

The conditions to spread the proposed disaster management education programs in Tochigi Prefecture are now improving. Such education programs have become widespread in schools in Tochigi Prefecture. For example, the disaster management education using such programs are obligated to be implemented in schools in certain municipalities in Tochigi Prefecture. To promote further the introduction of practical disaster prevention education all over the country, the "Support for Disaster Management Education" [27] has been established in the homepage of the Utsunomiya Local Meteorological Office. The disaster management education programs can be downloaded free from this website.

In certain municipalities in Tochigi Prefecture, the disaster management education programs are now exercised under the sponsorship of the Boards of Education. However, such proposed programs are yet to be standardized to be applied to all prefectures. Tochigi Prefecture participates in the MEXT's "Comprehensive Support Project for Practical Safety Education." The results of this study

is distributed to schools in other prefectures. In the future, the disaster management education programs will be promoted further by making use of this mechanism. Moreover, the preparation for the disaster management education programs for volcanic eruption, which is supposed to be among the characteristic natural disasters in Tochigi Prefecture, is underway. Such future programs will also be implemented and verified in different schools.

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Name:
Toshimitsu Nagata

Affiliation:
Senior Scientific Officer for Earthquake and Tsunami Disaster, Utsunomiya Local Meteorological Office of Meteorological Agency

Address:
1-4, Akebono-cho, Utsunomiya, Tochigi 320-0845, Japan

Brief Career:

1985-1988 Toyama Local Meteorological Office of Meteorological Agency, Japan
1995-1999 Observation Department of Meteorological Agency, Japan
2010-2013 Kumagaya Local Meteorological Office of Meteorological Agency, Japan
2014-2015 Senior Scientific Officer for Volcanic Disaster, Utsunomiya Local Meteorological Office of Meteorological Agency, Japan

Selected Publications:

- "Case Study Research in Disaster Management Education to Develop "a Zest for Life" of Children Using Earthquake Early Warning System – the Way of the Cooperation of Local Meteorological Observatory –," Journal of Social Safety Science, Vol.21, pp. 81-88, 2013 (in Japanese).
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Academic Societies & Scientific Organizations:

- Japan Institute of Social Safety Science (JISSS)

Name:
Reo Kimura

Affiliation:
Associate Professor, Ph.D., School and Graduate School of Human Science and Environment, University of Hyogo

Address:
1-1-12 Shinzaike-honcho, Himeji, Hyogo 670-0092, Japan

Brief Career:
1994-1998 School of Human Science, Waseda University
1998-2003 Graduate School of Informatics, Kyoto University
2003-2009 Assistant Professor, Graduate School of Environmental Studies, Nagoya University
2009-2011 Associate Professor, Graduate school of Environmental and Disaster Research, Fuji Tokoha University

Selected Publications:
- "Recovery and Reconstruction Calendar," Journal of Disaster Research, Vol.2, No.6, pp. 465-474, 2007.
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- Japan Institute of Social Safety Science (JISSS)
- Japan Society for Natural Disaster Science (JSNDS)
- Japanese Psychological Association (JPA)
- Japanese Society of Social Psychology (JSSP)
- Japan Sociological Society (JSS)
- Seismological Society of Japan (SSJ)
- Japan Society of Civil Engineering (JSCE)