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Virtual Currency as Gamification for Learning in a Disaster Museum to Increase the Number of Revisitors

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Abstract: Disaster education plays an important role in protecting our lives and information, and communication technology-based disaster education (ICTDE) has received much attention. We focus on virtual currency as gamification to enable visitors to learn about disasters more deeply while having fun at a disaster museum that serves as a central facility for disaster education; accordingly, visitors can be motivated to revisit the museum. In our gamified ICTDE program, "Knowledgeonaire." visitors can take quizzes while observing exhibits and obtain VC as a reward when they provide correct answers. In addition, visitors will think about how to make effective use of their VC when receiving VC, buying hints, and buying gifts. We developed a web-based Knowledgeonaire system (K-System), which has a simple mechanism of quiz presentation using near field communication (NFC). Through a preliminary comparative experiment, we discovered that K-System did not perform better than a non-Knowledgeonaire system (NFC-based simple quiz presentation system), but can motivate visitors to revisit the museum.

Keywords: Virtual currency, gamification, quiz, learning at museum, disaster education

1. Introduction

Disasters that cause catastrophic damage are increasing in number around the world. In Japan, for example, the Great East Japan Earthquake and the resulting tsunami caused many deaths. Each time a disaster occurs, we are motivated to learn about disasters; thus, disaster education plays an important role in protecting our lives. However, disaster education is yet to be fully established. For example, evacuation drills are often conducted as part of traditional disaster education programs, but participants do not necessarily commit to such drills. We cannot know exactly when and where a disaster is likely to occur and therefore, we often regard the occurrence of a disaster as someone else's problem. In other words, we are prone to lower the priority of disaster education and do not acquire sufficient knowledge about disasters through conventional disaster education programs.

One approach to overcoming this situation is to diversify disaster education. For diversification, information and communication technology (ICT) has attracted much attention, and there have been various kinds of ICT-based disaster education (ICTDE) programs. For example, programs using digital games enable participants to learn about disasters while having fun through high interactivity and the use of audio-visual effects (e.g., Tsai et al., 2015; Wahyudin & Hasegawa, 2015; Kawai et al., 2016). Programs involving interactive simulations enable participants to plan proper evacuations from visualizations of panoramic disaster damage (e.g., Kobayasi at al., 2008) or by evacuating virtual three-dimensional worlds (e.g., Dunwell et al., 2011; Capuano & King, 2015). In addition, disaster big data, collected from social media (e.g., Twitter) and sensor nodes (e.g., Global Positioning System on smartphones), clarify disaster phenomena and provide lessons for surviving disasters (e.g., Power et al., 2016).

In this study, we deal with ICTDE in a disaster museum that serves as a central facility for disaster education in Tokushima prefecture (approximately 0.78 million citizens) in Japan. It is expected that Tokushima prefecture will be damaged by a massive earthquake and tsunami in the near future; thus, Tokushima citizens have an interest in disasters, and many of them must have visited the museum at least once (e.g., as an extracurricular lesson for students). The museum has experience-oriented simulators (e.g., earthquakes, storms, and smoke) and permanent exhibits (e.g., pictures, video materials, tangible models, and expository panels). In addition, the museum regularly conducts special exhibits (e.g., reports on the latest disaster cases), and museum attendants offer visitors supplemental explanations regarding the exhibits. However, the museum has difficulty in attracting revisitors even though it is recognized as an important facility for learning about disasters, because disasters contain serious, negative themes (e.g., death). In other words, the citizens look away from disasters and are not motivated to revisit the museum. We believe that repeated revisits will lead to acquiring broad and diverse knowledge regarding disasters.

To increase the number of revisitors, we focus on gamification and introduce virtual currency (VC) to digital quizzes on permanent and special exhibits. We refer to this gamified ICTDE program as "Knowledgeonaire." In Knowledgeonaire, visitors can take quizzes while observing exhibits and obtain VC as a reward when they provide correct answers.

The remainder of this paper is organized as follows. Section 2 describes the fundamental idea and the developed system of Knowledgeonaire. Section 3 reports a preliminary experiment. Section 4 summarizes this study.

2. Knowlegeonaire

VC can be regarded as extrinsic motivation. In Knowledgeonaire, visitors can learn about disasters to earn VC. Some people claim that visitors should learn about disasters based on intrinsic motivation. However, citizens who do not have or retain an interest in disasters will not revisit the museum. We believe that VC provides a strong incentive that can motivate such citizens to revisit the museum.

2.1 Gamification and Virtual Currency (VS) in Education

Gamification is typically defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011) and "a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation." (Huotari and Hamari, 2012) The game design elements, which encourage participants to struggle with tasks with continuous motivation (affordances), are provided as such rewards as points, budges, and leaderboards. Gamification has attracted attention in various domains, including education (Seabirn and Fels, 2015). In the domain of education, gamification is a promising approach to increasing learning motivation, engagement, and effectiveness (Erenli, 2013; Dicheva et al., 2015; Lister, 2015). On the other hand, Hanus and Fox (2014) reported that gamification was not effective in motivation, satisfaction, and empowerment owing to such conditions as the degree of learners' intrinsic motivation.

There is no single definition of VC. For example, VC is defined as "a type of unregulated, digital money, which is issued and usually controlled by its developers, and used and accepted among the members of a specific virtual community." (European Central Bank, 2012) Another concise definition indicates that VC is used only in closed worlds (e.g., on-line games). Some studies have focused on the kind of VC that can play a positive role in gamified learning. For example, O'Donovan at al. (2013) introduced VC in lecture-related digital quizzes and puzzles enabling university students to buy additional answering chances and hints. Other types of VC allow students to extend a due date for homework submission (Goehle, 2013) and buy a passing grade and their final course grade (Chen et al., 2015).

2.2 Digital Quiz

As the platform for Knowledgeonaire, we focus on digital quizzes about exhibits. Digital quizzes have often been introduced into game-based learning in museums. For example, Sung et al. (2013) developed a museum guidebook system that presents quiz questions about exhibits on a tablet computer and enables visitors to interact with virtual characters in game-style materials. Xhembulla et al. (2014) developed a mobile learning system that provides visitors with mini-games including quizzes about exhibits and allows visitors to explore the museum freely according to their interests and agendas. Mikalef at al. (2013) reported that interactive quizzes with a time limit immersed visitors in exploratory learning and heightened their performance in the post-assessment test.

In Knowledgeonaire, digital quizzes (multiple-choice questions) are presented sequentially to prompt visitors to explore exhibits in a fixed order. Visitors might dislike the sequential presentation, because they cannot answer quizzes according to their interests and agendas; it might differ from the predominant learning styles in museums (i.e., free-choice learning and self-directed learning). In terms of learning effects, however, we think that visitors should learn about disasters while considering the context (e.g., earthquake, tsunami, and then aftershock). In terms of learning motivation, we think that a sequential presentation can achieve story-based gamified learning (e.g., a mystery-solving game that suggests which exhibit has the next question). Museums occasionally aim at increasing learning motivation and effectiveness by adopting an approach different from the usual. The typical approach is to adopt controlled learning styles (e.g., orienteering). We believe that the sequential presentation will enable the visitors to learn about disasters more deeply while having fun.

The sequential presentation, which designates the first and last quizzes, can be used to recognize visitors' learning levels, i.e., how often they have revisited the museum, by counting the number of times they reach the last quiz. Our digital quiz can encourage visitors to revisit the museum by changing quiz questions according to their learning levels; a revisitor is given higher-level quiz questions as the number of his or her revisits increases. This stepwise presentation enables revisitors to acquire broad and diverse knowledge regarding each exhibit.

2.3 Virtual Currency Framework

In Knowledgeonaire, visitors can acquire a fixed amount of VC each time they provide the correct answer on a quiz. On the other hand, they lose a fixed amount of VC when they provide an incorrect answer—their minimum amount of VC is zero. The VC's monetary aspects are (1) visitors can buy hints for quizzes, and (2) they can buy real commemorative gifts of the museum. This VC framework encourages visitors to learn strategically, i.e., to think about how to make effective use of their VC. Visitors make the following decisions about their VC (Figure 1).

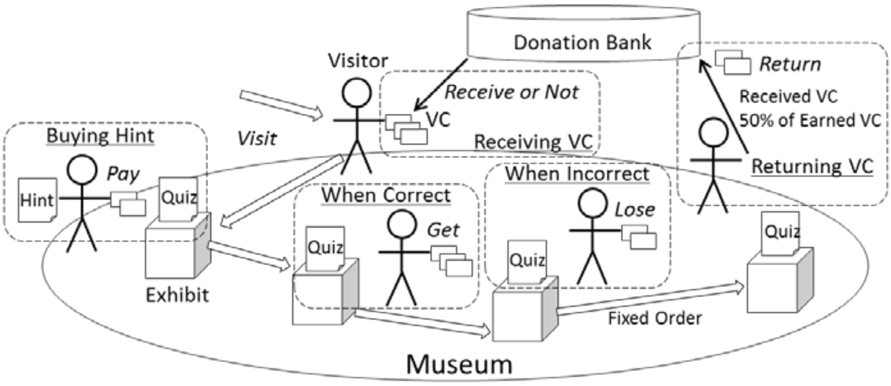

Figure 1. Virtual Currency Framework in Knowledgeonaire

2.3.1 Receiving VC

VC is accumulated as a donation from visitors who earned their VC by having correct answers. At the beginning of Knolwedgenaire (every visit to the museum), visitors can decide whether or not to receive an amount of VC from the donation bank. The donees (i.e., the visitors who receive VC) have the following duties: (1) they must return the full amount of their received VC to the donation bank after the last quiz and (2) they must donate half of their earned VC (reward received for providing correct answers) to the bank. Visitors who need hints can receive the donated VC.

2.3.2 Buying Hints

For each quiz, visitors who have a specific amount of VC can buy a hint with it. The hint is a short text that narrows down the correct answer from several options. Visitors who do not want to lose their VC will observe exhibits carefully and guess the correct answers without hints.

2.3.3 Buying Gifts

After the last quiz, the visitors can decide whether or not to buy the gifts with their earned VC. Note that before buying the gifts, the donees must fulfill their obligation regarding the donation (as described in 2.3.1)―they can decide to buy gifts with their remaining VC.

2.4 Knowledgeonaire System

We developed a web-based Knowledgeonaire system (K-System), which has a simple mechanism of quiz presentation using near field communication (NFC); the quizzes are presented on a standard web browser installed in NFC-enabled mobile devices (e.g., smartphones and tablets). Figure 2 schematically shows the composition of K-System. Each major exhibit has an NFC tag with the corresponding identifier (ID). Each exhibit's ID corresponds to a quiz (a multiple-choice question, options, and the correct answer). The web server has a common data interface and a database that consists of exhibit, quiz, visitor, log, gift, and other tables. When a visitor reads an NFC tag using his or her mobile device, the web server receives the tag's ID from the device and sends the corresponding question to the device. When the visitor answers the presented question, the web server receives and judges his or her answer and sends the feedback depending on whether it is correct or incorrect.

K-System's user interface is optimized for a web browser in the vertical position of a mobile device (Figure 3). To begin Knowledgeonaire, a visitor reads the initial NFC tag at the reception desk; at the first visit, the visitor is required to complete visitor registration (i.e., create his or her login account for K-System). After the successful login, the visitor moves to a page for receiving VC and determines the amount of VC to be received from the donation bank. He or she searches for the first quiz tag (exhibit) according to a receptionist's instruction. Immediately after the visitor reads the proper tag, the corresponding quiz consisting of a short text and several options is presented. If necessary, the visitor can buy a hint with his or her VC. Immediately after the visitor answers the quiz (i.e., selects one of the options), feedback is presented that includes whether the answer was correct or incorrect, the current amount of the visitor's VC, expository text, and indication, or implication of the next tag. The visitor reads the final tag at the reception desk, and a shopping page is presented that enables him or her to buy gifts from the list (name, price, and picture).

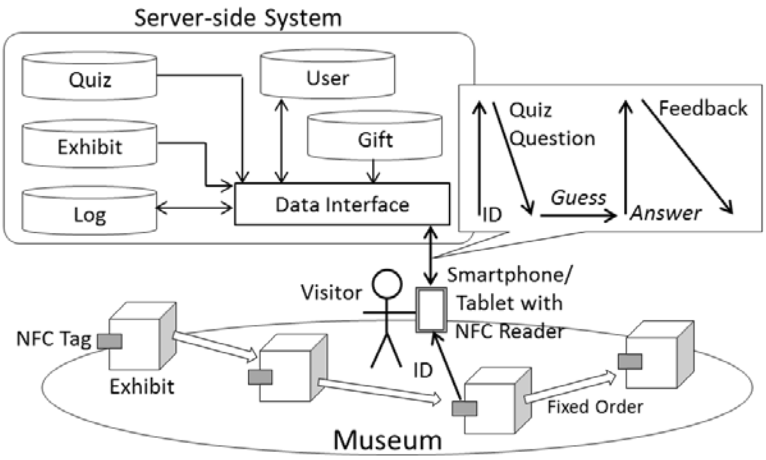

Figure 2. Composition of Knowledgeonaire System

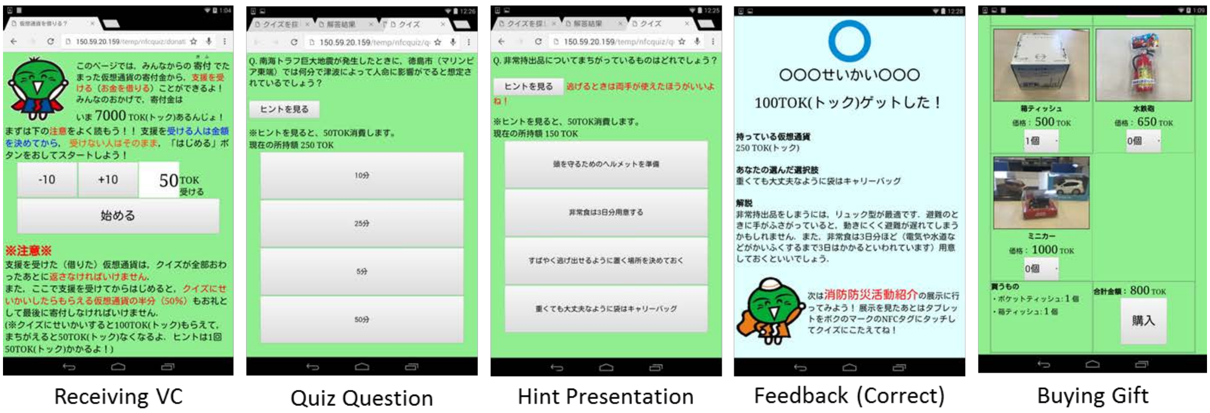

Figure 3. User Interfaces

3. Preliminary Experiment

To examine how Knowlegeonaire influences visitors, we conducted a preliminary comparative experiment at the museum using two types of systems: K-System and a non-Knowledgeonaire quiz system (NK-System) that used NFC-based simple quiz presentation but not VC.

3.1 Settings

Thirty-one visitors (7 to 50 years old) participated in this experiment and were divided into two groups: Group-K (14 participants who used K-System) and Group-NK (17 participants who used NK-System). They were instructed on how to use their assigned systems and began taking quizzes (Figure 4). We prepared eight quizzes for eight exhibits and made the following settings for VC, referred to as “TOK” (currency unit)—if participants of Group-K do not receive VC from the donation bank and answer all of the quizzes correctly without hints, they earn TOK800.

```
# At Beginning
if I receive VC then
    MyReceivedVC = x;
    MyVC += x;
endif

# When Answering Quiz
if I buy hint then
    MyVC -= 50;
endif
if My answer is correct then
    MyVC += 100;
else
    MyVC -= 50;
end if
```

```
# After Last Quiz
if I received VC then
    MyEarnedVC = MyVC–MyReceivedVC;
    MyVC = MyEarnedVC * 0.5;
    DonationBank += (MyReceivedVC + MyVC);
end if
while MyVC > 0 do
    if I buy gift then
        I select gift(i).
        if MyVC > price[i] then
            MyVC -= price [i];
            I receive gift(i).
        end if
    else
    exit;
    end if
end while
```

After the final quiz, the participants of Group-K can buy gifts (e.g., a water pistol for TOK650). The participants of both groups answered a questionnaire regarding the systems they used (five-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The questionnaire consisted of the following questions:

- *Q1. This quiz system enhanced my interest in disasters.*
- *Q2. This quiz system enhanced my knowledge of disasters.*
- *Q3. This quiz system was easy to use.*
- *Q4. This quiz system motivated me to revisit this museum.*
- *Q5. Virtual currency of this quiz system motivated me to answer quizzes. [only for Group-K]*

Figure 4. Snapshots of Preliminary Experiment

3.2 Results

Nine (64.2%) of the 14 participants of Group-K completed all of the quizzes, i.e., the other participants stopped taking quizzes in the middle. On the other hand, twelve (70.5%) of the 17 participants of Group-NK completed all of the quizzes. The mean values of the learning time (i.e., time between the first and last quizzes) of Group-K and Group-NK were 1,009 and 991 seconds, respectively—the incomplete participants were eliminated from the calculation. A two-tailed t-test showed that there was no significant difference between the two groups. Finally, five participants of Group-K had to return all of their VC to the donation bank. The mean amount of the other participants was approximately TOK280, and a few participants were able to buy the less expensive gifts using their VC. We did not find participants of either system who revisited the museum within one week.

The mean values of the correct answer rates of Group-K and Group-NK were 0.18 and 0.28, respectively. A two-tailed t-test showed that there was a significant difference at the 1% level between the two groups.

Table 1 shows the mean values, standard deviations, p-values (two-tailed t-test) for the questionnaire results. For all of the common questions (Q1 to Q4), the mean values of Group-K were lower than those of Group-NK. For Q1 and Q4, the mean values showed significant differences at the 5% level. For Q2, the mean values showed a significant difference at the 1% level. For Q3, there was no significant difference. The mean value of Q5 was favorable. We obtained just one remark on VC from free descriptions: "It is a good idea that VC is used to motivate taking quizzes."

Table 1: Results of questionnaire (* $p < 0.05$, ** $p < 0.01$)

	Group-K *Mean (SD)*	Group-NK *Mean (SD)*	t-test *p*
Q1	4.21 (0.80)	4.82 (0.39)	0.018 *
Q2	4.28 (0.72)	4.94 (0.24)	0.005 **
Q3	3.78 (1.18)	4.11 (1.05)	0.417
Q4	4.28 (0.82)	4.82 (0.39)	0.038 *
Q5	4.42 (0.85)	--	--

3.3 Consideration

Concerning the completion rate and learning time, we think that participants of both groups took quizzes similarly. The completion rates of both groups were lower than we expected. It is possible that participants had compelling reasons to finish quickly (e.g., tight schedule) and/or they were frustrated with the difficult quizzes; actually the correct answer rates of both groups were not high. Although the completion rate of Group-NK was higher than that of Group-K, two participants of Group-NK completed all of the quizzes in an extremely short time (419 and 552 seconds); concerning the learning time, therefore, the standard deviation of Group-K (166) was smaller than that of Group-NK (315). These two participants might not have learned deeply by observing the exhibits, because the simple quiz presentation did not provide the participants with any disadvantages, even when they answered incorrectly. We supposed that participants of Group-K would learn deeply to earn their VC (or not to lose their VC) and accordingly, spend more time for learning. However, the comparative results of the learning time and the correct answer rates might indicate that participants of Group-K did not learn deeply. From these unexpected results, we must conclude that K-System cannot always encourage visitors to learn deeply at the museum.

For both groups, the mean values of all of the questions were favorable and indicate that visitors can positively accept both systems and be motivated to revisit the museum. This indication might be supported by the mean values of Q4. However, we expected that the mean values of Group-K would be higher than those of Group-NK. One conceivable reason why K-System did not dominate over NK-System is that participants of Group-K did not really find fun in the VC framework. In other words, they did not care about or had difficulty in understanding how to make effective use of their VC. On the other hand, participants of Group-NK might have concentrated on taking quizzes. We think that the simple quiz presentation intrinsically enabled visitors to learn while having fun at the museum. If we interpret these questionnaire results in a negative light, K-System does not necessarily predominate, and VC is to be regarded as just an option.

Free descriptions included some positive remarks regarding the NFC-based simple quiz presentation: "Learning disasters by taking quizzes is fun, especially for children," "Quizzes prompted me to observe exhibits carefully," "I learned about disasters effectively by answering quizzes," and "Quizzes made me interested in exhibits." However, the mean values of Q3 were lower than those of other questions. In other words, the usability of both systems was low. We think that the low usability resulted from the low sensitivity of the tablets' NFC readers used in this experiment. For high sensitivity, we must prepare a high-sensitivity NFC reader and take account of NFC tags' attachment positions, because sensitivity occasionally depends on surrounding environments of the tags.

In this experiment, we could not control the experimental conditions; for example, visitors to the museum were diverse, and the participants were not homogeneous between the two groups in terms of such factors as age and estimated staying time. Therefore, the experimental results appear to lack persuasiveness in the comparison. In addition, we have not examined in the longer term whether the participants actually revisited the museum after this experiment. These limitations must be removed in a subsequent larger-scale experiment.

4. Conclusion

To increase the number of revisitors at a disaster museum, K-System uses NFC-based quiz presentation and VC. K-System encourages visitors to learn about disasters (exhibits) deeply while having fun and accordingly motivates them to revisit the museum; visitors can take quizzes while observing exhibits and obtain VC as a reward when they provide the correct answers. In addition, visitors can be expected to think about how to make effective use of their VC when receiving VC, buying hints, and buying gifts. Questionnaire results obtained from a preliminary comparative experiment indicated that visitors can positively accept K-System and be motivated to revisit the museum. At the same time, however, overall experimental results indicated that K-System cannot always realize its aim. To increase the number of revisitors, we must pursue a simplified VC (i.e., gamification) that balances fun and usability (e.g., additional operations).

In the future, we must reconsider the concept of K-System and improve it from the refined concept. If it is too complicated for visitors, the VC framework (e.g., donation) must be simplified or minimized. If visitors feel uneasy about security issues on VC (e.g., hacking and improper trade), the VC framework (e.g., user authentication) must guarantee the security. Furthermore, we must evaluate K-System in more detail through a more controlled larger-scale experiment while increasing the number of quizzes at the museum.

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References

Capuano, A., & King, R. (2015). Knowledge-based assessment in serious games: An experience on emergency training. *Journal of e-Learning and Knowledge Society, 11*(3), 117-132.

Chen, Y., Burton, T., Vorvoreanu, M., Whittinghill, D.M. (2015) Cogent: A case study of meaningful gamification in education with virtual currency. *International Journal of Emerging Technologies in Learning, 10*(1), 39-45.

Deterding, S., Dixon, D., Khaled R., & Nacke L. (2011). Game design elements to gamefulness: Defining “Gamification.” *Proceedings of the 15th International Academic MindTrek Conference (MindTrek2011)*, (pp. 9-15).

Dicheva, D., Dichev C., Agre G., & Angelova G. (2015). Gamification in education: A systematic mapping study. *Educational Technology & Society, 18*(3), 75-88.

Dunwell, I., Petridis, P., Arnab, S., Protopsaltis, A., Hendrix, M., & Freitas, S. (2011). Blended game-based learning environments: Extending a serious game into a learning content management system. *Proceedings of Third International Conference on Intelligent Networking and Collaborative Systems (INCoS)*, (pp. 830-835).

Erenli, K. (2013). The impact of gamification - Recommending education scenarios. *International Journal of Emerging Technologies in Learning*, 8(Special Issue 1), 15-21.

Europian Central Bank (2012). Virtual currency schemes, https://www.ecb.europa.eu/pub/pdf/other/virtualcurrencyschemes201210en.pdf (Accessed on May 1st, 2017)

Goehle, G. (2013). Gamification and web-based homework. *Primus, 23*(3), 234-246.

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education, 80,* 152-161.

Huotari, K., & Hamari, J. (2012). Defining Gamification - A Service Marketing Perspective. *Proc. of the 16th International Academic MindTrek Conference*, (pp.17-22).

Kawai, J., Mitsuhara, M., & Shishibori, M. (2016). Game-based evacuation drill using augmented reality and head-mounted display. *Interactive Technology and Smart Education, 13*(3), 186-201.

Kobayashi, K., Narita, A., Hirano, M., Tanaka, K., Katada, T., & Kuwasawa, N. (2008). DIGTable: A tabletop simulation system for disaster education. *Proceedings of Sixth International Conference on Pervasive Computing (Pervasive2008)*, (pp. 57-60).

Lister, M.C. (2015). Gamification: The effect on student motivation and performance at the post-secondary level. *Issues and Trends in Educational Technology, 3*(2).

Mikalef, K., Giannakos, M.N., Chorianopoulos, K., Jaccheri, L. (2013). Does informal learning benefit from interactivity? The effect of trial and error on knowledge acquisition during a museum visit. *International Journal of Mobile Learning and Organisation, 7*(2), 158-175.

O’Donovan, S., Gain, J., & Marais, P. (2013). A case study in the gamification of a university-level games development course. *Proceedings of South African Institute for Computer Scientists and Information Technologists Conference*, (pp. 245-251).

Power, R., Robinson, B., & Moseley, A. (2016). Comparing felt reports and tweets about earthquakes. *Proceedings of the 3rd Information and Communication Technologies for Disaster Management (ICT-DM2016).*

Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of. Human-Computer Studies, 74*, 14-31.

Sung, Y.T., Chang, K.E., Hou, H.T., & Chen, P.F., (2010). Designing an electronic guidebook for learning engagement in a museum of history. *Computers in Human Behavior, 26*, 74-83.

Tsai, M. H., Wen, M. C., Chang, Y. L., & Kang, S. C. (2015). Game-based education for disaster prevention. *AI & Society, 30*(4), 463-475.

Wahyudin, D., & Hasegawa, S. (2015). Mobile serious game design for training ethical decision making skills of inexperienced disaster volunteers. *The Journal of Information and Systems in Education, 14*(1), 28-41.

Xhembulla, J., Rubino, I., Barberis, C., & Malnati, G. (2014). Intrigue at the museum: Facilitating engagement and learning through a location-based mobile game. *Proceedings of 10th International Conference Mobile Learning 2014*, (pp. 41-48).