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Optimizing Desktop VR for Immersive Experiences Through User-Centered Design Approach

Zilong Pan[1], Robson Araujo-Junior[1], Alec Bodzin[1], Thomas Hammond[1], David Anastasio[1], Na Chen[1], Luke Wong[1], Brandon Yee[1], and Papa Asibuo[1]

[1] Lehigh University, Bethlehem, Pennsylvania, USA
zip322@lehigh.edu

Abstract. Flood Adventure is a desktop VR game designed to prepare learners to gain knowledge and skills about flood preparation through authentic and immersive experiences. To enhance learners' experiences and maximize learning outcomes, we optimized the features in the environment following a user-centered design approach. The optimization process focused on four key areas, including Authenticity and Relevance, Guidance and Feedback, Knowledge Enhancement, and User Control and Customization.

Keywords: Desktop VR, User-centered Design, Flood Preparation.

1 Introduction

Due to incremental climate change, flooding occurrences pose a significant threat to the safety of individuals and result in extensive harm to both property and infrastructure [1]. Recognizing the necessary preparations for flooding events within a community and in one's home is a crucial educational requirement that can mitigate the risks individuals face during such events. A challenge in teaching about flood preparation is that learners need to envision the practical application of this knowledge. Even if they successfully memorize all the pertinent information, it is difficult to anticipate how effectively they can apply this knowledge in an actual flooding event. To address this challenge, we have been developing and testing a fully functional desktop virtual reality (dVR) game called Flood Adventure to provide diverse learners with an authentic and immersive experience to acquire necessary practical knowledge for flood preparation. This dVR experience allows learners to acquire, practice, and, most importantly, apply knowledge about flood preparation. They can also reinforce learning outcomes by playing the game repeatedly.

Despite the fact that dVR could provide authentic and immersive experiences for learners to acquire knowledge about flood preparations, it is a relatively new digital tool that might not be familiar to individuals across different digital backgrounds. Thus, there is a need to optimize the current Flood Adventure dVR environment so that learners with diverse needs can be sufficiently supported and guided throughout the experiences and achieve the expected learning outcomes. To ensure that the optimization process of the Flood Adventure dVR gameplay experience aligns with learners' needs, in this project, we synthesized the feedback collected in the previous usability testing [2] and followed a user-centered design approach to enhance the entire immersive learning experience. A user-centered design approach emphasizes a thorough comprehension of users' experiences with design products, involving an understanding of how users process information and make decisions within the contexts, as well as considering their learning objectives and preferences [3]. Therefore, guided by these aspects and informed by the feedback collected from usability testing, we optimized the Flood Adventure dVR game in four key areas: Authenticity and Relevance, Guidance and Feedback, Knowledge Enhancement, and User-control and Customization.

2 User-Centered Design Components

In Flood Adventure, learners explore a house near a creek, navigating five rooms with 50 household items. The 15-minute experience consists of three stages. In the first stage, players learn movement and object manipulation, watch a climate change video in the living room, and gather flood essentials within 3 minutes. This stage intentionally ends in failure, revealing it as a bad dream, which leads to the second stage. Then, a video on flood preparation precedes a tutorial to create a flood kit. Learners spend 3 minutes gathering items, concluding by loading them into a car with feedback encouraging additional preparedness. The final stage starts with actual flood alerts. Players have 3 minutes to gather more items before ending the experience by flipping the garage's power switch or waiting for the timer. The overall storyline provides an immersive experience within the house. There is no disturbing scenes depicting flooding or the devastating damage caused by flooding in Flood Adventure. This is to minimize the potential for re-traumatizing users who have experienced flood events in real life.

2.1 Authenticity and Relevance

To better curate an immersive and authentic experience, we enhanced the plot by asking learners, before they evacuate the house, if they intended to call their neighbors before switching off the power (Figure 1). These plot elements were added as they could enhance the realistic aspects and are also recommended steps before leaving a house prior to a flood event. In addition, we also added sound effects for when learners drop unneeded items to enhance the authentic experience.

Fig.1. Power switch and metacognitive prompts for calling the neighbors.

2.2 Guidance and Feedback

This environment situates learners in a house where they act as the house owner and are presumably familiar with the house layout. However, when learners begin this experience, especially new learners, they may lack knowledge of the house layout. To reduce the learning curve to understand the floorplan, we added a top-view mini-map with green highlights and labels to indicate the room the learners are currently in (Figure 2). In this case, learners are provided with more information about the rooms, allowing them to focus more on considering essential items to collect, which is the main point of the game, rather than learning about the house layout.

Fig.2. The mini-map is located on the top right of the screen.

An important interaction that learners would perform in Flood Adventure is picking up essential items in the house. In the previous design, a reticle was used where learners could point the reticle at an object, click the mouse, and collect the item in the inventory. Considering our learners come from diverse backgrounds and may not be familiar with using reticle, we replaced it with a dynamic hand (Figure 3). The hand remains open until the user points it at a collectable item, as the hand closes, indicating that the item is collectable. Considering the diverse population of potential users, this optimization provides learners with more guidance and intuitive feedback when interacting with items in the house.

Fig.3. Dynamic hand for enhanced interaction visual feedback: Step 1 (left) and step 2 (right).

2.3 Knowledge Enhancement

The main goal of the game is to equip learners with sufficient knowledge to prepare for a flood event. The key information we expected learners to gain is the identification of essential items that should be prioritized to collect before a flood. To reinforce their knowledge about essential items, a checklist with highlights marking the collected items was added to the left of the screen (Figure 4). This checklist provides users with a holistic list of essential items to collect before a flood and their corresponding rooms in the simulation, mirroring likely locations in real life. It also reminds users of the essential items already collected by presenting them with yellow highlights, allowing users to plan accordingly for collecting the rest of the essential items.

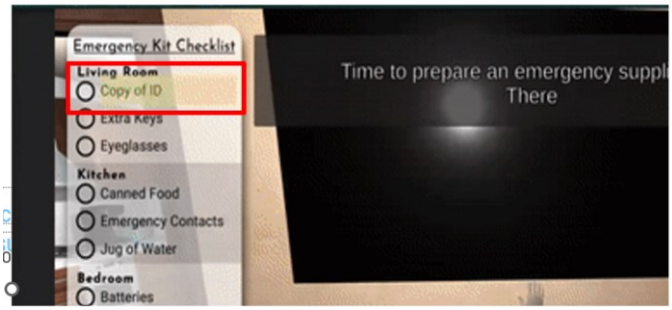

Fig.4. Improved checklist with responsive item highlights added to the left of the screen.

Furthermore, with the goal of providing more useful knowledge about flood preparation, we added seven information cards at the end of the experience to offer additional safety tips for learners to consider after they leave their house. For instance, figure 5 presents two examples of information cards aimed to inform learners about things to be aware of while driving in flooding areas. The content of these information cards is coherent with the game storyline, as learners drive away toward higher (and safer) grounds.

Fig.5. Examples of information cards that provide further instruction to enhance players' flood preparedness skills.

2.4 User-control and Customization

Considering different learners have a variety of preferences while progressing through the experiences in Flood Adventure, we optimized the main menu and customization options. Learners can easily pause the game or adjust sounds and enable the mini-map based on their preferences (Figure 6). These features allow learners to customize their experience, making it more comfortable for them and facilitating a more successful learning experience. This component is essential as users would have control over how to optimize their experiences to proceed through the game.

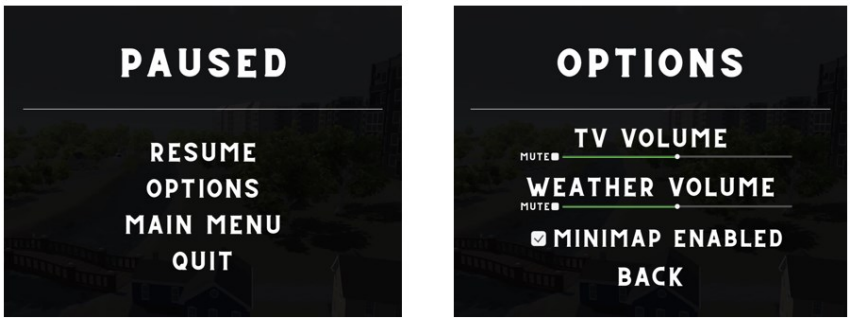

Fig.6. Main menu and customization option.

3 Conclusion and Implication

Following a user-centered design approach, this project proposes a four-component framework aimed at refining a desktop virtual reality experience to address diverse users' needs in preparing for a flood adventure. These components include Authenticity and Relevance, Guidance and Feedback, Knowledge Enhancement, and User Control and Customization. They were generated based on researchers' iterations of usability testing and redesign. Future projects seeking to design similar VR experiences could also apply this four-component framework to cater to diverse users' needs in the corresponding contexts.

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References

1. IPCC, "Global Warming of 1.5°C", Intergovernmental Panel on Climate Change," 2018. Accessed: February 1, 2022. [Online]. Available: https://www.ipcc.ch/sr15/
2. Araujo-Junior, R., Pan, Z., Bodzin, A., Semmens, K., Hammond, T., Anastasio, D., Sechrist, S., Lerro, N., Rubin, E., and Vogel, J., "Flood Adventures: Evaluation Study of Final Prototype," in International Conference on Immersive Learning, pp. 426-435, Immersive Learning Research Network (iLRN), 2023.
3. Huynh, A. Madsen, S. McKagan, and E. Sayre, "Building personas from phenomenography: a method for user-centered design in education," Information and Learning Sciences, vol. 122, no. 11/12, pp. 689-708, 2021.