https://doi.org/10.20965/jdr.2021.p1121

Paper:

Development of Disaster Management Education Program to Enhance Disaster Response Capabilities of Schoolchildren During Heavy Rainfall – Implementation at Elementary School in Nagaoka City, Niigata Prefecture, a Disaster-Stricken Area

Masaki Ikeda[*1,†], Toshimitsu Nagata[*2], Reo Kimura[*3], Tai-Young Yi[*1], Shingo Suzuki[*1], Shingo Nagamatsu[*1], Takashi Oda[*4], Shun Endo[*4], Mitsuhiro Hatakeyama[*4], Seigo Yoshikawa[*4], Satoru Adachi[*5], Shinya Miura[*6], and Junya Take[*7]

[*1]Disaster Resilience Research Division, National Research Institute for Earth Science and Disaster Resilience (NIED)
3-1 Tennodai, Tsukuba, Ibaraki 305-0006, Japan
[†]Corresponding author, E-mail: m-ikeda@bosai.go.jp
[*2]Niigata Local Meteorological Office, Japan Meteorological Agency, Niigata, Japan
[*3]Faculty and Graduate School of Human Science and Environment, University of Hyogo, Hyogo, Japan
[*4]Graduate School of Education, Miyagi University of Education, Miyagi, Japan
[*5]Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience (NIED), Yamagata, Japan
[*6]Disaster Information Research Division, National Research Institute for Earth Science and Disaster Resilience (NIED), Ibaraki, Japan
[*7]Disaster Management, Cabinet Office, Government of Japan, Tokyo, Japan
[Received February 22, 2021; accepted July 26, 2021]

In this study, an education program for heavy rainfall risk management was developed using the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model of instructional design (ID) to enhance the disaster response capabilities of schoolchildren to encourage them to think and act responsibly to protect themselves during a disaster following heavy rainfall. The program's effectiveness was evaluated by its implementation at Nagaoka Municipal Senju Elementary School in Nagaoka City, Niigata Prefecture, which was devastated by the heavy rainfall caused by 2019 Typhoon No.19. The learning effect was confirmed throughout the program. Furthermore, the program has improved because of its implementation and evaluation.

Keywords: flood, elementary education, disaster management, instructional design (ID), ADDIE

1. Background and Objective of the Study

1.1. Present Conditions and Problems Associated with Disaster Education for Heavy Rainfall

Weather disasters have become more violent and frequent worldwide in recent years, and have caused serious harm to humans in Japan as well [1]. The government revised "the Fundamental Plan for National Resilience" in December 2018 [2], considering the lessons learned from the Western Japan Heavy Rain Disaster in July 2018, which claimed the lives of 237 people [3]. This revision incorporates disaster management education as the first of the 12 individual policies, which also includes the policy that "enabling them be conscious about their responsibility to protect their own life, and to take evacuation behavior on their own judgement ... disaster prevention exercises and disaster prevention education will be promoted continuously through schools, workplaces, local autonomous organizations, and other relevant organizations."

In addition, "to surely link disaster management information, such as weather information and evacuation information, with residents' evacuation actions" is alluded to as a lesson learned from disasters in recent years. Furthermore, the Flood Control Act, which plays a major role in flood control in Japan, was revised and implemented in 2017, following the disaster resulting from heavy rainfall in recent years [4]. Following the implementation of the Act, river managers advocated for a revision of flood hazard maps and to increase public awareness among residents [5].

In "development of disaster management education to nurture 'Zest for Life'," the Ministry of Education, Culture, Sports, Science and Technology (MEXT) takes the above into consideration and focuses on heavy rainfall disaster management education, to set real examples for learning about disasters resulting from heavy rainfall [6]. Furthermore, the materials for school disaster management prepared by the boards of education across the country contain some examples of heavy rainfall disaster management education [7]. However, the learning depicted in

these documents focuses on knowledge acquisition rather than how to judge and behave to protect our lives, although it treats the disaster as a learning opportunity.

Besides, the disaster management administrative organizations, river offices of the Ministry of Land, Infrastructure, Transport and Tourism, and the Japan Meteorological Agency have developed various educational materials using their knowledge of river management and meteorological service specialists [8, 9]. Additionally, researchers also have developed educational materials incorporate expertise in disaster management, such as hazard maps, in their previous research [10]. However, if teachers try use these materials in their classes, they require a significant amount of time and effort, or support from experts.

As per past studies, despite the availability of teaching materials for acquiring knowledge, there is a lack of learning practices and teaching materials to foster an awareness of "protecting our own lives." Considering the above, it is critical to develop materials and programs that enable teachers to educate children, which can enhance their ability to take necessary actions based on their judgment and evacuate during disasters resulting from heavy rainfall.

1.2. The Objective of This Study

In response to the issues raised in the previous section, this study aims to develop and improve educational programs to enhance the disaster response capabilities of schoolchildren to ensure they can respond actively to weather information based on their judgment to protect their lives in the event of a disaster following heavy rainfall. We also used the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) process of Instructional Design method hereinafter referred to as ID, to develop an education program on heavy rainfall disaster management, hereinafter referred to as "the program." We then conducted a practical verification of the program for the children in the target school, confirming the learning effect and improving the program.

This paper discusses the outline of the program's development, the results of the evaluation through implementation, and how the program's contents were improved based on the evaluation results.

2. Study Method

2.1. Development of Education Program

This program was developed based on the ADDIE of ID. ID is the learning theory used in the fields of pedagogy, psychology, and educational technology and is defined as "the models or the study field compiling methods to make educational activities more effective, efficient, and attractive, as well as the process to realize the learning environment by applying such models and methods" [11].

According to the ID theory [12], better teaching materials can be prepared by identifying the requirements of learners, such as the learning purpose, the problem, and the learning objective, and as well as the learning materials, the learning environment, and the knowledge required to be implemented, and developing by following the ADDIE process (**Fig. 1**).

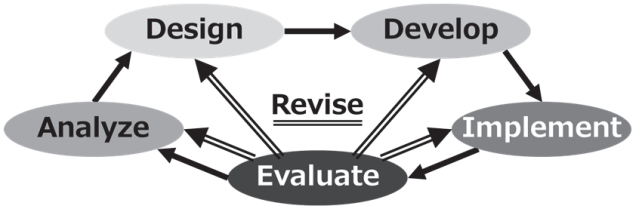

Fig. 1. The ADDIE process.

Previous studies that applied the ID theory to develop disaster management education programs include studies by Nagata and Kimura [13–16], who developed and generalized programs for earthquakes, tornadoes, and volcanic eruptions with the learning objective of "fostering the attitude to behave proactively." They also discussed the development and generalization of a disaster management education program for children with visual and cognitive disabilities [17, 18].

In addition, Higashino and Yoshimoto [19] developed e-learning materials for elementary school teachers by applying the ID theory and discussed the effectiveness of the materials. Examples of previous studies applying ID theory outside the field of education include the study by Umeno and Asada [20], who developed a large-scale disaster training program for medical institutions, the study by Ogasawara [21], who developed a learning support program for a company, and the study by Ishii et al. [22], who developed a technology management education program for an engineering liberal arts course. As previously stated, the application of the ID theory in Japan in recent years has been widespread beyond the field of education. In this study, we referred to these previous studies and applied the concept of the ADDIE process of ID theory to develop and evaluate a disaster education program based on scientific methods.

This paper describes the development process of the education program against heavy rainfall disasters according to ADDIE. As described in Section 1.1, we analyzed the current situation and issues surrounding heavy rainfall disasters and the knowledge of them in Japan. In Section 2.2, we identified the target school and class of this study based on the information in Section 1. Section 3.1 presents the analysis of the current situation, issues, and requirements for disaster education in the class under study. Consequently, we established the learning objectives of the program. Section 3.2 depicts the program's design based on the analysis; Section 3.3 presents the evaluation method of the program; Section 4.1 describes the implementation of the program in the target school; Sections 4.2 and 4.3 reveal the evaluation results of the implementation in the target school, and Section 4.4 highlights the problems and revisions of the program based on the evaluation results.

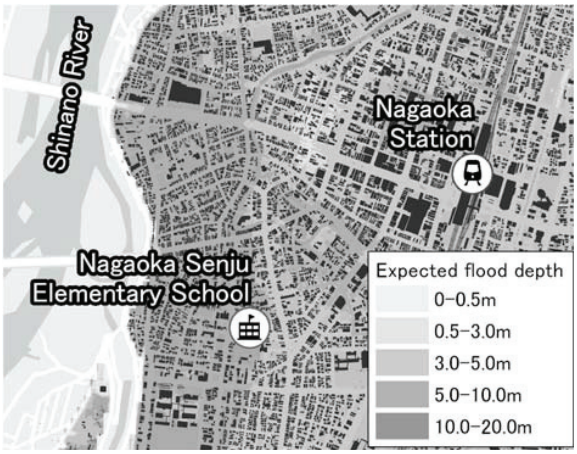

Fig. 2. Senju Elementary School and flooding hazard map of the Shinano River. Base map was made from the Fundamental Geospatial Data and Digital Land Numerical Information.

2.2. Outline of the Area for Study

The Shinano River, also known as the Chikuma River, is a Class A river[1] [23] that runs through Niigata and Nagano Prefectures and is the longest river in Japan with a channel length of 367 km. This river has suffered from several large-scale flood disasters in the past. For example, the heavy rainfall in July 1896, also known as the "Yokota burst," with a death toll of 75, the heavy rainfall in Niigata and Fukushima in July 2004 with a death toll of 15, and the heavy rainfall in Niigata and Fukushima in July 2011 with a death toll of four [24]. In addition, during Typhoon Hagibis in October 2019, the bank collapsed in Nagano City and there was flooding along several tributaries [25].

In 2019, Typhoon Hagibis caused flooding in the Shinano (Chikuma) River and some of its tributaries. Fortunately, there was no major damage in Nagaoka city. However, the Shinano River reached its highest level ever, which raised awareness within the city government and among the citizens about the Shinano River flooding. Therefore, the "Heavy Rain Disaster Management Project" was initiated in the Senju area, located near the Shinano River in the city. As a part of the project, Senju Elementary School, whose school district was included in the inundation hazard area (**Fig. 2**), was selected as a target school for the disaster education program of this study. To select the school, we analyzed the current status and issues with disaster education in the target classes of the school.

The project members included researchers from the National Research Institute for Earth Science and Disaster Resilience (NIED), experts from national disaster management-related organizations, a teacher, and graduate students from the National University of Education, led by the co-authors. They coordinated with the target school, prepared the program and learning materials, and developing the Information Communication Technology (ICT) tools.

1. Rivers subject to the River Law are classified into Class A and Class B rivers, depending on the importance of their roles. Class A rivers are managed by the national government (MLIT), prefectural governor, or ordinance designated city mayor.

3. Design and Development of the Heavy Rainfall Disaster Management Program

3.1. Designing Targets and Learning Objectives

Using the ADDIE process in this study, we developed an education program for heavy rainfall disasters. First, we analyzed the current status and issues of disaster education in Niigata Prefecture, where the target school is located.

The Prefectural Board of Education has prepared the "Niigata Prefecture Disaster Management Education Program" [7], hereinafter referred to as the "Prefectural Program," and 83% of the elementary schools in the prefecture implement disaster management education using the Prefectural Program [26]. The Prefectural Program provides learning materials for students in grades one through six. The flood disaster version of the program includes a river observation study by the third grade and a study program on specific flood disasters by the fourth grade. However, all the learning materials for the fourth grade and above are aimed at acquiring knowledge, and do not provide materials aimed at considering evacuation behavior based on weather information, evacuation information, and hazard maps.

Therefore, the existing Prefectural Programs are not capable of implementing disaster education that enhances children's ability to make their own decisions and take independent actions during heavy rains. In addition, interviews with teachers of the target classes, who had firsthand experience with the dangers of flooding, revealed that they were aware of the dangers caused by heavy rainfall disasters. They also considered the lack of learning materials on heavy rainfall disasters as a concern.

Consequently, the learning objectives of the program developed in this study were established as follows: to be aware of protecting one's life from heavy rainfall disasters; to understand weather information, evacuation information, and hazard maps; and to acquire the attitude to behave proactively during heavy rainfall using the acquired knowledge. The program assumed that the students had already acquired the learning content presented in the Prefectural Program up to the fourth grade.

3.2. Development of Learning Contents

In developing the learning content, we decided on a three-unit structure based on the findings of interviews with homeroom teachers about the knowledge already acquired by the target group and the amount of study time that could be expected (**Table 1**). We developed teaching plans, slide materials, and worksheets for each lesson (**Fig. 3**) according to the unit structure. The learning objectives and contents of each lesson are illustrated below.

Table 1. Unit structure table.

Unit	Lesson	Learning objective
Unit 1: Prior Learning	Lesson 1: Let us learn about characteristics and disaster control of large rivers	· Understand the character of large rivers. · Be informed about the flood control facilities of large rivers.
	Lesson 2: Let us learn how to gather information on dangerous rain	· Understand the disaster caused by heavy rainfall. · Acquire information on dangerous rainfall.
Unit 2: Active Learning by Individual	Lesson 3: Let us learn how to protect ourselves from flooding (1)	· Read the hazard map correctly.
	Lesson 4: Let us learn how to protect ourselves from flooding (2)	· Determine evacuation actions based on flood hazard at the spot.
Unit 3: Active Learning by Group	Lesson 5: Let us discuss how to evacuate according to the situation (1)	· Consider how to evacuate according to the situation. · Discuss evacuation actions within the group.
	Lesson 6: Let us discuss how to evacuate according to the situation (2)	· Summarize and present information on what you have learned. · Ask and discuss about heavy rains with adults living in the community.

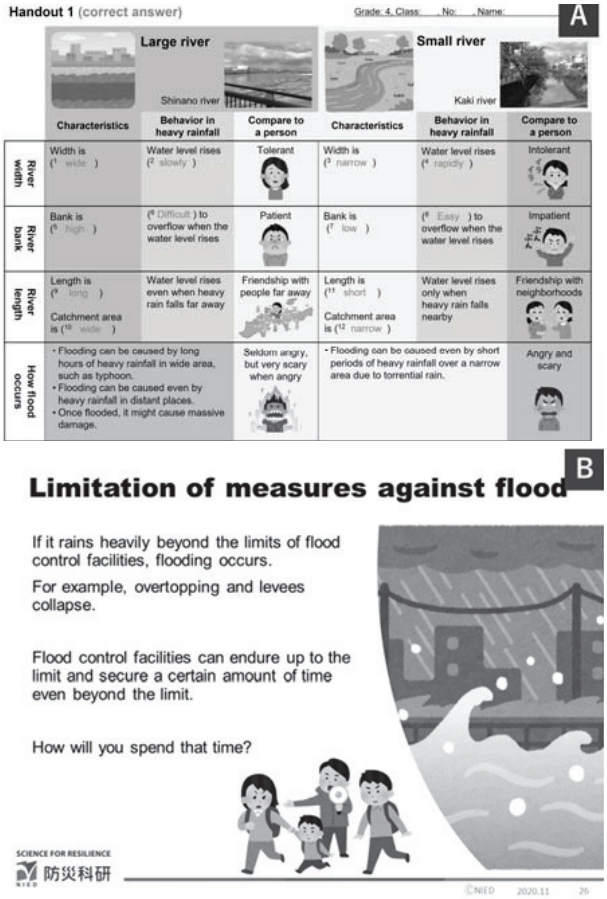

Fig. 3. Examples of worksheet (A) and slide (B).

Unit 1 is a prior learning unit aimed at making children conscious of protecting their own lives from heavy rainfall disasters and acquiring knowledge of the weather and the evaluation information necessary for proper judgments during heavy rainfall. This unit is divided into two lessons.

The learning objectives of Lesson 1 "Let us learn about characteristics and disaster control of large rivers" are to "understand the characteristics of rivers and the dangers of floods" and "learn about the preventive measures against flooding of large rivers." By reviewing the third-grade students' learning from the river observations, understanding the features of large rivers, how a flood occurs, the measures against the flooding of a large river, and their limitations, the learning materials help the schoolchildren understand the importance of their early behavior based on their judgment while residing near a large river that is prone to low-frequency large-scale disasters.

The learning objectives of Lesson 2: "Let us learn how to gather information on dangerous rain" are to "understand the disasters caused by heavy rainfall" and "know about the dangers caused by heavy rainfall." The learning objectives are to understand the importance of making decisions based on the information by learning how difficult it is to recognize the relation between rainfall intensity and to intuitively recognize the danger of a disaster through video materials, etc., and to understand the probability of a disaster depending on the topography, the weather information, and the evacuation information.

Unit 2 adopts active learning and consists of lessons that students learn how to make evacuation decisions during heavy rainfall using a flooding hazard map. Active learning is a learning method recommended by MEXT based on new courses of study, in which students work independently and actively, using their knowledge and skills to discover problems and deepen their thinking to solve them [27].

Lesson 3: "Let us learn the behavior to protect ourselves from a flood, part 1" and Lesson 4: "Let us learn the behavior to protect ourselves from a flood, part 2" are the two lessons of this unit. The learning objectives for Lessons 3 and 4 are to "read hazard map correctly" and "judge evacuation actions according to the danger at the spot." Students learn how to use an ICT tool to confirm the expected flooding depth at one's own home on a flood hazard map, as well as to assess the evacuation destination and route during heavy rainfall. The ICT tool "YOU@RISK Your Flood Evacuation" [28], developed by NIED with the aim of "providing the opportunity to learn what should be known and how to behave against risk in the event of a disaster," has been used in this program. ICT-based learning is thought to have a strong affinity for active learning [29] and is being introduced into the field of education based on the IT policies of education and the infection control measures against COVID-19.

Unit 3 is an active learning unit to develop the attitude

to behave actively when learners recognize heavy rainfall weather information.

The learning objectives for Lesson 5 "Let us discuss how to evacuate according to the situation, part 1" are to "consider an evacuation action according to the situation," and "discuss evacuation actions in a group." The learning style is group discussion, and groups are formed in the basis of their home location. The situation assumed is that when children go to Nagaoka Station, heavy rains will increase the risk of the Shinano River flooding. They confirm the expected flooding depth using the above-mentioned ICT tool, discuss each idea on evacuation actions, and decide the evacuation destination and route.

The learning objectives for Lesson 6 "Let us discuss how to evacuate according to the situation, part 2" are "To summarize what you learned and explain this to other people," and "To ask an adult living in the area any questions." By presenting what the schoolchildren have learned to representatives from each area and questioning each other to exchange opinions, the schoolchildren can connect their thoughts with the local flood history and the behavior of local residents in the past to learn how to behave as members of the local community.

3.3. Method for the Program Evaluation

The effectiveness of the developed program is evaluated using a "learning questionnaire" based on the learning objectives. In ID theory, Gagne et al. state, "the program performance is definitely defined by the evaluation of the learner" [30]. Following this concept, a method to quantify the effectiveness using a learner questionnaire was adopted in this study. In addition, Nagata and Kimura evaluated the learners' performance by using pre- and post-questionnaires to measure the effectiveness of their educational program [13–18].

As for the question items, questions corresponding to the three units were formulated, six questions per unit, totaling 18 questions.

The question items for Unit 1 are as follows: Q.1 "Do you know what kinds of flood hazards exist depending on the characteristics of the river?" Q.2 "Do you know what kinds of disaster risks due to heavy rain exist along the nearby river?" Q.3 "Do you know how flood control facilities, such as levees, function during heavy rain?" Q.4 "Can you imagine what will happen to your neighborhood in a disaster following heavy rains?" Q.5 "Do you know what kinds of information is available about disaster risks due to heavy rain?" and Q.6 "Do you know how to collect information about disaster risks due to heavy rain?"

The question items for Unit 2 are as follows: Q.7 "Can you use a hazard map to find out the estimated flooding depth in a certain area?" Q.8 "Do you know where the safe evacuation sites are located in your neighborhood during heavy rain?" Q.9 "Do you know where to avoid going during heavy rain?" Q.10 "Can you make evacuation decisions according to the rainfall situation?" Q.11 "Are you ready to decide what you do if you know it will rain heavily in a few hours?" and Q.12 "Can you instruct people around you what to do during heavy rain?"

The question items for Unit 3 are as follows: Q.13 "Can you look up evacuation sites and routes for various situations using YOU@RISK?" Q.14 "Can you organize opinions discussed in groups about evacuation during heavy rain?" Q.15 "Can you evacuate correctly when a river is likely to flood?" Q.16 "Can you make a presentation of what you observed and thought about the flood?" Q.17 "Can you explain what you found out and thought about floods to your family members?" and Q.18 "Can you ask questions and discuss about floods with neighborhood residents?" In addition, Qs.13 to 16 evaluates the learner's ability to behave proactively based on their knowledge and skills.

The schoolchildren responded with a 4-point Likert scale: "Think so or can do so – 4 points," "Think so a little or can do so a little – 3 points," "Don't think so much or cannot do so well – 2 points," and "Don't think so or cannot do so – 1 point." Moreover, the program is also evaluated on this 4-point Likert scale.

Table 2. Schedule of the implementation and evaluation.

I/E	Contents	Date
E	1st learning questionnaire	Nov. 10, 2020
I	Unit 1, Lessons 1 and 2 (45 min × 2)	Nov. 11, 2020
E	2nd learning questionnaire	Nov. 12, 2020
I	Unit 2, Lessons 3 and 4 (45 min × 2)	Nov. 25, 2020
E	3rd learning questionnaire	Nov. 26, 2020
E	4th learning questionnaire	Dec. 21, 2020
I	Uni. 3, Lessons 5 and 6 (45 min × 2)	Dec. 22, 2020
E	5th learning questionnaire	Dec. 23, 2020

I: implementation, E: evaluation

4. Implementation, Evaluation, and Improvement of the Education Program

4.1. Implementation of the Program

The program was implemented over three days for 52 fourth-grade students of Nagaoka Senju Elementary School, in two classes. The lessons are taught twice for each of the three units (45 min × 2), for a total of six lessons. The questionnaire was distributed a total of five times before and after each unit to measure the effectiveness (**Table 2**).

Unit 1 was implemented on November 11. The lesson was conducted by the class teacher in a mass-teaching style using a blackboard and slides according to the teaching guide. The students wrote down their learning on the worksheet. A part of the lesson was implemented as a team-teaching activity with the authors (**Fig. 4**).

Unit 2 was implemented on November 25. After the teacher demonstrated the model for using the ICT tool using a PC, the students examined the inundation depth, the evacuation site, and the evacuation route near their own homes. They then completed the worksheet with their

Fig. 4. Lesson of Unit 1.

Fig. 5. Lesson of Unit 2.

Fig. 6. Lesson of Unit 3.

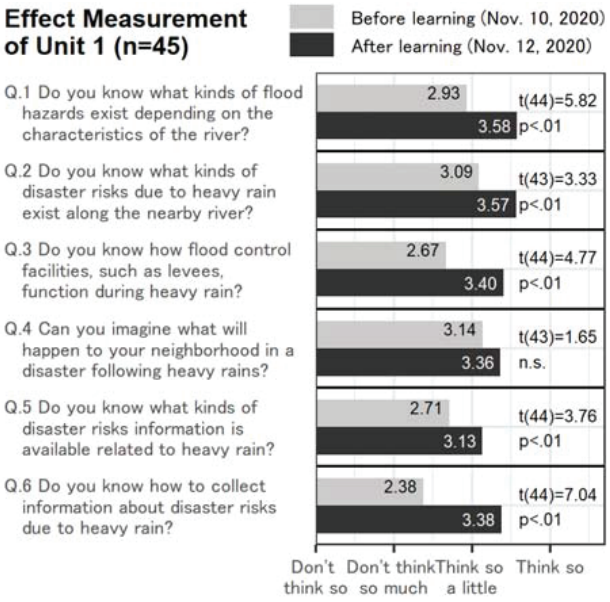

Fig. 7. Measurement results of the learning effect on Unit 1.

learning (**Fig. 5**).

Unit 3 was implemented on December 22 as a group learning exercise. The presentations and questions with the residents of the Senju Elementary School district were conducted using the Zoom web conference platform to prevent the spread of COVID-19 (**Fig. 6**). The eight participating residents gathered at the Senju community center near the elementary school to watch the children's presentations and to interact with each group online.

4.2. Evaluation Results of the Program Through Implementation

As mentioned earlier, the "learning questionnaire" was administered to the children before and after the program study to assess the learning effects of each unit. The paired t-test was used as a statistical analysis method.

The learning effect of Unit 1 was measured before (November 10, 2020) and after (November 12, 2020) the learning. The results are presented in **Fig. 7**. Q.1: "Do you know what kinds of flood hazards exist depending on the characteristics of the river?" displays a statistically significant increase with a mean score from 2.93 pre-learning to 3.58 post-learning ($t(44) = 5.82$, $p < .01$). Q.2: "Do you know what kinds of disaster risks due to heavy rain exist along a nearby river?" displays a statistically significant increase with a mean score from 3.09 pre-learning to 3.57 post-learning ($t(43) = 3.33$, $p < .01$). Q.3: "Do you know how flood control facilities, such as levees, function during heavy rain?" displays a statistically significant increase with a mean score from 2.67 pre-learning to 3.40 post-learning ($t(44) = 4.77$, $p < .01$). Q.4: "Can you imagine what will happen to your neighborhood in a disaster due to heavy rain?" does not reveal a statistically significant increase with a mean score from 3.14 pre-learning to 3.36 post-learning ($t(43) = 1.65$, n.s.). Q.5: "Do you know what kinds of information is available about disaster risks due to heavy rain?" displays a statistically significant increase with a mean score from 2.71 pre-learning to 3.13 post-learning ($t(44) = 3.76$, $p < .01$). Q.6: "Do you know how to collect information on disaster risks due to heavy rain?" displays a statistically significant increase with a mean score from 2.38 pre-learning to 3.38 post-learning ($t(44) = 7.04$, $p < .01$).

In Q.4, a statistically significant increase is not recognized. However, the mean score of the pre-learning at 3.14 is already high. It seems that the schoolchildren acquired the knowledge concerned because the class teachers taught the lesson on local flood history before this program.

Next, the learning effect of Unit 2 was measured before (November 10, 2020) and after the learning (November 26, 2020). The results are presented in **Fig. 8**. Q.7: "Can you use a hazard map to find out the estimated flooding depth in a certain area?" displays a statistically significant increase with a mean score from 2.87 pre-learning to 3.59 post-learning ($t(45) = 3.86$, $p < .01$). Q.8: "Do you know where the safe evacuation sites are located in your neighborhood during heavy rain?" displays a statistically significant increase with a mean score from 2.96 pre-learning to 3.30 post-learning ($t(45) = 2.27$, $p < .05$). Q.9: "Do you know where to avoid going during heavy rain?" displays a statistically significant increase with a mean score from 2.91 pre-learning to 3.26 post-learning ($t(45) = 2.19$, $p < .05$). Q.10: "Can you make evacuation decisions according to the rainfall situation?" displays a statistically significant increase with a mean score from

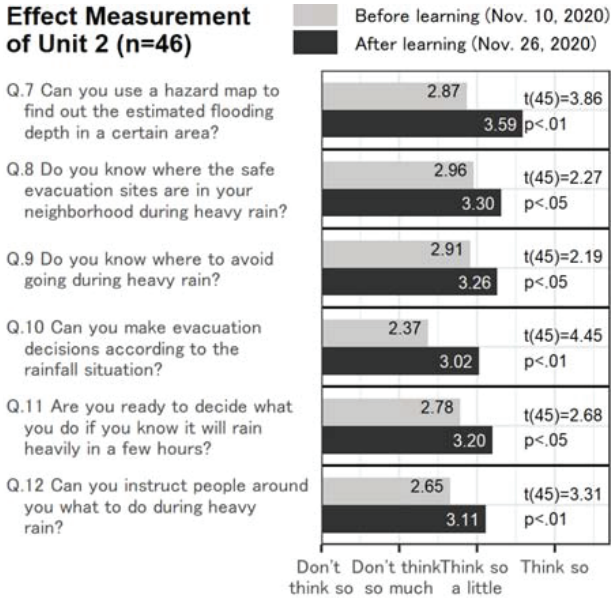

Fig. 8. Measurement results of the learning effect on Unit 2.

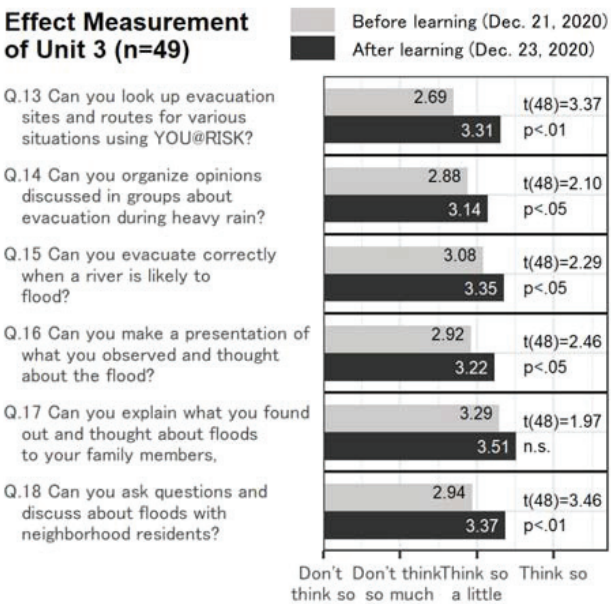

Fig. 9. Measurement results of the learning effect on Unit 3.

2.37 pre-learning to 3.02 post-learning ($t(45) = 4.45$, $p < .01$). Q.11: "Are you ready to decide what to do if you know it will rain heavily in a few hours?" displays a statistically significant increase with a mean score from 2.78 pre-learning to 3.20 post-learning ($t(45) = 2.68$, $p < .05$). Q.12: "Can you instruct people around you what to do during heavy rain?" reveals a statistically significant increase with a mean score from 2.65 pre-learning to 3.11 post-learning ($t(45) = 3.31$, $p < .01$).

Paying specific attention to the questions on learning with ICT, which is the merit of this learning, the average score of Q.7 increased by 0.68, and that of Q.10 increased by 0.65, indicating a larger increase than other questions, indicating a particularly high learning effect.

Finally, the learning effect of Unit 3 was measured before (December 21, 2020) and after the learning (December 23, 2020). The results are presented in **Fig. 9**. Q.13: "Can you look up evacuation sites and routes for various situations using YOU@RISK?" displays a statistically significant increase with a mean score from 2.69 pre-learning to 3.31 post-learning ($t(48) = 3.37$, $p < .01$). Q.14: "Can you organize opinions discussed in groups about evacuation during heavy rain?" displays a statistically significant increase with a mean score from 2.88 pre-learning to 3.14 post-learning ($t(48) = 2.10$, $p < .05$). Q.15: "Can you evacuate correctly when a river is likely to flood?" displays a statistically significant increase with a mean score from 3.08 pre-learning to 3.35 post-learning ($t(48) = 2.29$, $p < .05$). Q.16: "Can you make a presentation of what you observed and thought about the flood?" indicates a statistically significant increase with a mean score from 2.92 pre-learning to 3.22 post-learning ($t(48) = 2.46$, $p < .05$). Q.17: "Can you explain what you found out and thought about the flood to your family members?" does not reveal a statistically significant increase with a mean score from 3.29 pre-learning to 3.51 post-learning ($t(48) = 1.97$, n.s.). Q.18: "Can you ask questions and discuss about floods with neighborhood residents?" indicates a statistically significant increase with a mean score from 2.94 pre-learning to 3.37 post-learning ($t(48) = 3.46$, $p < .01$).

Paying attention to the questions about ICT learning, the increase in the average score of Q.13 is 0.62, which is the highest, and therefore, the effect of ICT learning is confirmed. In Q.17, a statistically significant increase was not recognized. Furthermore, the average score of Q.17 before the learning was higher at 3.24. This could be attributed to the fact that the homeroom teacher instructed the students to have a home study of the discussion on the learning of Unit 2 with their family, which was not included in the program, so that the students' ability related on Q.17 was high even before the learning of Unit 3.

4.3. Analysis on Retention of Learning Effect

Next, the repeated measures analysis of variance, or ANOVA, was applied to the four measurements of Units 1 and 2 to verify if the knowledge and skills acquired by the implementation of the program could be retained across time and other conditions. The results are presented in **Figs. 10** and **11**.

As for the learning from Unit 1, the results of the analysis of variance display statistical significance in five items except for Q.4, where the average score was high before the learning. Therefore, the learning effect was verified throughout the program. As for Unit 2, statistical significance was confirmed in three items of Qs.7, 10, and 12. Qs.7 and 10 are related to ICT learning, and it is thought that the expected learning effect was achieved. In Q.12, it is thought that the effect was enhanced by explaining the learning results in class and at home. Except for Qs.8 and 9, in ten items, the mean score decreased slightly in the third effectiveness measurement. However,

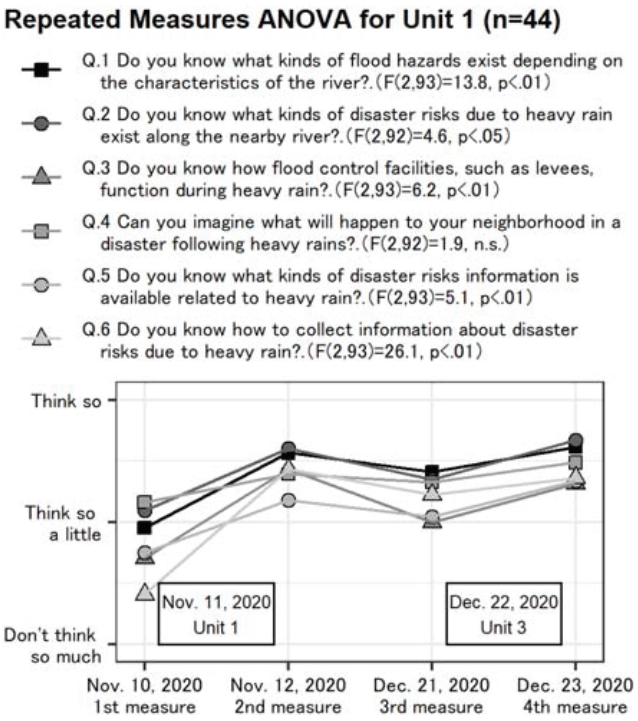

Fig. 10. Results of ANOVA for Unit 1.

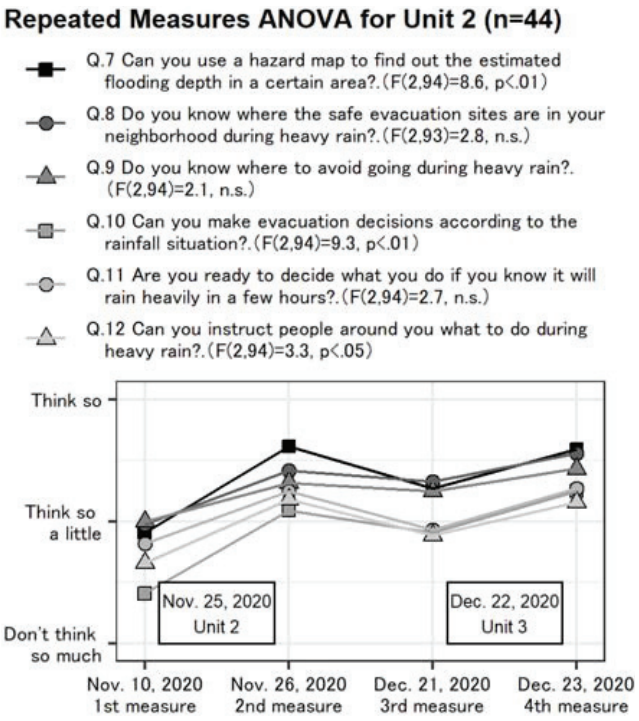

Fig. 11. Results of ANOVA for Unit 2.

the reduction in learning effectiveness over time was minor and had no effect on the effectiveness of the overall program. However, after the learning of Unit 3, the average score of these items increased again at the fourth measurement. Although Qs.8 and 9 are not statistically significant, the mean scores continued to increase over the four measurements. This suggests that there was a learning effect, as awareness and attitudes changed through learning, and safe and dangerous spots were more apparent.

From the above, it is confirmed that the group learning activity and the exchange with the local residents conducted in Unit 3 could retain the learning effects of Units 1 and 2 and deepen the understanding of the schoolchildren.

4.4. Revision of the Program Based on Evaluation

From the above evaluation results, the learning effect of this program can be substantiated. Furthermore, to enhance the learning effect of the education program, it was improved based on the analysis results. Specifically, the program is improved by summarizing the challenges as follows: focusing on the items where the average score is low after the lesson and increases only a little between before and after the lesson, and referring to the opinions of the class teachers.

4.4.1. Improve Understanding of Weather Information

In Unit 1, the average score of Q.5 "Do you know what kinds of information is available on the disaster risks due to heavy rain?" is the lowest, and the increase in the average score between before and after the learning is likewise minor at 0.43. A meteorological expert who observed the class noted that the program was not designed to teach students through the flood occurrence process, from rainfall as the trigger, to rivers as the land factor and that this might have led to a lack of understanding of the importance of weather information. The homeroom teachers also agreed with this observation.

Accordingly, Unit 1 of the program has been revised to begin with Lesson 1 "Let us learn about disasters caused by heavy rain," while Lesson 2 "Let us learn about disaster control of large rivers" in **Table 3** has been moved ahead of Lesson 3 "Let us learn about the information on dangerous rainfall" in **Table 3**. In addition, to deepen the practical visualization and the understanding of heavy rainfall disasters, as per the teachers' suggestions, the lessons on how heavy rainfall disasters occur based on "Where rainwater goes and the conditions of the ground," the learning materials for science for the fourth grade, and the materials to watch videos of heavy rainfall disasters that have occurred in recent years have been added.

4.4.2. Enhance Ability to Make Decisions in Response to Weather Situations

In Unit 2, the average score of Q.10 "Are you ready to make a decision on evacuation depending on the situation of rain etc." is the lowest at 2.94, and the increase in the average score of Q.11 "Have you already roughly decided what kind of behavior you should display if you know that it would rain heavily after several hours" is minor at 0.38.

Accordingly, following improvement was examined to enhance the judgment on the behavior depending on heavy rainfall and its timing. The learning to treat the

Table 3. Revised unit structure table.

Unit	Learning	Learning objective
Unit 1: Prior learning	Lesson 1: Let us learn about disasters caused by heavy rain	· Understand the disaster caused by heavy rain. · Create a concrete image of the disaster caused by heavy rain.
	Lesson 2: Let us learn about the disaster control of large rivers	· Understand the characteristics of large rivers. · Know the measures against floods in large rivers and their limitation.
	Lesson 3: Let us learn about the information on dangerous rainfall	· Know the information on dangerous rainfall. · Consider the judgment to act based on the information.
Unit 2: Active learning (individual)	Lesson 4–5: Let us learn how to protect ourselves from flooding	· Read hazard maps correctly. · Determine the evacuation action based on the flood hazard at the spot.
Unit 3: Active learning (group)	Lesson 6–7: Let us discuss how to evacuate according to the situation	· Summarize and represent what you have learned. · Ask questions and discuss about heavy rains with the adults living in your community.

timeline indicating the issuance of weather information, evacuation information, and the time the flood that occurred during heavy rainfall disasters in recent years has been added as materials to the contents of Lesson 2 of Unit 1 "Let us know about dangerous and heavy rainfall and how to collect the information." Moreover, according as the teachers' suggestion, a teacher will ask a question to children about evacuation decision making based on weather information and situation, and they will discuss these topics in pairs or small groups in Unit 2.

4.4.3. Retention of the Ability to Think and Express Evacuation Actions

The increase of the average score of Q.12 in Unit 2 "Can you instruct people around you what to do during heavy rain?" is minor at 0.43 and the average score after the lesson is also low at 3.08. However, statistical significance is recognized in the repeated measures because after learning Unit 2, the teachers instructed the students to explain their learning achievements, the map, and the worksheet in which the lessons were recorded at their homes and to engage in discussions about the topic.

Therefore, according to the teachers' suggestion, it was added to Unit 2 of the program to offer homework to the students and to discuss the learning outputs with their families following the lesson.

Based on the above improvements this program was revised. 1) Unit 1 has been changed as follows to enhance understanding of weather information. Unit 1 consists of three lessons – Lesson 1 "Let us know about the disaster caused by heavy rainfall"; Lesson 2 "Let us know about the characteristics of large rivers and flood preparedness"; and Lesson 3 "Let us know how to collect the information on heavy rainfall." In Lesson 1 "Let us know about the disaster caused by heavy rainfall" has been added to review "Where rainwater goes and the conditions of the ground," in school textbooks of science for the fourth grade, and learn about heavy rainfall disasters in recent years by videos. Moreover, in Lesson 3 "Let us know how to collect information on heavy rainfall," the learning has been added to which treats the timeline demonstrating the release of weather information and the evacuation information during the floods following heavy rainfall in recent years. 2) To enhance students' ability to make decisions in response to weather situations, questions have been included in the teaching plan of Unit 2. The questions ask students to make decision based on weather information and situation, and they discuss them in pairs or small groups. 3) Furthermore, for retention of the ability to think and express evacuation actions, an instruction has been added to assign them homework to explain the map and the worksheet to be created in the Unit 2 lessons to their family members, and discuss these with them. The unit structure table reflecting the above modifications is shown in **Table 3**, and the instructional plans is shown in **Figs. 12–16**.

5. Conclusions and Future Development

In this study, an education program for heavy rainfall risk management was developed using the ADDIE process of ID to enhance the disaster response capabilities of schoolchildren by encouraging them to think about and behave proactively to protect their own lives during disasters resulting from heavy rainfall. The program was evaluated through an implementation at Nagaoka Municipal Senju Elementary School in Nagaoka City, Niigata Prefecture, which was affected by floods caused by Typhoon No.19. Thus, the statistical significance between before and after the learning was recognized and the learning effect was verified throughout the program. The program was further improved through its implementation and evaluation.

This program is planned to be developed at elementary schools in Nagaoka City by the NPO Hometown Future Creation Hall in the city, a cooperator of the study, through a city-commissioned project called "Disaster Management Treasure Box." It is expected that by repeating the cycle of implementation, evaluation, and revision for local elementary schools with similar high flood risk as Senju Elementary School, the program would be enhanced, and its effectiveness would be increased in the future. We also want to develop a program for heavy rainfall disaster management education treating urban inundation and sediment disasters in hilly and mountainous areas.

Acknowledgements

The authors express their gratitude to the two teachers and 52 fourth-grade students of Nagaoka Municipal Senju Elementary School, for implementing the disaster management education in this study, as well as other school officials and the members of the Senju Town Planning Promotion Department who assisted with

Lesson 1: Let us learn about disasters caused by heavy rain	
Time table	・:Learning process, T:Teaching and questioning of teacher, C:Expected response of children, *Learning aim*
Introduction, 10 min.	・Review "Where does rainwater go and the conditions of the ground T: How does the rainwater drain? C: Sink into the ground C: Flows from high locations to low ones C: Flows into drainage systems and rivers C: Flows into the sea ・Show the video materials etc. if you have time. ・Have the children write their learnings in the worksheet. What will happen to the ground and rivers during heavy rain?
Process 1, 15 min.	*Understand how disasters are caused by heavy rainfall* T: How does the volume of rainwater sink into the ground during heavy rainfall? C: Increase T: If the volume of rainwater seeping into the ground increases, how does the soil react? C: Become mushy, soft, etc. T: How is the ground softened when the water flows on a steep slope? C: Collapse T: Disasters caused by the collapse of slopes are called "landslides" T: How is the volume of water flowing into drainage? C: Increase T: What happens when the water level increases and cannot drain? C: Overflow T: Disasters caused by an overflow on the ground when the water cannot be drained is called "inundation." T: If the volume of water flowing from the drainage into the river increases, how does it flow? C: River water overflows. T: Disaster caused by overflow of river is called "flood." T: As explained above, how the disaster occurs differs depending on the location. ・Have the children write the lessons in the worksheet.
Process 2, 10 min.	*Image of the actual disaster caused by heavy rainfall* ・ Explain the differences in disasters according to the location by using slides and other materials relating to neighboring areas. ・ Display videos on heavy rainfall disasters in recent years. ・ Display the chronological flooding of the Shinano River. T: How do you feel after watching the video and chronology? C: Frightened, terrible if it occurs, it has occurred repeatedly, etc.
Summary, 10 min.	*Summarize the learning contents* ・Make the children write a summary of the learning contents on the worksheet, as shown below. Disaster hazards vary according to location.

Fig. 12. Revised teaching guide for Lesson 1 of Unit 1.

the lessons. The authors also express their gratitude to Nagaoka City's Crisis Management Disaster Prevention Headquarters, as well as the NPO Hometown Future Creation Hall, for coordinating the implementation of this study.

References:

[1] Cabinet Office, "White Paper on Disaster Management 2019, Chapter 1 Disasters in 2018, Section 1 Consecutive Disasters, Special Feature Consecutive Disasters – Toward the Establishment of a Disaster Conscious Society –," http://www.bousai.go.jp/en/documentation/white_paper/2019.html [accessed February 1, 2021]

Lesson 2: Let us learn about disaster control for large rivers	
Time table	・:Learning process, T:Teaching and questioning of teacher, C:Expected response of children, *Learning aim*
Introduction, 10 min.	*Take an interest in the characteristics of rivers* ・ Display pictures of large and small rivers during normal situation using slides. T: What do you know or think about the Shinano River? C: Many insects and plants outside the bank. C: The Shinano River is the longest river in Japan. T: What do you know or think about the Kaki River? C: Flood occurred repeatedly at Kaki River. C: There are no banks, or the bank is low along the Kaki River. *Change the river's name to match your school's region. ・ Use the image map to organize the children's remarks. ・ Show pictures of rivers during disasters. What are the conditions in large and small rivers during heavy rain?
Process 1, 15 min.	*Understand the characteristics and flood risk of large rivers* ・ Distribute the worksheets and get the children to fill the blanks with the characteristics of rivers. T: What word can be used to fill the blanks in the worksheet about the width of large rivers? C: Wide T: Which river increases more rapidly during heavy rainfall, a wide river or a narrow one? C: Narrow river T: Large rivers are wide and rise slowly during heavy rainfall. T: How high is the bank of a large river? C: High T: Which is more likely to overflow during heavy rainfall, a river with high bank or low bank? C: Rivers with low banks T: When a large river has high banks, even if water increases during heavy rainfall, it is difficult for the water to overflow. T: The Shinano River is the longest river in Japan. Which prefectures does this river run through? C: Niigata and Nagano prefectures T: The Shinano River can flood even with rainfall in the distant Nagano Prefecture. This can be compared to a person maintaining a friendship with people far away. T: Now that you understand the characteristics of large and small rivers, which one will be more frightening during heavy rain? C: Both T: Small rivers are scary because they are like an intolerant and impatient person. Large rivers are scarier, like a person who seldom gets angry but gets really angry once annoyed. When large rivers flood, a lot of water overflows and causes deep inundation over a wide area. Who prepares during the flooding of a large river and how?
Process 2, 10 min.	*Learn about the measures against the flooding of large rivers and their limitations* ・ Show slides explaining the flood control facilities. T: In large rivers, we prepare for floods by building dams and banks. Many agencies, such as the central and prefectural governments and construction companies are involved in such projects. Even with these measures, heavy rainfall beyond their limits could cause flooding. Do you think these measures are unnecessary? C: I do not think it is unnecessary. T: Why do you think so? T: They can not only prevent flooding, but also provide a time gap. What will you use that time for? C: Evacuation T: Then, when should you evacuate? C: I do not know ・ Ask children how they can notice a disaster about to happen and take action to protect themselves and let them discuss in pairs or small groups. ・ Tell children to get information on heavy rainfall in the next lesson.
Summary 10 min.	*Summarize the learning contents* A large river seldom overflows; however, it can be a lethal disaster. Flood control facilities such as dams and banks have been built to prevent floods, and many people are involved, but we should evacuate when it rains dangerously.

Fig. 13. Revised teaching guide for Lesson 2 of Unit 1.

Lesson 3: Let us learn about dangerous rainfall	
Time table	・:Learning process, T:Teaching and questioning of teacher, C:Expected response of children, *Learning aim*
Introduction, 5 min.	*Review of the previous lesson* T: Because many measures have been taken, does disaster not occur? C: Could occur T: What should you do in such case? C: Evacuate, protect myself. T: Then, when should you evacuate? How do you notice a disaster about to happen?
Process 1, 15 min.	*Gather information on heavy rainfall* T: It is difficult even for an adult to judge how much damage heavy rainfall will cause. Hence, it is important to collect the information issued by specialized agencies. T: How can you collect such information? C: Television, radio, municipal radio, publicity advertising car, smart phone, etc. T: What kind of information do you have? ・ Distribute the worksheets and show the slides. T: "Weather information on disaster mitigation" released by the Japan Meteorological Agency (JMA) indicates the level of danger from rain, etc. This includes flood warnings and tropical cyclone forecasts. Flood Warnings and Advisories can also be released along the designated rivers. This is broadcast on televisions and radios, found on the JMA's website, and sent through early warning e-mails and a smartphone app such as Yahoo! JAPAN Disaster Alert. ・ Have children repeat the name and explain the information from the JMA. T: Municipalities release "evacuation information" to help make decisions about evacuation, referring to information from JMA. T: Warning levels are defined in weather information on disaster mitigation and evacuation information to make it easier to judge how dangerous the situation is and when to evacuate. ・ Have C repeat warning levels and its explanations.
Process 2, 15 min.	*Consider how and when to respond based on information* T: Which level do you think is the best to start evacuation? ・ Have C raise their hands to the warning level they think is the best and let them explain why. ・ Show the timeline of the floods and the relay of information issued in recent disasters with slides or other materials. * The following is an example of Nagano City during Typhoon Hagibis in 2019. T: The bank of the Chikuma (Shinano) River was breached at Nagano City during Typhoon Hagibis in 2019. The timeline of the information issuance at that time was as follows, ・Oct, 11, 11:00 a.m., Press Conference by JMA (possibility of issuing an emergency warning) ・Oct.12, 3:30 p.m., Heavy Rain Emergency Warning in Nagano Prefecture, etc. ・Oct.12, 5:30 p.m., Flood Warning of Chikuma River in Ueda City ・Oct. 12, 6:00 p.m., Evacuation Advisory in Nagano City ・Oct.12, 11:40 p.m., Evacuation Order in Nagano City ・Oct. 13, 1:40 a.m., the Chikuma River Overflowed in Nagano City ・Oct.13, 2:12 a.m., The bank of the Chikuma River was breached in Nagano City T: The evacuation advisory was issued before the flood. In the Naganuma district, Nagano city, residents evacuated quite early. However, two deaths were reported due to the delayed evacuation at Naganuma district, Nagao City. The evacuation was delayed because the evacuation advisory and order were issued at night. T: When referring to these materials, when the orders are issued, we should examine which information to consider to evacuate. ・ Ask C when they think it is best to start evacuation. * Have C discuss in pairs or small groups if you have time. T: The evacuation would be difficult if information was not issued on time, did not reach the residents appropriately or was issued at night. T: Protect your life, by yourself. For this purpose, it is important to collect not only the evacuation information but also the various information including the weather information and respond in time for our safety.
Summary 10 min.	*Summarize the learning contents* ・ Collect information first if heavy rainfall is expected. ・ Judge not only based on evacuation information but also based on information from various sources. ・ Take action earlier to protect yourself.

Fig. 14. Revised teaching guide for Lesson 3 of Unit 1.

[2] Cabinet Secretariat, "Fundamental Plan for National Resilience – For Building a Strong and Flexible Country –," https://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/en/fundamental_plan.pdf [accessed February 1, 2021]

[3] Cabinet Office, "White Paper on Disaster Management 2019, Chapter 1 Disasters in 2018, Section 1 Consecutive Disasters, 1-1 The Heavy Rain Event of July 2018 (Western Japan)," http://www.bousai.go.jp/en/documentation/white_paper/2019.html [accessed February 1, 2021]

[4] Ministry of Land, Infrastructure, Transport and Tourism (MLIT), "'The Flood Control Act, etc. Partial Amendment Law' is now in effect," https://www.mlit.go.jp/river/suibou/suibouhou.html (in Japanese) [accessed February 1, 2021]

[5] MLIT, "The guideline for creating flood hazard maps," 2016, https://www.mlit.go.jp/river/basic_info/jigyo_keikaku/saigai/tisiki/hazardmap/suigai_hazardmap_tebiki_1.pdf (in Japanese) [accessed February 1, 2021]

[6] Ministry of Education, Culture, Sports, Science and Technology (MEXT), "Reference Materials for Disaster Management at School – Development of Disaster Management Education to Foster Zest for Life –," 2013, https://anzenkyouiku.mext.go.jp/mextshiryou/data/saigai03.pdf (in Japanese) [accessed February 1, 2021]

[7] Niigata Prefectural Board of Education, "The Niigata Prefecture Disaster Management Education Program: Flood Disaster Edition," 2015, http://furusato-bousai.net/Download/program/03_2_kouzui.pdf [accessed February 1, 2021]

[8] Shimodate River Office, "My Timeline Study Tool for Elementary and Junior High School Students - Escape Kid," https://www.ktr.mlit.go.jp/shimodate/shimodate00626.html (in Japanese) [accessed February 1, 2021]

[9] Japan Meteorological Agency, "Workshop on What Do You Do When Unprecedented Heavy Rains Occur?," http://www.jma.go.jp/jma/kishou/know/jma-ws/ (in Japanese) [accessed February 1, 2021]

[10] N. Kuwasawa, T. Katada, Y. Oikawa, and M. Kodama, "Development of Comprehensive Scenario Simulator in Flood Time and Its Application to Disaster Education," Doboku Gakkai Ronbunshuu D, Vol.64, No.3, pp. 354-366, 2008 (in Japanese).

[11] K. Suzuki, "Instructional Design for e-Learning Practice," Japan J. of Educational Technology, Vol.29, No.3, pp. 197-205, 2006 (in Japanese).

[12] T. Inagaki and K. Suzuki, "Manual for Design of Classes Ver.2: Instructional Design for Teacher," Kitaooji Shobo Publishing, 2015 (in Japanese).

[13] T. Nagata and R. Kimura, "Practice of Disaster Management Education to Enhance 'Zest for Life' by Using Earthquake Early Warning – Cooperation among Local Meteorological Observatory, Board of Education and Schools," Papers of Institute of Social Safety Science, No.21, pp. 81-88, 2013 (in Japanese).

[14] T. Nagata and R. Kimura, "Suggestion for Disaster Management Education Program to Develop Students' 'Zest for Lives' Clarifying their Disaster Responses at the Tornado – A Case Study for Saitama Tornado Disaster on September 2nd in 2013 –," Papers of Institute of Social Safety Science, Vol.24, pp. 161-169, 2014 (in Japanese).

[15] T. Nagata and R. Kimura, "An Attempt of Development the Tornado Disaster Management Education Program Based on the Knowledge and Lessons of the Tornado-affected School and Applying them on Schools out of the Affected Area," Papers of Institute of Social Safety Science, Vol.28, pp. 117-126, 2016 (in Japanese).

[16] T. Nagata and R. Kimura, "Development of Disaster Management Education Program to Build Competency in Students' 'Zest for Lives' against Volcanic Disaster," Papers of Institute of Social Safety Science, Vol.29, pp. 175-184, 2016 (in Japanese).

[17] T. Nagata and R. Kimura, "A Development of the Disaster Management Education and Trainings Program for Students with Visually Impaired to Improve 'Zest for Life' in the Event of A Disaster – A Case Study on Tochigi Prefectural Special School for the Visually Impaired –," Papers of Institute of Social Safety Science, Vol.33, pp. 115-125, 2018 (in Japanese).

[18] T. Nagata and R. Kimura, "Developing a Disaster Management Education and Training Program for Children with Intellectual Disabilities to Improve 'Zest for Life' in the Event of a Disaster – A Case Study on Tochigi Prefectural Imaichi Special School for the Intellectually Disabled," J. Disaster Res., Vol.15, No.1, pp. 20-40, 2020.

[19] T. Higashino and N. Yoshimoto, "Creating an e-Learning Course for Elementary School Teachers on Cloud Observations," JSSE Research Report, Vol.33, Issue 7, pp. 33-36, 2019 (in Japanese).

[20] A. Umeno and Y. Asada, "Reviewing the Wide-scale Disaster Simulation Training to Improve Using an Instructional Design," Japanese J. of Occupational Medicine and Traumatology, Vol.63, No.6, pp. 378-384, 2015 (in Japanese).

Lesson 4-5: Let us learn how to protect ourselves from flooding	
Time table	・:Learning process, T:Teaching and questioning of teacher, C:Expected response of children, *Learning aim*
Introduction, 10 min.	*Review of the previous lesson* T: What kind of disaster do you think you should be concerned about near a river during heavy rainfall? C: Flood T: What should you do first if heavy rainfall is expected? C: Collect information T: It is important to collect various information to judge and take action earlier. * If there is time, have C discuss in pairs or small groups about their actions based on the information to protect themselves by asking questions as follows: <Examples of questions> ・A heavy rain advisory was issued when you are out with friends. Will you go home? Call your family? ・You plan to go out during the weekend, but a typhoon is approaching. Will you change the destination? Or will you cancel your plan? ・ Show and explain the flood hazard map of the municipality. T: Do you know what this is? C: Hazard map T: This is a hazard map made by the municipality. You can see where and how deep the Shinano River will flood when it overflows, and to where you can safely evacuate. *Change river's name to match your school area. Find out dangerous spots and safe sites to evacuate if a large river floods.
Process 1, 20 min.	*Find your home on the map* T: How deep do you think your home will be flooded if the Shinano River floods? Look at the hazard map on a computer. ・ Explain how to operate YOU@RISK on your computer. T: Start "YOU@RISK" on your computer. T: Find our school on the map, and then zoom in. T: Find your own home. Next, click "My home" button. Then click on the location of your home on the map, and the home icon ( ) will appear at the point you clicked. T: Switch the base map to satellite imagery.
Process 2, 15 min.	*Look up the expected flood depth at your home* T: Switch the menu of YOU@RISK to 2. Then, the flood hazard map will be displayed. What do you think the colors of the hazard map mean? C: Depth of the flood. Location of inundation. ・ Distribute the worksheet. T: Let us read the description of the expected flood depth. T: When it rains more heavily than expected, the flood area can be wider and deeper than these colors. T: Next, observe the evacuation decision flowchart. If the estimated flood depth is less than 50 cm, raise your hand. Will you evacuate or stay at home if the Shinano River floods? C: Stay home. T: Although your homes will possibly be flooded below the floor level, you will be able to stay home safely. T: If the flood depth is between 50cm and 3m, raise your hand. Till which floor could your home be flooded? C: Till the first floor T: If the first floor of your home will possibly be flooded, and if your home is only one floor high, should you evacuate? T: If the flood depth is between 3m and 5m, raise your hand. Till which floor could your home be flooded? C: Till the second floor T: The second floor may be flooded, so if your home is more than three floors high, you may be able to evacuate to the upper floors. T: If the flood depth is between 5m and 10m, raise your hand. Till which floor could your home be flooded? C: Third floor or higher T: You cannot stay in the place if the flooding depth is 5 to 10 meters. Evacuate to a safer place.

Time table	・:Learning process, T:Teaching and questioning of teacher, C:Expected response of children, *Learning aim*
Process 3, 10 min.	T: Besides the colors indicating the flooding depth, there are shaded areas. The pink shaded area indicates the homes where the ground has been torn away and are at risk of caving in. Is anyone living in this area? Will you evacuate? C: Yes, I am. I will evacuate. T: All people living in this area must evacuate. T: The purple shaded area indicates that wooden homes are at the risk of collapsing because the water flow is fast. Is anyone in this area? Will you evacuate or stay home? C: Yes, I am. I will evacuate. T: People living in wooden homes in this area must evacuate earlier. If you are not sure whether your home is made of wood, ask your family later.
Process 4, 25 min.	*Consider the evacuation destination and route* T: You have confirmed the expected flooding of your home on the hazard map. If your home is in danger, where should you evacuate to? Read the explanation of the evacuation site. ・ Have C read the explanation of the evacuation site together. T: Switch the menu of YOU@RISK to 3 to view evacuation sites where you can safely evacuate from your home. Find a safe evacuation site as close to your home as possible, which is as little flooded as possible. T: Click the "concentric circle" button to view the circle centered on your home to confirm the distance. T: If you select an evacuation site, click "Evacuate here". *Find out dangerous areas to avoid during the evacuation* T: Switch the menu of YOU@RISK to 4 to view areas of danger. Exclamation mark ( ) indicates an underpass and bridge mark ( ) indicates a bridge. These are dangerous spots where people or cars cannot go through if they are inundated, or the river rises during heavy rainfall. T: Click the "evacuation route" button to view the route from your home to the evacuation site you have selected and the altitude graph. If you want to change the evacuation site, go back to menu 3 and select the evacuation site again. T: Finally, determine the best evacuation destination and route and write the name and route on the worksheet. ＊If there is time, pair with someone nearby, share what is written on the worksheet, and listen to the opinions of your partner.
Summary 10 min.	*Summarize the learning contents* ・ Collect various information and take action earlier if the Shinano River is about to flood. ・ If you cannot evacuate far enough away early, evacuate to a safe place nearby, paying attention to the depth of flooding, underpasses, bridges, etc.

Fig. 15. Revised teaching guide for Lesson 4–5 of Unit 2.

Lesson 6-7: Let us discuss how to evacuate according to the situation

Time table	・:Learning process, T:Teaching and questioning of teacher, C:Expected response of children, *Learning aim*
Introduction, 15 min.	*Review up to the previous lesson* T: We learned about two rivers for comparison. What are their names? C: Shinano River and Kaki River T: Which one is larger? C: Shinano River T: What are the characteristics of large rivers? <The characteristics of large rivers regarding flood> A large river seldom floods because it is wide and protected by flood control facilities such as high banks and dams. However, if it rains heavily beyond their limits, flooding may occur and cause lethal damage. T: What is the first thing to do when heavy rain or flooding is about to occur? C: Collect information T: We learned it is important to collect various information and take action early to protect our own lives. ・ Distribute the worksheet. T: In the last lesson, we learned how to act when we are at home and it is about to rain heavily. The decision on the evacuation destination and route will vary depending on the situation. Read the situation in the handout. <Example of situation> A group of our class members on holiday, gathered in front of the station to prepare for the school festival. A large monitor in front of the station showed information that it was raining heavily in Nagano and other prefectures and a flood warning had been issued for Nagaoka City. The group discussed and decided to go to a safe place nearby to wait until A' s family came to pick us up. Where is the safe place near the station? T: Let us discuss in groups and determine the safe evacuation destination and route. Discuss in groups how to act according to the situation.
Process 1, 30 min.	*Discuss in groups about the evacuation destination and route* ・ Work in groups according to each neighborhood association. ・ Distribute tablet PCs and large maps for group work. T: Identify the station on the map and put a blue seal on it. Next, look at the expected flooding depth at the station by operating menu 1 of YOU@RISK. Is it safe to stay there? C: No, it is not safe. Need to evacuate. T: Then, look up evacuation sites near the station by operating menu 2, and discuss where you can be safe. ・ Monitor the progress of each group's discussion. T: After deciding on the evacuation destination, operate Menu 4 to check for any dangerous spots and determine the evacuation route. After discussion, the destination can be changed by returning to Menu 3. T: After deciding the evacuation destination and route, mark the destination on the map with a green sticker and the route with a green pen. If there are any dangerous spots near the route, put a red sticker on it. Then, complete the text by writing the name of your group's neighborhood association, the name of evacuation site you chose, the dangerous spots near the route, and the reason for choosing the destination and route in the blanks of the worksheet. The activity should be completed by discussing with group members. T: If your group completed the text, practice the presentation.

Time table	・:Learning process, T:Teaching and questioning of teacher, C:Expected response of children, *Learning aim*
Process 2, 10 min.	*Make a presentation on the results of the group discussion* T: The representative from each neighborhood should join each group. Before the presentation, please introduce yourself to your neighbors. T: The children have learned about the Shinano River's flood control measures. Today they discussed safe evacuation sites near the Station by using the hazard map. Now please listen to the presentations. Each group, please begin your presentation. C: (Each group will make their presentation.) T: Presentation time is over. If you have any questions or comments, please feel free to ask them. If there are any questions from your neighborhoods, please answer them with your leader. C: (Questions and answers in each group.)
Process 3, 25 min.	*Address the question to the adults in your neighborhood about flood preparedness * T: Today the representatives of your neighborhoods have come, so please ask them any questions you have. C: (Ask the questions as per the questionnaire that has been prepared in advance according to the theme.) < Example questions: Theme 1> ・ Describing the past floods that have occurred in the local community. ・ Other questions about the Shinano and Kaki rivers < Example questions: Theme 2> ・ How was the local community at the time of the Typhoon Hagibis in 2019. ・ Questions about disaster preparedness activities in your community at present. T: Question time is over.
Summary, 10 min.	*Summarize the learning contents* T: What kind of stories did you hear about the flood in the past and the activities of disaster preparedness in your local community? C: (Children representing each group share their questions and answers.) T: You have all learned about past floods and local disaster preparedness activities. From now on, it is important for you to keep learning by fielding questions to neighborhoods and telling them what you know, so that we can all learn together and be prepared for floods. T: Finally, let us give special thanks to the people who have come here today. C: Thank you very much. ・ The end.

Fig. 16. Revised teaching guide for Lesson 6–7 of Unit 3.

[21] T. Ogasawara, "Support of Learning by Instructional Design," J. of Assisting Dialogue and Communication Studies, Vol.4, pp. 75-87, 2017 (in Japanese).

[22] K. Ishii, M. Nakano, and M. Mizutani, "Development of Management and Career Design Program in a Liberal Arts Curriculum," J. of JSEE, Vol.65, Issue 2, pp. 2_21-2_25, 2017 (in Japanese).

[23] MLIT, "River Administration in Japan," 2007, https://www.mlit.go.jp/river/basic_info/english/pdf/RiverAdministrationInJapan(e).pdf [accessed February 1, 2021]

[24] Hokuriku Regional Development Bureau, MLIT, "Let's learn more about the Shinano and Chikuma Rivers," http://www.hrr.mlit.go.jp/shinano/367/disaster/index.html (in Japanese) [accessed February 1, 2021]

[25] Hokuriku Regional Development Bureau, MLIT, "Flood Summary

Report of Typhoon No.19 in October in 2019," 2020, https://www.hrr.mlit.go.jp/shinage/shinano-plan/ryuiki/ryuiki/2kai/s-1.pdf (in Japanese) [accessed February 1, 2021]
[26] K. Morohashi, "Development of Niigata Prefecture Disaster Prevention Education to Nurture the Power to Survive from Disasters," Proc. of the General Meeting of the Association of Japanese Geographers, Vol.2019a, ID S209, 2019 (in Japanese).
[27] MEXT, "Standards for Curriculum in Elementary and Secondary Education (Advisory)," 2014, https://www.mext.go.jp/b_menu/shingi/chukyo/chukyo0/toushin/1353440.htm (in Japanese) [accessed February 1, 2021]
[28] National Research Institute for Earth Science and Disaster Resilience (NIED), "Information products to help users make decisions," https://www.bosai.go.jp/activity_special/250s_introduction.html (in Japanese) [accessed February 1, 2021]
[29] R. Takaoka, "Current Situation and Future Direction of School Lesson and Learning with ICT," Trans. of Japanese Society for Information and Systems in Education, Vol.33, No.1, pp. 6-21, 2016 (in Japanese).
[30] R. M. Gagne, W. W. Wager, K. C. Golas, and J. M. Keller, "Principles of Instructional Design (5th Edition)," Wadsworth Pub. Co., 2004, Translation Supervised by M. Iwasaki and K. Suzuki, "Principles of Instructional Design," Kitaooji Shobo Publishing, 2007 (in Japanese).

Name:
Masaki Ikeda

Affiliation:
Technical Staff, Disaster Resilience Research Division, National Research Institute for Earth Science and Disaster Resilience (NIED)

Address:
3-1 Tennodai, Tsukuba, Ibaraki 305-0006, Japan

Brief Career:
2007-2012 Bachelor of Science, Tohoku University
2012-2014 Master of Science, Tohoku University
2012-2016 President, The Informatization Council for Welfare Promotion and Disaster Prevention
2016- Researcher, NIED
2020- Doctor Course of Science, Tohoku University

Selected Publications:
• M. Ikeda and S. Sato, "Survey and Analysis on the Actual Use of the Great East Japan Earthquake Archives," J. of Social Safety Science, Vol.37, pp. 219-226, 2020.
• M. Ikeda, Q. Cui, T. Toyoda, H. Nakamura, and H. Fujiwara, "Developing an Automated System for Simple Estimation of the Direct Damage Amounts from Earthquakes," J. Disaster Res., Vol.16, No.2, pp. 275-286, 2021.

Academic Societies & Scientific Organizations:
• Institute of Social Safety Science (ISSS)
• Association of Japan Geographers (AJG)
• Tohoku Geographical Association (TGA)

Name:
Toshimitsu Nagata

Affiliation:
Senior Coordinator for Weather Information, Niigata Local Meteorological Office, Japan Meteorological Agency

Address:
1-2-1 Misaki, Chuo, Niigata, Niigata 950-0954, Japan

Brief Career:
1985-1988 Toyama Local Meteorological Office, Japan Meteorological Agency
1995-1999 Observation Department of Meteorological Agency, Japan
2010-2014 Kumagaya Local Meteorological Office, Japan Meteorological Agency
2014-2016 Senior Scientific Officer for Volcanic Disaster, Utsunomiya Local Meteorological Office, Japan Meteorological Agency
2016-2019 Senior Scientific Officer for Earthquake and Tsunami Disaster, Utsunomiya Local Meteorological Office, Japan Meteorological Agency

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 –," J. of Social Safety Science, Vol.21, pp. 81-88, 2013 (in Japanese).
• "Suggestion for Disaster Management Education Program to Develop Students' "Zest for Lives" Clarifying their Disaster Responses at the Tornado – A Case Study for Saitama Tornado Disaster on September 2nd in 2013 –," J. of Social Safety Science, Vol.24, pp. 161-169, 2014 (in Japanese).
• "An Attempt of Developing the Tornado Disaster Management Education Program Based on the Knowledge and Lessons of the Tornado-affected School and Applying them to Schools out of the Affected Area," J. of Social Safety Science, Vol.28, pp. 117-126, 2016 (in Japanese).
• "Development of Disaster Management Education Program to Build Competency in Students' "Zest for Lives" against Volcanic Disaster," J. of Social Safety Science, Vol.29, pp. 175-184, 2016 (in Japanese).
• "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," J. Disaster Res., Vol.12, No.1, pp. 17-41, 2017.
• "A Development of the Disaster Management Education and Trainings Program for Students with Visually Impaired to Improve "Zest for Life" in the Event of A Disaster – A Case Study on Tochigi Prefectural Special School for the Visually Impaired –," J. of Social Safety Science, No.33, pp. 115-125, 2018 (in Japanese).
• "Developing a Disaster Management Education and Training Program for Children with Intellectual Disabilities to Improve 'Zest for Life' in the Event of a Disaster – A Case Study on Tochigi Prefectural Imaichi Special School for the Intellectually Disabled," J. Disaster Res., Vol.15, No.1, pp. 20-40, 2020.

Academic Societies & Scientific Organizations:
• Institute of Social Safety Science (ISSS)
• Japanese Association of Safety Education (JASE)

Name:
Reo Kimura

Affiliation:
Professor, 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 Sciences, 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:
- "Development of a "Disaster Management Literacy Hub" for Collecting, Creating, and Transmitting Disaster Management Content to Increase Disaster Management Literacy," J. Disaster Res., Vol.12, No.1, pp. 42-56, 2017.
- "A Study on the 2016 Kumamoto Earthquake: Citizen's Evaluation of Earthquake Information and Their Evacuation and Sheltering Behaviors," J. Disaster Res., Vol.12, No.6, pp. 1117-1138, 2017.
- "Research for Contributing to the Field of Disaster Science: A Review," J. Disaster Res., Vol.15, No.2, pp. 152-164, 2020.
- "The Determinants of Residents' Evacuation Behavior in the Torrential Rain in Western Japan in 2018: Examination of Survey Data of Victims in Okayama Prefecture," J. Disaster Res., Vol.15, No.7, pp. 1011-1024, 2020.

Academic Societies & Scientific Organizations:
- Institute of Social Safety Science (ISSS)
- Japan Society for Natural Disaster Science (JSNDS)
- Japanese Psychological Association (JPA)
- Japanese Society of Social Psychology
- Japan Sociological Society (JSS)
- Seismological Society of Japan (SSJ)
- Japan Society of Civil Engineering (JSCE)

Name:
Tai-Young Yi

Affiliation:
Senior Researcher, National Research Institute for Earth Science and Disaster Resilience (NIED)

Address:
3-1 Tennodai, Tsukuba, Ibaraki 305-0006, Japan

Brief Career:
2008 Researcher, Toyota Transportation Research Institute
2008 Part-Time Lecturer, Daido University
2009- Researcher, NIED

Selected Publications:
- "Making of Disaster prevention radio drama," NHK Publishing, Inc., 2011 (in Japanese).
- Tai-Young Yi et al., "Effect of risk communication method on earthquake disaster prevention activity – A case study in Tsukuba City –," J. of Japan Association for Earthquake Engineering, Vol.17, pp. 1_63-1_76, 2017 (in Japanese).

Academic Societies & Scientific Organizations:
- Society for Risk Analysis, Japan (SRAJ)
- Institute of Social Safety Science (ISSS)
- Korean Society of Disaster Information (KOSDI)

Name:
Shingo Suzuki

Affiliation:
National Research Institute for Earth Science and Disaster Resilience (NIED)

Address:
3-1 Tennnodai, Tsukuba, Ibaraki 305-0006, Japan

Brief Career:
2006 Great Hanshin-Awaji Earthquake Memorial, Disaster Reduction and Human Renovation Institution
2007- Disaster Prevention Research Institute, Kyoto University
2015- NIED

Selected Publications:
- S. Suzuki and H. Hayashi, "Spatial Exposure Analysis on Tokyo Metropolitan Earthquake Disaster," J. Disaster Res., Vol.5, No.1, pp. 45-53, 2010.

Academic Societies & Scientific Organizations:
- Architectural Institute of Japan (AIJ)
- Institute of Social Safety Science (ISSS)
- Japan Society for Disaster Information Science (JASDIS)

Name:
Shingo Nagamatsu

Affiliation:
Kansai University
National Research Institute for Earth Science and Disaster Resilience (NIED)

Address:
7-1 Hakubaicho, Takatsuki, Osaka 569-1098, Japan
3-1 Tennnodai, Tsukuba, Ibaraki 305-0006, Japan

Brief Career:
2000-2002 Associate Professor, School of International Public Policy, Osaka University
2002-2007 Research Scientist, Disaster Reduction and Human Renovation Institution
2007-2009 Special Researcher, NIED

Selected Publications:
- S. Nagamatsu, et al., "Return Migration and Decontamination After the 2011 Fukushima Nuclear Power Plant Disaster," Risk Analysis, Vol.40, No.4, pp. 800-817, 2019.
- S. Nagamatsu, "Building back a better Tohoku after the March 2011 tsunami: Contradicting evidence," V. Santiago-Fandino, S. Sato, N. Maki, and K. Iuchi (Eds.), "The 2011 Japan Earthquake and Tsunami: Reconstruction and Restoration," pp. 37-54, Springer, 2018.

Academic Societies & Scientific Organizations:
- Institute of Social Safety Science (ISSS)
- Japan Society for Disaster Recovery and Revitalization (JSDRR)
- Integrated Disaster Risk Management (IDRiM) Society

Name:
Takashi Oda

Affiliation:
Associate Professor, Graduate School of Education, Miyagi University of Education
Deputy Director-General, 311 Disaster Risk Reduction Learning Institute for Educators (DRR-LIFE), Miyagi University of Education
Address:
149 Aramaki, Aoba, Sendai, Miyagi 980-0845, Japan

Name:
Shun Endo

Affiliation:
Master's Course Student, Graduate School of Education, Miyagi University of Education
Address:
149 Aramaki, Aoba, Sendai, Miyagi 980-0845, Japan

Name:
Mitsuhiro Hatakeyama

Affiliation:
Master's Course Student, Graduate School of Education, Miyagi University of Education
Address:
149 Aramaki, Aoba, Sendai, Miyagi 980-0845, Japan

Name:
Seigo Yoshikawa

Affiliation:
Master's Course Student, Graduate School of Education, Miyagi University of Education
Teacher, Sendai City Higashi Sendai Junior High School
Address:
149 Aramaki, Aoba, Sendai, Miyagi 980-0845, Japan
2-16-1 Higashisendai, Miyagino, Sendai, Miyagi 983-0833, Japan

Name:
Satoru Adachi

Affiliation:
Researcher, Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience (NIED)
Address:
Tokamachi, Shinjo, Yamagata 996-0091, Japan
Brief Career:
2011- Otaru Museum
2012- Snow and Ice Research Center, NIED
Selected Publications:
• "Application of a magnetic resonance imaging method for nondestructive, three dimensional, high-resolution measurement of the water content of wet snow samples," Frontiers in Earth Science, Vol.8, ID 179, 2020.
Academic Societies & Scientific Organizations:
• Japanese Society of Snow and Ice
• Japan Society Snow Engineering

Name:
Shinya Miura

Affiliation:
Principal Research Fellow, National Research Institute for Earth Science and Disaster Resilience (NIED)
Address:
3-1 Tennodai, Tsukuba, Ibaraki 305-0006, Japan
Brief Career:
2003 Kawasaki Local Government Research Center
2015- NIED
Selected Publications:
• "Participatory Risk Communication Method for Risk Governance Using Disaster Risk Scenarios," J. Disaster Res., Vol.3, No.6, pp. 442-456, 2008.
• "311 Informatics: What and How the Media Communicated," Iwanami Shoten, 2012.
• "Study on Disaster Prevention Countermeasures and Examples for Local Governments in Consideration of Regional Characteristics," J. Disaster Res., Vol.13, No.1, pp. 172-192, 2018.
Academic Societies & Scientific Organizations:
• Japan Society for Disaster Information Studies (JASDIS)
• Japan Sociological Society (JSS)
• Institute of Social Safety Science (ISSS)

Name:
Junya Take

Affiliation:
Director, Digital Transformation and Relief Supplies, Disaster Management, Cabinet Office
Director General, Disaster Management, Cabinet Office
Address:
No.8 Central Common Government Offices, 1-6-1 Nagatacho, Chiyoda, Tokyo 100-8914, Japan