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Game-based System to Resolve Knowledge-to-Action Gaps in Disaster Prevention Learning

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Abstract: It is quite simple for most residents to understand the knowledge of disaster prevention. However, people sometimes fail to apply such knowledge to take an appropriate action, which is often referred to as knowledge-to-action gap. In this paper, we presents a learning support method based on gaming simulation, which allows learners to form intentions for and also induce unsafe evacuation behavior. Evaluation of the proposed method is given as the results of psychological experiments.

Keywords: disaster education, learning strategy, gaming, knowledge-to-action gap

1. Introduction

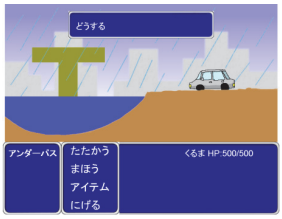
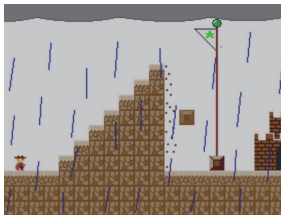
It is reported by a survey (Fitzgerald, Du, Jamal, Clark, & Hou, 2010) reported that many people became victims due to unsafe evacuation behavior, such as by getting across a flooded waterway by car, despite a trespass warning. This type of intentional actions is called "unsafe acts" that impede the personal safety (Reason, 1990). Unsafe evacuation behaviors are likely to be taken as an attempt to achieve an objective other than the one with a higher priority to ensure their own safety. Therefore, having learners assume a different objective than ensuring their own safety during an evacuation scenario is expected to induce unsafe evacuation behavior. This study proposes a learning support method to induce unsafe evacuation behavior by suggesting objectives to be achieved other than the primary safety objective, and investigates the effectiveness of the proposal with regard to the elimination of the gap between knowledge and behavioral intention.

2. Learning Support System to Induce Unsafe Evacuation Behavior

Simulations incorporating game-type elements (i.e., gaming simulations) have been used to increase learners' motivation (Duke, 1974), as these gaming simulations (subsequently, gaming) enable learners to simulate situations undesirable to experience in real life, such as accidents and failures. Since most of the existing disaster-prevention gaming (subsequently, plain gaming) simply provides opportunities of experiencing unsafe evacuation behavior, it is probable that learners do not take unsafe evacuation behavior spontaneously; as such, the plain gaming ends without experiencing any dangerous situation. To ensure learners experiencing dangerous situation, it is possible to enforce them to encounter negative situations in the gaming as part of the safety education program (subsequently, gaming with enforcement). However, the goal assumed in the gaming with enforcement is still consistent with the objective of ensuring safety, and it is unlikely for the learners to form the intention for unsafe evacuation behavior. In this study, a learning support method is proposed that allows learners to form intentions for and also induce unsafe evacuation behavior, by providing an objective in an evacuation scenario other than ensuring their own safety (subsequently, gaming with inducement).

In a prototype of the learning support system, three types of hazardous place ("underpass," "cliff" and "bridge" as in Table 1) were used from among the places found in flood hazard map (Tanaka, Hirai, Ikeda, Hori, 2014). In the gaming with inducement for "underpass," for example, the

Table 1. Descriptions of the inducement and the assumed objective for each hazardous place.

	Underpass	Cliff	Bridge
Safe evacuation behavior (knowledge)	When faced with a flooded underpass, you must not enter and instead turn back.	If the cliff shows signs of collapsing, you must keep your distance from it.	If the river's water level is rising due to heavy rain, you must not cross the bridge and instead turn back.
Gaming screen			
Description of the inducement	Shows the underpass as an enemy	Positions the goal flag (right side) beyond the cliff	Shows arrows in the middle and at the end of the bridge
Assumed objective	Defeat the enemy	Grab the goal flag	Cross in the middle of the bridge
Behavior necessary to achieve the objective	Fight	Climb the cliff	Cross in the middle of the bridge

rule for safe evacuation behavior is "you must not enter and instead turn back" (see Table 1). In this case, "turn back" is safe behavior and "enter" is unsafe behavior. This rule is not exposed explicitly to players as a gaming rule; rather, it is given as disaster knowledge in advance. In the gaming with inducement, the underpass is presented as an enemy to be defeated, like a battle scene in a role-playing game (RPG). The players can be aware of the underpass as an enemy, and then the intention of fighting with the enemy is formed to win the battle. In this way, the players are induced to take unsafe evacuation behavior, in accordance with the objective and regulations within RPG fight scenes.

3. Evaluation of the Prototype Learning Support System

3.1 Experiment 1: Inducing unsafe evacuation behavior and motivation for learning

24 university students were participated in this experiment, and evacuation knowledge on the hazardous places (Table 1) was used as the learning target. A learning support system without inducement (subsequently, gaming without inducement) was prepared as the object of comparison with the proposed gaming with inducement. In addition, as another object of comparison, a learning support system was prepared that directly presented knowledge in the form of text and illustrations merely following the composition of the gaming screen (subsequently, the direct-display system).

In order to confirm whether the gaming with inducement was able to encourage learners to adopt unsafe evacuation behavior, the number of learners who chose unsafe evacuation behavior (19/24) was compared to the number of learners who chose similar unsafe behavior in gaming without inducement (15/24). No difference was observed between the two types of gaming (McNemar's test: $p = .13$). The reason for this was thought that when carrying out the experiment, the participants were given the instruction of "Please cooperate with the evaluation of the game app," and so they might try to investigate the games rather than to play with them. Furthermore, the number of learners who chose unsafe evacuation behavior during the first gaming session were compared, and it was found that more learners chose unsafe evacuation behavior in gaming with inducement (19/24) than in gaming without inducement (5/24) (McNemar's test: $p < .001$). From this result, it is expected that the gaming with inducement will effectively induce learners to engage in unsafe evacuation behavior.

After completing the learning using the prototype support system, the participants completed an evaluation questionnaire, in which they were asked to rate statements about whether they "Enjoyed it (enjoyment)," whether "It left an impression (impression)," and whether "They wanted to play again

Table 2. Rates of correct answers in the knowledge and intention tasks.

Experienced unsafe evacuation behavior	Relevant problem number	Knowledge task	Intention task	Z	p	r
Did not experience (knowledge display only)	48	1.00	0.90	-2.00	.03	.32
Did not experience (not selected)	58	1.00	0.89	-2.65	.01	.35
Had experience	38	1.00	0.88	-2.00	.05	.33

(re-use)" on a seven point scale (1: I strongly disagree through 7: I strongly agree). Upon applying a variance analysis to the evaluation values, it was found that the proposed method with inducements received significantly ($p < .001$) higher evaluation scores for enjoyment (5.42), impression (5.58), and re-use (5.17) as compared to the other two learning systems. Also, regarding the number of times the learners attempted to use the learning support system, the proposed method was used significantly ($p < .001$) more times (2.88) than the other two learning support systems.

3.2 Experiment 2: Formation of intention for safe evacuation behavior

The objective of this experiment was to investigate the effect of the proposed method on the formation of intention for safe evacuation behavior, and the influence of presentation style (game playing and storytelling) because success and failure of the inducement depended on the styles in the experiment 1. 48 university students were participated in this experiment. As in the experiment 1, in order to confirm whether gaming with inducement encouraged the learners to adopt unsafe evacuation behavior, the number of learners who chose unsafe evacuation behavior were compared. In this comparison, no significant differences were observed between the two presentation styles (McNemar's test: both $p > .10$). To investigate the inducement effects from the styles, the number of learners who chose unsafe evacuation behavior in the game playing and storytelling styles, and the number of learners who chose unsafe evacuation behavior during the first gaming session were compared. The number of learners who chose unsafe evacuation behavior was significantly higher for the game-playing style than for the storytelling style in both cases during the entire session from the beginning to end ($\chi(1) = 4.09$, $p = .43$, $\varphi = .29$), and during the first gaming session ($\chi(1) = 5.37$, $p = .02$, $\varphi = .33$),.

In order to confirm the effect of the simulated experience of unsafe evacuation behavior, the problems presented were classified into selected unsafe evacuation behavior, unselected unsafe evacuation, and behavior that could not be selected (as only the knowledge was displayed), and the correct-answer rates for the knowledge task and the intention task were compared. Results for all of the problems show that the correct answer rate for the intention task was significantly lower than for the knowledge task, which confirmed the existence of a gap between knowledge and behavioral intention (Table 2).

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