Employing a User-Centered Design Process to Create a Multiplayer Online Escape Game for Older Adults

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Abstract. The purpose of this study was to explore a user-centered design (UCD) process to create a multiplayer online escape game with embedded learning content for older adults. Older adults aged 65 and over were involved in the needs assessment and prototype evaluation. The needs assessment assisted the researchers and developers in understanding older adults' social interaction in real-life escape rooms, which resulted in a list of design recommendations for the online escape game. The findings of prototype evaluation illustrated that older users enjoyed the theme of classical literary work, crossword puzzles, and the format of dual play. It was also found that our UCD process could not effectively address all design challenges of developing a digital escape game for older adults.

Keywords: Older adults · Escape game · Life-long learning · Social interaction · Puzzles

1 Introduction

1.1 Learning in Later Life

The population all over the world is ageing [1]. Later life is defined as "the stage in life when a person is no longer primarily involved in the labour market, raising a family, or both" [2, p. 7]. Terms such as "older adults", "third agers", and "fourth agers" have been used to refer to people at this stage [2]. By review the concepts of active aging, productive aging and successful aging, Merriam and Kee [3] emphasized that older adults should not be considered as uselessness, or frailty. Due to the increasing longevity, good health, and improved quality of life, a large number of older adults are still active and participative [4]. In spite of cognitive decline, older adults are still capable of learning [5]. Real-life learning allows older learners to draw on prior knowledge, expertise, motivation, and strategies, which are products of life experience [6]. Research has suggested that lifelong learning is tightly associated with sustained cognitive function [7, 8], as well as maintained social interaction to society [9]. Participation in learning activities is beneficial to older adults' physical and psychological wellbeing [10]. It provides opportunities to try new things, reduce stress and escape from life temporarily [11].

Learning in later life is qualitatively different from learning experienced in the past and by children and younger people [9]. The time factors are unique to older adulthood

and influence approaches to learning [12]. Older learners are highly selective and self-directing [13] and prefer to take charge of their learning [10]. Their choice of learning is no longer determined by career goals [14], but is connected to their personal interest and growing [5]. Learning new things about a long-term interest or hobby and for fun and enjoyment (also called leisure learning) is one of the three types of learning needs to older adults [15]. They are less interested in examinations, certificates or degrees [10]. Adult education and life learning is usually through non-formal (e.g., book club) or informal (e.g., a long-held interest) means [3]. Older learners are satisfied when making achievement, and are not concerned about how long it takes them to complete the learning task [12].

1.2   Social Interaction for Successful Aging

Social engagement is a core component of successful aging [16]. It enables older adults to deal with the stress of negative life events [17], as participation in social activities provides a social context for social support, self-regulation of stress and negative emotions, and reappraising lives [18]. People who feel supported during times of need have a stronger sense of meaning in their lives [19]. Both structural (i.e., the number and type of social partners in a given network) and functional (i.e., the perceived receipt of support) aspects of social networks contribute to emotional wellbeing [17] and mental health [20], and are associated with higher levels of cognitive functioning [21]. Research also shows that people with positive emotional experience are at lower risk for morbidity and mortality [22, 23].

1.3   Game-Based Learning

Digital games have a substantial influence on how we spend our leisure time [24]. Playing digital games has become a popular leisure activity for children, adolescents as well as adults [24]. In the last decade, research efforts have been made to explore the potential and benefits of digital games for the purpose of learning and instruction [25]. Digital games are hypothesized to affect learning by increasing intrinsic motivation and stimulating the cognitive processes [25]. Games include the most important factors that intrinsically motivate players to engage in appealing activities which could help them to learn, including challenge, curiosity, and fantasy [26, 27]. Factors such as meaning, autonomy, and competence also contribute to the moment-to-moment experience that is inherently enjoyable and appealing [25], a state which can be described in terms of Csikszentmihalyi's [28] flow experience.

   Digital games appear to provide learning activities that are active, experimental, situated, and problem-based [24]. Gee [29] argued that digital games are good for learning and identified sixteen learning principles built into good games. Digital games are also virtual environments where performing the game tasks involves the same cognitive processes that are required for task performance in the real world [30]. Prensky [31] offered examples of what children can learn about real life from games, indicating that skills obtained from games, such as problem-solving, are useful in real life. Digital games for learning have been used across a variety of subject disciplines such as

mathematics, engineering, language, history and business [32]. Vogel et al.'s [33] meta-analysis study suggested that digital games yielded higher cognitive outcomes than did conventional learning methods. Wouters et al.'s [25] meta-analysis study found that digital games were more effective in terms of learning and more motivating than conventional instruction methods.

1.4   User-Centered Design

User-Centered Design (UCD) is a broad term for "a philosophy and methods which focus on designing for and involving end users in the creation of computerized system" [34, p. 12]. It was originally used to transform complicated and professional technologies in industry for real-world application and for people without professional knowledge [35]. The users' needs, the goals of the activity and context should guide the development [36]. The creation process should be both iterative and incremental [36]. The iterative design is corresponding with three phases of iterative testing with end users. This usually includes conceptual model evaluation before coding, prototype evaluation to get early feedback about its usability, and product evaluation after the interface is ready [37]. A wide range of methods (e.g., paper sketches, mock-ups and prototypes) can be used to support the creative process, elicit requirements and visualize ideas and solutions, but the principles, methods and the order of activities must be adapted to the particular context [36].

The meaningful participation of end users is important to a UCD approach. However, there has been a lack of a consensus about what constitutes a UCD, and how central users should be in the creation process [38]. Lowdermilk [39] indicated that a UCD does not mean offering users what they want. Users may be experts in terms of usage, but they have little knowledge on how to effectively design complex systems and deliver information [39]. There is a wide range of ways in which end users can participate in a UCD design, and can be involved in one way or another, such as participation in requirements gathering and usability testing, or being involved as partners with designers throughout the design process [34].

2   Research Purpose and Question

The number of older adults who are active gamers has been increasing in recent years [40]. The entertainment and motivating features of digital games and the potential of digital games for effective learning are in line with older adults' needs of leisure learning. Digital games can be designed to contain some elements that have been identified as important to older adults' enjoyment, including mental fitness, competition and winning, fitting their time in a way that provide satisfaction, and a sense of belonging in social games [41]. Civilization and SimCity are two examples of commercial digital games for learning. However, they are not specifically targeted at older adults. There is shortage of practice focusing on designing digital games for older adults' learning.

Real-life escape games are adventure games in which a group of players are locked in a room with the goal of seeking clues and solving puzzles tied to a story or theme to

escape the room within a time limit, usually in one hour [42]. The first real-life escape games were developed in the mid-2000s. By 2015, over 2800 room escape venues are in operation worldwide, making it a lucrative game business [43]. Real-life escape games are also viewed as a type of alternate reality games (ARGs). ARGs are "immersive, interactive experiences where players collaboratively hunt for clues, make sense of disparate information, contribute content, and solve puzzles to advance a narrative that is woven into the fabric of the real world" [44, p. 26]. All players are at the center of the story and have direct influence over the actual outcome of the story [45]. Research has shown that in order for a game to promote learning and increase motivation, the design of a game must provoke a sense of autonomy, identity, and interactivity [46]. It should also enable players to strategize actions, test hypotheses, and solve problems [47]. Seeking clues to resolve challenging puzzles collaboratively allows players to immerse in the narrative and escape the room by testing hypotheses, changing strategies, and trying again. Thus, playing escape game provides opportunities to increase older adults' motivation, learning, and social interaction with other players.

The purpose of this study is to explore a UCD process to create a multiplayer online escape game for older adults with learning content embedded. This research can offer insights on the effectiveness of a UCD process that leads to the development of useful products and services for productive aging.

3   Research Design

In this study, the research team who co-authored this paper, along with five game developers and a large group of older adults aged 65 and over, participated in the design, implementation, and evaluation of a multiplayer online escape for older adults. Figure 1 shows the UCD process we employed to create the game. The game developers used Unity game engine and Adobe Photoshop to design and develop the game.
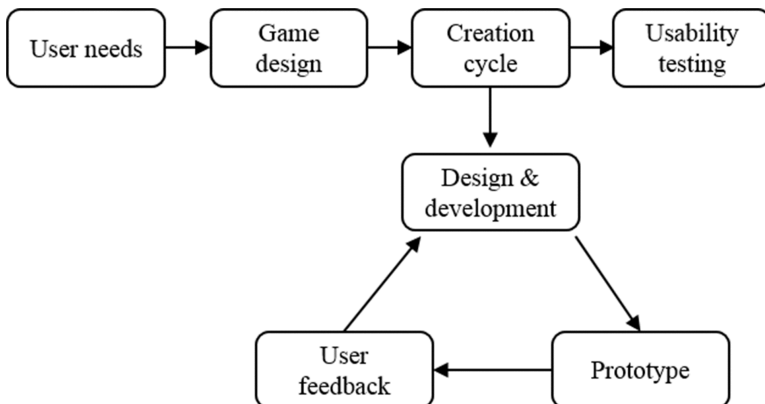

Fig. 1. The UCD process to create a multiplayer online escape game for older adults

This study followed the following steps:

- *User needs assessment*. There is a lack of study examining how players interact with each other in real-life escape rooms. Therefore, a face-to-face escape game study was conducted to understand the needs and interaction of older adults in real-life escape games.
- *Co-designing game ideas*. The research team and the game developers co-designed the game ideas.
- *Creation cycle*. The research team, the game developers, and a group of older adults were engaged in an iterative process to create the game.
- *Usability testing*. A usability test will be conducted to understand how this game meets the needs of older adults.

4   The UCD Process

4.1   User Needs Assessment

The needs assessment of the target users consisted of two phases, in order to explore whether variables such as the number of players in an escape room, their characteristics, and a given escape room design would affect the players' interaction. In the first phase, three groups of older adults played two different real-life escape games: two small groups of four players and a larger group of six players. In the second phase, two intergenerational groups played the same two escape games as those in the first phase. Each intergenerational group included two intergenerational pairs (i.e., grandparents and younger family members). A focus group interview was conducted after every game for each group. Table 1 presents the findings of the needs assessment and corresponding design recommendations for a multiplayer online escape game.

Table 1. Findings of user needs assessment and corresponding design recommendations

Findings of user needs assessment	Design recommendations
Depending on their personalities, some people liked the time limit, but some did not	Allow the players to set the time limit based on their pace and needs
Dim lighting of the room, which was part of its design, made it difficult for older adults to see	Make fonts and other elements large enough so that the players can easily see them
Hints provided by the escape room's staff were useful	Provide hints during the game, so that older adults can search for help when they do not know how to proceed
The players appreciated the realistic historical themes which allowed them to get more immersed into the story	Design puzzles and room elements that are realistic for the story chosen
They tended to enjoy the room more when they achieved more success and proceed in the game	Focus on the successes in the room is just as important as the themes. Gradually increase the difficulty of the puzzles to promote self-efficacy and sense of achievement
The players enjoyed rooms with stories that were immersive	Create an immersive story where they feel they can influence the end result
Different people enjoyed different puzzles. Some liked word puzzles, while others preferred math or sorting puzzles	Include a wide variety of puzzles that include letters, words, numbers, mechanical skills, etc.
Although players were supposed to explore the escape room and seek clues as their own ways, older adults preferred to doing things systematically and exploring the room by following specific steps in comparison to younger people	Provide clear guidance to help older adults understand the purpose of the game
The players enjoyed the experience more when the storyline and the instructions were clear to them before playing the room	Have clear instructions and storyline
The communication among all group members was not well-organized. They did not take up the roles of leaders and followers	For a multiplayer game, a chat function or even a video chat function is useful. Design different roles to allow them to work together to solve the puzzles and facilitate group coordination and collaboration
The players enjoyed moments when the team came together and solved an important puzzle	

4.2 Co-designing Game Ideas

At this stage, older adults did not participate in the design of game ideas for two reasons. On the one hand, the social and emotional meanings of gameplay among older adults are divergent [48]. On the other hand, previous study has already identified the learning interests of older adults such as literature, history, religion, and political/world events [49]. Therefore, the game ideas of this study were co-designed by the researchers and developers. Classic works of literature were chosen as the theme with embedded learning content, because it is familiar and interesting to the older learners [49].

The game is entitled, *A Tale of Tales*. The basic storyline starts with a game character called Ink Monster who drinks the words out of the pages of the players' favorite stories so that they have to seek clues to resolve puzzles in order to recover the stories stolen by the Ink Monster. One room (a maze in this study) is designed after a classic story (e.g. *Alice in Wonderland* and *Sherlock Holmes*) with puzzles that are related to that story. Currently, this game allows two distant players to play synchronously. Once entering a virtual maze, the two players will select the role of either the navigator or the follower. The navigator can see the whole maze and the locations of the puzzles (see the golden stars in Fig. 2), while the follower is situated inside the maze and needs guidance from the navigator. In addition, each player can only see parts of the puzzles and clues distributed in the maze, which requires them to communicate and coordinate with each other to solve the puzzles and escape the maze.
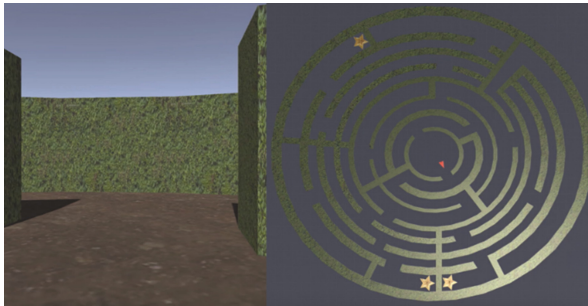

Fig. 2. Follower and navigator

4.3 Creation Cycle

The creation cycle was an iterative process. The game developers met with the research team every two weeks for a period of 13 weeks to show their prototype and receive feedback for the next iteration. Older adults were also involved in the prototype evaluation twice.

The first evaluation by older adults was conducted when the game was relatively playable but some puzzles had not been completed. The purpose of involving older adults at this stage was to receive early feedback about the design elements and the usability of the game. A total of 12 older adults aged 65 and over were paired up and played the prototype for one hour. Ten of them had played a real-life escape game. The two members of each pair were separated and communicated with each other via headphones. Since some puzzles were not completely developed, each older adult was offered a paper sheet including clues for the puzzles. Immediately after the first prototype testing, the 12 older adults completed a questionnaire with both open and closed questions, and then participated in a focus group interview. They mostly enjoyed the theme, crossword puzzles, the sense of accomplishment when resolving a puzzle, and working with their co-players for the same goal. Table 2 summarizes older adults' comments on the prototype and corresponding suggestions for further improvement.

Table 2. Summary of older adults' comments and suggestions for further improvement

Older adults' comments	Suggestions for further improvement
Need more rewards for solving a puzzle	Provide more information and rewards to motivate older adults
Want to know more about the levels and number of puzzles	Provide information about the game mechanism once entering the game, and highlight the puzzles in the maze
Figuring out the sequence was a bit frustrating	Exploring the sequence of the clues, resolving puzzles, and escaping the room are features that make escape games attractive. So, we decided to not provide information about the "steps", but to add a "Hint" button. Older adults can click the "Hint" button for clues when they do not know what to do
The second puzzle was too difficult	Order the puzzles based on difficulty level
Not enough information about what to do next	Explain the purpose of each puzzle; provide more directions once a puzzle is finished; create a tutorial video
Difficult to use the arrow keys	Provide keyboards and mouse so that older adults have more options

The second evaluation by older adults was carried out on a refined version of the game which had new features and fully functional components. The purpose of this evaluation was to get feedback for further refinement before the large-scale usability testing. Twelve older adults aged 65 and over participated in this evaluation. Seven of the participants were also involved in the first test, and five were new to this project. The processes of prototype testing and data collection were the same as the first test. The older adults found the tutorial video helpful to understand the gameplay, although they thought it was fast-paced. The five new participants also enjoyed the theme, the two-player format, and the crossword puzzles. No one had any difficulty in communicating with their partners. Eight of the 12 older adults reported that they would play this game again. Those who said they would not play it again argued that they already knew the puzzles and stories. Five older adults who used arrow keys or touchpads to navigate the game had difficulties with these controllers, while the other older adults who used a mouse did not report any difficulty in navigating the game.

Two shortcomings of the prototype game that most participants reported were lack of direction and insufficient context from the story. First, six older adults, four of whom had participated in the first test, encountered difficulties in understanding what to do next. The majority of participants reported that they still needed some clear, real-time directions and more feedback from the gameplay. For example, the exit door was barely noticeable to them. "If the door had opened automatically, we would know what to do after resolving a puzzle," one participant said. Second, they suggested that the game could include more stories and clues to sustain continued interest. Some older adults also provided feedback for improving the interface design. The following is a list of suggestions for further improvement:

- Provide clearer explanation and instruction
- Expand the game by adding more stories and clues
- Improve the real-time help hints
- Slow down the pace of the tutorial video
- Improve interface design to fit the characteristics of older adults
- Fix the bugs that may cause confusion, such as walking through the bushes

4.4   Usability Testing

The game developers continued working on the prototype for another two weeks to improve it based on the feedback from the second prototype evaluation by older adults. The research team and the game developers held two more meetings during this time to discuss the improvements and plan the next step, which is conducting a large-scale usability testing study to examine the extent to which the game can achieve the goals of this project.

5   Discussion and Conclusion

Escape games have the potential to promote older adults' social interaction and learning activities. However, real-life escape game is a new entertainment for older adults. There is a dearth of practice and research related to the development of digital escape games. Thus, this study aimed at developing a multiplayer online digital game for older adults based on a UCD process. The needs assessment was useful to understand older adults' social interaction in real-life escape rooms, and to generate a list of design recommendations for the online escape game. In this study older adults were not involved in the design of game ideas. Older adults participated in two prototype evaluations: the first one was conducted on an earlier prototype with limited playability, and the second one on a fully functional prototype. The timing of these two evaluations was determined by the research team and the developers. Older adults' comments and suggestions offered insights and directions for further improvement.

In addition, the findings of the two prototype evaluations indicated that they enjoyed the literary theme, crossword puzzles, and interaction with their partners. Crossword puzzle is something older adults are familiar with, and is one of their favorite entertainments. The core feature of this game is one person guiding another one and escaping the maze by communicating and collaborating with each other to resolve the puzzles. It was found that older adults enjoyed this format of playing in pairs because interaction with partners was easy. Each person had different views and could contribute to achieving a common goal.

However, providing useful instruction to help older adults understand the purpose and the tasks of the game was a design challenge. There are also other challenges that need to be addressed in further research. For example, how to enhance the features and core gameplay of escape games, but also make it clear for older adults what they need to do? How to design puzzles that are challenging enough for older adults, but do not frustrate them? How to design a variety of puzzles and individual escape rooms to sustain

older adults' attention? What graphics and other audio and visual elements to employ to create an immersive environment that is interesting to older adults with various needs? Some of these problems were already mentioned during the needs assessment (see Table 1), but they have not been completely resolved by the end of this project.

For the current study, the UCD process was useful to help the researchers and developers understand older adults' needs and get feedback for further improvement. However, the UCD process was not the key to resolve all design challenges discussed above. We have not conducted a large-scale test to evaluate the usability of the created game. Therefore, we cannot still assert whether a UCD process leads to usable products and services for older adults. However we argue that creating an online escape game for older adults requires an in-depth understanding of various aspects of the nature of older adults' play, as well as game design principles, such as game thinking, game elements, curve of interest, motivation, aesthetes, and the needs and challenges older adults would face during the game.

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