IETC 2014

Validation of the Educational Game for Seniors:
"Live Well, Live Healthy!"

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Abstract

A literature review was conducted as part of a development project to flesh out a number of issues: How can game component design be adapted to accommodate seniors' physical or intellectual limitations? How should a game interface and its components be displayed on the screen to facilitate game navigation? What restrictions should be considered when selecting computer game equipment to be used by seniors? What are the guidelines for efficient game audio, video and text readability? This communication first presents the pedagogical and technological adaptations of the online educational game: "Live Well, Live Healthy!" This adaptation of the Bingo game has allowed us to introduce learning content with the objective of improving the quality of life for seniors. Second, the methodology used for the validation of the ergonomics of this educational game with seniors and third, the results of validation and the recommendations from the seniors to improve the ergonomic conditions.
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Peer-review under responsibility of the Sakarya University.

Keywords: Educational Game; Seniors, Ergonomic conditions, Validation

1. Introduction

Online games aimed at seniors need to address the particular needs and physical limitations of this target group. Several researchers have attempted to use commercial digital games in their investigations with seniors, while others have adapted games or have done research to establish requirements for digital games for seniors. However, research is still limited about the ergonomic requirements of online games created for seniors.

These are being studied as part of a project funded by an Insight Grant from Canada's Social Sciences and Humanities Research Council. The goal is to examine, through the use of online games designed for seniors, the key factors for effective implementation of digital games for this audience. More specifically, our study has the following objectives: 1) develop and publicize online educational games for maintaining or adopting healthy lifestyles for retired seniors 55 years and older; 2) test these games with the target audience to check their ergonomic

quality (design, user-friendliness and educational readability) and 3) test these games with the target audience in order to assess the effect they have on the adoption of healthy lifestyles. In this paper, we describe the pedagogical and technological adaptations we made to an online Bingo game to introduce learning content, taking into account the ergonomic criteria that we identified in the literature for seniors 55 and older, the methodology and the testing results of 27 seniors as well as their recommendations to improve the game, "Live Well, Live Healthy!"

2. Seniors and Games

The aging population represents a serious challenge for healthcare systems and social insurance in the 21st century. The number of people aged 60 and over is growing faster than other age groups and is expected to reach two billion in 2050 (Aalbers, Baars & Olde Rickert, 2011). In 2010, almost five million Canadians were over the age of 64 years. In 2036, they will number more than 10 million (HRSDC, 2011).

These aging seniors are facing the decline of their physical and cognitive abilities, loss of long-term companions and social support, changes in their familial or professional environment, different lifestyles, and the increased likelihood of developing chronic and disabling diseases. But what are they doing to improve their quality of life? Can games help them effectively meet the challenges of aging?

An increasing number of studies have demonstrated that video games can have a positive impact on seniors: digital games can provide physical training for seniors and can overcome their isolation (Rosenberg, Deep, Vahia, Reichst, Plamer & Kerr, 2010; De Schutter, 2011; Diaz-Orueta, Facal, Herman Nap & Ranga, 2012; Astell, 2013). These studies also show that the effects of these games depend on the needs and individual characteristics of seniors and that systems need to be developed that are capable of adapting to the demands of this population. An inappropriate design can act as a barrier to seniors' use of games, thus reducing the games' physical, cognitive and social benefits and consequently seniors' health and quality of life (Whitlock, McLaughlin & Allaire, 2011). It is therefore important to ensure that games offered to seniors have appropriate ergonomics.

In the case of online educational games, the ergonomist develops solutions that inform and guide the user while minimizing the cognitive and technological information load as much as possible (Barnard, Bradley, Hodgson & Lloyd, 2013). A technology will be adopted if the person is attracted to using it, and its user-friendliness must be appropriate for the user: the technology must not be too difficult to use.

In order to establish the ergonomic indicators of online games for seniors, we rely on three quality criteria: 1) the design: the components of the game must adapt to the characteristics of the users, 2) user-friendliness: the game interface and computer equipment must be easy to use, and 3) readability: the way in which the text, illustrations and videos are visually presented must facilitate reading and understanding by users.

We now examine how we addressed these criteria during the educational adaptation and computerization of the Bingo game for seniors.

3. The adaptation of the Bingo Game

According to a survey of 932 Canadian seniors, the game Bingo turns out to be the most mentioned game by respondents. In the remainder of this paper, we look at how the structure and content of this popular game have been adapted to create an educational online game for seniors.

3.1. The Game Design

An increasing number of studies advocate that it is necessary to create a design specifically tailored to players from the 'baby boomer' generation. Various aspects of the Bingo game have been adapted in terms of design to create an educational game for seniors (Callari, Ciairano & Re, 2012; De Schutter, 2011; Diaz-Orueta, Facal, Herman Nap & Ranga, 2012; Hwang, Hong, Hao & Jong, 2011; Lopez-Martinez, Santiago-Ramajo, Caracuel,

Valls-Serrano, Hornos & Rodriguez-Fortiz, 2011; Marin, Lawrence, Navarro & Sax, 2011 ; Ogomori, Nagamachi, Ishihara, Ishihara & Kohchi, 2011; Pham & Theng, 2012; Sauvé, 2010a; Shang-Ti, Huang & Chiang, 2012; Theng, Chua & Pham, 2012; Whitlock, McLaughlin & Allaire, 2011; Wu, Miao, Tao, & Helander, 2012).

Challenge. The game must maintain a constant challenge for the players. In our "Live Well, Live Healthy!" game, we have put in place mechanisms (Figure 1B) that allow players to choose from three levels of difficulty at the start of the game. These levels are based on the seniors' knowledge about the learning content (easy, medium and difficult) of the game (Figure 2A): easy corresponds to 75 % of the content which refers to the prior knowledge of the seniors; medium is 50 % and difficult is 25 %. We also integrated into the game mechanics Bonus balls that are drawn at random during the game, thus reducing the gap between the players that are too strong and those that are weaker (easy = 3, medium = 2 and difficult = 1).

Fig. 1. Main page interface of the game

Competition. The game must create competition among seniors to maintain their interest. In our "Live Well, Live Healthy!" educational game, we first determined it would take three participants or more to create competition between seniors. We gave the opportunity to vary the duration of the game by allowing players to choose how the game ends and thus decide the playing time: a complete row of vertical boxes requires less time than a full card or the contour of the card (Figure 2A). Similarly, players choose the degree of difficulty (easy, medium and difficult) before starting the game. We opted to display the scoring system in the game interface at any time for each player (Figure 2B). Then we inserted points that reward or penalize the player according to whether they answer the question correctly or not, which in turn allows the player to place a token in one of the boxes on the card. The penalty is 50% less than the gain in order to maintain the interest of players, in particular, for those who have little knowledge about the content to be learned. Finally, we changed the rules that determine the winners and losers in the context of an online game without a game master: the first player to click on the Bingo button (Figure 2C) after correctly placing their tokens on the Bingo card wins 50 points. Players who have a "Bingo" at the same time but were not fast enough to click on the "Bingo" button first, only receive 25 additional points. Should a player click on the Bingo button and not have their tokens placed correctly, the game continues and the player loses 25 points.

Learning Content. To ensure effective learning, the game must incorporate learning content while maintaining a balance between learning time and play time to maintain the player's interest. In our "Live Well, Live Healthy!" game, we have built a mechanism to display a question every time the number of a ball drawn at random is on a card of one or more players. If the player answers the question correctly, a token appears in the box and the player earns points (20 points for an easy question, 30 points for a medium question and 50 points for a difficult question). If the player does not correctly answer the question, the token will not appear in the box and the player loses half of the points allocated to the question. We prepared 40 questions instead of 75 (the number of balls) to ensure that these questions come at least twice during a game whose aim is to complete a full card.

Fig. 2 Point system

Feedback. The game must provide feedback to support the learning of the defined content Immediate feedback, related to each learning task, allows the player to identify successful activities and those they have failed. In our "Live Well, Live Healthy!" game, we have integrated visual feedback in the question card window (Figure 3); it uses a smiley or sad face to communicate the results of game (A) and textual and audible feedback to explain the correct answer (B-C). A tutorial is also included to guide the seniors as the game progresses. Players can open or close the tutorial at any time with a single click. At the end of a game, each player's total points is listed, where achievement is highlighted with the sound of applause and players are ranked according to their ability to correctly answer questions and carry out learning activities. The game must allow players to see what they have learned by providing an overview of the results of the game's learning activities. When the game is over, each senior can see their learning process in a personalized environment.

3.2. The game's user-friendliness

Studies have found that seniors' problems with technology use are most frequently associated with user-friendliness and could be solved by an appropriate design of the screen display and game navigation (Pearrow 2007; Hwang, Hong Hao & Jong, 2011; Marin, Lawrence, Navarro & Sax, 2011; Sauvé, 2010b; Whitlock, McLaughlin & Allaire, 2011).

The display screen of the game and the learning activities. The board, tokens, navigation buttons, instructions, score and rules must be displayed and accessible to ensure that the game runs smoothly. In our "Live Well, Live Healthy!" game, we restricted the display size of the game board to the smallest resolution used by our target audience: 1024X768. For screens with larger dimensions, 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 regardless of other superimposed windows that appear. A second window may appear superimposed onto the game board. It contains questions, answers, feedback, the tutorial or the rules of the game. The size of this window is variable but always smaller than the board.

Navigation in the game. The game should provide easy navigation and must meet certain conditions. In our "Live Well, Live Healthy!" game, we divided the game interface into three zones (Figure 3): a) the Bingo card, rules, and tutorial; b) information on the game's progress: the type of game, randomly drawn ball, and the Bingo

button for ending the game; and c) information related to the actions of players: players' names and their scores as well as the control of the microphone and chat. At all times, the board, tokens, navigation buttons, instructions, score and rules must be displayed and accessible to ensure that the game runs smoothly. All player actions are done using single clicks. We opted for buttons with words rather than symbols for ease of use by seniors who were not born in the digital age. Finally, we limited the number of superimposed windows to a maximum of two. When a second window appears in the center of the screen, the game board will be grayed out and become inactive.
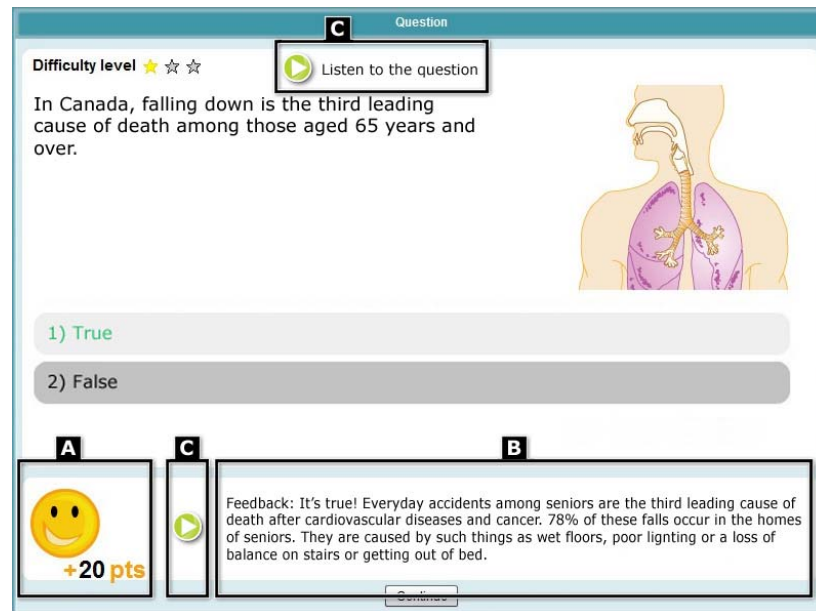

Fig.3 Question Cards

The controller used to play the game. The game console (machine) should be adjustable to the physical limitations of the players. In our "Live Well, Live Healthy!" game, we eliminated all actions that require a double click to perform an action, whether to answer questions, to place a token on a square, or to interact with other players using real-time verbal communication tools.

3.3. Educational Readability for Multimedia

By readability, we mean the way in which a text, an illustration or a video is visually presented (formatting) in order to make reading and understanding easier for users. A readable interface is an indispensable component of any digital product (Ergolab, 2003), particularly one intended for seniors. Educational games must meet certain formatting criteria for text, videos and illustrations (Kellner, 2008; Millerand & Martial, 2001; Nogier, 2005; Marin et al, 2011; Melonio, Tarantino & Mascio; 2012; Thoa, 2004).

Text. The layout of the text on the screen must facilitate reading and viewing. In our "Live Well, Live Healthy!" game, the text is left-justified and the only font used is Arial (12 pts for regular text and 14 pts for headings). This font is the most commonly used on the web, as it provides users with the best readability. Upper case is only used for headings on the site to facilitate navigation. The vocabulary used in our rules, instructions, questions and feedback were adapted to our target audience. Experts and our target group validated our adaptation via game trials.

Illustrations. The use of illustrations must be relevant to the content of the game. In our "Live Well, Live Healthy!" game, we included mechanisms to facilitate the viewing of images. Players may enlarge illustrations to full screen with a simple click of the mouse. We also tested the length of display time for illustrations using various

types of connections: low, medium and high speed. Computer display time in all cases was immediate. Finally, we assessed the usefulness of each image illustrating game questions by the inter-rater method.

Sound. Use of spoken texts can motivate seniors. In our "Live Well, Live Healthy!" game, we integrated a virtual voice so players may listen to the questions, rules and instructions, instead of reading them, therefore facilitating game play for seniors who suffer from visual impairments. Sound control is always available and associated with a button to activate or mute the sound, thus giving players full control over sound features.

4. Methodology

In order to validate the "Live Well, Live Healthy!" game, we used the *Learner Verification and Revision* (L.V.R.) method. This method focuses on the user, is characterized by flexibility and is well adapted to the context in which the product will be used (Nguyen et al, 2008). It allowed us to identify and correct errors and problems (Thulal, 2003; Maddrell, 2008) and to effectively validate a prototype in the course of development with a sample of the target users for whom it was created. This method, also known as a user trial, has also been used in educational games development research (Sauvé, 2010c). The process involves validating the prototype through a sample of the target audience in order to measure its effectiveness. For validation of the game's ergonomics, we chose a sample of 27 seniors aged 55 and over and who are retired.

In addition to the demographic data, knowledge of the Internet and online gaming, and the type of computer equipment - 8 statements on the ergonomics of the online educational game were evaluated using a short online Likert scale questionnaire. Efficiency of design - 16 statements - covers competition, challenge, learning content and feedback. User-friendliness - 17 statements - refers to the instructions and rules linked to navigation within the communication tools and the ease of carrying out the action as well as the display size and the layout of the web game. Educational readability - 8 statements - focuses on the vocabulary used and the visual treatment of the text, photos and videos. Each ergonomic aspect also included one open-ended question. An observation grid filled out by an auxiliary researcher completes the qualitative data.

Participants in the validation process were informed of the research and signed a consent form. All measurement scales were found to possess satisfactory psychometric characteristics. Overall, the analysis shows that the scales used were adequate because for the vast majority they explain beyond 50% of the variance of the measured variables and their accurateness indices are beyond 0.60, which is sufficient for an exploratory study.

5. Main Results

Respondents. There were 27 seniors who participated in the experiment of which 56% were women and 44% were men. Those aged 55-59, or 33%, formed the largest group of respondents, followed by those aged 60-64, or 26%, then those aged 65-69, or 22% and finally those aged 70-74, or 19%. All participants are independent and live at home or in an apartment. They evaluate their computer skills as intermediate (59.3%), beginner (29.6%) and expert (11.1%). The vast majority (92.6%) have played Bingo. More than two-thirds of them use tablets (iPad or Android) and less than half (40.7%) use a smartphone. Finally, less than half (44.4%) play games on the internet.

Design. Respondents identified that playing against other people (4.5 / 5), having the choice of duration (4.0 / 5) and how the game ends (3.9 / 5), obtaining points or not as they answer correctly or not (4.3 / 5) helps maintain competition (4.28 / 5) among the players. Integrating Bonus balls (4.27 / 5) and the choice of the level of difficulty of the questions (4.0 / 5) maintains a sense of challenge (4.13 / 5) throughout the game. As for the learning content (4.05 / 5), respondents indicate that the game takes into account their prior knowledge (4.35 / 5) to help them earn points and that the questions were not too difficult (4.0 / 5), most have opted for the Easy level, and that the repetition of the questions (3.92 / 5) in the game more or less helped them to earn points. Regarding the feedback mechanisms (4.32 / 5), they consider that the feedback for their incorrect answers to questions helped them to correct themselves (4.35 / 5), the smiley or sad faces quickly informed them about their performance regarding the

question (4.38 / 5), the tutorial informed them on actions to be performed during the game (4.26 / 5) and that having access to a summary of their right or wrong answers helped them to measure what they have learned and allowed them to review any incorrect answers to the questions (4.29 / 5).

User-friendliness. In terms of the display (4.37 / 5), respondents indicate that animations add interest to the game (4.2 / 5), that the game board (4.4 / 5) and the questions (4.4 / 5) are displayed within the screen, the Rules (4.3 / 5) and Tutorial (4.3 / 5) buttons are visible on the game interface and easily accessible, the positioning of the tutorial in the center of the game allows them to read the instructions properly (4.3 / 5), the score of the players is well located (4.6 / 5) to track the progress of the players, the Bingo button is well located in the game (4.7 / 5) and finally, that the button for the microphone is more or less visible (3.9 / 5). Regarding navigation (4.1 / 5), the game requires little computer knowledge from the seniors (4.1 / 5), the tutorial (4.1 / 5) and rules (4.0 / 5) helps them to understand how the game works and the rules (4.0 / 5) are available at all times with a single click. With respect to the controller used to play the game (4.1 / 5), the keyboard (4.1 / 5) and mouse (4.4 / 5) are easy to use during the game while the touch screen (3.9 / 5) is a little less easy.

Educational readability. The text (3.97 / 5), the size (4.1 / 5) and the color (4.1 / 5) of the characters of the words found on the card and the tutorial allows for easy reading; however, the font size of the questions (3.7 / 5) seem less easy to read. The respondents felt that the language is appropriate (4.1 / 5). Regarding the sound (4.0 / 5), the respondents noted that it is audible whether for the rules or the questions and that the sound control button is easy to use. Finally, the images are large enough to be well seen on the screen and the time for them being displayed is instantaneous on all computers (4.3 / 5).

Table 1. Results of validation

Categories	Conditions	Results
Design	Challenge	4.13
	Competition	4.28
	Game content	4.05
	Feedback	4.32
Readability	Text	3.97
	Illustrations	4.27
	Sound	4.00
User-friendliness	Display	4.37
	Navigation	4.09
	Controller	4.14

6. Recommendations for Revising the Game

Various recommendations were drawn from the observations and qualitative data of the questionnaire to improve the game.

Challenge. Respondents suggest adding a second Bingo card to increase their chances to win, to set a response time to reduce the wait between the drawing of two balls when the player does not have the number on his card, to display a message when a player has correctly answered all questions from a difficulty level to encourage the player to move to a higher level, to readjust the message that says that players must click on the Bonus number on their card corresponding to the Bonus ball in order to avoid making the other players wait and thus crippling the game until the player executes the action.

Competition. Respondents have a diverging view on the time allotted for answering the questions: according to the rhythm of the players or a timed response. Some players take a long time to respond, which may slow the pace of the game and reduce the motivation of the waiting players. Several players suggested reducing the minimum number of players to two instead of three, which would allow them to play as a couple or with one of their grandchildren.

Learning content. Respondents have conflicting opinions concerning the repetition of questions during the game; for some it is viewed as a good way to winning more points and for others, it reduces competition.

Feedback. Respondents recommend displaying a message inviting them to view their results (good and bad responses) when the game is over; this consultation would help them perform better during future games.

Display. Players suggest increasing the size of the Rules and Tutorial buttons to make them more visible to some respondents. They suggest adding a message to the tutorial explaining their location and operation. They suggest moving the display of the Bonus ball from the center to the right of the interface to allow players to view the entire Bingo card as well as being able to click in the O column. They find that it would be important to know the name of the player who created the gaming session, especially when there are multiple games being played at the same time because they do not know which game to join.

Navigation. Respondents propose including in the first message of the tutorial explaining the choice of the level of difficulty and how the game ends that you need to click the Continue button to activate the game. This action is not intuitive for some players. They recommend eliminating the message, "This number is not on your card" when the player does not have the number on the card, and consider it an unnecessary message. They suggest adding a message to the tutorial explaining how the Bonus ball works. Players understand they cannot answer a question or gain points if the number on the ball is a Bonus ball they have previously won on their card. Finally, they suggest adding an explanation for the Microphone button as soon as the game starts.

Text. Respondents recommend increasing the font size of the words in the questions by at least 2 pts or include a button allowing them to magnify the question screen.

Illustrations. Respondents suggest increasing the color contrast of the buttons (Join, Start Game) in order for them to be easily seen and read on the screen.

Sound. Players suggest slightly accelerating the speed of the virtual voice to improve listening.

The recommendations of the respondents were taken into account and have been included in the pedagogical and IT revisions of the game.

Conclusion

As part of this developmental research, the "Live Well, Live Healthy!" game for seniors is being prepared with the help of the generic shell of the educational game of Bingo, which has been developed by taking into account the ergonomic conditions that we identified from the literature; for references and more detail, see http://cvje2concepteur.savie.ca. This game was validated with 27 seniors using the LVR method. While recognizing the limitations of the testing: the seniors were recruited through the suggestions of names from the students and members of the team (family and friends) and through word of mouth of these people among their friends, the positive results of validation will allow us to review the games and to experiment on them in the autumn of 2014 with seniors (n=150) in both French and English.

When ergonomic conditions are included during the design stage, online educational games become easier to use and thus costs to correct problems can be avoided. In other words, good ergonomics will increase the degree to which a specific group of users are able to play a game and effectively accomplish tasks; therefore, ensuring that good results are obtained to the satisfaction of users in a specific usage context. Display selection, fonts, screen element organization, navigational elements, visual, audio and text formatting on the game interface, as well as rules and tutorials all play an important role in ensuring that the educational game is adapted to the specific needs of seniors, and ensure that the game environment is user-friendly, useful, simple and motivating.

Acknowledgements

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