
3 A Concept for Creating Mobile Games for Enhanced Disaster Preparedness in Cooperation with Local Communities

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3.1 Introduction

Enhancing disaster preparedness and resilience is a key objective of disaster management agencies and authorities. In order to achieve this goal, authorities often use top-down communication approaches – usually based upon disaster management practitioners’ analysis and scientific evidence – to inform the public about potential hazards and recommended disaster preparation and mitigation measures. This approach is based upon the information deficit model (IDM) of risk communication, which stipulates that a lack of disaster preparedness is primarily caused by information deficits, i.e., by lack of knowledge about relevant risks, and recommended protective action. However, based on a literature survey about the IDM, Abunyewah et al. [1] conclude that the information deficit approach has not been very effective because it “situates the public in a passive, disentangled role”. They therefore propose an amended model that includes community participation as an additional success factor and show that such participation can significantly increase the citizens’ intention to prepare for disasters. Unfortunately, participation with the public – albeit being widely acknowledged as necessary – is a “currently unrealized means of governing socio-environmental challenges” [2] such as disasters, as Cook and de Lourdes Melo Zurita state. Appleby-Arnold et al. [3] argue that authorities should involve citizens to develop “cultures of disaster preparedness, which are informed by citizens’ values and experiences rather than imposed from above”. Following such an approach “will help community members learn from each other about local hazards and disaster risks, and so strengthen community spirit for improved community responses in the event of a disaster” [3]. In order to foster such community involvement, different types of activities involving disaster survivors have recently been developed and tested in cooperation with schools, universities, and volunteer organisations [4]. One such example are disaster days with public discussions about disaster risks and disaster preparedness, another are courses at schools and universities which use testimonies of disaster survivors and photographic materials provided by eyewitnesses to create open educational resources about historic disasters from citizens for the citizens. Another promising approach to better involve citizens in risk communication are digital serious games [5], i.e., computer or mobile games which focus on disaster learning while actively engaging the player and enhancing the impact of learning through an appeal to emotional factors. In this paper, we will propose an approach how to combine community participation and the development of mobile serious games from citizens for citizens in order to enhance disaster preparedness and resilience. In the next section, we will provide an overview of previous research on digital serious games for risk communication. Thereafter, the concept of the proposed approach is presented, and we conclude with an outlook on future research.

3.2 Digital Serious Games for Disaster Preparedness and Resilience

Serious games have been widely used to enhance disaster risk management. In their 2018 study, Solinska-Nowak et al. [6] identified and analyzed 45 such games, which included a mix of single-hazard and multi-hazard approaches. The most frequently addressed disaster risk was flooding (27 out of 45 games), followed by earthquakes (10 games), droughts (7), and storms (7). The majority of games focused on the early phases of the disaster management cycle, with 39 games emphasizing disaster preparedness and 25 games addressing disaster prevention and mitigation, whereas only 22 games included aspects of disaster response and just 7 games also included the recovery phase. However, these findings did not only include digital but also some analog serious games, and the statistical findings do not differentiate between the two types of serious games. Gampell et al. [7] specifically analyze disaster-related videogames, and they also find a focus on the early phases of the disaster management cycle, with 12 out of 15 games addressing preparedness, 8 out of 15 addressing mitigation, and 10 out of 15 addressing disaster prevention. Although the impact of disaster-related digital serious games still needs to be analyzed more systematically and comprehensively [8], available research findings show the benefits of game-based learning for disaster preparedness. For three digital games on landslide disasters,

for example, Chun-Hsiung et al. [5] found that computer games significantly enhanced the players' willingness to learn, learned content, and learning attitude. Learners found the learning environment more attractive than in traditional approaches and games stimulated the "learners to complete required learning tasks".

A number of mobile disaster games has also been developed. [9], for example, present a mobile game for earthquake and tsunami disaster education and demonstrate that the learning impact was positively evaluated by users. Mobile games provide several advantages compared to desktop-based games. They can be played (almost) everywhere anytime including at the locations at risk, they can be played on an everyday device most people have access to, and the use of extended or augmented reality functionalities allows for an in-situ experience of disaster risks at the locations / zones at risk. George and Oliva [10] outline potential benefits of including immersive / extended-reality technologies in digital disaster-learning games for schools. However, while doing so, they emphasize the importance of including teachers, pupils, community leaders, and volunteers in the game creation process, thus once again advocating for strong community participation, including in game design.

While previous research underlines the potential of digital games for disaster prevention learning in general and of mobile games in particular, there is, to our knowledge, no systematic approach so far on how to involve the community in the creation of such games. We therefore propose a concept on how such a co-creation approach could look like and report how it is currently being implemented and tested at a university in Argentina. In doing so, we place a focus on the issue of mobile human computer interaction and argue for including accessibility aspects in the game design and creation process in order to make the created products usable for as many people as possible.

3.3 Creating Mobile Games for Disaster Preparedness with Local Communities

The proposed approach strives to include the local community in three phases of the development process: game design, content creation, and implementation. In order to be able to conduct all three phases with the community, it is necessary that some participants either have or are currently learning programming skills, e.g., as part of a university course, or an advanced course in informatics at high school. Please note, however, that game design and content creation can also be conducted independently of the implementation. Basis of all activities is an introduction to local disaster risks and into fundamentals of risk communication (approx. 2 hours). We also propose to provide a link to a website with easy-to-implement protective measures (e.g. nature-based solutions to mitigate the impact of heat waves or floods) and access to a platform that provides disaster-related information created by citizens, such as survivor interviews or multimedia materials from private archives. A prototype of such a platform is currently being implemented as part of the CITADINE research project [11]. This platform enables participants to familiarize themselves with disaster impacts and the consequences of historic disasters (from the own region or from similar disasters in other regions of the world). If possible, we also propose to invite at least one disaster survivor to discuss his or her experiences with the group of citizens working on the mobile application. Finally, we propose to include an introduction to mobile design principles and accessibility on mobile devices if participants are not yet familiar with these concepts. The design and development process then proceeds as follows:

- **Game design:** After the introductory phase, we propose to conduct creativity workshops (e.g., a design thinking workshop) to develop initial ideas of mobile disaster games. Initial ideas are then detailed with storyboards. At this stage, we propose a discussion and review of the proposals with regard to suitability, feasibility, and required implementation effort (in particular if students or volunteers will do the latter). Revised concepts can then be detailed and concretised using wireframing and mock-up tools. At this stage, accessibility issues need to be discussed, and all solutions should offer at least one theme of the user interface that does meet accessibility requirements for visually impaired people. The user interface should also be suitable for use with screen readers to support use by blind people to the greatest possible extent.
- **Content creation:** Content needed for the implementation of the game can either be provided via the aforementioned platform with open educational resources or, if suitable content is missing, it can be created in cooperation with local disaster survivors and eyewitnesses. Our experiences so far indicate that most survivors of natural disasters do communicate quite frankly about their experiences and are willing to share their knowledge as well as –if available - also often photographic material of the disaster that they experienced. In order to facilitate this information collection process, community participants have access to suitable interview guidelines and a structured schema for the classification of content. Provided that informed consent is given by the survivors, tagged interview segments and multimedia materials can then be uploaded to the open educational platform in order to further enrich available materials for the ongoing as well as future projects.
- **Implementation:** It is desirable that the implementation will also be conducted by (some) of the participants involved in the project, i.e., "by the community for the community". The concept behind this approach is to encourage members of the local community to advertise their own disaster game among family, friends, and peers, thus enhancing its impact. However, as our concept foresees an implementation as part of university or school projects, the somewhat limited programming skills of the developers need to be taken into account. In addition to possibly limited skills, lack of access to dedicated game development platforms and engines may also limit the feasibility of solutions. Nevertheless, experience from previous mobile programming courses shows that students are usually able to successfully implement solutions such as quizzes, memory games, or games where selection decisions have to be taken (e.g. with regard to evacuations). One question related to mobile human computer interaction will be to what extent programmers with limited experience will also be able to meet accessibility criteria.

3.4 Preliminary Results

At the time of submitting this article, the proposed approach is being tested with approximately 15 informatics students of Universidad Nacional de La Plata in Argentina. All students were participants of the User Experience Design UED course, a subject which belongs to the last year of the undergraduate degree in Computer Science. In the practical part of the course, the students' task consisted of developing an educational serious game about disaster topics or related themes. In addition to the steps identified in section 3, students were provided with comprehensive information about the issue of floodings, which are the most serious threat from natural disasters in the region. Some topics about serious game development and related usability best practices were added to the original curriculum in order to provide necessary additional knowledge for the students. Student projects then had to complete different stages of the user centered design process using different usability techniques. User investigation, context analysis, benchmarking of apps for catastrophes, focus groups to evaluate the preliminary designs, usability best practices research and accessibility compliance, prototyping, heuristic evaluation, and usability testing were some of the engineering methods the students had to apply. Initial results look promising but are still at the implementation stage, thus the effectiveness of the approach cannot be fully evaluated yet.

Initial results show that the students interpreted the topic of "mobile games" broadly. While most students chose to implement accessible responsive web apps (e.g., quizzes or a tool to create digital photoalbums about disasters enriched with multimedia materials), one group also decided to develop a haptic IoT solution: an interactive real emergency backpack which reacts to the items that users try to put into it while preparing for an emergency. The backpack shall provide positive haptic, auditive, or visual feedback if the selected item is suitable for, e.g., an evacuation, and negative feedback if it is not. Regarding the development of accessible responsive web apps, we present an example by Daniel Cesanelli and Francisco Ale [12] who are in the process of implementing a puzzle that supports learning about nature-based solutions for flood preparedness using materials from the CITADINE platform. The gameplay is as follows. Initially, the user is presented briefly with a photo of a nature-based solution, as can be seen in Fig. 1. Pieces of that image are then mixed and have to be reconstructed in the correct way by the user (Fig. 2).



Figure 1: Presentation of the initial picture



Figure 2: The puzzle

When the user puts all the pieces in order, an embedded educational video is shown to explain how to make use of the presented solution at home and how the proposed measure can enhance disaster resilience. An example of such a video can be seen in Fig. 3. The user can adapt the game according to his requirements. The app allows some accessibility configurations like contrast, difficulty level, or the possibility to set up the use of numbers to identify each picture to reduce complexity during the game interaction (Fig. 4). At the time of submitting the final version of this paper, the students were beginning with usability and accessibility testing of their prototypes. Students will have to check that the apps comply at least with the A and AA levels of the WCAG 2.0 guidelines. Also, they will have to test the games with different profiles of users with regard to different ages, disabilities, and experience.



Figure 3: Educational video on vertical gardens



Figure 4: Accessibility settings

3.5 Conclusion and Outlook

In this paper, we showed that it is in principle possible to develop mobile serious games to increase disaster resilience as part of university courses. Successfully implemented formats included quizzes and puzzles (with puzzles being more suitable for devices with larger screens such as tablets). IoT based game solutions such as the interactive emergency backpack are also feasible for students with good programming skills. Once the development, evaluation, and optimization of the student projects has been completed, the next step will be the practical evaluation of these mobile games developed by the local students for the community. This will include the following dimensions: attractiveness of the games for the players, dissemination and uptake, and – most importantly and highly influenced by the two factors before – the contribution of the games to enhanced disaster preparedness and resilience, i.e., what players were able to learn during their play. We also plan to test the concept a second time during the winter term 2021/2022 with students in Germany. Goal of this second test will be to see if and how the proposed concept works in a different regional and cultural setting. A second dimension of future work is to make more content on regional disasters available as open educational resources. One approach here could be to analyze if it is possible to get access to photographic materials on disasters collected by automated reporting tools for disaster professionals, which have been proposed by [13]. However, one key challenge that would have to be addressed here is how to make sure that only suitable materials will be provided, i.e., material that is ethically acceptable (e.g., not showing dead bodies), and which does not violate any other personality rights or copyrights.

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