ORIGINAL ARTICLE

Gaming Simulations as the Medium for Disaster Education in Schools and Community-based Disaster Risk Reduction

Yusuke Toyoda[1]

[1] College of Policy Science, Ritsumeikan University
2-150 Iwakura-cho, Ibaraki, Osaka 567-8570 JAPAN

*E-mail: toyoday@fc.ritsumei.ac.jp

Abstract: This study developed a method to promote community-based disaster risk reduction (DRR) at the higher education level. It has been found that while neighborly mutual help is important, conventional disaster education aimed at students to raise their level of disaster risk knowledge has had little effect on their behavior. Therefore, this study developed a Gaming Simulation (GS) methodology in which participants experienced the aftermath of disasters as a possible way to improve community-based DRR. Specifically, an Evacuation Simulation Training (EST) program was developed as a GS for university students in which they were able to experience disaster situations at the local community level, after which debriefing sessions were held to encourage the students to develop solutions for their community-based DRR. It was concluded that employing GS was a successful method for introducing students to disaster education, developing their knowledge of community-based DRR, and making them aware of solutions for real life community-based DRR. The EST also helped students understand the importance of the balance between self-help and mutual help.

1. Background

Natural disasters can severely affect local communities and although there have been few disasters that have totally ruined whole cities (Vale and Champanella 2005), most have caused significant human and economic losses. As a consequence of the many disasters in the past decades, there has been a great deal of research into mitigation and preparedness. Therefore, it is important to mitigate the possible influences of disasters by ensuring a balance between self-help (disaster management by individuals and households), mutual help (disaster management in the local community), and public-help (disaster management by public entities such as the Cabinet Office, 2016). Lessons learned from the past indicated that a greater amount of mutual help could reduce human casualties. Researchers have

examined this issue from urban planning, information science, sociology, psychology, and other academic perspectives; however, there have not yet been any definitive answers to this challenge.

Studies on disaster education at schools that encourage students to take risk reduction actions have been somewhat successful in cultivating disaster management knowledge in future generations. However, while some schools have involved local residents in disaster education so as to connect the students with local residents, the connection among disaster education, community-based disaster risk reduction (DRR), and disaster management has not been widely discussed in academic studies. To go some way in filling this gap, this paper defines DRR as the measures that are taken to reduce disaster risks before a disaster strikes and disaster management as a complete concept from DRR to emergency response to recovery.

2. Study Objective

This study provides a method for promoting community-based DRR within school education. First, the several challenges faced by DRR in local communities in Japan and how these challenges are treated in the training content are examined, after which the elements of effective disaster education are summarized. Gaming Simulation (GS) is then introduced as a possible tool to mediate disaster education at school and community-based DRR. Finally, through a discussion on the GS output from an exercise conducted with university students, it was proven that disaster education at school and community-based DRR can be effectively connected and that

utilizing GS can assist participants recognize the importance of balancing self-help and mutual help.

3. Community-Based DRR Challenges
3.1 Lessons from Past Disasters

One of the most important evacuation lessons learned from the past disasters is the importance of mutual help. This lesson was re-learned after the Great Hanshin-Awaji Earthquake hit Kobe and surrounding areas in 1995. The destruction of the urban infrastructure hindered public-help such as rescue teams reaching the affected areas, with many victims having to be rescued by family members and neighbors. Kawata (1997) estimated that around 35,000 residents had been buried alive under their houses after the earthquake. About 27,000 of them were rescued by neighbors and about 80 percent of these survived. However, when victims were finally found by the rescue teams, more than half had already died. Therefore, social capital and cooperation between residents were proven to be effective in actioning rescue activities in the local communities through mutual help (Kurata 1999, Kumamoto University Community Development Study Group 2010, Kaji, et al. 2012).

3.2 Challenges for Community-based DRR

Based on these lessons, the Japanese Government wished to cultivate mutual help in communities by supporting community-based DRR and amending its policies to encourage residents to cooperate in achieving a balance between the three types of help. To date, a plenty of studies has comprehensively examined these issues. However, some residents have been involved in conducting disaster training activities, the number of residents participating remains

small, with the majority being older people (Toyoda 2016).

Further, disaster training has tended to be more conventional such as learning how to use a fire extinguisher or basic first-aid. While these activities are important, it is insufficient for community-based DRR as when evacuating, the residents need to be able to solve problems within their communities in concert with other residents. Mifune (1998) claimed that conducting training at specific venues (often at evacuation shelters) using instructions and manuals was not suitable and suggested that training should be conducted first at the participants' houses to give them guidance on how to evacuate to shelters and how to overcome the problems they may face on the way.

Consequently, to overcome the challenges above, some more innovative training programs were developed such as DIG (Disaster Imagination Game) (such as Komura 2002), HUG (Evacuation Shelter Management Game) (such as Shizuoka Prefecture 2014) and other exercises using GS, all of which provided participants with disaster scenarios that required them to overcome the problems collaboratively and understand the reasons for success and failure. However, no study has tackled to connect these exercises with disaster education at schools. This paper developed a GS program so that university students could experience community-based DRR and develop their own solutions for local communities.

4. GS to Promote Disaster Education Output
4.1 Important Disaster Education Aspects

Previous studies on disaster education have concluded that DRR education is more likely to succeed if it focuses on behavior based on experience rather than conducting classes or seminars using textbooks. Yamori (2013) claimed that besides the campaigns to raise disaster awareness, it is also necessary to develop programs that encourage participants to find solutions and understand their capacity. Shaw, et. al. (2011) collected disaster education cases from several countries and concluded that it was important for students to learn what they could do in their own communities. A case study from Nepal found that while conventional education was successful in raising disaster awareness, it did not inform people about how to behave to reduce the disaster risks, and a case from New Zealand, showed that even after disaster education, many people had little knowledge of how to behave and react in disaster situations.

In sum, encouraging students to experience what can happen in a disaster situation in connection with their own communities is vital for effective disaster education.

4.2 GS for Disaster Education

In this paper, GS is proposed as an effective disaster education method as all important aspects discussed above can be included. In a GS, players are able to experience disaster situations in a virtual gaming world and can learn lessons from failure without any risks. Through such experiences, they can learn more than through lectures or other conventional education methods. Moreover, as one of the GS components in interactive role-play, participants experience and understand reality through the virtual world and

gain varying viewpoints; therefore, GS involves learning-by-doing.

One of the most important GS components is the after-game play debriefing, at which trained facilitators calm participants down, and encourage participants to (re-)recognize what they experienced in the game and reflect on its connection to reality, which strengthens the learning and gives participants a stronger connection to the reality of disaster situations than more conventional methodologies.

When designing these types of GS, designers are able to incorporate models based on lessons learned from past disasters in the game world, which means that participants are able to experience the realities of the real world through the game play, achieve their own goals by following the rules and their assigned roles, and understand how their decisions influence the game results through a dynamic model where the decisions are the inputs and the consequences are the outputs.

In a community-based DRR context, the participants can take on the role of residents who have no evacuation information, local community leaders, or any other roles in the game world. By playing within their designated roles, players learn the effect of their decisions after the disaster changes the situation. Therefore, participants experience what they can do and the consequences in disaster situations, all of which are reflected on in the debriefing. As mentioned above, theoretically, GS can attain all aspects important to disaster education.

5. EVACUATION SIMULATION TRAINING as a Disaster Education Tool

This section introduces the EVACUATION SIMULATION TRAINING (EST) originally designed to promote community-based DRR (for full details, please refer to Toyoda and Kangae 2014, and Toyoda, et al. 2014), and demonstrates how EST is able to connect disaster education and community-based DRR and give students knowledge about certain situations in community-based DRR and the consequences of certain actions.

5.1 Outline of EST

Developed from past disasters or previous studies on conditions in local communities, the EST first randomly assigns certain roles to participants that evacuees might be expected to face in an earthquake evacuation, such as being an injured person unable to navigate a street blocked by bricks or being someone who goes to the incorrect temporary evacuation site. Participants are then required act within these roles as players in the virtual world. The players evacuate from their own homes; however, they encounter some situations on the way such as streets being blocked by bricks, unexpected behavior by others, or interactions with other players that they need to resolve, as the final goal is to reach the designated evacuation shelter or site despite the problems. The EST can create situations similar to real disaster conditions. The EST was first conducted for a local community in Japan, and was applied at the university level by the present author.

In May, 2017, the EST was conducted on 10 university students and one teaching assistant (as one student came late, the participant numbers

Table 1 Situations and Roles Assigned in the first round of EST

Situations	Roles about initial situation*	Roles about knowledge*
1. Block walls well down! The street is shut down and you cannot pass.	1. You are fine without furniture falling down. You can start evacuation.	1. You do not know the location of an evacuation shelter.
2. Because of an after shock, a house collaposed! If you are alone, you got stocked by the collaposed house. If you are two or more, another resident rescue you and you can pass.	2. You are the injured by furnuture falling down. But you can start evacuation.	2. You have heard by chance neibors talking that the location of an evacuation site is A (room number).
3. Block walls fell down! If you are injured on your leg, you can pass after 5 seconds if being with one player without injuries.	3. You are the buried under your collaposed house. You cannot start evacaution without three or more residents' support. As you are pressed by heavy debris, you cannot make voice until rescued. But you did not get injured.	3. You have heard from the neighbor the location of an evacuation site is at A (room number).
4. Because of an after shock, a house collaposed! If you are alone or two, you got stocked by the collaposed house. You need three or more residents to get rescued. You need to wait them. If you are three or more, you can excape but it takes 30 seconds. You can pass after 30		4. You have heard from the leader of Jisyubosaikai (community-based DRR group) the location of an evacuation site as B (site name).
5. The area seems dangerous by surrounding wooden houses standing closely. But it seems safe and you can pass.**	4. You are the community leader. You are the burid under your collaposed house. You cannot start evacaution without three or more residents' support. As you are pressed by heavy debris, you cannot make voice until rescued. You decided with the leader of Jisyubousaikai (community-based DRR group) the location of an evacaution site at B (site name) three years ago. But you are worried	
6. This way seems safe and you can pass.		

*Roles distributed to participantas are combination of initial situation and knowledge.

**This situation is located near the situation number 2.

were 9 or 10 in this study excluding the teaching assistant) who had registered for the course "Simulation & Gaming" in which students first experienced some of GSs and then designed and played with their own GS prototypes. These students were interested in a variety of areas from international relations to urban planning but had little comprehensive knowledge about community-based DRR. The EST was one of the GSs for the students in the course. Students were asked to assume that the school building was the local community for this game, and were required to evacuate from their homes to the evacuation sites, which were designated sites inside the building. Following the initial briefing when the rules were given and roles distributed, the students as residents were required to go to a designated site (their house) one by one so that did not know where the other residents would evacuate from. At a designated time, they started to evacuate, with some encountering events such as blocked streets, while others had to wait for rescue as their homes had collapsed and they were unable to evacuate. The specific situations and roles are shown in Table 1.

After the first round, the students shared their evacuation experiences and discussed what they should have done during the evacuation and what they should have done before the earthquake. After a lunch break, they played the EST again (second round) but with different situations (only

Table 2 Roles Assigned in the second round of EST

Roles about initial situation*	Roles about knowledge*
1. You are fine without furniture falling down. You can start evacuation.	1. You do not know the location of an evacuation shelter.
2. You are the injured by furnuture falling down. But you can start evacuation.	2. You have heard from the neighbor the location of an evacuation site is at B (site name).
3. You are the burid under your collaposed house. You cannot start evacuation without three or more residents' support. As you are pressed by heavy debris, you cannot make voice until rescued. But you did not get injured.	3. You do not know the location of an evacaution site, but you know that the leader of Jishubosaikai (community-based DRR group) knows the location who lives at E (room number).
4. You are the leader of Jisyubosaikai (community-based DRR group). You by chance was traveling when the earthquake striked and did not stay at home. Please wait at D (site name) until the game ends.	4. You have seen the location of an evacuation site at C by a smartphone applicatin provided by a city.
	5. You are a member of Jisyubosaikai (community-based DRR group). You know the location of an evacuation site at C. And you are trained so you have capacity as the same as two peoples' (even if one needs two people, you can rescue him/her by yourself alone).

*Roles distributed to participantas are combination of initial situation and knowledge.

Table 3 Questions on Questionnaire

Timing to Answer	No	Question
Before the EST	1	What are the important things when evacuating after earthquake? Please list down five things that you think important.
After the 1st Round	2	Role Number of the first round
	3	Please describe your evacuation experience of the first round.
	4	What did you talk with other evacuees during the training?
	5	What problems were you faced with in the training and how did you solve them? If you could not solve, please also write down as questions or challenges in the next question.
	6	Please write questions and challenges in disaster evacuation from your experience.
After the 2nd Round	7	Role Number of the second
	8	What are the important things when evacuating after earthquake? Please list down five things that you think important.
	9	What are difference between the first and second trainings? Please describe any difference in your experience except for situations and roles assigned. If you find no difference, please write 'nothing.'
	10	Please write questions and challenges in disaster evacuation from your experience.
	11	Please explain what you have learnt from disaster evacaution and GS through the EST.

situation locations were changed from the first round) and different roles designed by the facilitator based on their first-round suggestions, as itemized in Table 2, after which there was a second debriefing. The total time for the two EST rounds was about 4 hours; however, the effects of the EST were evident after only one round.

The questions shown in Table 3 were distributed prior to the EST and the students were required to respond to these three times; before, during (after the first debriefing) and after the EST. The analysis hereafter is based on the student discussions, the questionnaire results, and the author's observations as game facilitator.

5.2 EST Experiences by the Students

Questions 3, 4, and 5 asking the students about their experience of the first evacuation and the observations revealed that some students had

evacuated smoothly to the evacuation sites, while others had not. Some had evacuated and then waited at a wrong evacuation site, some had waited to be rescued for a long time, while others had looked for the other players missing from their evacuation sites. During the game, some players shared information about the road situations and the evacuation site, and made use of the shared information to search for other players (where they had searched and where they had not).

From the answers to question 6 about the challenges the students had experienced, as well as the discussion in the debriefing, it was clear that the students had faced some challenges; reinforcing houses; finding out where other residents lived; and communicating with residents on normal days because if they were subsequently buried alive under a collapsed house, they would not be rescued if they did not have strong relationships with their neighbors. Although they did recognize the value of mutual help, they also found it difficult to cultivate relationships with their neighbors. Other challenges were to quickly find the injured and the need to move in a group after the disaster struck.

To alleviate these challenges, the students proposed several solutions, such as promoting neighborly communication, conducting events, sharing information about where residents lived, developing a smartphone application which identified evacuation site locations, and training some residents in rescue techniques.

Roles were revised in the second round. Some residents shared information and developed a housing map of those who shared information,

some residents were trained so they could rescue more effectively than others, and some residents used the smartphone app to locate the evacuation site. The second EST also included a resident who was traveling and was not in local community but had not informed the neighbors, which was included so that the students could be aware of the uncertainties in disaster situations.

Question 9 asked about the differences between the first and second rounds and question 10 asked about the evacuation challenges. The second debriefing was conducted when the students were discussing the second evacuation challenges. Although they were more effective in searching for the missing than in the first round as they had separated into two groups to search different areas, there were some additional challenges; several people searched the same place where other survivors had checked before separation, and they found it was not enough to merely make a resident housing map as all people sought to evacuate after the disaster so if they went to the house, there were no residents. They also discussed how to tackle the problem of residents who were traveling and suggested that perhaps a note could be attached after evacuation to indicate whether they were at home or not. They also felt it was important to tell neighbors if residents were going away.

Question 11 was focused on what the students had learned from their experiences in the two rounds. One student said that they had learned the importance of being prepared for a variety of situations, one recognized the importance of mutual help, but felt that self-help was more important as effective mutual help required strong relationships between neighbors, and one claimed

Table 4 Shift of Students' Opinion from Self-help to the Balance between Self-help and Mutual-help

Important Things in Evacuation	Pre-EST		Post-EST	
	Mean	Standard Deviation	Mean	Standard Deviation
Items on Self-help	4.25	0.71	2.63	1.30
Items on Mutual-help	0.50	0.53	1.75	1.39

*As some students wrote 4 items not 5, the totals of means are not at 5.

N=8

that EST gave participants realistic experiences, and also recognized the importance of mutual help. Overall, most students recognized the importance of mutual help.

In sum, the participating students in the EST recognized that: houses needed to be reinforced if mutual help cannot be expected; events were needed to promote communication between residents on normal days; a smartphone application was needed to announce the evacuation locations; the injured needed to be found quickly and people needed to move in groups in disaster situations; some residents needed to be trained in rescuing people; after evacuating, residents needed to attach a note to their doors so that others would know they were not there; and residents needed to inform neighbors if they were going away.

5.3 Common Output between the EST Conducted at the University and Community-based DRR

To evaluate the EST, the student solutions were compared with real solutions from community-based DRR to assess if the students would suggest the same or similar solutions when faced with the same challenges in a real community, and to check whether their understanding had shifted to a balance between self-help and mutual help.

The students' understanding that they needed to

find the injured quickly and needed to move in a group in a disaster situation were lessons learned from past earthquakes and had become Japanese Government policy. The suggestions to hold more events to allow residents to get to know each other and share information about disaster vulnerability have also been recognized as important (such as Cabinet Office 2014), with resident lists being put together in many communities (such as Japanese Red Cross Society 2006); however, privacy issues have been an obstacle (Toyoda and Kanegae 2014). The smartphone application has been realized such as in the development of SuperGeo (n.d.) that indicates the surrounding evacuation site locations, and the training of residents in rescue was actioned a long time ago in the establishment of *Shobodan* (community-based fire fighters), whose main task is to extinguish the fire before the fire fighters arrive and to act as first responders in disaster situations to rescue residents or extinguish fires; the students were not aware of this organization. Leaving a note to inform of evacuation has also been realized in some communities, where a handkerchief is used (Kumano City n.d.). These findings demonstrated that without any prior information about real local communities in Japan, the EST students experienced similar challenges and developed similar solutions. Therefore, it was concluded that the EST provided students with similar experiences to those in the community-based DRR.

Questionnaire results also indicated that they had shifted from a self-help concentration to a balance between self-help and mutual help although the number of samples is limited. Question 1, which was answered pre-EST, asked students to list five important evacuation issues and question 8 asked the same question post-EST. As shown in Table 4, the mean for self-help and mutual help changed from 4.25 to 2.63 and from 0.50 to 1.75, indicating that there has been a shift in awareness to the importance of a balance between self-help and mutual help during evacuation.

6. Conclusion

This study examined how GS could be used to give university students situational experiences similar to those in a community-based DRR. First, the study examined the several challenges faced by DRR in local communities in Japan and how these challenges are treated in the training content, and it summarized the important aspects for effective disaster education. Then, the GS was found to be able to connect disaster education and community-based DRR as there were several commonalities between the solutions suggested by university students and the measures developed in real community-based DRR practice. It is also implied that the EST allowed students to understand the importance of balancing self-help and mutual help, in disaster situations.

However, as the GS was conducted only once with only nine samples, the focus of this study was on qualitative data such as free answers to questions and debriefing discussions. Further studies could provide quantitative data to prove the value of EST in connecting school-based disaster education and community-based DRR. Drawing from wider range of disaster situation examples and giving students a wider range of roles could possibly give rise to more connections between disaster education and community-based DRR and be able to better prepare them for possible disaster situations.

References

1) Cabinet Office (Japan), 2014. Community Disaster Management Plan Guidelines, Cabinet Office, Tokyo, 56 p (in Japanese).

2) Cabinet Office (Japan), 2016. White Paper on Disaster Management of 28th Heisei Year, Cabinet Office, Tokyo, 328 p (in Japanese).

3) Japanese Red Cross Society, 2006. Guideline for the Vulnerable People in Disaster, Japanese Red Cross Society: Tokyo, 53 p (in Japanese).

4) Kaji, H., Sawada, M. and Kanei, J., 2012. Capacity of Community for Disaster Risk Reduction, Kaji, H. and Tsukagoshi, I. (Eds.), Urban Disaster Risk Reduction: Theory and Practice of Earthquake Disaster (2nd Edition), Gakugei Publishing: Kyoto, Japan, 173-215 (in Japanese).

5) Kawata, K., 1997. Estimate of Human Causalities by Great Earthquake Disaster, Journal of Natural Disaster Science, 16(1): 8 (in Japanese).

6) Komura, T., 2002. For more Safety Kathmandu Valley: Report of DIG (Disaster

Imagination Game) on KV Earthquake Disaster Mitigation, URL: http://open_jicareport.jica.go.jp/pdf/11685823_09.pdf (last date accessed: 8 August 2017).

7) Kumamoto University Community Development Study Group, 2010. Introduction to Community-based Disaster Risk Reduction for Those Who Start Studying Disaster Risk Reduction, Seibundo Publishing: Osaka, Japan, 200 p (in Japanese).

8) Kumano City, n.d. Announcement of Yellow Handkerchief and White Handkerchief for Checking Safety in Disaster, URL: http://www.city.kumano.mie.jp/bousai/pdf/27han kati.pdf (last date accessed: 8 August 2017) (in Japanese).

9) Kurata, W., 1999. Bosai-Fukushi Community: Integration of Community Welfare and Community-based Disaster Migitation, Minerva Shobo Publishing: Kyoto, Japan, 210 p (in Japanese).

10) Mifune, Y., 1998. Disaster Risk Reduction and Civil Network, Gakugei Publishing: Kyoto, Japan, 207 p (in Japanese).

11) Shaw, R., Shiwaku, K. and Takeuchi, Y. (Eds.), 2011. Disaster Education (Community, Environment and Disaster Risk Management), Emerald Group Publishing: WA, UK, 175 p.

12) Shizuoka Prefecture, 2014. Earthquake Preparedness in Shizuoka Prefecture, Japan, Shizuoka Prefecture: Shizuoka, Japan, 36 p.

13) SuperGeo, n.d. Geographic Information System for Disaster Evacuation and Rescue, URL: http://www.supergeotek.com/inner/Download/Geographic%20Information%20System%20for%20Disaster%20Evacuation%20and%20Rescue-20120810104840.pdf (last date accessed: 8 August 2017).

14) Toyoda, Y. and Kanegae, H., 2014, A Community Evacuation Planning Model against Urban Earthquakes, Regional Science, Policy and Practice, 6(3): 231-249.

15) Toyoda, Y., 2016. Gaming simulations with Action Learning for community-based disaster reduction training, Action Learning, Action Research Journal, 22(1): 162-183.

16) Toyoda, Y., Kanegae, H. and Sakai, K., 2014. Gaming Simulation for Community-Based Disaster Reduction, Kriz. W.C. (Eds.), The Shift from Teaching to Learning: Individual, Collective and Organizational Learning through Gaming Simulation, W. Bertelsmann Verlag: Bielefeld, Germany, 330-344.

17) Vale, L.J. and Campanella, T. J. (Eds.), 2005. The Resilience City; How Modern Cities Recover From Disaster, Oxford University Press, Oxford, UK, 392 p.

18) Yamori, K., 2013. Risk Communication for Mass Disaster: New Forms of Disaster Information, Minerva Shobo Publishing: Kyoto, Japan, 226 p (in Japanese).