

The Third Information Systems International Conference

## Web-Based System for Designing Game-Based Evacuation Drills

Hiroyuki Mitsuhara<sup>a\*</sup>, Takehisa Inoue<sup>b</sup>, Kenji Yamaguchi<sup>b</sup>, Yasuichi Takechi<sup>b</sup>,  
Mari Morimoto<sup>b</sup>, Kazuhisa Iwaka<sup>a</sup>, Yasunori Kozuki<sup>a</sup>, Masami Shishibori<sup>a</sup>

<sup>a</sup> Tokushima University, 2-1, Minami-josanjima, Tokushima, 770-8506, Japan

<sup>b</sup> OPTPIA Co., Ltd., 3-56-1, Nakashimada, Tokushima, 770-0052, Japan

---

### Abstract

A game-based evacuation drill (GBED) using the program Real-World Edutainment is effective disaster education. For the successful GBED, an evacuation scenario and digital materials are important. We are developing a web-based system to design GBEDs through community survey, digital material creation and evacuation scenario composition. This system works with a standard web browser and allows a wide range of people to participate in the GBED design process through simple operations.

© 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of organizing committee of Information Systems International Conference (ISICO2015)

*Keywords*; Game-based evacuation drill; evacuation scenario; digital material; disaster education; web-based system

---

### 1. Introduction

Natural disasters (e.g. earthquakes, volcanic eruptions and typhoons) have occurred frequently all over the world. Every time a natural disaster occurs, many people subsequently recognize the importance of disaster prevention. A promising approach to disaster prevention is disaster education; however, establishing effective disaster education that motivates people to act towards disaster prevention is difficult because it has to be adapted to individual communities. Even if comprehensive knowledge about disaster prevention (including worldwide examples) is taught, people will not always be motivated to act.

For effective disaster education, evacuation drills have been the typical focus because such drills are often designed for and conducted in a specific community (e.g., residential quarter and school). However,

---

\* Corresponding author. Tel.: +81-88-656-7497.

E-mail address: [mituhara@is.tokushima-u.ac.jp](mailto:mituhara@is.tokushima-u.ac.jp).

conventional evacuation drills are monotonous and insufficient. Participants simply follow fixed evacuation routes. Some participants will not be motivated to engage in such conventional evacuation drills. During a real evacuation, evacuees may encounter serious situations and may have to make various decisions. For example, they may have to choose alternative routes when the predetermined evacuation route is impassable. Therefore, new evacuation drills should be realistic.

As a new evacuation drill, we previously proposed a game-based evacuation drill (GBED) using the program Real-World Edutainment (RWE) [1]. In the GBED, digital materials that represent serious disaster situations (virtual disaster damages) correspond to a participant's current location are presented on his/her tablet computer according to a branched evacuation scenario (Fig. 1). Accordingly, the user can learn about disaster prevention by viewing the materials and real-world situations (e.g. scenery) and making appropriate decisions during an evacuation. The GBED is a type of community-based disaster education through an adventure game that combines the virtual (digital) and real worlds. We have conducted the GBED several times primarily at elementary and junior high schools. We found that the GBED can motivate participants to think about and act towards disaster prevention.

The evacuation scenario and digital materials are important in the GBED. If they differ significantly from reality, the participants may feel that the drill is simply a game. Reality becomes the difference between success and failure. To enhance the degree of reality in evacuation drill design (i.e. in the scenario and corresponding digital materials) for a specific community, we have worked together with disaster prevention educators familiar with the given community. However, GBEDs are not always realistic. A realistic scenario should simulate as many disaster situations as possible. For example, during an earthquake, there may be collapsed buildings, injured people, fire, liquefaction phenomena and tsunamis. Therefore, more people in each community should be involved in the design process, thus compiling their information, knowledge, imagination, skill and experience. From another perspective, the design process can be regarded as an effective disaster education process because disaster education aims at initially motivating individuals to act towards disaster prevention and finally leads the whole community to organized disaster prevention. In other words, participation in GBED design can be considered active learning (e.g. problem/project-based learning and inquiry-based learning).

From this perspective, we are developing a web-based system, which we refer to as 'Bosai Yattosar' (BY), to design GBEDs. The BY system works with a standard web browser and allows a wide range of people to participate in the GBED design process through simple operations.

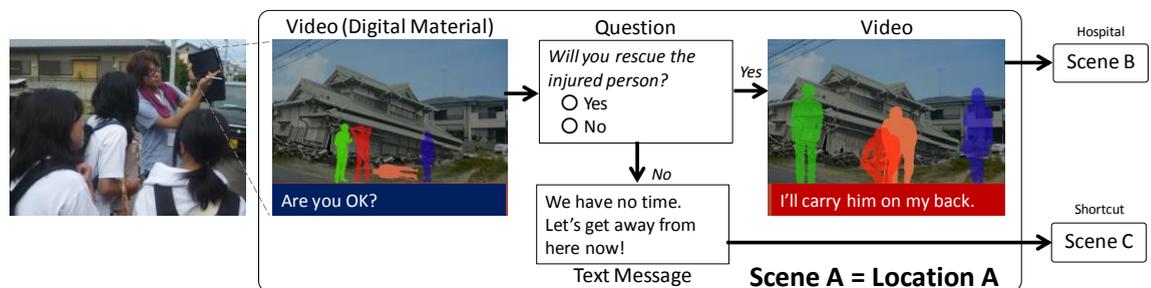


Fig. 1. Snapshot and digital materials in GBED

## 2. Game-Based Evacuation Drill using Real-World Edutainment

### 2.1. Motivation

In the past, GBEDs have been realized primarily as simulation games in virtual worlds. For example, in a particular 3D simulation game about fire evacuation [2], learners are required to follow principles for

safe evacuation in a virtual building fire. We think that such GBEDs are promising but insufficient for effective disaster education. In an evacuation drill in a virtual world, it is difficult for participants to realistically feel the surrounding environment, psychological pressures and physical tiredness. In contrast, in real-world evacuation drills, it is difficult for participants to engage in disaster situations because such drills are conducted in simulated conditions. Therefore, new GBEDs should be more realistic and combine the virtual and real worlds using RWE.

## 2.2. Real-World Edutainment

The RWE program provides game-based learning in the real world by attaching importance to a particular learning scenario (game storyline) to increase learning motivation and effectiveness. The RWE system, which works on a tablet computer with a GPS receiver, presents digital materials (e.g. videos and slideshows) that correspond to a learner's current location according to a branched learning scenario. Thus, the learner can learn from the virtual (digital materials) and real worlds (e.g. real objects).

### 2.2.1. Branched learning scenario

A branched learning scenario is composed of scenes categorized into 'stay' scenes (SSs), 'move' scenes (MSs) and 'interrupt' scenes (ISs). Each SS corresponds to a location and is composed of at least one cut. MSs and ISs are independent of location and are conceptually located between SSs. The cut is the smallest unit used to present digital material. The branched learning scenario, which is converted to our XML-based scenario description language (a scenario file), represents a location-based structure (presentation order) for digital materials (Fig. 2).

There are two types of branching conditions. Normal conditions are assessed at the end of every cut (digital material presentation). The timer interrupt conditions for ISs are independent of the learner's current scene. Immediately after a condition is satisfied, the learner moves to the next scene designated by the condition.

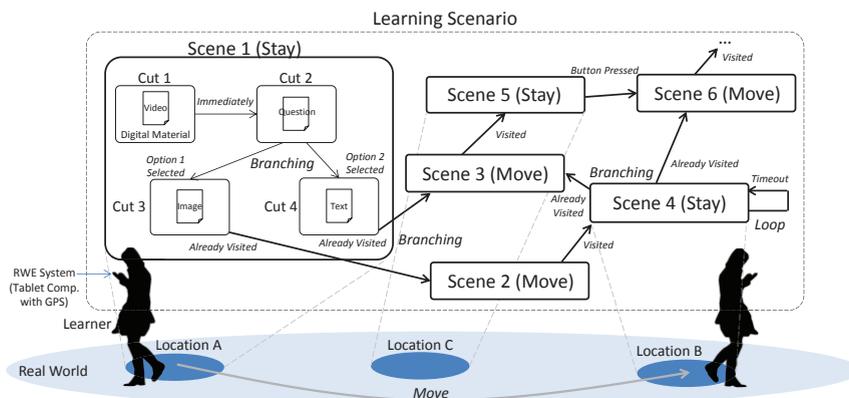


Fig. 2. Branched learning scenario in RWE

### 2.2.2. Digital materials

The digital materials are text messages, single-choice questions, images, sounds, videos and slideshows. Following a visual format such as an adventure game, the slideshow is created and executed using our own method rather than commonly used software (e.g. Microsoft PowerPoint). Each slide, which is composed of a background image, foreground images and a subtitle, is converted to a composite image. Figure 3 shows example slideshow compositions and a slideshow configuration (i.e. a scenario file).

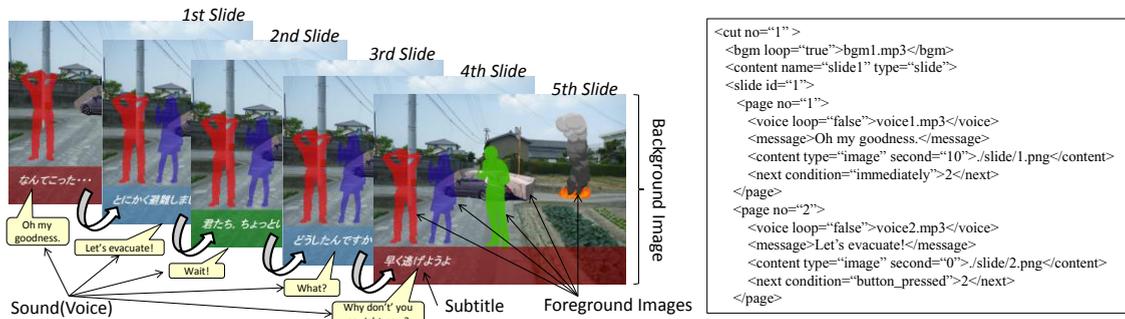


Fig. 3. Slideshow composition and configuration

### 2.3. How to use RWE for GBED

When RWE is used for a GBED in a community, the learning scenario is designed as an evacuation scenario that begins at a certain location and ends at a designated evacuation site in the community within a time limit. For example, in an evacuation scenario during a subduction-zone earthquake (i.e. a massive earthquake), people in coastal areas must get to higher elevation no later than a tsunami event. More importantly, they must make decisions about disaster situations that may occur in the community. For example, they may encounter impassable routes, injured people, missing family members and so on. In particular, life-saving and safety-promoting actions that go against the principle of ‘a speedy escape’ can be considered moral dilemmas—difficult decisions that must be made between multiple right choices. Disasters often cause moral dilemmas. Therefore, in an evacuation scenario, it is important to create very realistic situations that consider moral dilemmas; in other words, situational reality must be considered.

The digital materials represent disaster situations. It is important to make the situations more realistic using audio-visual effects. Therefore, the designers must consider auditory-visual reality. For example, digital materials, such as videos and slideshows, for a massive earthquake can be used effectively to represent collapsed buildings, panicking people, liquefaction phenomena and so on realistically with sounds (e.g. sirens and screams). Single-choice questions can be used to ask participants about their behaviour during serious disaster situations (e.g. ‘Will you rescue injured people?’)

## 3. Game-Based Evacuation Drill Design

Many people should be involved in the GBED design process. However, the degree of involvement, that is, each person’s given task, varies according to the individual. Therefore, the GDED design should be divided into small tasks that are applicable to as many people as possible. We set up three tasks: community survey, digital material creation and evacuation scenario composition.

### 3.1. Tasks

#### 3.1.1. Community survey

The first task in designing a GBED for a community is to survey the community from a disaster-prevention perspective. As the outcomes of this task, data available in the subsequent tasks are collected. In particular, dangerous locations should be identified beforehand. These locations become the SS candidates. For example, cliffs, narrow streets and areas with densely built wooden houses can be dangerous during an earthquake. Data about such dangerous locations should be collected for the GBED design. Various survey methods can be used in this task (e.g. literature research and questionnaires).

Currently, an easy method would be to photograph dangerous locations using a mobile camera device (e.g. a smartphone). The photos (digital images) can be used as background images in the RWE slideshow. Many people can act as practitioners (surveyors) because the task is easy and because most people are curious about dangerous locations in their communities.

### 3.1.2. Digital material creation

In the second task, which can sometimes be done in parallel with the first task, digital materials for the GBED are created. In this task, not many people are able to become task practitioners (creators) because, to create a realistic evacuation scenario, the creators must represent disaster situations, enhance the situational and auditory–visual reality based on their imaginations, computer skills and, if applicable, actual disaster experience. In RWE, the digital materials are files linked from scenario files. Therefore, the creators can create these materials with commonly used software (e.g. painting software and video editing software). The digital materials, such as text messages, single-choice questions and slideshows (configuration), exist as descriptions in each scenario file. In addition, each slide in slideshow is a composite image generated from several images.

### 3.1.3. Evacuation scenario composition

The last task is to compose an evacuation scenario for the GBED, i.e. compose (link) scenes and cuts with the branching conditions. As with the second task, not many people can be task practitioners (composers) because, to create a more realistic evacuation scenarios, the composers must be familiar with their communities and think about disaster prevention panoramically and pedagogically. More precisely, they must determine which disaster situations (digital materials) will be selected and linked from many candidates to enhance the situational reality and must consider the movable area, time limit, participants' characteristics (e.g. age and gender) and so on. In some cases, the effective situational reality will depend on the sequence of disaster situations that the participants encounter. Encountering a series of different situations may not be realistic. The sequence and type of situations should be balanced with the GBED learning goals.

## 3.2. GBED design as disaster education

The above tasks can be regarded as learning activities. For example, digital material creation and evacuation scenario composition may be similar to 'learning by authoring', which aims at improving analytical and interpretative skills [3]. This learning process comprises three steps: constructing collected information, analysing the constructed information and developing learning materials from the analysed information.

Through the community survey task, the surveyors will become interested in disaster prevention in their communities, which is an important learning effect in disaster education. Their collected data will motivate them to continue this task and proceed to the second task.

Through digital material creation tasks, the creators will be able to develop their imaginations, which is an indispensable learning effect in disaster education. One of the lessons learned from the Great East Japan Earthquake is '*Do not believe assumptions based on the past!*' This lesson indicates that survival can depend on peoples' abilities to imagine disasters that are more severe than past disasters.

The evacuation scenario composition tasks will enable composers to lead organized disaster prevention in their communities. Performing this task can improve their imaginations and will provide knowledge, skills and community-based experience, which are the ultimate learning effects of disaster education. The composed scenarios are community disaster prevention assets that will motivate the composers to continue this task in their roles as community leaders.

## 4. Bosai Yattosar System

We are developing the BY system, a web-based system to design GBEDs. This system, which allows non-registered users to view limited survey outcomes, helps registered users execute the three aforementioned tasks by performing easy operations on a standard web browser.

### 4.1. Community survey

Surveyors can upload their survey outcomes to the BY system (database server) through a web browser (user interface provided by the BY system). When uploading a photo through a web browser, a surveyor selects the photo (stored in his/her personal computer) and inputs information about the photo (e.g. category, keyword, comments and the sharable range of users). In addition, a surveyor also indicates the photograph's location on Google Maps. On the map, the uploaded survey outcomes are shown as icons representing the category and keyword. By clicking on an icon, users in the sharable range can view the content of the corresponding survey outcome.

The surveyors can easily take and upload photos using a GPS-enabled smartphone with our developed application. When a surveyor takes a photo, this application automatically attaches the location data (current latitude and longitude) to the photo. The surveyor can input the category, keyword and other information manually on his/her smartphone and send the photo to the BY system.

### 4.2. Digital material creation

The creators can upload digital images, sounds and videos to the BY system. They have to create text messages and single-choice questions in a scenario file (in the evacuation scenario composition) and create slideshows as successive composite images. The BY system provides a slideshow creation tool. When creating the slideshow, the creator superimposes foreground images onto a background image and sets the presentation duration of the slide. If necessary, he/she can attach a subtitle and sound (e.g. characters' dialogue) to the slide. Candidates for foreground images (uploaded beforehand by the registered users) and background images (uploaded as the survey outcomes) are retrieved from the BY system and shown as thumbnails in each tab on the left frame. Background and foreground images are selected by clicking on a candidate image. The selected foreground images are superimposed onto the selected background image (Fig. 4-a). The position, size and layer of each of the superimposed foreground images can be adjusted by a mouse operation. The subtitle content is input as a text component (Fig. 4-b) by selecting visual settings for the subtitle (e.g. size, colour and font style). The creator can preview the retrieved sounds to select an appropriate sound for each slide. The presentation duration (seconds) for each slide is input in a textbox. Finally, the created slideshow is converted to successive composite images and saved in the BY system together with the slideshow configuration in the evacuation scenario.

### 4.3. Evacuation scenario composition

The BY system provides a scenario composition tool that composers can use to define and visually structure scenes and cuts. First, a composer launches an evacuation scenario and inputs its metadata, such as the scenario name, keyword and validated date. Then, he/she defines a scene (SS, MS or IS) and cuts in it. When defining an SS, the composer sets a squared area for the corresponding location on Google Maps (Fig. 4-c) and then defines cuts by setting the sound (BGM), text message, digital material and so on. The input digital material comprises single-choice questions, the number of options, option items, correct option(s) and time limit, among other factors. If the material is an image, sound, video or slideshow, the

composer selects one of the retrieved results. After more than one cut is defined, the defined cuts are structured with directed links by clicking on two cuts successively. Every link has a cut transition condition. If the cut transition is a single-choice question, there can be more than one link from the cut to the other cuts. The condition parameter is selected from the corresponding pull-down menu (Fig. 4-d). MSs and ISs do not require location data. Each MS is linked to the previous SS(s) and the subsequent SS(s). The composer links an IS with an SS (from the IS to the SS). If the ‘already visited (cut)’ condition is set for an SS, the SS can be linked to more than one MS for the already visited cuts. The composed scenario is visualized panoramically so that the composer can grasp the whole scenario (Fig. 4-e). In the visualized scenario, each type of scene (SS, MS, IS and SS as the end point) is shown in a different colour; thus, the different types of scenes can be recognized easily.

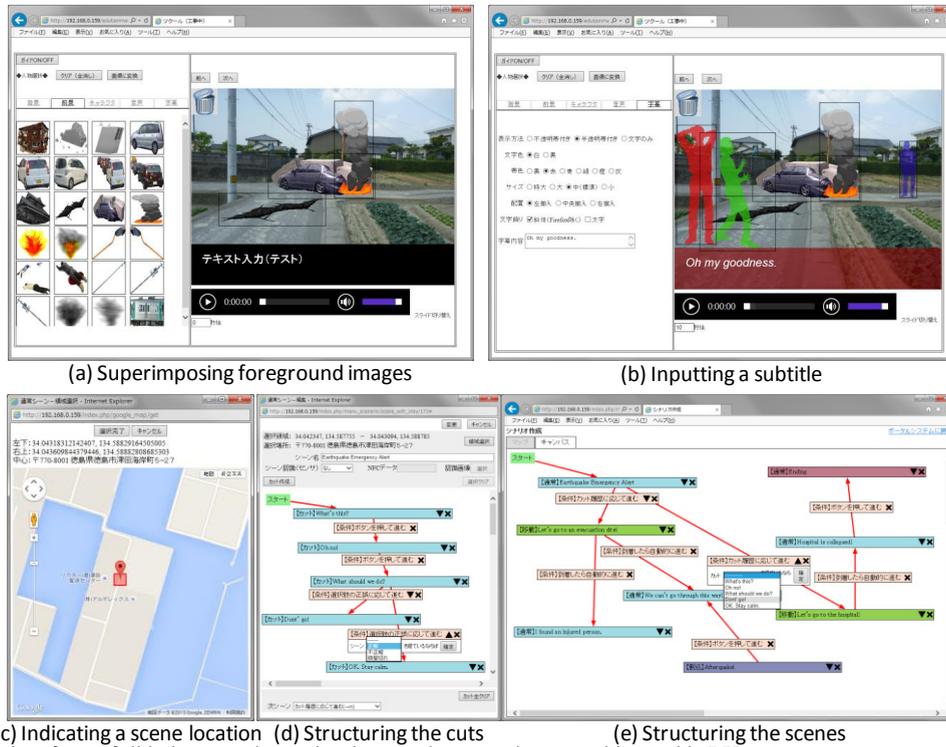


Fig. 4. User interfaces of slideshow creation tool and evacuation scenario composition tool in BY system

**5. Related Works**

Many educational-game-authoring systems that include visual language systems have been developed. Such systems simplify authoring tasks and enable novice authors (non-programmers) to compose interactive learning scenarios (game storylines) on GUIs. An intelligent authoring system [4], which deals with a scenario comprising a ‘state’, ‘event/action’ and ‘goal’, can validate the scenario based on linear logic (e.g. deadlock detection). One domain-specific visual language system [5], which deals with a scenario comprising a ‘state’, ‘action’ and ‘feedback’, enables authors use sophisticated visualizations to set up complex multi-interactions. A particular non-linear scenario-authoring system [6] for scenario-driven 3D games enables authors to edit scenarios efficiently by design verification (panoramic visualization) and logical consistency testing. A certain storytelling editor [7] based on the Microsoft Workflow Foundation is used to compose digital materials, such as textboxes, images, videos, audio and flash files, for narrative-based disaster education.

Some authoring systems for location-based games have been developed. For example, SILO [8] is a web-based authoring system that permits a game creator to construct a storyline as a set of missions in different locations. Another authoring system [9] deals with a game-based city tour in which images and questions corresponding to specific locations as well as a story are presented on a smartphone. This system enables authors to designate specific locations on digital maps and compose stories including branches on GUIs. Although these systems do not appear to handle complicated scenarios (storylines), it can be used to design relatively simple GBEDs. The BY system enables users to design complicated scenarios and various digital materials while focusing on locations and game elements for GBEDs.

## 6. Summary

This paper has described a web-based system for designing GBEDs that allow many people to be involved in the design process, which we believe is an important consideration. The system supports (simplifies) the three tasks in GBED design. For example, in the ‘evacuation scenario composition’ task, the scenes and cuts can be easily structured by using the panoramically visualized scenario.

In future, we intend to continue investigating GBED design as disaster education and clarify its learning effectiveness. We plan to make the system available by the end of 2015. We want to make the GBED and its design available as soon as possible.

## Acknowledgements

This work was supported by the Strategic Information and Communications R&D Promotion Programme (SCOPE) of the Ministry of Internal Affairs and Communications of Japan. Thanks are expressed to Mr. Kawai, Ms. Kitajima and Ms. Yamasumi for their efforts in this work.

## References

- [1] Mitsuhashi H, Sumikawa T, Miyashita J, Iwaka K, Kozuki Y. Game-based evacuation drill using real world edutainment. *Interactive Technology and Smart Education* 2013;**10**(3): 94-210.
- [2] Dunwell I, Petridis O, Arnab S, Protopsaltis A, Hendrix M, Freitas S. Blended game-based learning environments: extending a serious game into a learning content management system. *Proc. of Third International Conference on Intelligent Networking and Collaborative Systems (INCoS)* 2011;830-835.
- [3] Dochev D, Agre G. Supporting learning-by-doing situations by semantic technologies. *Proc. of 17th Annual Conf. on Media and Web Technology (EUROMEDIA'2012)* 2012; 49-53.
- [4] Dang KD, Champagnat R. An authoring tool to derive valid interactive scenarios. *Proc. of 2013 AIIDE Workshop on Intelligent Narrative Technologies* 2013;9-15.
- [5] Marchiori EJ, Del Blanco A, Torrente J, Martinez-Ortiz I, Fernández-Manjón B. A visual language for the creation of narrative educational games. *Journal of Visual Languages and Computing* 2011;**22**(6): 443–452.
- [6] Erdem AT, Utku B, Abaci T, Erdem ÇE. Advanced authoring tools for game-based training. *Proc. of the 2009 Summer Computer Simulation Conference* 2009; 95-102.
- [7] Mangione G.R., Capuano N., Orciuoli F., Ritrovato P. (2013), Disaster education: a narrative-based approach to support learning, motivation and students' engagement, *Journal of e-Learning and Knowledge Society* 2013;**9**(2):129-152.
- [8] Guribye F, Wake JD, Wasson B. The practical accomplishment of location-based game-play: design and analysis of mobile collaborative gaming. *International Journal of Mobile Human Computer Interaction* 2014; **6**(3):32-50.
- [9] Grüntjens D, Groß S, Arndt D, Müller S. Fast authoring for mobile gamebased city tours. *Proc. of 2013 International Conference on Virtual and Augmented Reality in Education-Procedia Computer Science* 2013;**25**:41-51