

User-Centered Design: An Effective Approach for Creating Online Educational Games for Seniors

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Abstract. To be effective, development of online educational games for older adults should be rooted in a user-centered design (UCD) process. This design approach is derived from computer ergonomics, in which the needs, expectations, and characteristics of users are taken into account at every stage of development. This differs from other approaches in that it seeks to adapt the product (in this case, an online educational game) to the needs and preferences of the end user rather than imposing characteristics imagined by the product's designers. In this chapter, we present the UCD process which allowed us to identify areas for improvement during the modelling phase (through testing a mock-up of the game on paper), the prototype phase (testing a limited version of the programmed game) and during implementation of the final version of the game (online testing of the full game). In our experience over the past 25 years, our online educational games have normally required two or three iterations to finalize a game's design. The results of the approach show that UCD considerably reduces the costs inherent in game design and development while ensuring a high degree of player satisfaction.

Keywords: Educational game, user-centered design, seniors, older adults

1 Introduction

Researchers [1-4] point out that the effectiveness of online educational games depends on the individual needs and characteristics of the players and that systems must be developed that are able to adapt to the needs of the target audience. An inappropriate design can act as a barrier to seniors' use of online educational games.

In order to develop an online educational game adapted for seniors, we first conducted a survey of seniors in Quebec and British Columbia to identify promising games to adapt [5]. The game Solitaire was identified as a favorite game of older adults.

In order to ensure that our Solitaire-based game performs well for our target population, we used user-centered design (UCD), which integrates an ergonomic approach into product development. This methodology makes it possible to identify the points to be improved at the different development stages: during modelling (building the game in paper format), prototyping (programming the game on a computer), and building the nearly-finalized version (an online game offered in a restricted version). Normally, it only takes two to three iterations to finalize the design of a game [6].

In this chapter, we will describe how the creation process of the game "In Anticipation of Death," based on UCD, made it possible to adapt this game to the needs of seniors [7]. First, we report on the methodology used to adapt the Solitaire card game for older adults. Then, we describe how we took into account ergonomic aspects of game design for seniors in developing the game mock-up. We then present the Alpha version of the game, which included certain parameters for user-friendliness. Subsequently, we explain the Beta version, for which the game's external environment was developed. Finally, we offer recommendations in the form of a guide for educational game designers. This chapter differs from the proceedings of the CSEDU [8] conference, since the latter dealt only with adaptation of the game design for seniors.

2 Methodology

When creating an online educational game for a particular population, the UCD process consists of testing the product (an educational game) at different stages of its development with its future users (in our case, older adults) and making any modifications needed. Table 1 summarizes our process for the game Solitaire Quiz.

Table 1. Summary of the UCD Process as Applied to Our Game

Product	Paper Game (Mock-up)	Alpha Game (Prototype)	Beta Game (Online)
Participants	6	12	42
Purpose of the test	Educational game design	User-friendliness	Educational game design User-friendliness
Number of times the game is played	3	3 to 6	5 to 9
Place of testing	Laboratory	Laboratory	Senior associa- tions, retirement homes
Measuring instruments	Observation grid Interview Recording game- play actions	Observation grid Interview System to track players' responses	Questionnaires (2) Interview System to track players' responses
Duration of the test	3 days	3 days	14 days

The experiment took place over the course of two months after being approved by the TELUQ university's ethics committee. Each participant was made aware of the study's research purpose and signed a paper or online consent form.

Various ergonomic aspects noted in the literature were taken into consideration during the development of the educational game: the design of the educational game in the mock-up version and the user-friendliness of the game in the Alpha version. We first discuss the type of game that became the object of our development project.

2.1 Choice of the Game

We relied on a survey of 931 seniors from Quebec and British Columbia, as part of the project "Aging Well: Can Digital Games Help?" (2012-2016), in which the game of Solitaire (paper and digital) was identified as a favourite for older adults [5]. This short game (five to 15 minutes) is recommended for seniors.

2.2 Description of the Game

Game board: Solitaire is a single-user game that is played with a deck of 52 cards. The first 28 cards are arranged into seven columns of increasing size that form the Board. Only the last card of each column on the Board is placed face up. The 24 remaining cards (face down) make up the Stock pile, also called the Deck. Cards from the Stock pile are discarded, three at a time. Only the visible cards can be used.

Goal of the game: The game ends when all the cards are placed into four piles for each suit and sorted in ascending order (from Ace to King), or when a player declares forfeit because they cannot move any more cards. In the latter case, the player can start a new game.

Movement in the seven columns: Cards can be moved from one column to another provided that the card being moved can be placed immediately on a higher card and of a different color, for example, a red 6 on a black 7. Aces are set apart to form the beginnings of the four piles to be reconstituted.

2.3 The Contribution of Digital Technology to Solitaire

In a review of existing digital Solitaire games, we noted the addition of various features to the original paper game. Some rules and options are included in our version, such as the choice of playing with one or three cards at a time, the addition of scoring in connection with the movement of cards, and scoring based on the time taken by the player to build the four piles.

Elements to customize and add interest complete the game, for example, changing the card layout for right-handed or left-handed players; displaying gameplay time and movements; and personalizing the game environment by choosing a theme, the size of the numbers on the cards, images on the backs of the cards, and the color of the playing surface.

The interface also provides access to certain functions: Play (start a new game), Start again (use the same cards, shuffled) and Personal data (score, statistics, and successes). Advantages help players to reach the goal of the game: *Hint* shows possible card movements, *Undo* clears the last actions, and *Help* (?) provides access to the game rules.

At the end of a game, different elements are displayed, including animation, display of results and statistics (best score, rank, etc.), display of successes achieved during the game, and display of the personal badge earned according to the player's game successes.

3 The Mock-Up of the Solitaire Quiz Game

The mock-up is a paper version of the Solitaire Quiz game that is inspired by the digital version of the game Solitaire. The mock-up version takes into account the ergonomic aspects of educational game design for seniors, as described below.

3.1 Educational Game Design

The design of an educational game first refers to its essential attributes: players, competition/ challenge, rules, the predetermined goal, learning content, and feedback [9-10]. We will now examine the ergonomic requirements for these aspects of game design.

Players

Solitaire is a one-player game. For our version, the player is a senior who is at least 55 years old [11] and retired [12]. The player is considered to be a beginner in terms of their technological skills, as much for the use of a computer or a mobile (tablet, phone) as for using online games. In the context of developing an educational game, the player has not necessarily played online games.

Competition/Challenge

Various mechanisms are found in the literature to ensure challenging and competitive online educational games [13]. To support competition, the game should include levels of difficulty or challenges appropriate to the knowledge, age, and physical abilities of the targeted players [2]. Concerning knowledge, the learning content must be graduated from simple to complex to maintain motivation [14]. It is suggested that a game should offer at least three levels of difficulty in terms of learning content [15]. It is equally important that the mechanics of the game allow players to select increasingly difficult questions from one game to another in order to maintain a sense of challenge, especially for older adults.

Rules

The rules are instructions, simple or complex, which describe the relationship between the players and the game environment [15]. Understanding the rules of the game and mastering them gives players a sense of control in the game interface (buttons, movement in the game, etc.) [16].

A recommended way to engage seniors is to use known games with few and well-understood rules, since confusion about the rules can discourage seniors from playing [17]. Researchers [18-19] suggest adding new rules to known games to maintain a sense of challenge and manage the integration of learning content. Finally, we must make the rules accessible at any time through a single click from any page of the game's environment [15].

Predetermined Goal

The predetermined goal of a game refers to how a game ends and to its notions of reward and victory. A game must have a goal and winners [20, 21]. The rules that determine winners and losers can be formulated to engage players' abilities and knowledge; for example, giving points for correct answers and actions [22].

Learning Content

Studies show that a balance between play time and learning time is needed to maintain players' motivation. To maintain this balance, the learning content in the game must be properly measured so that there is a place for chance and for actions that are only related to the pleasure of playing [13, 15].

To integrate learning content into the game without creating cognitive overload for seniors, information should be broken up into small units (one or two lines) or simple questions. It seems best to use closed questions (true/ false or multiple choice with one or more answers or objects to be matched), therefore facilitating older adults' participation without highlighting their memory difficulties. Repeating content elements allows seniors to recognize them and consider them useful for their progress in the game [2, 13, 15].

For educational games, it is important to link points gained to positive learning outcomes and their loss to negative results [22, 23]. However, fewer points must be lost than are gained in order to maintain seniors' interest, particularly for those who have little knowledge of the game's subject matter [24]. Acquiring points in connection with performance increases older adults' self-confidence, while displaying players' scores and highlighting the winner motivates seniors to replay the game.

Feedback

For learners who perform actions in the game to achieve learning, on-the-spot feedback is recommended [25]. The result of each learning activity (success or failure) should be highlighted by visual or audible feedback, such as a smiling or sad face, a positive or negative sound tone, and/ or points added to the player's score [26]. For an incorrect response, the game should provide textual, visual, or auditory feedback about the content, together with additional information about a correct response, in order to sustain the player's interest and promote learning [27].

At the end of a game, it is important to display the learning outcomes with a general view of players' results for the learning activities, and to provide access to learning materials for reviewing subject matter that was not learned [10-15].

For older adult players, immediate feedback about their actions is also recommended. This feedback often takes the form of a tutorial, guiding each player throughout the game to enable them to see the results of their actions [24, 28]. The tutorial facilitates understanding the game without forcing seniors to learn the rules quickly, thus reducing their cognitive load [27]. The instructions should be simple and contextualized to facilitate comprehension of the game, helping seniors to avoid demotivating mistakes [26].

3.2 The Description of the Game Mock-Up

Game Board

For the paper version of the game, we used a 16X20 mock-up to reproduce the game's interface (Figure 1). Playing cards were used and placed on the mock-up sheet. Question cards were developed, and feedback was written on the back of each card. A privilege sheet was also provided to the player. Finally, the rules were provided on paper.

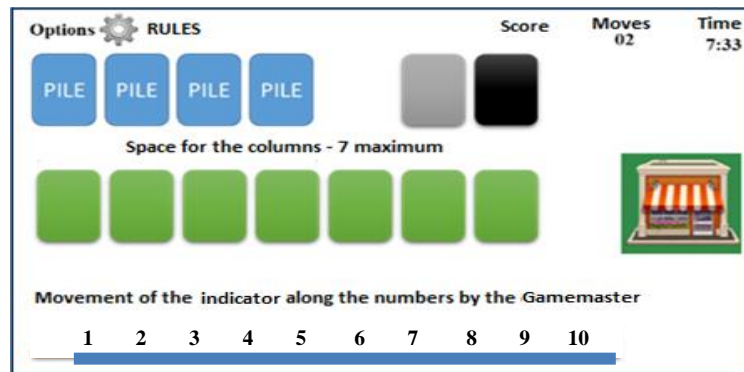


Fig. 1. Paper Mock-up of the Game Solitaire

At the beginning of the game, the modified rules of the game were given to the player without precise instructions. The player had to choose the game mode (one or three cards) and the difficulty level of the questions (easy, intermediate and difficult). Regardless of the level of difficulty chosen, the player received the same \$500 in credits at the start of the gameplay. The player shuffled the cards and deposited them on the mock-up of the game interface.

During the game, the gamemaster performed the actions that the computer would do in the digital version, as follows:

- For the movement indicator, he moved the cursor after each player moved.
- After a given number of moves, he asked the player a question and had him read the feedback. If the answer was correct, the gamemaster marked down the credits earned and displayed the total credits available. If the answer was incorrect, he subtracted the credits lost.
- When a player chose one of the privileges as a reward, the player performed the action requested by the privilege and the gamemaster subtracted the number of credits from the accumulated sum.

Rules of the Game

First of all, we made no changes to the goal of the game. Our new rules were related to the educational aspects that we introduced into the Solitaire digital game and to privileges that helped players to finish the game.

With regard to the game mode, we introduced a choice for question difficulty level that allowed us to add a question score to the standard Solitaire scoring. This encouraged learning by reading feedback, helping seniors to build their knowledge of the game's theme (Table 2).

Table 2. Rule for Question Scoring

Depending on the difficulty of the game, the computer displays a question that the player is asked to answer:

- If the player answers correctly, he earns points according to the degree of difficulty of the question: 20 points for an easy question; 35 points for an intermediate question, and 50 points for a difficult question.
- If the player does not answer correctly, he loses points according to the difficulty of the game being used: 10 points for an easy question; 20 points for an intermediate question, and 35 points for a difficult question.

We also introduced the option of purchasing privileges to help players break a stalemate in a game that promises to be stuck or simply to earn extra points. To manage these purchases, we established a new rule (Table 3).

Table 3. Rule to Manage Privileges

At any time, a player who has accumulated enough credits can buy privileges from the Store, which increases the chances of finishing the game and earning points.

- 15\$ - *Buying a Question*: Answer a question correctly to accumulate points.
- 25\$ - *Going Backwards*: Undo the last action taken to move a card from the Tableau or one of the piles.
- 50\$ - *Joker's Advice*: Buy help from the Joker to view all possible moves.
- 75\$ - *Risky Freedom*: Randomly draw a hidden card from the board.
- 100\$ - *Selective Freedom*: Take a card from the hidden cards on the Tableau.
- 150\$ - *The Red King*: Release the king (heart or diamond) hidden on the board or in the deck to place it in a blank column.
- 150\$ - *The Black King*: Release the king (spade or club) hidden on the board or in the deck to place it in a blank column.
- 200\$ - *Ace of Aces*: Release an ace hidden among the cards on the Tableau and place it on a pile.
- 300\$ - *The Chameleon Joker*: Replace any card on the Tableau.
- 300\$ - *The Imperial Discard*: Return a card of your choice to the deck.

Game Questions (Quiz)

To choose a content theme for the quiz questions, we interviewed 167 adults aged 55 and over. These participants were interested in the actions to be taken upon the death of their spouse; more than 72% expressed a lack of knowledge about putting the affairs

of their spouse in order, recovering what is due to their spouse, paying debts, and fulfilling their spouse's wishes concerning the disposition of their body [7].

In Solitaire Quiz, we dealt with the learning content by using closed questions (true/false or multiple choice with one or more answers), to which we added feedback to be displayed when the player answers a question. We also limited the number of questions to 40 so that each is used at least twice during a game. Finally, we split the learning content into small units, divided into three levels of difficulty (15 easy, 15 intermediate and 10 difficult) identified by one, two, or three stars.

To ensure a balance between playing and learning, we opted to pose a question after 10 card movements. These movements are represented by an indicator that moves on a progression bar, with a fraction to indicate its progress. If the player answers the question correctly, they earn points, and if they do not answer the question correctly, they lose points. Finally, we integrated feedback in the form of a smiling or sad face as well as text and audible feedback to explain the correct or incorrect answer (Figure 2).

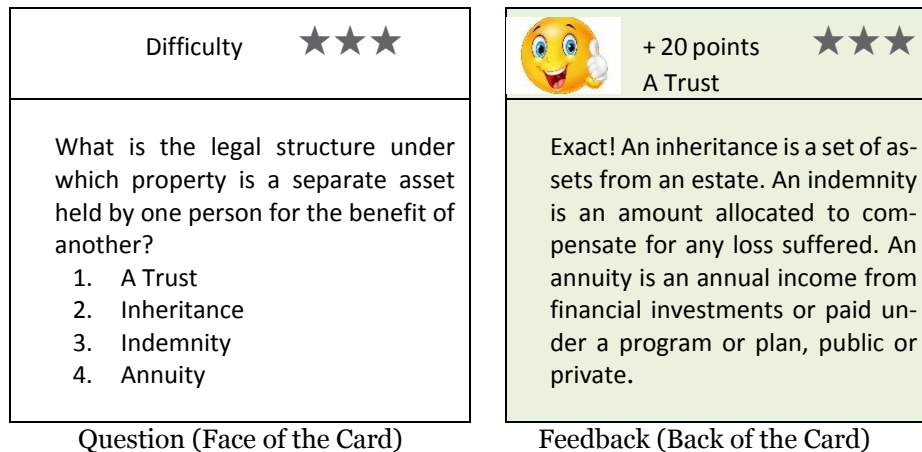


Fig. 2. Question Card

3.3 Testing the Mock-up

Six people participated in the test of the paper version: three seniors aged 55 to 64 and three aged 65 to 72. Each played the paper game three times for three days, with all of their gameplay actions recorded. Observations were taken using an observation grid, and individual interviews with the players were conducted following their tests.

First of all, all the respondents liked playing the Solitaire Quiz paper game. They described the game as simple, requiring little time to play. They appreciated the choice of game mode (one or three cards), as well as the integrated questions that offered them a pleasant way to learn. Players found that the type of questions were easy to answer, and they took time to read the feedback. In addition, they considered that the question types (True or False, Multiple Choice, etc.) did not slow the gameplay.

Regarding elements to be improved, recommendations were identified based on the comments from the participants and the development team:

- The number of card movements to display a question was too high. Players did not answer all of the questions at least twice. Reduce the number of moves to eight to have players answer more questions and accumulate more money credits.
- Rearrange the gaming space to move the discard pile to the left of the game and the four in-play piles to the right.
- Clarify some rules of the game. In the test, two respondents read the rules of the game before starting to play, two read the rules during the game, and two did not read the game rules at all. Some requests were made for clarification of the rules.
- Some privileges were not used by respondents (Selective Freedom, Discard, Joker's Advice). Wait for the Alpha version before removing these privileges.
- Two players mentioned that the game could offer the additional challenge of playing against time. Other players found this idea interesting but suggested making it optional. Incorporate an option for playing against time: finishing a game in 0-5 minutes (100 points bonus or 100 points loss), 5-10 minutes (50 points bonus or 50 points loss), 10 minutes or more (no bonus or loss).
- The audible reading of the questions was appreciated by the participants, given that the size of the characters were not easily read by two players. Incorporate a digital voice function for game questions.
- The development team suggested locating the rules and the game tutorial in the Options menu to maximize space for the game interface.

4 The Alpha Version of the Game

In the Alpha version (prototype of the computerized game), we took into account both criteria from the literature for user-friendliness of digital games for older adults and recommendations arising from the first test (rules and some options).

4.1 User-Friendliness Criteria for Seniors' Digital Games

User-friendliness refers to the qualities of a digital game that make it easy and pleasant to use and understand, even for someone with little computer knowledge. The role of the game's environment is to help the player focus on what is important.

Problems reported by older adults with the use of technologies are predominantly associated with user-friendliness (navigation and display) and can often be resolved by appropriate design. For seniors, the game's user-friendliness also depends on using appropriate physical equipment to accommodate eyesight and dexterity problems.

Navigation and Display in the Game

To make a game environment intuitive for seniors, designers should ensure that players can easily access all components (cards, navigation buttons, instructions / tutorials and score) needed for the game to run smoothly [23, 24, 29, 30]. To facilitate players' movement in the game, it is very important to make sure that the game and its components are displayed without overflowing the screen and without blocking some game

elements [15-26]. For a comfortable gameplay experience, the design should use a pre-determined frame or a responsive web design to maintain a standard display layout across screens. The game board and accessories for playing should cover most of the screen, and scroll bars in page displays should be avoided.

To facilitate navigation within the game, the game elements and question content should be limited to one screen page. This avoids long and tedious scrolling on the screen, which particularly demotivates seniors with short attention spans [15, 23, 24, 29, 31].

It is also important to minimize the use of superimposed windows during the course of a game, since some older users are less likely to notice page changes and can become confused. A clear notification of a change of screens should be displayed, for example, when the player goes from the "Game" page to a "Questions/ Information" page [32].

Images should be processed to avoid waiting for their on-screen display, which frustrates players. To prevent the user from believing that his equipment has failed, it is best to notify him if the estimated download time will exceed five seconds [17, 26, 33-37]. Also, we must avoid using sounds to support each gameplay action.

Similarly, if question content is integrated into the game, all relevant information must be available to the player through single clicks.

Gameplay Equipment

Physical equipment should provide options for seniors to adapt the gameplay to their reaction speed, degree of autonomy, and physical ability [13, 38-39]. Game equipment such as a laptop, tablet, keyboard, or joystick must be used with some constraints to make it comfortable for seniors [10]. Complicated physical actions, such as those requiring a double mouse click, or that force the player to precisely control a pointer on the screen while having to correctly press a button, should be avoided [7-26]. Mouse handling should be reduced to essential actions, since it requires hand-eye coordination and increases cognitive load [18]. It is preferable to use the arrow keys of a standard keyboard or a keyboard adapted to handle the game. For seniors, game equipment should avoid newer technologies that require high skills for effective use [26].

If a game controller is used, it better to use a one-handed device such as a computer mouse or the Wii Remote. Tablets must have screen sizes that are large enough to clearly display needed information [18-20].

4.2 Application of User-Friendliness Criteria to Solitaire Quiz

We now look at how the structure and content of Solitaire Quiz specifically considered ergonomic factors appropriate for older adult players.

Navigation and Display

We restricted the display format of the game board to the smallest configuration used by our target audience: 1024x768. For larger screens, we inserted a background of the same color as the background of the board and programmed the display so that the

board is positioned in the center of the screen. This window is always visible independently of the other windows that are superimposed.

We limited the number of windows to only two. When the second window appears in the center of the screen, the game board becomes gray and inactive.

We designed learning questions to include all relevant information (question statements, answers, degree of difficulty, feedback, credits earned or lost) on the same page. The questions, answers, feedback, etc. are displayed in a second window superimposed on the game board. The size of this window is always smaller than the board.

We processed and tested image display times with low, medium, and high speed connections. The display time in all cases does not require a waiting period for the computer. Finally, using the inter-rater method, we assessed the relevance of each image that illustrates a question in the game.

Sound effects were added to maintain the player's interest: music at the start of the game, Yay! for a positive answer to a question, and a discordant sound for a negative answer to a question.

Gameplay Equipment

We avoided requiring a double click to perform any action, whether to answer questions, move cards in the game, open the tutorial, purchase a privilege, or choose gaming options.

We opted to run the game on computers with a mouse, 15" touchscreen laptops, and 10" tablets; this allows seniors to move the elements of the game with a mouse or with their finger. We also integrated buttons with words and symbols to make it easier for seniors who were not born in the digital age.

4.3 Changes to the Game Based on the Paper Testing

The requested changes were made to the production specifications in terms of the interface, rules and questions.

Game Interface

We changed the order of the elements in the game interface and the number of card movements needed for displaying a question to be answered. We divided the game interface into three areas (Figure 3) to make it easier to navigate. Zone 1 (Information) contains all the information needed to understand how the game unfolds: the Options menu, the timer, the number of accumulated credits, and the access icon for the Privilege Store. Zone 2 (Game board) includes all the playing elements of the game: the Stock pile, the seven columns and the four stacks of cards. Zone 3 (Apprenticeship) refers to the educational aspect of the game: a tutorial accessible at all times and a progression line that allows you to display a question to be answered after every eight card movements in the game.

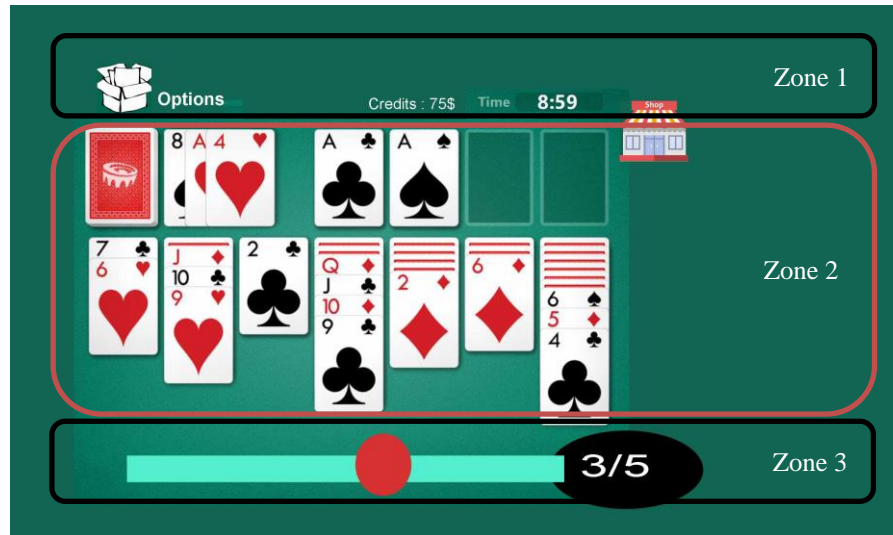


Fig. 3. Game Interface

We also grouped together the informational elements and the tutorial to help navigation in the Options menu.

Rules of the Game

We clarified the rules of the game by simplifying and illustrating them. To ensure a bigger challenge, we added the option of playing against time and wrote a rule to explain how it works. Finally, we corrected the rule governing the number of moves needed in the game to display a question (Table 4).

Table 4. The Addition of Two New Rules.

- It is possible to play with a time limit: 0-5 minutes (bonus of 250 points); 5-10 minutes (bonus of 125 points); 10 minutes or more (loss of 100 points). This is optional.
- Questions appear at each 8th Movement, when the indicator reaches the end of the progression line. A correct answer allows for the accumulation of credits. These credits allow for the purchasing of privileges from the Store. These privileges are for taking shortcuts, or to finish a stuck game.

Questions and Feedback

We integrated a digital voice application that allows players to listen to the questions and answers of the game instead of reading them, thus facilitating the accumulation of credits while overcoming seniors' visual impairments.

4.4 Testing of the Alpha Version

Twelve people participated in the testing of the Alpha version: five seniors aged 55 to 64 and seven seniors aged 65 to 75. They tested the game on an Android tablet three to six times over a three-day period. Their gameplay actions were recorded in detail by the game system. We recorded observations on an observation grid and conducted individual interviews with participants. They made various comments and recommend further refinements to the development team:

Comments and Recommendations About the Game Interface

- All respondents liked playing the digital form of Solitaire Quiz.
- Most of them found that the positioning of the majority of the elements in the game interface was readable on a 10-inch tablet but a little less on a seven-inch tablet.
- When there were too many cards in a column, it was difficult to see the last card because of the movement counter: Review the displaying of cards and the movement counter to make the last card in the column readable.
- The Store placed to the right of the game reduces the game visualization: Position the Store in the first third of the game interface.
- Most respondents (10 out of 12) would have liked to answer questions faster in order to earn credits: Reduce the number of movements of the indicator on the counter to 5.

Comments and Recommendations About the Rules of the Game

- Eight players indicated that there was no information indicating that they lacked enough credits to buy a privilege: Add a statement (“X, Not Available”) to warn players that they do not have enough credits to buy certain privileges.
- The privileges *The Chameleon Joker* and *Selective Freedom* were not used. Players did not understand their purpose: Remove these privileges.
- The purposes of the privileges *Going Backwards* and *Joker’s Advice* were not clear: Review the wording of these privileges.
- Eight respondents questioned the allocation of \$500 regardless of the degree of game difficulty. They considered this amount to be too great and suggested a graduated amount depending on the degree of difficulty: Review the number of credits based on the degree of difficulty: \$200 for Easy, \$100 for Intermediate and \$0 for Difficult.
- Six players suggested keeping the game rules in the Options menu to make them available as needed to those who do not know them: Keep game rules in the Options menu.

Comments and Recommendations About the Feedback

- Four players found that the sound used to indicate a correct answer (Yay!) was irritating after a few games: Reduce the volume of this sound and wait for the final test before changing it.

- Six players wanted help in understanding certain aspects of the game. They wondered about the positioning of the tutorial under the Options menu: Insert real-time contextual help in the game interface, Options, and the Store, and remove the tutorial from the Options menu.

5 The Beta Version of the Game

In order to finalize the game and make it accessible to the general public, we integrated some aspects that had not been developed in the Alpha version: the external environment of the game and contextual help, the choice between two languages (French and English), and an end-of-game page that is present in all online Solitaire games.

We also made the following requested changes: the privileges offered by the Store were revised and some of them removed, and real-time contextual help was developed and integrated into the game interface, Options, and Store. Finally, the game Solitaire Quiz was made available on the Google Store to make it available to the general public.

5.1 Navigation in the Game's External Environment

To make a game intuitive, its external environment (interface) should not require that seniors have to think hard about what they have to do [38]. First, the different pages of the game's interface must be standardized by using screen layouts, navigation, and terms that are consistent, simple, and easily understood [26, 35]. Navigation information needs to be simplified in order to minimize the amount of information to be memorized [40]. It is necessary to avoid complex visual displays by using known visual clues to reduce searching; seniors often forget command names and waste a lot of time searching for basic information. The number of steps and controls needed to accomplish a task must be minimized [17-40]. Older people prefer a more direct way to access information without deep hierarchies [37].

5.2 Development of the Game's External Environment

In the Beta version, the game's homepage includes a form for creating an account, access to the game by access code, a function for a forgotten password, and a game access button (Figure 4)



Fig. 4. Homepage and Registration.

Wishing to offer different learning content for the game Solitaire Quiz, we developed a page to allow players to choose a content using a search tool (Figure 5).

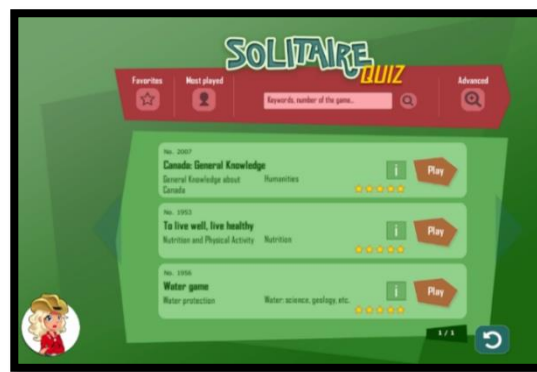


Fig. 5. Game Selection Page.

Similarly, two pages allow players to choose the mode of play, the degree of difficulty of the game and the time challenge (Figure 6).

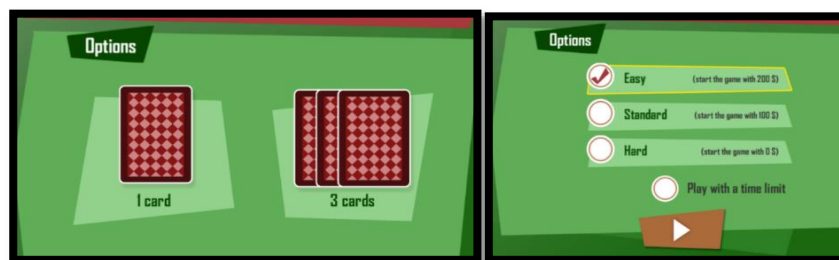


Fig. 6. Game Options – Game Mode and Degree of Difficulty (Source: [8, p. 215]).

5.3 Modifications Applied to the Game

Contextual help (Figure 7), accessible as needed, was included to guide seniors throughout the game. They can close it and open it at any time with a simple click on the corresponding icon.



Fig. 7. Example of Contextual Help

Finally, we integrated feedback on the player's performance in the form of a score at the end of the game. This score consists of money credits earned during the game plus a bonus if the player has chosen the option of playing with a time limit. In order to motivate seniors to play more often, a ranking of all players registered for the game is available at the end of the game by using the Ranking button (Figure 8).



Fig. 8. Ending the Solitaire Game (Source: [8, p. 216]).

5.4 Testing of the Beta Version

To test the limited online version of the game, we recruited independent seniors living at home, members of associations and seniors' clubs, and older adults living in seniors' residences. Their gameplay actions were recorded by the game system. Pre- and

post-test questionnaires were administered, and individual interviews were conducted. Of the 42 participants, 90.5% played the game at least five times during the 14-day test period for an average duration of 7.3 minutes, and 42.9% played between six and nine times.

Demographic Data

Among the 42 participants in the Solitaire Quiz experiment, there were 19 women and 23 men. The sample included 20 participants aged 55 to 60 (47.6%) and 22 subjects aged 61 and over (52.4%).

Participant's Gaming Habits

Among the sample, nine players said that they did not have the skills to use digital games, while 18 players identified themselves as "beginners" and 15 as "intermediate" digital game players.

Most participants (88%) had already played Solitaire. Over three quarters of them (78.6%) had some experience with other digital games: six players had experience of one year or less, more than half (19) had between one and five years of experience, and eight had been playing for more than six years.

Of the 33 players who had some experience with these types of games, five people (15.2%) typically used them on only one day per week. Eleven players (33.3%) used digital games two or three days per week, and the same number of participants played between four and five days per week, which shows a strong preference among seniors for the use of technology for entertainment purposes (66.7% of participants played between two and five days per week). Also, of the 33 players who had experience with playing games, 11 played up to 60 minutes per day and, interestingly, 21 people (63.6%) used games between two and three hours per day.

Player Perceptions of the Educational Game Design

With respect to the design of the educational game, 88.1% of respondents found that the game's duration was short enough that they could finish their game in less than 10 minutes, and 97.6% of them found that the privileges allowed them to finish the game. As for the challenge posed by the game, three aspects were measured: 85.7% of respondents considered that the degree of difficulty of the questions represented well the challenge that they posed. For the two options, "Playing with a time limit" and the game mode (one-card or three-cards), their opinions are more moderate (57.1% and 69.0% respectively rated them as appealing).

With regard to the educational aspects of the game, 90.5% of the participants responded that the game took into account their prior knowledge, since they could answer a large number of questions when they chose the "Easy" difficulty level. All players reported that question repetition was an effective strategy to help them remember and respond correctly. Nearly all respondents agreed that the game's feedback helped them to progress in the game (92.9%), that the smiling or sad face told them clearly if a question was or was not answered correctly (95.2%), and that the sound emitted after a good answer increased their motivation (88.1%). In addition, 90.5% of the participants

agree that the audible reading of questions and feedback facilitated their comprehension and avoided fatigue related to reading on the screen. In addition, 85.7% of respondents found that the images used for the questions were representative of the content. Finally, 97.6% of respondents found it to be an original way to learn about certain topics.

Player Perceptions of User-Friendliness

The first aspect of the game's user-friendliness of the game is the ease of navigating the game without contextual help. Most participants (90.5%) considered navigation in the game's external environment (registration, choice of game learning content, choice of game mode, degree of difficulty, time challenge, and starting the game) to be easy, while 16.7% of the players needed to use the help function in real time. As for the game interface (game board, questions / feedback, rules of the game, Privilege Store, contextual help), 88.1% of respondents navigated without difficulty, while 40.5% of players needed to use the help in real time. Only 9.5% of the players consulted the rules of the game, but they judged them to be well explained. Finally, more than half of the respondents considered the sounds and music in the game to be stimulating.

In terms of the gameplay equipment, moving the cards using a touch screen was judged easy by 85.7% of players. Similarly, moving the cards with a mouse was described as easy by all respondents.

Revision Requirements for the Beta Version

During the testing, 10 participants (five men and five women) took part in interviews to check if certain game elements should be improved. They made the following comments and recommendations:

- Respondents reiterated their interest in maintaining the option "Playing with a time limit." Most would like to experiment with this option after achieving 100% on the easy or intermediate level of difficulty.
- Respondents expressed their interest in keeping the game mode choice of one card or three cards. Having never played with the one-card mode, the majority of respondents initially chose it to familiarize themselves with the game. They found that this mode allowed them to finish the game more easily. However, two of them, considering themselves intermediate-level in the use of online games, suggest maintaining the three-card mode because it represented a greater challenge for them.
- Most respondents did not use the rules of the game. After reading the rules during the interview, however, all recommend keeping the rules accessible at all times in the Options menu, especially for those who have never played Solitaire Quiz.
- All respondents emphasized the importance of having contextual help in real time. Some of them pointed out that these aids allowed them to understand the new rules that are not in the classic Solitaire game and that they explained how the Quiz works.
- Three respondents suggested offering the players the option of modifying the Wild West theme with a theme of their choice.

- The majority of respondents confirmed that moving cards with a finger or a mouse did not require special dexterity on their part and that accessing the different elements of the game was easy.
- Five respondents suggested integrating a mute control for the sound, music, and digital voice.

6 Recommendations

The vast majority (95.2%) of the participants liked to play Solitaire enhanced with a Quiz, and 90.5% of the players wished that they could try a new quiz. All participants would recommend the game to other older adults. Building on their feedback, the literature, and our experience during this game development process, we propose the following recommendations to help developers of educational games build online educational games for seniors:

6.1 Competition / Challenge

- Offer games of short duration to maintain seniors' motivation, while integrating the option of allowing players to vary the duration of the game.
- Add new rules (add-ons) to maintain a sense of challenge in known games. Older adults prefer to play games that they know, with add-ons that engage them.
- Integrate the option of "Playing with a time limit" for gaining additional points in order to maintain a motivating challenge. The availability of two game modes (one card or three cards) also represents different challenges in the game, according to the players' responses.
- Incorporate multiple difficulty levels or challenges to the user to foster competition, facilitate learning, build self-confidence and concentration, and better engage older adults in the game.

6.2 Learning Content

- Balance learning time and playing time by integrating at least three levels of difficulty for the questions.
- Classify the learning content from simple to complex in order to offer multiple levels of difficulty and inform the players that the "Easy" level corresponds to their basic knowledge, thus encouraging everyone to participate.
- Use closed questions to facilitate the use of prior knowledge for progressing in the game and accumulating points. It is crucial to analyze the learning content and to break it down into small units of information; this makes it possible to formulate simple questions in order to avoid cognitive overload in seniors.
- Limit the number of questions in a game to allow older adult players to recognize them and see them as useful for progression in the game.
- Ensure the representativeness of images used in the questions.

- Use visual or audible feedback to reinforce the answers to the questions. For example, the face that accompanies each feedback comment, along with the sound emitted for a correct response, makes it easy to quickly tell whether or not the question was answered correctly.

6.3 Navigation

- Group gameplay actions on one page without a superimposed window.
- Reduce the number of windows and clicks needed to access and play the game. This speeds up the pace of the game and promotes player motivation.
- To avoid player confusion, organize gameplay information into zones and reduce as much as possible the number of controls necessary to accomplish a task.
- Design the game board components to minimize the game's download time.

6.4 Gameplay Equipment

- Facilitate the movement of objects on the game board by using a touch screen (for tablet and touch-screen users) or a mouse (for PC and Apple users).
- Avoid actions that require a double click of the mouse or that force the player to precisely control the pointer on the screen.

7 Conclusions

Our participants were interested and engaged in playing this educational game. Although their perceptions as observed in this study relate to a specific game (Solitaire Quiz) with specific content (actions to be taken on the death of a spouse), the results can be applied to different types of games. Our study shows that the design of an educational game must take into account its target audience: it is important that a game for older adults provide an appropriate duration of play, display game progression, provide an appropriate level of difficulty, and be adapted in many specific ways for this audience. It is also important to reduce the risk of player frustration by posing an interesting challenge.

To make the game easier for seniors to use, it is important that the components of the game are visible within the screen, that the grouping of players' actions accelerates the game and keeps up players' motivation, and that the use of the mouse or the touch screen makes actions in the game easy to perform and requires little manual dexterity.

Finally, our use of the user-centered design process enabled significant changes to be made to the game interface in the first two versions of the Solitaire Quiz, which helped to improve the design for seniors as well as saving costs, since unnecessary features or critical usability issues were identified early in the development process [33].

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