Linking geomorphological features and disaster risk in a school district: The development of an in-service teacher training programme

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Abstract. The dimension and degree of a disaster can depend on the vulnerability of the location, the people and the community. One of the key lessons learnt from the 2011 Great East Japan Earthquake disaster was that schools should prepare a school contingency plan in advance. To do so, they should fully understand their school’s disaster risk in the worst-case scenario in order to protect children’s lives at the school. Therefore, schools are required to customise their preparedness measures according to the school’s locality. The training programme, ‘Understanding disaster risk based on geographic features of a school district’ was developed and implemented in Ishinomaki City, Miyagi Prefecture, which was severely affected by the 2011 tsunami. The training programme was a spin-off of a school-based disaster education programme implemented in Ishinomaki City and was expected to support the customisation of schools’ disaster manuals according to the school district’s disaster risk. In order to strengthen teachers’ map-reading skills, the training was organised in three steps. The first step was to enable teachers to acquire basic map-reading skills and read a contour map to understand the geomorphological features of their school district. The second step was to have teachers compare these maps to hazard maps (for tsunamis, floods and landslides) to understand the links between geomorphological features and disaster risk. The third step was to have them identify emergency evacuation sites and evacuation shelters for each hazard type in their school district. It was found that the training helped to increase the participants’ confidence in understanding these maps.

1. Background

The magnitude 9.0 Great East Japan Earthquake occurred at 14:46 on March 11, 2011. Since this was a Friday afternoon during school hours, the education sector was affected. Among children of school-going age from the kindergarten to high school levels in Ishinomaki City, Miyagi Prefecture, 166 children were killed and 16 went missing, which accounted for 50% of the students lost (166 out of 327) and 46% of the children missing (16 out of 35) in Miyagi Prefecture. All of the 71 educational facilities in the city were damaged.

Ishinomaki City also experienced a tragic incident at Okawa Elementary School, where 74 out of 108 pupils, 10 teachers and many local people under school supervision were killed by the 2011 tsunami, which travelled upstream along the Kitakami River. This public elementary school was located on the riverside in Ishinomaki City 4.5 kilometres inland to the northeast of the mouth of the Kitakami River. On March 11, the principal was off duty and the vice principal was in charge of evacuating the children. Children, teachers and people from the local community remained on the school grounds in the second evacuation area for about 50 minutes before they proceeded towards a nearby riverbank bridge rather
than up a nearby hill. According to a tsunami hazard map produced by Miyagi Prefecture, the school was outside of the expected tsunami inundation area and was a designated evacuation shelter for the community.

A third-party investigation board completed their final report in March 2014 with 24 recommendations for action by relevant agencies, residents and educational and disaster risk reduction (DRR) experts to avoid similar tragedies at schools (Okawa Elementary School Accident Investigation Board 2014). Since the release of the final report by the investigation board, 23 families of the child victims have sued Miyagi Prefecture and the Ishinomaki City government in the civil court. In April 2018, the Sendai High Court ordered the government of Ishinomaki City and Miyagi Prefecture to pay the families $13 million. The court ruled that the deaths of the elementary school children could have been prevented if Miyagi Prefecture and the city government had updated its disaster contingency plan. The judgement states that the school had obligations to designate a third tsunami evacuation area and to clarify evacuation areas and evacuation routes in its risk management manual in advance and that by failing to do so it was guilty of negligence. In Japan, the School Health and Safety Act of 2009 sets out the requirements for securing children’s safety at school. The ruling was finalised after the Supreme Court rejected governments of the City and Prefecture appeal in October 2019.

The confirmation of the ruling is expected to have a significant impact on disaster safety at Japanese schools. The decision means that all public schools in the country are responsible for preparing a school contingency plan. This plan should not only be based on the authorised hazard map. Each school is responsible for understanding that the hazard map is based on certain scenarios and should prepare for the worst-case scenario.

Therefore, it can be said that one of the lessons learnt from the 2011 tsunami disaster is that schools must prepare their disaster safety plans based on their school’s local geographic conditions. The 16th recommendation in the final report on the Okawa Elementary School accident by the third-party investigation board specifies that municipalities should create an evacuation plan with community participation based on the authorised hazard map and that residents should review the hazard map themselves and prepare a customised and detailed map to determine their community’s disaster risk. It also recommended that schools should make their DRR efforts to compare the hazard map to the school’s location and prepare for the school original evacuation map (Okawa Elementary School Accident Investigation Board 2014).

Landform is one of the risk factors that can turn a natural hazard into a natural disaster and is a determining factor of the degree of damage a disaster can inflict on the community. It is also one of the foundations of hazard maps. The Geospatial Information Authority of Japan (GSI) makes geographic information available to the public through GSI homepage. The municipal governments publish hazard maps to raise awareness of disaster risks and to promoting disaster preparedness in the home and the community. However, a barrier still exists for schoolteachers, most of whom do not always have a background in physical geography and disaster science, to access and understand such information for ensuring disaster preparedness at their schools.

In Ishinomaki City, the “Disaster Reconstruction and Disaster Risk Reduction (R-DRR) Mapping Program” has been developed and implemented at elementary and junior high schools since the 2012 school year. The programme has a four-fold structure covering orientation, town-watching, map-making and presentation. Beginning as a tsunami disaster recovery programme at coastal schools, the R-DRR Mapping Program has been expanded to schools located inland along the Kitakami River over a period of eight years. In the 2016 school year, the R-DRR Mapping Program introduced contour maps and geomorphological maps to support children in conducting town-watching, making a school disaster risk reduction map, and presenting the map to the school and the community (Sakurai et.al. 2019). To help schoolteachers customise the R-DRR Mapping Program to their school location, a teachers’ guide was developed in the 2016 school year and revised in the 2018 school year. The teachers’ guide included information on how to utilise geomorphological maps of their school district for disaster education (International Research Institute of Disaster Science 2019). Through the process, it was found that schoolteachers required training to strengthen their map-reading skills before using these maps for the
children’s education. In the 2019 school year, a training programme, “Understanding disaster risk based on geomorphological features of a school district”, was developed and implemented in Ishinomaki City. Figure 1 summarises the background to the development of the school disaster preparedness programme in the city.

Figure 1. Background to the development of school disaster preparedness in Ishinomaki City

2. Objectives and methods
This paper addresses the teacher training programme, “Understanding disaster risk based on geomorphological features of a school district”, which was developed and implemented in Ishinomaki City, Miyagi Prefecture. Since the authors developed and implemented the training programme, this study uses an action research approach. This paper aims to present the background to the training programme, the process of developing it and contents of the programme, focusing especially on teachers use of geographic maps for to identify natural hazards in their school district. The paper quantitatively examines the changes in teachers’ perceptions of their own map literacy. It also discusses the achievements of the training programme and the challenges of scaling it up to the prefecture level.

3. Findings
1.1. Summary of the teacher training programme
The teacher training program, “Understanding disaster risk based on geographic features of a school district” was conducted in June 2019 in Ishinomaki City as one component of a one-day training program for DRR teachers in the City. The purpose of the training was to deepen DRR teachers’ understanding of disaster risk in their school district by strengthening their map-reading capacities. Since 2012 in Miyagi Prefecture, a DRR teacher has been appointed at each public school to play a leading role in updating the school disaster manual, guide the school DRR activities, offer advice and promote coordination on DRR matters with local stakeholders. After the training, it was expected that the DRR teachers would utilize their acquired skills and knowledge to improve disaster management and disaster education at their schools.

Fifty-five DRR teachers participated in the training from 3 kindergartens, 27 elementary schools, 16 junior high schools and 1 high school in the city. As Figure 2 shows, the backgrounds of the DRR teachers are diverse with respect to their number of years teaching and undergraduate major. Practical
training was required for the DRR teachers to confidently and effectively promote DRR activities at their schools.

Figure 2. Background information about the participants

The training was conducted in the morning over a three-hour period. The itinerary and content of the training are presented in Table 1. It was framed by pre-training and post-training questionnaires and include a series of mini-lectures and group exercises. Participants were divided into 19 groups according to the 19 junior high school districts in the city.

Table 1. Itinerary and content of the training programme

| Flow                     | Contents                                                                 |
|-------------------------|--------------------------------------------------------------------------|
| 1. Pre-training questionnaire | Self-assessment of own map-reading skills                                 |
| 2. Group Exercise 1     | Identifying points on a contour map and hazard maps of own school district |
| 3. Lecture 1            | Acquiring basic map-reading skills, including an understanding of map symbols, azimuth direction, scale and contour |
| 4. Lecture 2            | Reading a geomorphological map to understand the microtopography of an alluvial plain |
| 5. Group exercise 2     | Identifying geomorphological features of a school district from maps      |
| 6. Lecture 3            | Understanding different types of hazard maps and reading hazard maps      |
| 7. Group exercise 3     | Understanding relationships between a contour map, a geomorphological map and hazard maps (tsunami, flood and landslide) in the school district |
| 8. Lecture 4            | Understanding the difference between emergency evacuation locations and evacuation shelters |
| 9. Group exercise 4     | Identifying evacuation locations and shelters according to hazard types and discuss why these places are safe or not |
| 10. Wrap-up             | Summary of the training programme                                         |
| 11. Post-training questionnaire | Self-assessment of own map-reading skills                                 |

The maps prepared for the training are explained in Table 2. The hazard types addressed in the training were limited to tsunamis, floods and landslides. Separate training on understanding earthquake-related risks was planned. The GSI maps can be found on the GSI website (http://www.gsi.go.jp/).

Table 2. List of maps and information provided for each group

| #  | Explanation of each map                                      |
|----|--------------------------------------------------------------|
|    |                                                              |

The school district is mainly lowland composed of back marsh and sand dunes. Part of the back marsh is still used as a rice field. All three schools are located on sand dunes, which are slightly elevated. The junior high school is located 1,500 metres north of the coastline.

The map on the right in Figure 2 is a tsunami inundation map. A comparison of the two maps helped the participants to understand the links between landform, tsunami disaster risk and evacuation information. For example, “W” elementary school is located on a sand dune, which is a highland in the alluvial plain and would normally avoid inundation. However, the 2011 tsunami was higher than the sand dune; the school recorded that the height of the tsunami was 2.5 metres. As a result, the school building was badly damaged. It was repaired and re-opened in 2014 in the same place as before the 2011 disaster. “W” junior high school was located on the oceanfront but was completely destroyed by the 2011 tsunami. The school was relocated inland and opened at its current location in the 2017 school year. “K” elementary school was the only school in the district that could be re-opened in April 2011 at the same location as before the 2011 disaster. Although the whole school district was inundated by the 2011 tsunami, the height of the tsunami was below floor level.

The group confirmed that tsunamis represent the highest disaster risk in the district and that there is a risk of landslides near the mountain. “W” junior high school and “K” elementary school are designated emergency shelters for tsunamis, landslides and floods. Since there are no other tall buildings nearby, “W” elementary school is a designated emergency tsunami evacuation building because it is a five-storey building equipped with outside steel stairs for local residents to access the rooftop.
4. Changes in teachers’ perceptions of their map-reading skills

The goal of the training, “Understanding disaster risk based on geomorphological features of a school district” was to deepen DRR teachers’ understanding of disaster risk in their school district by strengthening their map-reading skills. To evaluate the impact of the training, the participants were asked to respond to a set of questions regarding their map-reading skills. The results are presented in Table 4. The questionnaire contained eight questions on basic map-reading skills. The table presents the results of three of these questions because these three are directly linked to the goal of the training programme. After the training, participants felt more confident about their map-reading skills. The most significant change was observed from the responses to the question, “I can read the degree of a hazard by referring to the legend of a hazard map”. In total, 86% of the 50 valid responses were “Yes” after the training. Seventy-five percent of respondents who answered “No” before the training changed their assessment to “Yes” after the programme.

Table 4. Changes in participants’ self-assessment of their map-reading skills (N=50)

| Question                                                                 | Before (n) | Before (%) | After (n) | After (%) | B-A (n) | Change (%) |
|--------------------------------------------------------------------------|------------|------------|-----------|-----------|---------|------------|
| I can understand landform from a landform classification map.            | 22         | 44%        | 43        | 86%       | 21      | 75%        |
| I can read the degree of a hazard by referring to the legend of a hazard map. | 29         | 58%        | 46        | 92%       | 17      | 81%        |
| I can make links between a topographic map and a hazard map.             | 30         | 60%        | 43        | 86%       | 13      | 65%        |

(*) Change (%) is calculated using the formula (B-A)/(50-A), which calculates whether a person who did not understand before the training understood it afterwards. “B” stands for “before” and “A” for “after”.

5. Conclusion
The above findings show that the training programme “Understanding disaster risk based on geomorphological features of a school district” was successful in increasing the DRR teachers’ confidence regarding their map literacy and that it helped them to establish links between a contour map, a geomorphological map and hazard maps by exchanging information with other DRR teachers in the same junior high school district. In Ishinomaki City, after the 2011 disaster, all schools were requested to prepare a school disaster manual, which had to be customised according to the school district’s local geomorphological features. Thus, after the training, the DRR teachers were urged to revise their disaster manuals based on what they had learnt in the training. However, certain limitations were found when implementing the training programme. Although the GSI has made significant efforts to make electronic maps available on their webpage, not every schoolteacher was able to easily print a school district map using the printer available at their school. Easy access to contour maps and geomorphological maps of school districts is urgently needed to disseminate similar training in utilising maps. Since the training programme was a pilot scheme tested in a single city, further research is required to validate the programme’s effectiveness for further dissemination.

References
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