Mobile Puzzle Game Design: 100 Ways of Losing Lives at Home

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Research Review

How Can the Design of Mobile Puzzle Games Facilitate Players' Problem-Solving Strategies?

1 Introduction

In the digital age, educational games have caught much attention and have been proven useful for students' performance, motivation and learning outcomes (Melero & Hernández-Leo, 2014). People are showing interest in utilizing different kinds of games as educational tools, which can be online, on desktop PCs, and on mobile devices. Mobile games market is the fastest growing gaming sector in the world nowadays (Klopfer, 2008). A large variety of mobile games have been used in many fields for instructional purposes, although some games emphasize the entertaining features. Therefore, it is of great significance to design a mobile game with education purposes and effective learning content to meet the learners' needs (Shih, et al., 2010).

Mobile puzzle games (also known as puzzle-based games), as one of the typical genres of mobile games, is regarded as an instructional strategy that can nurture students' problem-solving skills, analytical skills and creative exploration (Melero & Hernández-Leo, 2014). Moreover, puzzle games can also be seen as problem-solving games, in which players have to figure out certain solutions (Huang, Cheng, & Chan, 2007). Problem solving is one of the vital cognitive processes of the brain and requires specific strategies to figure out a solution for a given problem, or to find a path for a given goal (Wang & Chiew, 2010), which can be connected with the basic design principles in mobile puzzle games.

Based on the strong connection between the design of mobile puzzle games and the cognitive process of problem solving, this article focuses on the following research question: how can the design of mobile puzzle games facilitate players' problem-solving strategies?

2 Definition

Mobile puzzle games, literally, are puzzle games played on mobile devices, such as mobile phones, tablets and portable media players. Mobile puzzle games present typical advantages and disadvantages in mobile environment, such as the flexibility of mobile navigation and the screen size limitation of mobile devices. There is a large variety of puzzle game categories, and most of them are made up of simple but challenging rules, content and clues (Huang, et al., 2007). Common categories of puzzle games include tile-matching games, action puzzle games, room escape games and so forth. In these puzzle games, players are required to collect helpful information and clues by themselves to overcome obstacles or solve a puzzle within limited time. During the processes of solving interesting puzzles, finding solutions for ill-structured problems, players can facilitate their creativity, critical and logical thinking skills, as well as problem-solving strategies (Huang, et al., 2007).

Problem solving, or problem-solving ability, is defined differently based on different disciplines. Here, we try to review the definition of problem solving and problem-solving strategies under the theoretical framework of cognitive science. The process of problem solving is related to certain well-defined or ill-defined problems needed to be solved in the real world or the virtual world. It is a reflection of human brain activities which consist of the process of searching in the memory space and finding a relationship between problems and solutions (Wang & Chiew, 2010). Problem-solving strategies, which present the mechanism of cognitive activities, are human efforts of achieving an explanation and defining optimal solutions (Newell & Simon, 1972). Wang and

Chiew (2010) came up with several problem-solving approaches/strategies such as divide-and-conquer, trial-and-error and analogy.

3 Facilitating Players' Problem-Solving Strategies

Problem-solving ability has been recognized as a critical skill for adapting to the living environment of the 21st century (Kuo, Hwang, & Lee, 2012). With the rapid development of network and mobile technologies, mobile puzzle games have become an important tool to boost the mobilization and practice of players' problem-solving strategies.

The design of subtasks in a mobile puzzle game targets players' "divide-and-conquer" strategy. Divide-and-conquer, as one of the computer intelligence approaches to problem-solving strategies, refers to "solving a whole problem via decomposing it into a set of subproblems" (Wang & Chiew, 2010). Hwang, Wu and Chen (2012) identified the first two steps of preparing the educational content in an online puzzle game model to be: (a) setting up the goal/task of the puzzle game ("determining the learning issue to be investigated"), (b) separating the major task into subtasks and encouraging players to search for solutions and tools in the game environment ("preparing a series of questions related to the issue for guiding students to search for information"). As previous studies suggest, the design of puzzle game mechanics usually follows a chain of logic, providing players with an opportunity to break down a large complex problem into pieces and go through them step by step. For instance, it is common for players to encounter several locked boxes before dealing with the locked doors in mobile room escape games such as *Cube Escape*. This is to reduce players' cognitive load and manage a proper level of difficulty.

The design of limited or unlimited trials targets players' "trial-and-error" strategy. Trial-and-error is the process that a series of trials is implemented until the erroneous random responses to a problem are replaced by the correct one (OED). Young (2009) connected the players' modes

of trials with the expected and realized payoffs the players get, and presented two modes of interactive trial-and-error learning in games: (a) players keep working on a strategy until they get satisfying outcomes if they feel it will lead to an expected payoff; (b) players randomly search for new strategies and settle on one with the highest probability if they find (a) fails to do so. The two modes are both practiced in mobile puzzle games such as *Cut the Rope*. Players can keep the previous cutting solution with minor adjustment of the cutting position if they feel this leads to the expected payoff, namely, completion of the level, otherwise they can try different ways of cutting the ropes in an unlimited number of times until they get anticipated outcomes. However, there are also disputes over the design principle of "trial-and-error". Game researchers pointed out that the gameplay mostly relied on one single correct solution (Syufagi, Purnomo, & Hariadi, 2012), which may not enhance the individualized way of solving a problem.

The design of simulated reality environment in mobile puzzle games brings players about the possibilities of using "analogy" strategy to solve a problem. Analogy in cognitive science refers to "reducing a new problem to an existing or similar one for which solutions have already been known" (Wang, et al., 2010). The analogy mapping between the gameplay and subject matter content (the reflection in real life in the context of this article) in puzzle games enables game learning and subject matter learning to be transformable (Martin, Silander, & Rutter, 2019). Puzzle platformers is a subcategory of mobile puzzle games that could offer a chance for players to go through cognitive processing in both directions: (a) players use existing real-life knowledge to tackle the puzzles in the game; and (b) players take what they have learned in the games to solve real-life problems. For instance, daily objects such as glass and wheels are embedded into the game *Limbo* so that the players know how to go through an obstacle (e.g. breaking the glass) while moving on the platform in the simulated game environment. And the solutions, such as

manipulating the rocker and dragging the boat onto the land, may trigger inspiration when players encounter similar situations in the real world.

4 Discussion and Conclusion

As mentioned above, we summarize the impact of different design mechanics of mobile puzzle games such as subtasks, trials and simulated reality environment on three problem-solving strategies of divide-and-conquer, trial-and-error and analogy. It is not hard to tell that many interesting tasks or level settings in mobile puzzle games can effectively improve the players' problem-solving abilities, and can help improve the educational aspects of mobile games.

Gaming is enjoyable, and its pedagogical implications deserve more attention from the perspective of game design. Mobile puzzle games, designed with specific instructional purposes, can also be utilized to facilitate players' problem-solving strategies. Referring to several popular mobile puzzle games such as *Candy Crush*, *Monument Valley* and *The Room*, there are abundant thoughts on effective game design: scoring and hint mechanics, interrelating scenes and pieces, virtual locations, magic and horror in different themes, etc. If designers are able to combine these innovative design ideas with the goal of enhancing the players' cognitive abilities, the educational implementation of mobile puzzle games will be further developed.

To sum up, we also identified two research niches. First, previous studies have not paid much attention to the difference between desktop and mobile puzzle games. Second, there is a strong need to refine the subcategories of mobile puzzle games (e.g. mobile room escape games) and their corresponding effects on learners.

Design Document

1 Introduction

1.1 Background

There are many potential hazards that may occur in the home when people do not realize certain situations to be dangerous. According to Injury Facts (2017), Home and community deaths in the US rose from 52,700 in 1999 to 127,300 in 2016, with the death rate increasing from 18.9% to 39.1%. Major causes of preventable injury-related deaths include positioning, falls, drowning, fires, flames and smoke, and so forth. Kitchen accidents involving gas explosion, burning, scalding, etc. have brought fatal outcomes to households (Thompson, 2005). Expositor (2001) also pointed out that bathrooms can be one of the most dangerous rooms in the home where falls always occur due to a wet slippery floor. Unexpected dangers take place all around in the home. However, people are not always aware of these dangers and their preventions, since schools do not offer specific home safety courses, and the internet as a major source of safety rules usually provides too long a list to be remembered. It is worth special attention for people with less life experiences to protect themselves and their households from fatal domestic accidents.

1.2 Problem Statement

Many people have little knowledge about safety in the home, and it is thus necessary for them to learn more about safety rules to protect themselves from home accidents. However, they lack effective tools and alternative ways to get engaged and remember those rules.

2 User Analysis

2.1 Target Audience

Our target audience is people aged between 15-30 who would like to know about potential dangers in the home and corresponding precautions, and who probably feel bored to read about traditional safety rules. We target this group since they are relatively young, and may thus make mistakes due to the lack of practical experiences in chores and housework.

2.2 Personas

Xueting, a 23-year-old female from China, is currently a graduate student at Teachers College. She has never cooked by herself or lived alone before she came to New York. She is nervous about cooking and using electrical appliances, and has met lots of difficulties since living abroad. She is willing to learn some tips to help her in daily life and cooking.

Allison, a 27-year-old female from the US, is also a graduate student at Teachers College. She loves cooking and has lots of experience in cooking, baking, and steaming. Even if she claimed to have good knowledge of home safety, she made dangerous mistakes sometimes. Therefore, she would love to know more about safety issues since she feels they are of great importance.

2.3 User Scenarios

Xueting, 23, Chinese, has lived with her parents and grandparents since childhood. She has almost never done housework at home before. Now it is her first time of being far away from home and living alone. She found herself facing lots of difficulties in daily life. She does not know how to cook, but she has to do that by herself now. When she was once cooking, she left the pot on the stove in the dorm kitchen and went back to her own room. Then the smoke set off the fire alarm due to overtime boiling, which made her realize that it was urgent for her to learn about safety rules. Two months ago, she heard from her roommate that a full egg could not be put into the

microwave oven directly, and she had never learned such tips before. She hopes to learn about safety tips such as “heating a full egg in the microwave oven can lead to explosion”, but finds it troublesome if she has to search on the internet each time she does something unfamiliar.

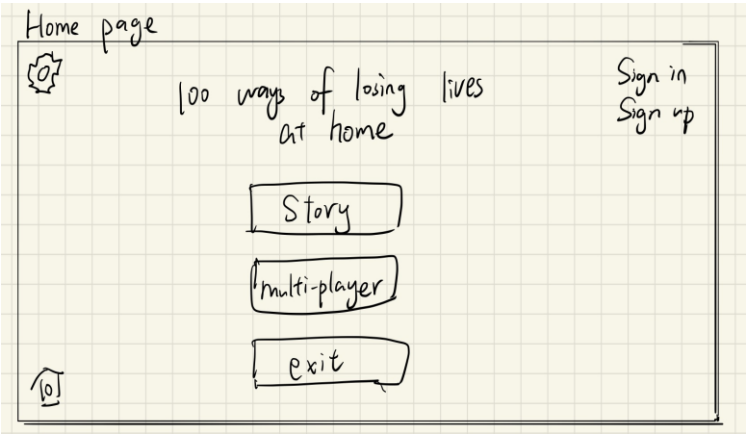
Allison, 27, American, was born into a family with three children, and is the youngest family member. When she was born, her two brothers were at the age of 15 and 20, and her parents were over 40. As she grew up, she always followed her parents and brothers when they were cleaning the house, mowing the grass, etc. And she became very familiar with the chore stuff. However, Allison has still experienced some dangerous situations. Once she set the oven on a small fire when baking bread, and still did not know why that happened. She thinks that learning from mistakes and experiences is impressive and effective, especially in the field of cooking and housework, but would expect to experience them in a safe and assured way.

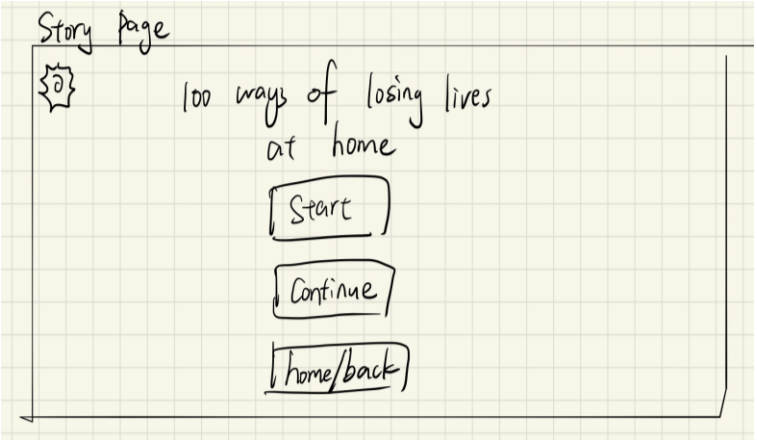
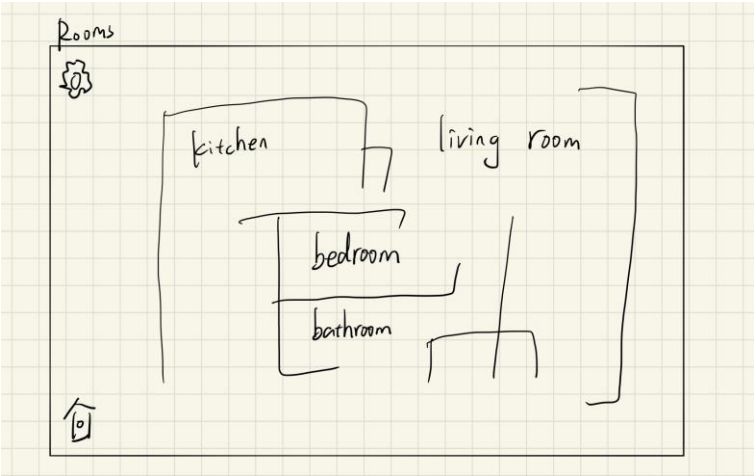
3 Solutions

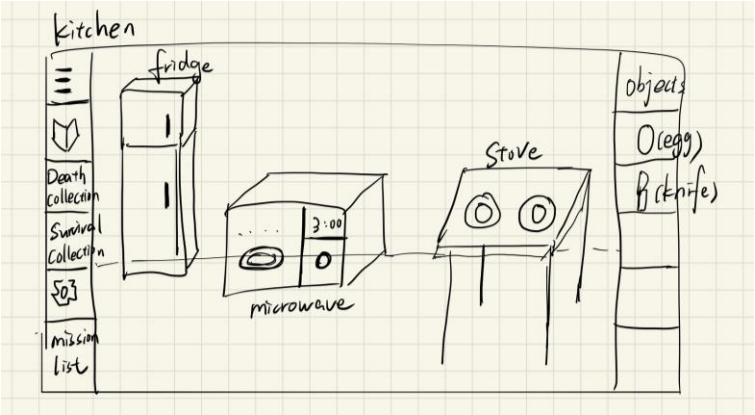
Based on our previous literature and research review, we chose mobile puzzle games as our delivery media. We identified that finding safe and correct ways of cooking and doing housework was a form of problem solving, which can be effectively facilitated through simulated puzzle games.

3.1 Paper Prototype

We first made a paper prototype as a wireframing model of our mobile game, including user interfaces, main functions, and major tasks (storyline). Following are the descriptions of each page of our paper prototype.

Paper Prototype	Description
	The main body of the home page shows the title of our game: “100 Ways of Losing Lives at Home”, and menu buttons including “Story” “Multiplayer” and “Exit”, indicating that our game can be played in both single-player mode and multiplayer mode. For the rest of the layout, the settings icon is in the top left corner, the home icon in the bottom left corner, and the sign-in and sign-up icons in the top right corner of the screen.

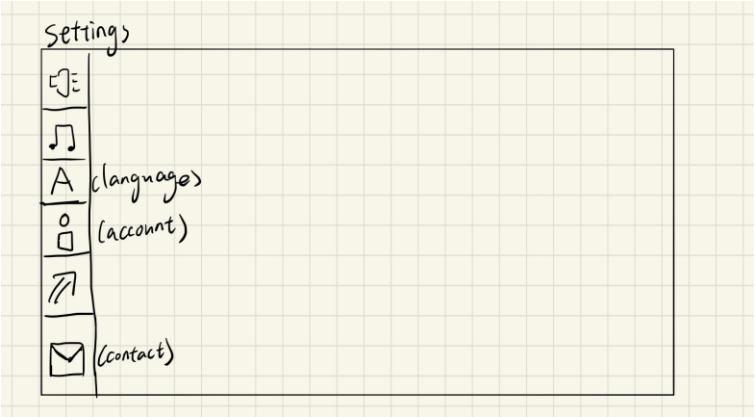
	After the users tap the "Story" button, the game will switch to the story page. There are three buttons showing up in the middle of the screen: "Start" "Continue" and "Home/Back". Users can choose to restart the game or enter a previously saved level.
	After the users tap "Start", a map including multiple rooms of a house will show up. Users can choose from different room areas on the screen to enter a certain room setting/scene, and then solve puzzles, complete missions, and collect different emblems for death and survival experiences.



In the kitchen scene, the main body of the interface is the common furniture sets in the kitchen, including a refrigerator, a microwave oven, and a stove.

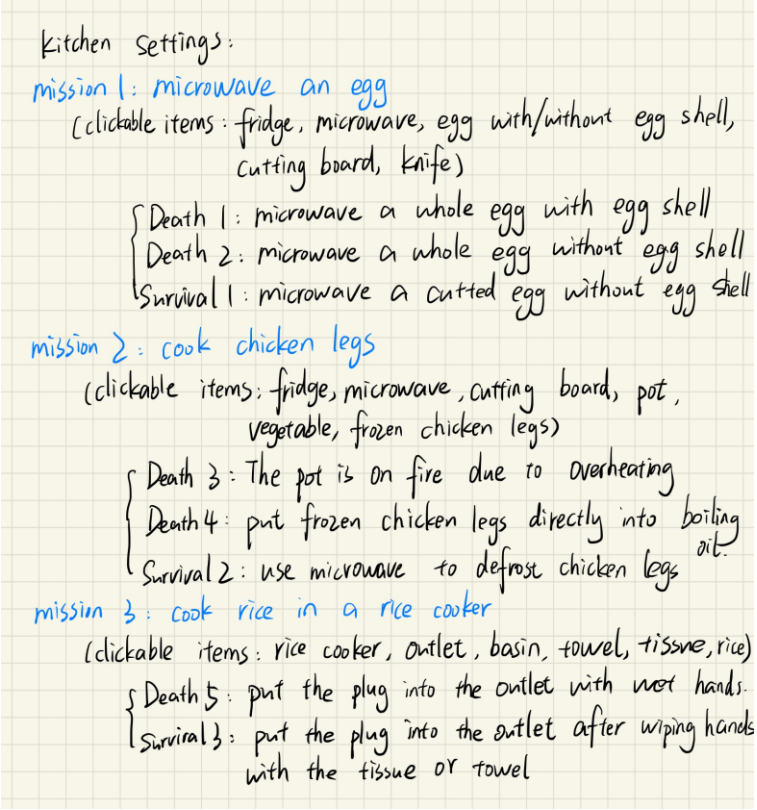
Different missions and mission descriptions will pop up on the screen. According to the mission requirements, users can tap the items in the room to collect required objects. Collected objects are presented in the inventory on the right side of the screen.

On the left side of the screen, there are several icons representing “wiki” “death collection” “survival collection” “settings”, and “mission list”. Users can view their game progress in the “mission list”, and learn about safety tips by tapping “death collection” “survival collection”, and “wiki”.



After tapping the “settings” icon on the left bar, several sub-items will be unfolded, such as “sound effects” “background music” “language” “account” “share”, and “contact us”.

Users can check their friends’ information and game progress inside the “account” section.



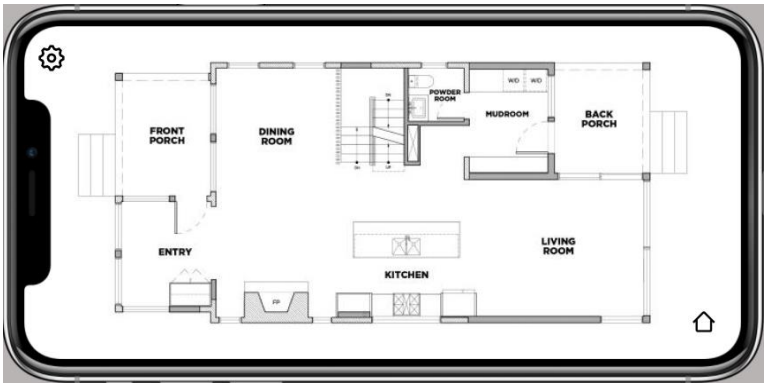
This information page shows the descriptions of some missions that we have designed for the kitchen scene.

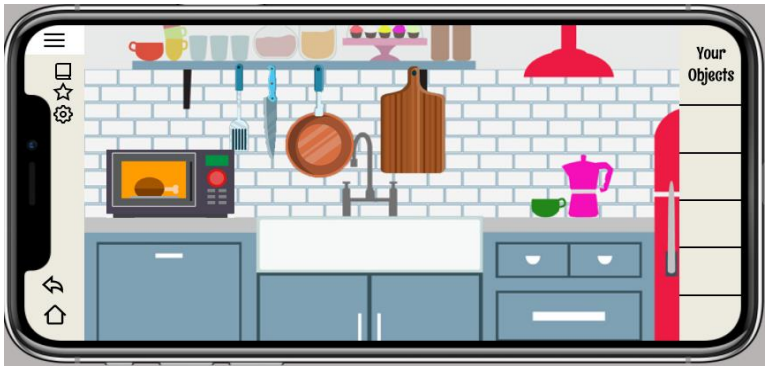
Some possibilities of death and survival are also included in the descriptions.

3.2 Digital Prototype

After finishing the paper prototype, we designed the first digital prototype with Figma, presenting the first mission of microwaving an egg with two ways of death and one way of survival. Then we conducted user tests, including observing players during the gaming process, interviewing them afterwards, and asking about their feedback about our digital prototype. The modified and improved prototype is shown below.

Digital Prototype	Description
	The start page of the prototype consists of the logo, “HOME SAFETY”, the game title, “100 Ways of Losing Lives at Home”, and three menu buttons. Users can tap “story” to enter a single-player mode, and “multiplayer” to enter a multiplayer mode. There is a settings button in the upper left corner.

	In the single-player mode, users can start a new game, continue a saved game, or return to the home page. To sign in through other social media accounts is available.
	Just as the paper prototype, the main interface of the game is a house map, with a clickable kitchen area.
	Complete the first mission: microwave an egg.
	To complete this mission, users will enter the kitchen scene. On the left are the basic functions users may need, and on the right



are the collected objects that users are able to interact with.

The kitchen setting can be zoomed in or out.

Design rationale: Icon alignment should depend on the size and type

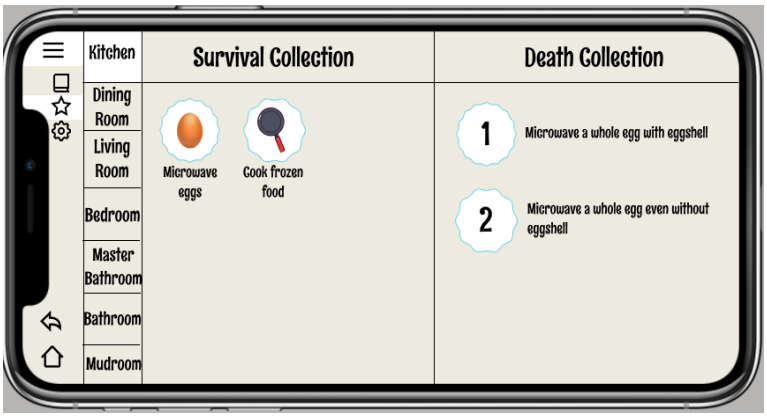
of different mobile devices.

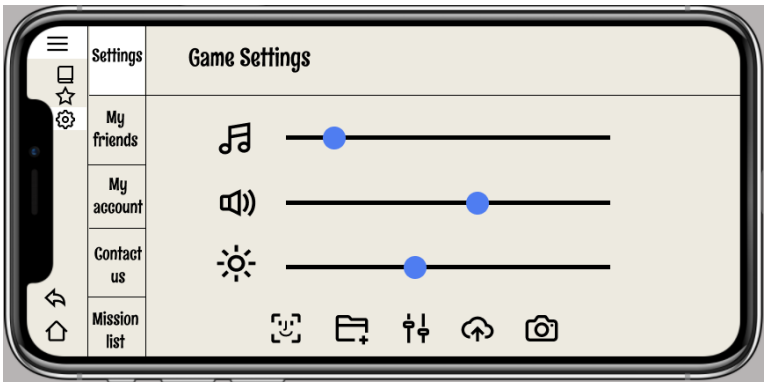
(Continued)

The three basic icons on the left are a wiki icon, a collection icon, and a settings icon.

After tapping the wiki icon, users can check a list of home safety tips whenever they want.

After tapping the collection icon, users can check their death collections and survival collections in different room settings (levels), which represents





their knowledge and understandings about home safety.

After tapping the settings icon, users can change the game settings such as volume, background music, lightness, etc. They can also view friends' game progress and information, send feedback messages, and check the mission list in the settings page.

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To complete the mission "microwave an egg", users first tap the fridge to open it and find a basket of eggs inside. An egg can be collected into the inventory on the right.

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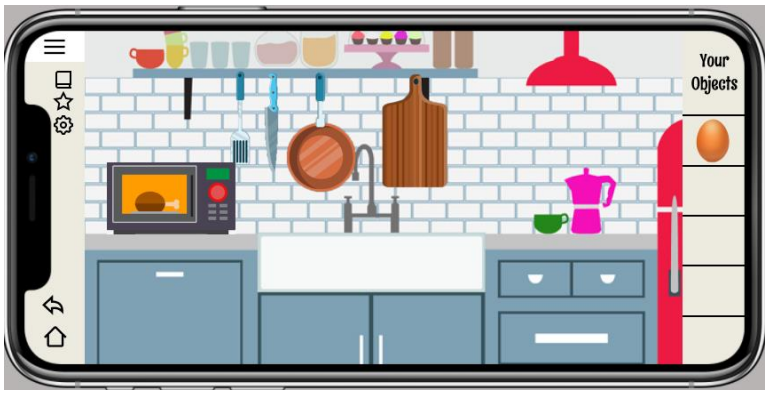
<td> 


</td>
<td>With similar navigations, users can zoom in on the screen and collect a knife.</td>
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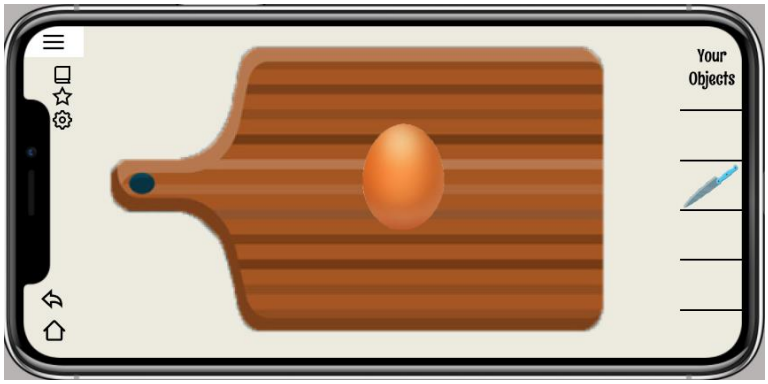
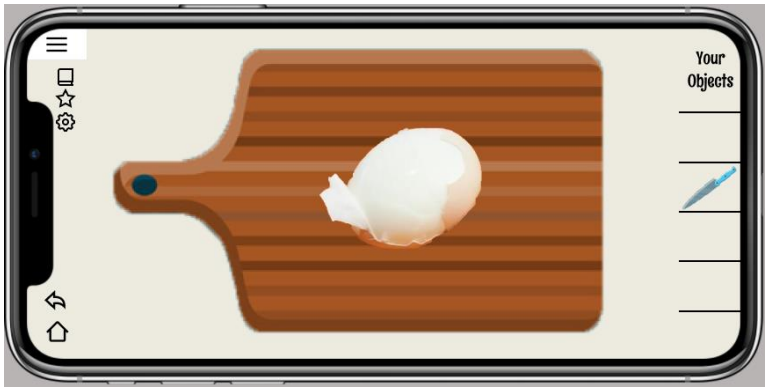
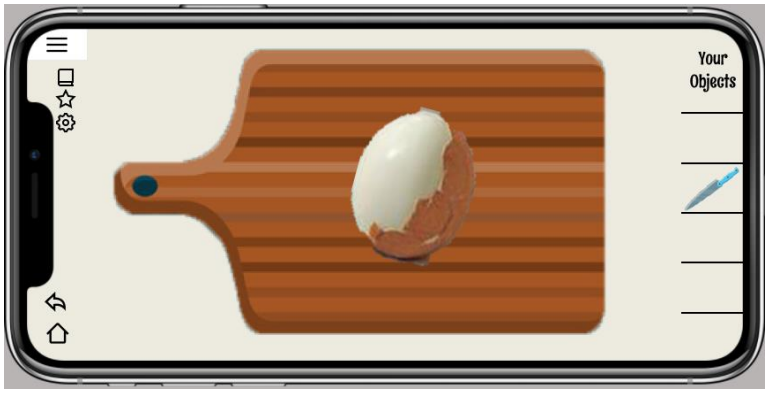
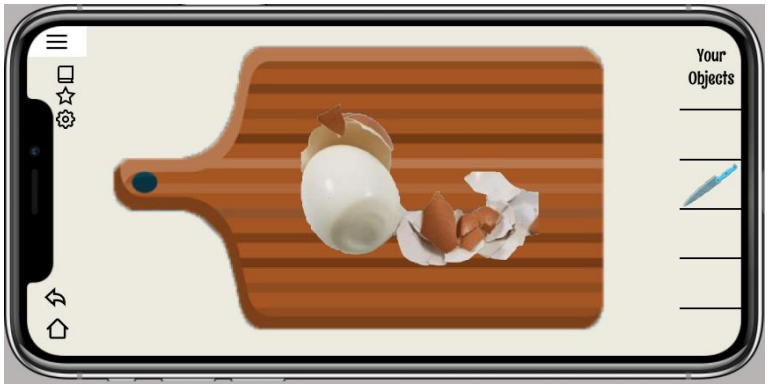
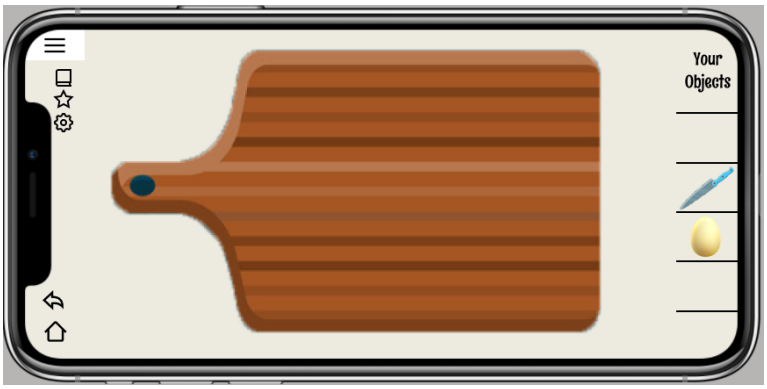
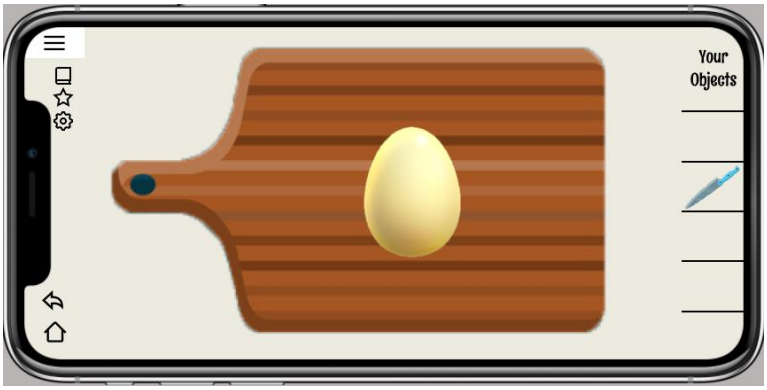
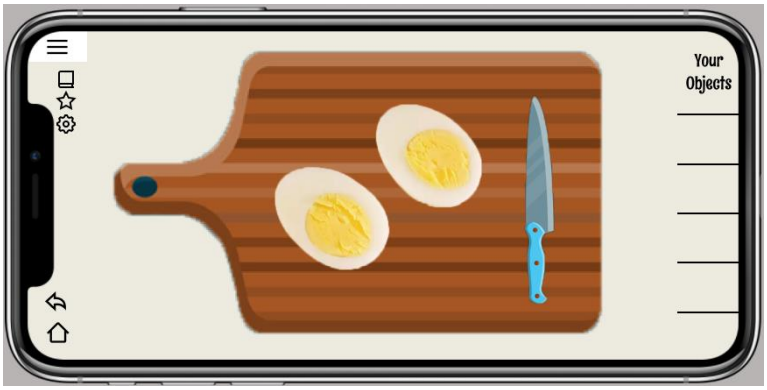








Then users can peel the egg shell on the cutting board, and collect the egg without eggshell.

(Continued) 	
  (Continued)	Next, users can drag the knife and the peeled egg they have collected onto the cutting board, and cut the egg.

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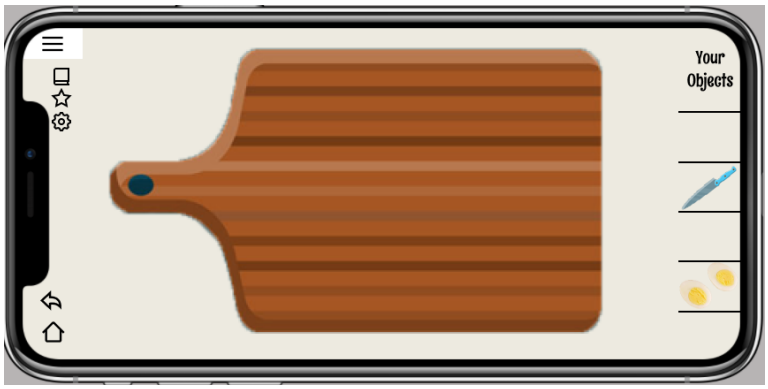
<td> 
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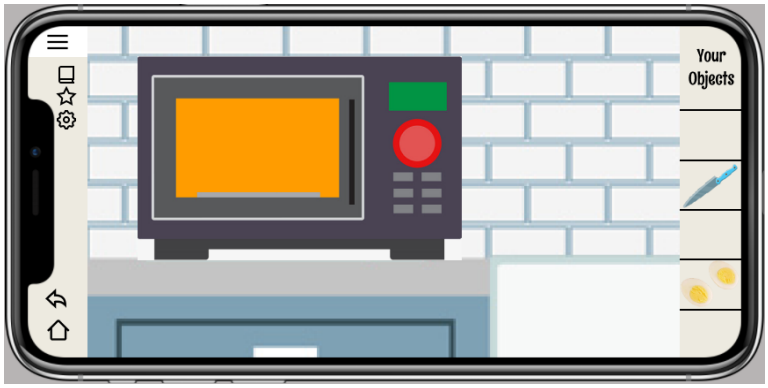
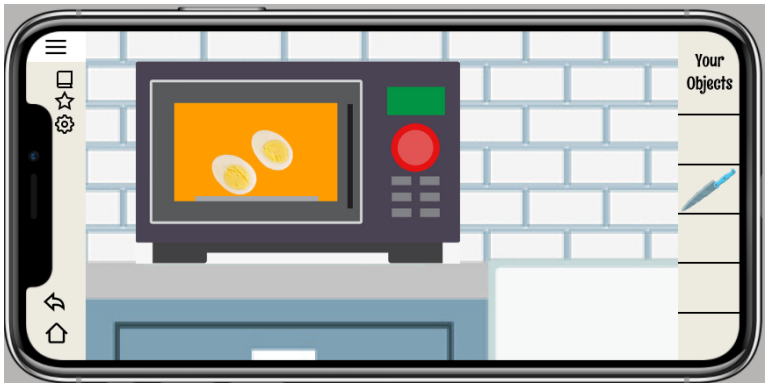
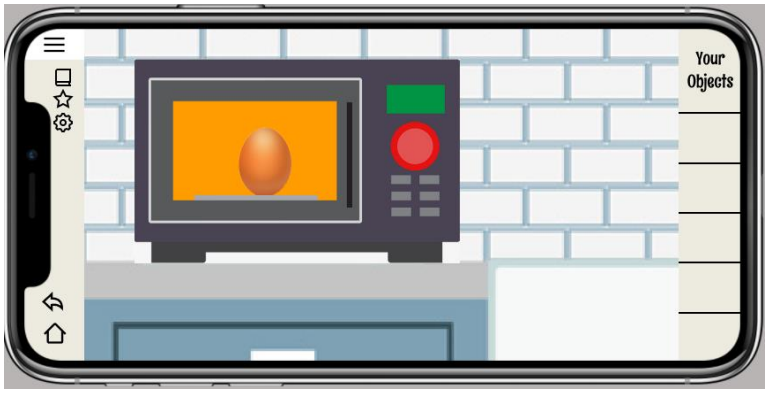
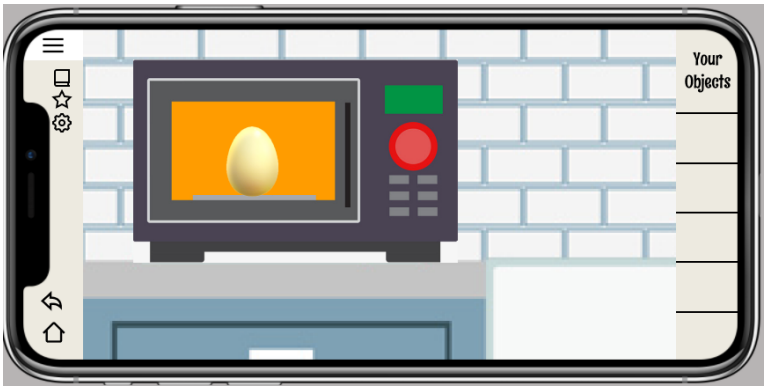
<td> 


</td>
<td>For the last step, users can tap the microwave and put the cut egg in it. Tap the red button on the microwave to heat and complete the mission of microwaving an egg.</td>
</tr>
</table>

	The users will receive a prompt message indicating that the first mission is completed, and will gain a survival collection. Users are able to tap “next” to start another mission, “replay” to replay this mission, and “home” to return to the home page.
  (Continued)	If users put a whole egg into the microwave without peeling and cutting it, the screen will fade into black, indicating the player has died. Users will then receive the prompt message showing the mission fails. Tap the bulb icon to check the hint, collect the first way of death and remember it! Users are able to tap “replay” to go through this mission again and tap “home” to return to the home page.



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Similarly, users will collect another way of death after doing wrong in another way (microwaving a whole egg only without eggshell).


YOU DIED!!!
REPLAY
HOME


No.2 way of losing life:
Microwave a whole egg even without eggshell
REPLAY
HOME

3.3 Digital Demo

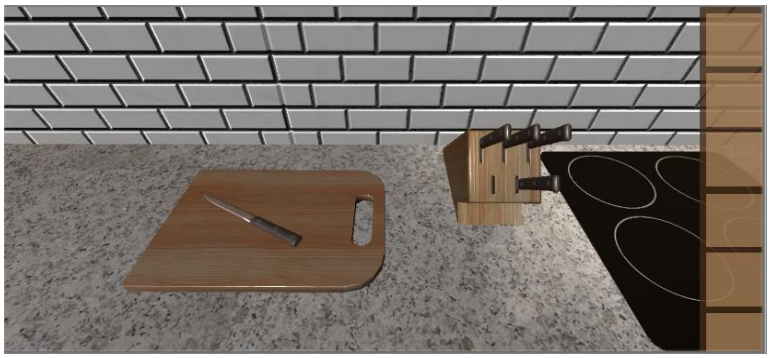
After digitizing the mechanics of our home safety game with Figma, we created a playable demo with Unity 3D. The simulation of home environment offers a realistic and immersive learning experience to players. This also aims to practice the design differences between PC and mobile devices, and explore the compatibility of navigation on a smaller touch screen without keyboard and mouse input.

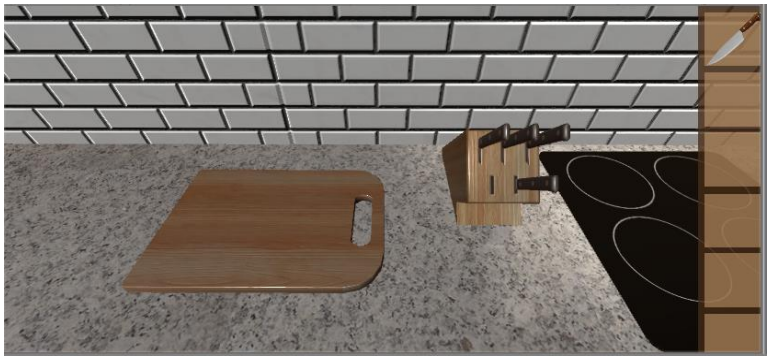
Digital Demo	Description
(original version) 	Originally, we set up a first-person scene. Players control their movement by a bottom-left joystick and slide on the remaining space of the screen to look around. However, during the user test, users reported a dizzy feeling when manipulating this way, which can be attributed to the incompatibility of joystick movement within a small space, so we changed to the camera movement.

When we figured out that camera movement could be a more steady choice for mobile devices, we limited the random movement of players, and enabled only the screen-sliding behavior to look around in the scene.

Players can approach objects they would like to examine by tapping the target on their screen, and the camera will shift automatically.

We use a double-tapping detector on touch screen when users open up things such as drawers, closets and refrigerators.





Without key character input and right-click function on mobile devices, players can hover on the objects they would like to collect for a second, and then can collect them into the inventory on the right.

More to be accomplished and improved...

4 User Test

4.1 Observation

During the user test of our first Figma version of the digital prototype, we observed that the users enjoyed themselves in the gaming process and their interaction with different objects such as the egg, the knife, and the cutting board. But since the interactable nodes in the prototype were not complete and perfect, sometimes users clicked on areas that were not clickable and became confused about what to do next.

Moreover, in our first version of the digital prototype, we assumed that all users would complete the mission in a specific sequence: collecting an egg - peeling the egg - collecting the knife - cutting the egg - putting the egg into the microwave. However, some users did not follow this sequence. They peeled the egg after collecting the knife, which did not affect the completion of the mission, but we need to consider this situation and others alike in the design process.

4.2 Interviews

We interviewed several users after playing our game. They reported that our game was highly playable, that the interface design was nice and exciting, and that the logic of the game was relatively clear. It is a moderately successful attempt for mobile learning.

They also mentioned some features for improvement. First, icon alignment should depend on the size and type of different mobile devices. For example, we have chosen the iPhone X as the ideal publishing device for our Figma prototype, which means that we need to reconsider the icon placement to fit into the irregular screen edges of the iPhone X. Second, they suggested that as a tool of learning, our game should be available for users to check and search essential home safety tips even when they are not in the gaming process. As a result, we enriched the “wiki” function based on their suggestions.

4.3 Feedback

After the observation and interview process during the user tests, we followed the suggestions collected and then improved our design. We made the second version of the Figma prototype and the first version of the Unity demo. We presented our digital prototype and Unity demo during class time and gained some feedback from our instructor and classmates.

Our classmates were impressed with our game and the tone of black humor, and were reminded of another famous game. They thought our game had great value and hoped that we could continue to work on the demo. They also pointed out that the topic of our game was novel and made them realize the importance of home safety in a fun way. Our instructor provided valuable feedback as well. He acknowledged that the name of our game, “100 Ways of Losing Lives at Home”, could attract people’s attention, and the mechanics of collecting death and survival emblems in the gaming process could also appeal to our target users effectively. Besides, based on the topic and the tone of our game, a 2D demo of the game could be more suitable since it enables users to have a more relaxing and fun experience beyond a realistic environment.

5 Strengths and Limitations

Our design has the following strengths:

a. Using black humor to raise awareness, as well as digitizing and gamifying detailed rules to be user-friendly
b. Breaking through the one-solution mechanic of traditional puzzle games, and prompting varied logics and constructivist learning of different players
c. Enabling multiplayer collaboration based on the capacity of social media, and enhancing connectivist learning

However, there are still limitations to be solved and improved:

a. Our mobile game does not support a keyword search function, and players have to refer to the “wiki” function to browse through all the tips.
b. An associated and absorbing storyline is still under development to link all the rooms and relevant missions together.
c. Players might generate a sense of over-uncertainty and horror at home after playing the game.

6 Reflection

For the design work, we have realized the importance of iteration and user tests. Users may not be able to point out exactly what they want at the preliminary stage of generating product ideas, but they definitely know what they do not want or what goes contrary to their intuition in the testing stage. Moreover, it is significant to make the presentation of a work best fit the core ideas to be delivered. Therefore, we will probably revise the Unity demo to be a 2D and less realistic game to exaggerate the humorous effect and stay consistent to our theme.

Finally, we really appreciate each other’s support and hard work during the three-month time. It has been a wonderful journey to experience an entire research, design and testing process in the course. And hopefully we can spark more ideas and work on them with the skills learned in future design.

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