Can Digital Games Help Seniors Improve their Quality of Life?

Louise Sauvé[1], Lise Renaud[2], David Kaufman[3] and Emmanuel Duplàa[4]

[1]Département Éducation, Télé-université / SAVIE, 455 Rue du Parvis, GIK9H6, Québec, (Qc), Canada
[2]Faculté de communication, UQAM, C.P. 8888, succ. Centre-ville, H3C3P8, Montréal, (Qc), Canada
[3]Faculty of Education, Simon Fraser University, 8888 University Dr, V5A1S6, Burnaby, (BC), Canada
[4]Faculty of Education, University of Ottawa, 145 Jean-Jacques Lussier St, K1N6N5, Ottawa, (ON), Canada

Keywords: Online Games, Seniors, Benefits, Quality of Life.

Abstract: A developmental research study aimed to design, publicize and evaluate an online educational game to improve the quality of life for seniors 55 years and older. The game Live Well, Live Healthy! (cvje2.savie.ca) is a Bingo game in which the learning content in the study was integrated into the mechanism of the game. A "pre-test/post-test" single group methodology measured the impact of the game in three dimensions of quality of life: psychological, physical and social. A total of 56 seniors played for a week in the multiplayer mode (real-time interaction with at least two other participants). The results indicate that the educational game improved the perception of seniors in a majority of the variables concerning the three dimensions: physical (fatigue, sleep, eating habits); social well-being (building ties, social connectedness, friendships) and psychological well-being (depression, difficulty doing activities, mood and feeling of being loved). Some variables (sadness, isolation, proximity to family and physical habits) generated a weak perception of positive benefits for these seniors.

1 INTRODUCTION

1.1 Background

The aging population represents a serious challenge for healthcare systems and social insurance in the 21st century. 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, changing lifestyles and the increased likelihood of developing chronic and disabling diseases. But what are we doing to improve the quality of life for seniors? Can online educational games help them age better?

1.2 Purpose of the Study

Our study aims to measure the benefits of an online educational game designed for seniors concerning their quality of life.

1.3 Research Questions

• What is the impact of the educational game on the perception of the seniors' physical condition?
• What is the impact of the educational game on the perception of the seniors' psychological state?
• What is the impact of the educational game on the perception of the seniors' social environment?

2 LITERATURE REVIEW

An investigation by CEFRIO in Quebec indicated that over a third of seniors aged 55 and over using the internet to play digital games either alone or in groups (Beaudoin et al., 2011). Given this interest, we wondered whether the use of online educational games for improving the quality of life of seniors could be beneficial.

Quality of life is a global concept describing the daily life of people, taking into account the emotional and social functions as well as purely physical conditions. Even though there does not seem to be a consensual definition (Kuyken and WHOQOL Group, 1995), the most widely used definition comes from the World Health Organization - WHO (1993). Quality of Life is defined as ''…individuals' perception of their

position in life in the context of the culture and the value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, level of independence, social relationships, personal beliefs and their relationship to salient features of their environment.''(WH0, 1997, p. 1).

This concept takes into account four dimensions: physical (autonomy and physical abilities), psychological (isolation, depression, emotion), relational (family, social, professional), symptomatic (impact of a disease and its treatment). Surveys (Bowling and Dieppe, 2005; Chen et al., 2013) reveal that a majority of seniors consider psychological well-being, involvement in social activities and physical health as conditions for successfully aging. Finally, Turcotte and Schellenberg (2006, p. 51) consider that "active participation in society can also be compromised if a person has difficulty hearing, seeing, walking, climbing stairs, bending, learning or doing similar activities. All these difficulties, if cumulative, can greatly impair the quality of life of a person of any age."

Digital games are becoming increasingly popular with seniors (Diaz-Orueta et al., 2012; Nacke et al., 2009). According to the World Health Organization - WHO (2001), digital games can influence both the health conditions of seniors (taking into consideration health in a perspective that is both broad and biopsychosocial) and their ability to perform activities in their current environment.

What does the literature say concerning the impact of digital games on the quality of life of seniors as it pertains to the physical, psychological and social aspects? Some studies on the impacts of digital games on an active lifestyle (i.e., the ability to maintain physical and functional independence) have shown beneficial effects on the quality of life of seniors (Figueira et al., 2008; Freitas et al., 2007; Pernambuco et al. 2012). Other studies have examined the contribution of games using the Nintendo Wii game console on the performance of physical and functional tasks. Studies from Jorgensens et al. (2013), Maillot et al. (2012) and Singh et al. (2013) conclude that improvements were apparent; however, those of Bieryla and Dold (2013) and Daniel (2012) do not find any improvements.

Social interaction and social support are constantly identified as key aspects of quality of life for seniors (Adams et al., 2011; Heylin, 2010; Reichstadt et al., 2010; Theurer and Wister, 2010). Seniors are already active users of interactive

technologies and they would be able to use digital games and be able to easily learn (Pew Internet and American Life Project, 2011). Studies are showing increasingly that digital games are a means of social interaction that may improve the quality of life of seniors (De Schutter and Abeele 2010; De Schutter, 2011; Ijsselsteijn et al., 2007; Khoo and Cheok 2006; Khoo et al., 2009; Mahmud et al., 2008; Stebbins 2007; Stowe and Cooney, 2015; Theng et al., 2012;). Whitcomb (1990) found that games develop a sense of well-being and social relationships among seniors while providing an enjoyable way to spend time. Astell (2013) suggested that digital games and interactive technologies (Skype, Facebook, etc.) offer social connections, especially for elderly people suffering from dementia.

Regarding physiological aspects, Allaire et al. (2013) found a significant difference between gaming (moderate and occasional) and non-gaming seniors, concerning socio-affective dimensions such as mood and depression. In addition, Wollersheim et al. (2010) reported that digital games breakdown isolation as well as decrease feelings of loneliness.

Despite these findings, few studies have addressed the psychological aspects of quality of life.

It is difficult to draw conclusions from current empirical studies because there is little overlap in these studies due to several factors:

- the variation in the demographic data of the participants; for example, the number (1-1000 respondents), age (45 to 87), educational level (secondary to university);
- the ratio of men vs. women (more women than men participate in most studies);
- the diversity of research methodologies;
- the use of various measuring instruments (few studies use the same instruments);
- the choice of digital games, which are not always developed for seniors.

What happens if we experiment on an educational game with learning content dealing with nutrition and prevention, in addition to the three quality of life dimensions: physical (physical activity benefits in the development of autonomy and physical abilities), psychological (actions to take to reduce anxiety, depression, emotions) and relational (the contribution of the social environment - family, social, professional - for the well-being of seniors). Can such a game change the perceptions of seniors towards the benefits that educational games can bring by educating them about the actions they can take to improve their quality of life?

3 GAME DESCRIPTION

According to a survey of 932 Canadian seniors (Kaufman et al., 2014), the Bingo game was found to be the most frequently one mentioned by respondents. Figure 1 represents the Live Well, Live Healthy! game interface which is divided into three parts: 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 players' actions: players' names and scores, as well as the microphone and chat control buttons.

Figure 1: Live Well, Live Healthy!

The Live Well, Live Healthy! game was developed using a generic shell for educational games (http://cvje2concepteur.savie.ca). The game's educational objectives are the following: to increase knowledge about nutrition and physical activities, to decrease risk situations (or to improve prevention situations) and to identify the importance of social interactions with friends and family members.

The Live Well, Live Healthy! game offers a mechanism to display a question every time the number of a randomly drawn ball is on one or more of the players' cards. 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 an average question and 50 points for a difficult question). If the player does not answer the question correctly, the token will not appear in the box and the player loses half the points allocated to the question. The 92 questions included in the game are distributed as follows: physical state (31 questions about nutrition, 24 about physical activities), psychological aspect (18 questions) and the social environment (19 questions).

The Live Well, Live Healthy! game provides feedback to support the learning of the preset content. Immediate feedback, related to each learning task, allows the players to identify successful activities and those they have failed.
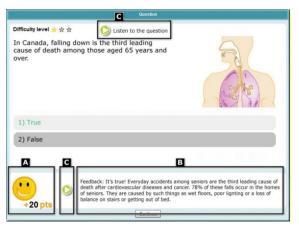

Figure 2: Question Card.

The game incorporates mechanisms (Figure 2) that: (1) highlight the results of each learning activity (success or failure) through visual or audible feedback (A) such as a smiling face or a sad one and positive or negative tone (i.e a signal that indicates whether the action in the game has been made correctly or not by the player) and (2) the correct and incorrect answers through textual, visual (B) or audible (C) feedback on the content of the learning activity or provide additional information to sustain interest in the case of positive responses; and (3) allow players to see what they have learned by providing an overview of the results of the game's learning activities, together with teaching materials to review subject matter that has not been learned.

For more details about this digital game and a good preview, please read Sauvé et al. (2014). This game (http://cvje2.savie.ca) will promote active living and healthy eating habits among seniors as well as giving them opportunities to interact with others by illustrating these themes with good quality images and animations.

4 METHODOLOGY

Opting for a single group pre- and post-test protocol, our study leads us to measure the physical, psychological and social dimensions of quality of life. Remember that quality of life is a subjective concept and the apprehension of the construct itself is complex. The definition of quality of life being adopted in this study specifies the items that the study will retain to measure the impact of the game.

Table 1: Quality of Life Dimensions.

Quality of Life Dimensions	Items Measured
Physical State	Sleep Tiredness Eating habits Physical activity habits
Psychological Aspect	Depression Isolation Feeling loved Mood Sadness Ease in doing activities
Social Environment	Strengthening ties Social connectedness Friendship Interactions with family Interactions with friends

These items (Table 1) were subjected to Likert scale to obtain the construct of the quality of life. To facilitate data collection, we opted for a self-administered questionnaire. It is therefore preferable to use scales having a limited number of questions to minimize the time it takes to fill out the questionnaire.

4.1 Handing out the Pre/Post Questionnaires

A questionnaire of 15 items was used for data collection. The questions were formed as a Likert scale with five levels (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree and 1 = strongly disagree). The questions were designed to determine the perceptions of the participants towards the benefits of playing online concerning physical, social and psychological well-being. The reliability of the instrument was determined to use the index of internal consistency from Cronbach's alpha (α = 0.87). The validity has been established by calculating the Pearson correlation coefficient between items belonging to the same dimension. The four items in the "Physical state" dimension showed significant correlations among them. Similarly, the five items comprising the "Social environment" dimension presented significant correlations among all items. Finally, significant correlations between the six items belonging to the "Psychological aspect" dimension amounted to 66%.

The pretest was completed prior to the participation of seniors in the *Live Well, Live Healthy!* game. Seniors were invited to play at least four games over a period of one month. Following their participation, they had to complete the post-test.

4.2 Sample

It is very difficult to find objective definitions of the terms "senior" or "elderly". "The new definitions proposed by experts are not getting consensual approval yet" (Turcotte and Schellenberg, 2006, p. 8). As part of our study, we selected two criteria: minimum age of 55 and that of being retired in establishing our sample of seniors.

Turcotte and Schellenberg (2006) identify two types of seniors: those who are currently 65, the threshold that delineates the elderly according to Statistics Canada and those who are considered the next generation of seniors, adults aged between 55 and 64. Beaudoin et al., (2011) also chose the age of 55 and over to designate seniors from generation A. Given this trend, we chose to form two age groups: 55 to 64 and 64 years and older.

On the retirement aspect, Turcotte and Schellenberg (2006) found that people aged 56 and over who are retired have more time to devote to their home computer. In a recent study in Australia realized by Brand et al. (2014), nearly one player in five is likely to be aged 51 and over. The reasons and motivations why players choose to play vary by age group, suggesting that the stages of life play an important role in the act of playing games. Following what these authors suggested, retired people were more available and interested in participating in the experiment.

The recruitment of our sample of seniors of 55 and over was carried out through elderly associations and retirement homes. The experiments were done on site during social activities organized by the associations or in the residences' living room in which computer equipment is made available to the participants. This project was approved by the ethics committee at each of the authors' universities. All participants signed a consent form and were able at any time to interrupt their participation without any prejudice. A list of available human resources in their region was provided to them if needed.

4.3 Analyses

The analysis comprised the calculation of frequencies and percentages for each question. The Fisher's exact test was used to determine the significance of the differences between the responses of the pretest and post-test. Since the variables were not normally distributed, the use of

parametric tests such as the paired samples t-test was discarded.

5 RESULTS

Of the 67 participants of the study, 56 (83%) completed the pre- and post-test questionnaires in their entirety, providing all the required information. Table 2 shows the analysis of the 56 respondents.

Table 2: Sample characteristics (sex, age group and level of online gaming skills (n = 56).

Age Group	Level of Online Gaming Skills	Men	Women	TOTAL
Between 55 and 64	Beginner	4	10	14
	Intermediary	2	4	6
	Subtotal	*6*	*14*	*20*
65 and over	Beginner	8	18	26
	Intermediary	1	9	10
	Subtotal	*9*	*27*	*36*
	TOTAL	**15**	**41**	**56**

The sample included 41 women and 15 men. 20 participants (36%) are aged 64 or under and 36 subjects (64%) are 65 or older. 40 players have stated they are "beginners" in relation to their level of online gaming skills, while 16 participants were considered "intermediate" (Initially we presented three skill levels. Two respondents were "experts". Given the low numbers, we decided to integrate them with the intermediate players).Note that the initial trial period was one month and that seniors were the participants have little invited to play at least one game per week for a minimum of four games with two other participants. However, the technological constraints of the locations for the experiment (little or no computer equipment or connectivity) reduced the experimental period for one week. All seniors played at least one game, 79% of them played two games and 21% of seniors played four games.

In the following subsections we present the perceptions of participants (n = 56) regarding the effects of playing online on their quality of life. These effects are grouped according to the previously described dimensions: physical state, psychological aspects and social environment. Table 3 shows the results related to these three dimensions.

Table 3: Results in connection with the three dimensions regarding the quality of life (n = 56).

Items	Physical State		p
	$\bar{x}$		
	Pre	Post	
Fatigue	2.95	3.57	0.069
Sleep	3.44	3.80	0.031
Eating Habits	4.05	4.20	0.083
Physical Activity Habits	2.18	2.53	0.462

Items	Social Environment		p
	$\bar{x}$		
	Pre	Post	
Strengthening Ties	2.90	3.79	0.001
Social Connectedness	3.32	3.44	0.056
Friendship	3.03	3.79	0.003
Interactions with Family	3.72	3.95	0.621
Interactions with Friends	3.69	4.13	0.064

Items	Psychological Aspects		p
	$\bar{x}$		
	Pre	Post	
Depression	3.76	4.21	0.022
Ease of Doing Activities	3.55	4.00	0.156
Mood	3.84	4.33	0.011
Isolation	3.79	4.15	0.158
Sadness	3.86	4.23	0.167

5.1 Perceptions about the Effects of Playing Online on Physical Well-being

Regarding the effects of the game on the players' physical state, the results show an increase in the means of the four items on this dimension, resulting in an improvement in participants' perceptions towards physical well-being (Table 3).

Fatigue - The average of the pre-test (2.95) showed a more neutral perception of the effects that playing online has on fatigue while the post-test average increased by 0.62 to place it in the favourable range (strongly agree or agree). The percentage of participants who thought that playing online does not tire them after a few hours of playing went from 43% in the pretest to 63% in the post-test. These differences are significant (Fisher's exact test, $p = 0.069$).

Sleep - The general assessment of the impact of online games on sleep also improved. Generally, participants believe that online play does not affect their sleep. Although the pretest average (3.44)

showed an already favourable position on this, it strengthened and increased by 0.36 in the post-test. This difference is significant (Fisher's exact test, p = 0.031).

Eating Habits - Both before and after playing online, the widespread opinion was that this activity does not encourage participants to skip meals. This perception was strengthened in participants (average rose from 4.05 to 4.20). The proportion of participants who were of the opinion that online gaming had no effect on feeding habits has gone from 84% in the pretest to 93% in the post-test. These differences are significant (Fisher's exact test, p = 0.083).

Physical Activity Habits - The perception of a positive effect from the game on physical activity was rather low. Before playing, only 12% of participants were of the opinion that online gaming encourages them to be more active. Although this proportion increased to 27% in the post-test, the average remains in the negative range (2.18 in the pre-test and 2.53 in the post-test). The result of Fisher's exact test shows that these differences are not significant (p = 0.462).

5.2 Perceptions about the Effects of Playing Online on Social Well-being

In regard to the effects of gaming on the social environment of the participants, the responses show an improvement in perception in this regard. Indeed, there was an increase in the averages of the five items included in this dimension (Table 3).

Strengthening Ties - With 36% in the pre-test to 75% in the post-test, the rate of participants who agreed with the idea that the game allows them to strengthen their ties increased significantly (p = 0.001). The average had an increase of 0.89. In other words, the perception of the game as a means of strengthening social ties has changed favourably.

Perception of Social Connectedness - Online gaming promotes a social connectedness with others. The pretest average (3.32) and post-test (3.44) support this assertion. The proportion of participants in agreement was 52% before playing and 66% thereafter. These differences are significant (Fisher's exact test, p = 0.056).

Friendship - In connection with the two preceding items, the rate of participants who were of the opinion that online play allows them to have friends has increased significantly (from 40% in the pretest to 73% in the post-test). The average increased by 0.76 and answers converged more around the average. These differences are significant

(Fisher's exact test, p = 0.003).

Interactions with Family - The perception towards interactions with family remains in the positive range. The average pretest was 3.72 and had an increase of 0.23. However, the Fisher exact test does not conclude that these differences are significant (p = 0.621). If NSP is considered (42 in the pretest and 29 in the post-test), the significance improves, but remains slightly nonsignificant (p = 0.139> 0.100).

Interactions with Friends - In the same vein, the results suggest that there has been a consolidation of the perception of interactions with friends. In the pretest, 74% of participants found this perception favourable. The percentage increased to 88% in the post-test. These differences are significant (Fisher's exact test, p = 0.064).

5.3 Perceptions about the Effects of Playing Online on Psychological Well-being

Regarding the effects of the game on psychological well-being, although three of the six items that make up this dimension do not show significant differences, we see significant increases in the averages as shown in Table 2.

Depression - According to participants' responses before they used the game, 74% of participants indicated they did not feel depressed in the current week. In contrast, 17% said they felt depressed. These proportions changed significantly after using the game. The percentage of participants who expressed not being depressed increased to 88% while only one participant responded unfavourably. These differences are significant (Fisher's exact test, p = 0.022).

Ease of Doing Activities – The day after the experiment, participants did not think that their daily activities required an effort, and this was found both in the pre-test (average of 3.55) and in the post-test (4.00). Although there was an increase of 0.45 in the average, the Fisher exact test does not confirm significant differences (p = 0.15683). Yet it should be noted that the NSP increased from 7 in the pretest to 15 in the post-test, which had an impact on the significance of the differences (If NSP is included, the Fisher exact test p = 0.069 is less than 0.100, then the differences may be considered significant).

Mood - The responses suggest that the game had a positive effect on the moods of participants. The rate of participants who expressed feeling in a good mood had a significant increase (0.012). It rose from 77% to 88%. These differences are significant (Fisher's exact test, p = 0.012).

Isolation - The percentage of participants who indicated they do not feel alone rose from 74% in the pretest to 90% in the post-test. In the same vein, the average was 3.79 and increased to 4.15. Nevertheless, these differences cannot be considered significant (p = 0.158> 0.100).

Sadness - Similar to the previous item, the percentage of participants who said they did not feel sadness has gone from 81% in the pretest to 88% in the post-test. Similarly, the average was 3.86 and went up to 4.23 for an increase 0.37. However, the Fisher exact test showed no significant difference (p = 0.167.).

Feeling Loved - Participants in the study felt loved. The answers show that this perception was positive both before and after the use of the game. This is confirmed by the averages of the pretest (4.24) and the post-test (4.37) and by the participant's rate of agreement (95% in the pretest and 90% in the post-test). These differences are significant (Fisher's exact test, p = 0.016).

6 DISCUSSION

We recall that the content of the Live Well, Live Healthy! game addresses the three dimensions of the quality of life in the form of closed questions: the physical state, the psychological aspect and the social environment.

Overall, the results showed significant differences in a majority of the variables that were analyzed. Playing the Live Well, Live Healthy! game online resulted in the participants improved perception of their quality of life concerning their psychological, physical and social states. So our hypothesis that digital games improve seniors' quality of life was confirmed through the physical, social and psychological aspects. Digital game development aimed at seniors is promising. However, certain items seem questionable. What about the non-significant variables?

The respondents reported that playing online gave them no incentive to be more active. It is true that most online games, individual or in group, are not combined with physical devices such as Nintendo Wii and Microsoft Kinect Xbox 360 from which according to Daniel (2012) and Singh et al. (2013), promote improvement in physical conditioning. The interactions in the *Live Well, Live Healthy!* game are done using a touch-screen or mouse. The content of the game covers how to adopt good physical habits. It seems that this way of educating seniors, that is, by offering models of

good physical habits without putting them into action from within the game, maintains their perceptions that online games do not encourage them to be more active.

As for their psychological state, playing online for a limited period does not seem to change the perception of seniors who feel isolated and sad. It is interesting to note that participants who reported feeling in a better mood after playing an educational game, which was linked to the enjoyment in playing the game according to Rosenberg et al. (2010), should have normally felt less sad as well but this was not the case. We would hypothesize that the source of their sadness is more due to their social isolation caused by lack of contact with friends and/or family (Wollersheim et al., 2010) and that their gameplay did not change this situation during the period of our intervention.

Despite the interaction of respondents with others (who were not family members) during the game, it seems that those who had this perception before the game did not change as a result of their participation in the Live Well, Live Healthy! game. These results lead us to question the time allowed to seniors for playing. Given the technological constraints that the participants had little or no computer equipment nor sufficient connectivity at their disposal particularly in their seniors residences, we limited the playing time to one week in order to move the equipment to the different locations. This may explain the results that were obtained? Most studies done with seniors that have obtained positive results on the cognitive, social, psychological or physical level (Sauvé et al., 2015) experimented on the games for a period of at least three weeks. Only the study done by Seçer and Satyen (2014) obtained no significant difference when they experimented on their game over a period of two to three weeks.

In terms of the social environment, playing online maintained their perception towards the proximity of the family but nothing more. However, during the testing of the game, few seniors played with their families; they mostly experimented with friends and people around them at the residence. Can the context of the experiment explain the participants' unchanging perception of this aspect? This is a question for further research.

7 CONCLUSIONS

The results of our study indicate that educational games among seniors, lead to an improved perception of their quality of life encompassing the

following aspects: physical state (fatigue, sleep, eating habits); social well-being (strengthening ties, social connectedness, friendship and interaction with friends) and psychological well-being (depression, ease of doing activities, mood and feeling loved). As for sadness, isolation, interactions with family and physical habits, the perception of a positive effect remains weak among seniors.

While showing very positive results regarding the three dimensions of the study, several limitations have nuanced our findings: the small number of respondents (n = 56), the experimental time (one week), the limited number of games in which respondents participated (between one and four games). Similarly, the use of a board game designed with learning objectives and offered online limits the generalizability of our results for the same type of games.

Further studies should be made to overcome these limitations and consider the impact of online educational games on seniors.

ACKNOWLEDGEMENTS

REFERENCES

Adams, K. B., Liebrandt, S., Moon, H., 2011. A critical review of the literature on social and leisure activity and well-being in later life. *Ageing & Society,* 31, pp. 683-712.

Allaire, J. C., McLaughlin, A. C., Trujillo, A., Whitlock, L. A., Laporte, L., Gandy, M., 2013. Successful aging through digital games: Socioemotional differences between older adult gamers and Non-gamers. *Computers in Human Behavior*, 29(4), pp. 1302-1306.

Beaudoin, J., Kooli, N., Thomas, F., Arlabosse, B., Couture, A., Danjou, R., 2011. *Génération @ : Portrait de l'utilisation d'internet et de l'ordinateur par les aînés internautes du Québec,* Rapport d'enquête. Québec: CEFRIO.

Astell, A.J., 2013. Technology and fun for a happy old age. In A. Sixsmith and G. Gutman (eds.), *Technologies for Active Aging* (pp. 169-187). New York: Springer..

Bieryla, K. A., Dold, N. M., 2013. Feasibility of Wii Fit training to improve clinical measures of balance in older adults. *Clinical Interventions in Aging*, 8, pp. 775–781. doi.org/10.2147/CIA.S46164.

Bowling, A., Dieppe, P., 2005. What is successful ageing and who should define it? *British Medical Journal,* 331, pp. 1548-1551.

Brand, J. E., Lorentz, P., Mathew, T., 2014. *da14 (Digital Australia)*. National Research. Australia: Bond University and Entertainment Association.

Chen, St.C., Huang, Y.G.L., Chiang, I.T., 2012. Using somatosensory video games to promote quality of life for the elderly with disabilities. *The Ieee Fourth International Conference On. The Digital Game And Intelligent Toy Enhanced Learning* (Digitel) (pp. 258-262). Takamatsu : Ieee, 27-30 March.

Daniel, K., 2012. Wii-Hab for Pre-Frail Older Adults. *Rehabilitation Nursing*, 37(4), pp. 195-201.

De Schutter, R., Vanden Abeele V., 2010. Designing meaningful within the psycho-social context of older adults. In V. V. Abeele, B. Zaman, M. Obrist, W. IJsselsteijn (eds.), Fun and Games 2010: *Proceedings of the 3rd International Conference on Fun and Games* (pp. 84-93). New York, NY: ACM.

De Schutter, B., 2011. Never too old to play: the appeal of digital games to an older audience. *Games and Culture,* 6(2), pp. 155-170.

Diaz-Orueta, U., Facal, D., Herman Nap, H., Ranga, M.-M., 2012. What Is the Key for Older People to Show Interest in Playing Digital Learning Games? Initial Qualitative Findings from the LEAGE Project on a Multicultural European Sample. *Games for Health*, 1(2), pp. 115-123.

Figueira, H., Figueira, J., Mello, D., Dantas, E., 2008. Quality of life throughout aging. *Acta Medica Lituanica,* 15, pp. 169-172.

Freitas, C.M., Santiago, M.S., Viana, A.T., Leão, A.C., Freyre, C., 2007. Motivational aspects that influence the elderly to enroll on and continue participating in physical exercise programs. *Revista Brasileira de Cine-antropometria & Desempenho Humano*, 9, pp. 92-100.

Heylin, L., 2010. The older, the lonelier? Risk factors for social loneliness in old age. *Ageing & Society,* 30, pp. 1177-1196.

Ijsselsteijn, W., Nap, H. H., de Kort, Y., Poels, K., 2007. Digital game design for elderly users. In B. Kapralos, M. Katchabaw, J. Rajnovich (eds.), *Proceedings of the 2007 Conference on Future Play* (pp. 17-22). New York, NY: ACM.

Jorgensen, M. G., Laessoe, U., Hendriksen, C., Nielson, O. B. F., Aagaard, P., 2013. Efficacy of Nintendo Wii Training on Mechanical Leg Muscle Function and Postural Balance in Community-Dwelling Older Adults: A Randomized Controlled Trial. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, 68(7), pp. 845–852. Doi: 10.1093/gerona/gls222.

Kaufman D, Sauvé L, Renaud L, Duplàa E, 2014. *Enquête auprès des aînés canadiens sur les bénéfiques*

que les jeux numériques ou non leur apportent [Survey of Canadian seniors to determine the benefits derived from digital games]. Research report, Québec, TÉLUQ, UQAM, Simon Fraser University, University of Ottawa.

Kuyken, W., WHOQOL Group, 1995. The World Health Organization Quality of Life Assessment (WHOQOL): Position Paper from the World Health Organization. *Social Science & Medicine*, 41(10), pp. 1403-1409.

Khoo, E., Cheok, A., 2006. Age invaders: intergenerational mixed reality family game. *The International Journal of Virtual Reality*, 5(2), pp. 45-50.

Khoo, E. T., Merritt, T., Cheok, A. D., 2009. Designing physical and social intergenerational family entertainment. *Interacting with Computers*, 21, pp. 76-87.

Mahmud, A.A., Mubin, O., Shahid, S., Martens, J.-B., 2008. Designing and evaluating the tabletop game experience for senior citizens. In *Proceedings of the 5th Nordic conference on Human-computer interaction building bridges - NordiCHI '08* (pp. 403-406). New York, USA: ACM Press.

Maillot, P., Perrot, A., Hartley, A., 2012. Effects of Interactive Physical-Activity Video-Game Training on Physical and Cognitive Function in Older Adults. *Psychology & Aging*, 27(3), pp. 589-600.

Nacke, L.E., Nacke, A., Lindley, C.A., 2009. Brain training for silver gamers: Effects of age and game form on effectiveness, efficiency, self-assessment and gameplay experience. *CyberPsychology & Behavior*, 12(5), pp. 493–499. doi: 10.1089/cpb.2009.0013.

Pernambuco, C.S., Rodrigues, B.M., Bezerra J.C.P., Carrielo, A., Dias de Oliveira Fernandes, A., Gomes de Souza Vale, R., Martin Dantas, E. H., 2012. Quality of life, elderly and physical activity, *Health*, 4(2), pp. 88-93.

Pew Internet and American Life Project, 2011. *Demographics of Internet users.* Retrieved on March 2012 from http://pewinternet.org/Static-Pages/Trend-Data/Whos-Online.aspx.

Reichstadt, J., Sengupta, G., Depp, C., Palinkas, L.A., Jeste, D.V., 2010. Older adults' perspectives on successful aging: Qualitative interviews. *American Journal for Geriatric Psychiatry,* 18(7), pp. 567-575.

Rosenberg, D., Depp, C.A., Vahia, I.V., Reichstadt, J., Palmer, B. W., Kerr, J., Norman, G., Jeste, D.V., 2010. Exergames for subsyndromal depression in older adults: A pilot study of a novel intervention. *American Journal for Geriatric Psychiatry*, 18(3), pp. 221-226.

Sauvé, L., Renaud, L., Kaufman, D., Duplàa, E., 2014. Validation of the educational game for seniors: "Live Well, Live Healthy!". *Procedia Social and Behavioral Sciences*, 176(2015) (pp. 674-682). International Educational Technology Conference, IETC 2014, 3-5 September 2014, Chicago, IL, USA, Elsevier Ltd, doi: 10.1016/j.sbspro.2015.01.526.

Sauvé, L., Renaud, L., Veniere, S., Mendozo, G.A., 2015. *Rapport d'expérimentation du jeu Vivons bien, vivons sainement!* Québec: Télé-université et UQAM.

Seçer, I., Satyen, L., 2014. Video Game Training and Reaction Time Skills among Older Adults. *Activities, Adaptation & Aging*, 38(3), pp. 220–236. http://doi.org/10.1080/01924788.2014.935908.

Singh, D.K.A., Rajaratnam, B.S., Palaniswamy, V., Raman, V.P., Bong, P.S., Pearson, H., 2013. Effects of balance-focused interactive games compared to therapeutic balance classes for older women. *Climacteric,* 16(1), pp. 141-146.

Stebbins, R., 2007. *Serious Leisure: A perspective for our time.* New Brunswick, NJ: Transaction Publishers.

Stowe, J.D., Cooney, T.M., 2015. Examining Rowe and Kahn's Concept of Successful Aging: Importance of Taking a Life Course Perspective. *The Gerontologist*, 55(1), pp. 43–50. http://doi.org/10.1093/geront/gnu055.

Theng, Y.-L., Chua, P.H., Pham, T.P., 2012. Wii as entertainment and socialisation aids for mental and social health of the elderly. Paper at *Proceedings of the 2012 ACM annual conference extended abstracts on Human Factors in Computing Systems Extended Abstracts*. DOI: 10.1145/2212776.2212840.

Theurer, K., Wister, A., 2010. Altruistic behaviour and social capital as predictors of well-being among older Canadians. *Ageing & Society,* 30, pp. 157-181.

Turcotte, M., Schellenberg, G., 2006. *Un portrait des aînés au Canada.* Canada: Statistiques Canada, p. 321.

Whitcomb, G.R., 1990. Computer games for the elderly. In R. S. Rosenberg (ed.), *ACM SIGGAS Computers and Society* (pp. 112-115). New York, NY: ACM.

Wollersheim, D., Merkes, M., Shields, N., Liamputtong, P., Wallis, L., Reynolds, F., Koh, L., 2010. Physical and psychosocial effects of wii video game use among older women. *International Journal of Emerging Technologies & Society*, 8(2), pp. 85-98.

World Health Organization, 1993. Study protocol for the World Health Organization project to develop a quality of life assessment instrument (WHOQOL). *Quality of Life Research,* 2, pp. 153-159.

World Health Organization, 1997. WHOQOL. Measuring Quality of Life. WHO/MSA/MNH/PSF/97.4. Retrieved on June 2000 from http://www.who.int /mental_ health/media/68.pdf.

World Health Organization, 2001. *International Classification of Functioning, Disability and Health* (ICF). Geneva: World Health Organization.