Games for Active Ageing, Wellbeing and Quality of Life: A Pilot Study

Journal:	*Behaviour & Information Technology*
Manuscript ID	TBIT-2017-0601.R2
Manuscript Type:	Original Research Study
Keywords:	games, ageing, wellbeing, quality of life, pilot study

Games for Active Ageing, Wellbeing and Quality of Life: A Pilot Study

The goal of this study is to identify a set of psychosocial variables and design domains important for game designers to encourage active ageing, wellbeing and quality of life. Sixty adult learners at four Universities of Third Age were randomly assigned to three groups: The Experimental group (G1), who tested firstly a game-based learning platform (GBLP) and then a computer-assisted platform (CAP); The Comparison group (G2), who tested firstly the CAP and then the GBLP; and the Control group (G3) that did not take part in the intervention. Participants were assessed on their health-related wellbeing and quality of life, using the SF36v2 and WHOQOL-BREF scales before and after each experiment. Findings suggest that there were differences between the group type and their perception on mental health ($F(2,57) = 3.771$, $p = .029$) and general health-related wellbeing ($F(2,57) = 5.231$, $p = .008$), in which the GBLP showed improvements relative to the CAP. The environment and mental health were some of the psychosocial domains that should be considered whereas storytelling, context-aware challenges, game space, immediate feedback, role-playing and social engagement were relevant design domains for these games.

Keywords: games; ageing; wellbeing; quality of life; pilot study

Introduction

A considerable amount of literature has been published about the use of technologies in active ageing, well-being and quality of life (*e.g.* Amichai-Hamburger & Barak, 2009; Costa & Veloso, 2015; Sixsmith & Gutman, 2013; McGuire, 1984). Indeed, different countries have brought to the fore their concerns with age-friendly environments and the wellbeing and quality of life of their citizens.

Although there is an urgent need to address these variables when designing digitally mediated approaches with both the delivery of Information and Communication Technologies as a service and the intertwining of technology to daily life and societal challenges – *e.g. gamification, games with a purpose, smart technology, active and assisted living*, the proposed solutions seem to focus on the cognitive aspects and rehabilitation (Costa & Veloso, 2017; Veloso & Costa, 2017). In fact, when designing solutions for active ageing, one should also address such concepts as Health (Physical and Cognitive activity, Nutrition, Social Relationships), Security and Participation in Society (Costa & Veloso, 2017a) as these are suggested to be relevant to the concept of active ageing, provided by the World Health Organization (WHO, 2002).

This study aims to identify a set of psychosocial variables and design domains important for game designers to encourage active ageing, wellbeing and quality of life. These psychosocial variables were based on the domains of health-related wellbeing and quality of life, regarding the fact that these were highlighted as the ultimate goals of active ageing (Costa & Veloso, 2017a). Among the scales used for assessing these domains, the SF36v2 and WHOQOL-BREF met the following criteria: (a) satisfactory reliability (coefficient alpha); (b) permission to use; (c) being validated in Portuguese language; and (d) being applied to the older adult population. These scales have also been previously recognised in a number of publications to assess health-related wellbeing and quality of life, having a high test-retest reliability and validity (*e.g.* Hart, et al., 2015; Von Steinbüchel, Lischetzke, Gurny, & Eid, 2006). Furthermore, previous research has suggested that the use of digitally-mediated programmes can foster health-related wellbeing and quality of life (*e.g.* Ferreira, Torres, Mealha, & Veloso, 2014; Shahrestani et al., 2017; Siegel & Dorner, 2017; Torres, 2011).

A mixed-method approach was used, specifically a quantitative randomized control trial, followed up by qualitative group discussions comprising the participants who tested both a game-based learning (GBLP) and a computer-assisted platform (CAP) (G1 and G2). This study sheds new light into policy research, development and auditing of the use of game-based approaches for active ageing, health and quality of life.

This paper begins by presenting the related work on games and active ageing followed by a description of the materials and methods used. It will then go on to provide information about the participants involved and the procedures used to carry out the study, ethical considerations and the instruments used for data collection and analysis. The paper concludes by outlining the main factors to take into account when designing games for active ageing, well-being and quality of life.

Related work

Over the past few years, much more information has become available on the use of digitally-mediated tools for a purpose that go beyond the mere consumption of information and entertainment – *e.g.* technologies for health, ageing well, behaviour changes, wellbeing or quality of life. Indeed, the proliferation of smart devices that meet the users' context and their surrounding environment has led to an increasing interest in designing and assessing the impact of technology on daily life (Costa, Veloso, & Mealha, 2017).

In terms of the adoption of game-based strategies and game elements to daily life, the debate has focused on its impact on illness prevention and rehabilitation (Leinonen, Koivisto, Sirkka, & Kiili, 2012; Pannese, Wortley, & Ascolese, 2016; Wiemeyer & Kliem, 2012), however a number of studies have revealed that games can also be effective in terms of subjective health-related wellbeing, when compared with other non-game approaches. For example, Allaire and colleagues (Allaire et al., 2013) have shown that regular and occasional older adult gamers had a positive wellbeing and self-reported health when compared to non-gamers. Other studies (Baranowski, Buday, Thompson, & Baranowski, 2008; DeSmet et al., 2014; Hall, Chavarria, Maneeratana, Chaney, & Bernhardt, 2012) have also revealed the potential benefits of games for mental wellbeing and behaviours. Indeed, they can improve cognitive functioning (e.g., short-term capacity, attention, hand-eye coordination) (Whitlock, McLaughlin, & Allaire, 2012); overcome communication problems and social isolation; encourage physical exercising and prevent from falls (Derboven, Van Gils, & De Grooff, 2012; De Schutter & Vanden Abeele, 2008).

An investigation into persuasive design for behaviour change in older adults by Vargheese et al. (2016) has revealed that there are such strategies that can be followed in order to foster social interactions as: (a) Increase social presence and reinforce friends and/or groups' networks; (b) Inform about the perceived benefits with the change; (c) Appeal to fun, using aesthetics and rewarding activities; (d) Provide a support role in the activity; and (e) Enable observation without participation.

Similarly, Costa and Veloso (2017b) have proposed the following design recommendations grounded in different behavioural change theories (Glanz et al., 2008): Simulate scenarios in which the seriousness of the problem is presented and inform about the change benefits; Enable scaffolding; Reward goal achievements; Provide alternative coping strategies; Associate different types of cues to actions and daily habits/routines; Provide easy-to-remember information; Link the information with previous knowledge/past experiences; Remind "small wins"; Promote social accountability; Enable social modelling; Build a trust network and a social status; Inform about policies/initiatives; Provide context-aware information and Create awareness to changes in behaviours.

Collectively, these design decisions may have a central role in health promotion campaigns (Ferrini, Edelstein, & Barett-Connor, 1994), improve health-related wellbeing (Jenkins, 2003) and advice giving (Potempa, Butterworth, Flaherty-Robb, & Gaynor, 2010).

Another significant studies have been published on the use of games in psychotherapy (Costa & Veloso, 2017a; Eichenberg & Schott, 2017; Ceranoglu, 2010) and its application in assistive environments by providing challenges that can exercise cognition and encouraging self-learning; stirring emotions and thus fostering emotional capacity; taking the physical condition of the player into account; supporting both competition, cooperation and social interactions between players; and linking the game activity to daily-life context (Veloso & Costa, 2017). When addressing the +50 market, the following elements are also suggested in order to meet the end-users motivations (Costa & Veloso, 2016; Costa & Veloso, 2015; Veloso & Costa, 2015): (a) familiarity of the game interface with real-world scenarios; (b) reinforcement of communication networks; (c) the cost of the equipment and the players' physical limitations; (d) player vs environment conflict over a player versus player; (e) history-based narrative (Costa & Veloso, 2016); (f) equality in game; (g) memory and logic challenges and avoidance of time limits or speed.

In a nutshell, these previous studies highlight the importance of the psychosocial variables in the design of games that can be applied to non-entertainment contexts, which is the main focus of this paper.

Materials and Methods

Given the research question 'In what way can game-based learning affect the perception of active ageing?', an exploratory mixed-method approach was required in order to understand both the design components that a game-based learning platform should have and the determinant factors related with the perception of health-related well-being and quality of life that can be affected by these interventions. Indeed, a mixed-method approach was used in this study owing to the fact that the solely use of a quantitative or qualitative approach would be insufficient to provide better understanding of the research problem and the research question (Cohen, Manion, & Morrison, 2013).

The origins of mixed-methods procedures date back to the late 1950s with the multitrait - multimethod matrix to study psychological traits developed by Campbell and Fiske (1959), however the practice of combining both quantitative and qualitative approaches to address a research problem is very recent. In addition, there has been an increasing use of this research method and a number of publications (Fang, Lin, & Chuang, 2009; Law & Sun, 2012) have also applied this approach to the areas of education and game studies.

As an exploratory study, the research began with a qualitative phase- i.e. Co-design sessions with adult learners aged 50 and over (G0) in order to assess and analyse the main requirements to develop both the Game-based Learning and Computer-Assisted Learning Platforms and, thus, understand the main design components that a digitally-mediated programme should have for affecting active ageing [PHASE 1 – The Participatory Action Qualitative Research].

Then, the quantitative phase consisted of an experimental study, involving two groups (G1 and G2) of adult learners aged 50 and over in the test of the learning programmes, previously co-designed with G0. The Experimental Group (G1) tested firstly a Game-based learning Platform (GBLP) and then a Computer-assisted Learning Platform (CAP) whereas the Comparison Group (G2) tested firstly the CAP and then the GBLP. A Control Group (G3) that did not take part in the intervention was also involved. These experiments had the purpose of testing whether there were significant differences between the type of experiment undertaken and the perceived health-related wellbeing and quality of life [PHASE 2 – The Quantitative Experimental Research and PHASE 3-Cooperative evaluation of the prototypes with G1and G2].

The rationale for using the mixed-method as a research design were:

- Develop better learning platforms addressed to the adult learners aged 50 and over by involving them in the process, collecting and analysing the qualitative data in order to assess its effectiveness to affect active ageing;
- Refine the learning platforms to serve as an instrument to an experimental study in order to assess their effectiveness to affect active ageing; and
- Cross the data obtained from the quantitative approach with the data obtained from the qualitative phase to assess the participants' context, the strengths and weaknesses of both platforms, self-perceptions of wellbeing and quality of life.

In the sections that follow, the phase 1 – The Participatory Action Qualitative Research, phase 2 – The Quantitative Experimental Research and phase 3 - Cooperative evaluation of the prototypes with G1and G2] will be described.

PHASE 1 – The Participatory Action Research

Game design

Two prototypes (a game-based learning platform and a computer-assisted platform) were developed as the research instrument based on the different domains of active ageing (health, security and participation in society), following a participatory action research (PAR) with 33 participants (48.5% male and 51.5% female, M=67 years old, minimum = 55; maximum = 82) and data was collected from March 2015 to December 2016 (2-hour session per week), using contextual inquiry, strategic visioning and future workshops (Namioka & Schuler, 1993). This process is further described in the papers *Co-designing a Game-based Learning Platform for Active Ageing: The Case of 'Jump'*

(Costa, &Veloso, 2017) and *Demystifying ageing bias through learning: Co-designing an online course about 'Ageing Well'* (Costa & Veloso, 2017b) and, therefore, will not be the focus of this study. The dimensions of health, security and participation in society are the modules that constitute these learning platforms. The health domain embodies the topics of physical and cognitive activity and nutrition (WHO, 2002).

In the game-based learning platform (GBLP), the player has a set of missions related to physical and cognitive activity by travelling to Hizen, 1709. This era was chosen in order to discuss the importance of controlling the body and the mind through the art of being a Samurai and the player can check the benefits of physical activity by completing a set of physical exercises that are recommended (Figure 1). In the end of these exercises, the biological effects of the ageing process and how to prevent from falls are introduced.

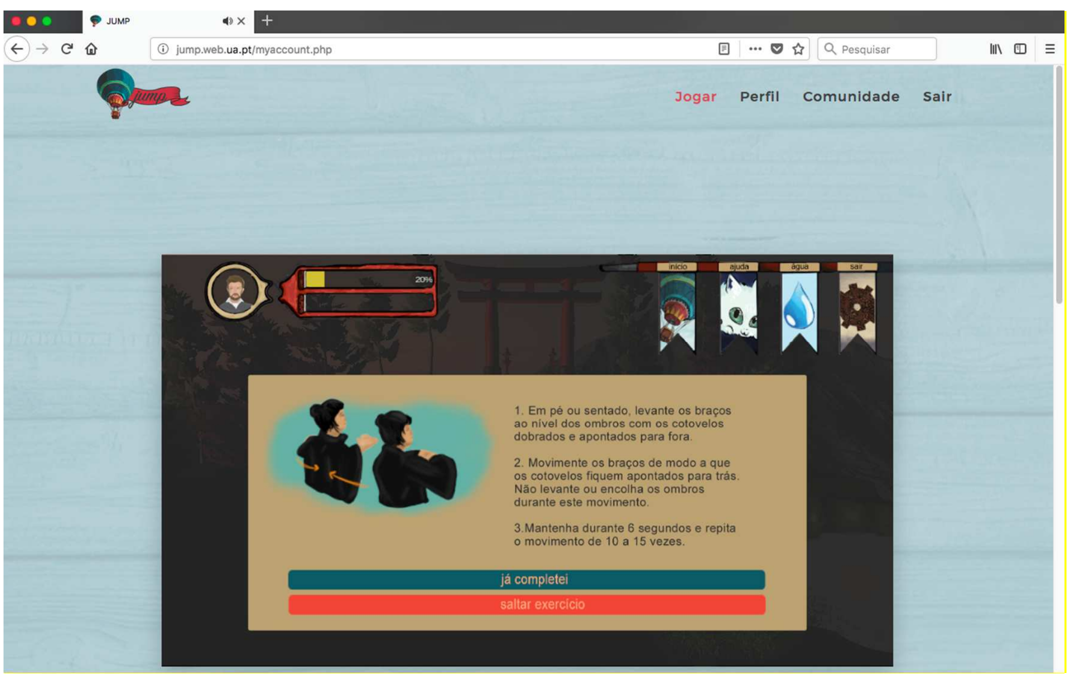

Figure 1. Game missions related with Physical Activity

The players can also train their sensation, perception, attention and memory through a set of mini-games (Figure 2), being aware of the improvement in their performance and scaffolding in their learning process (changes in the level of difficulty).

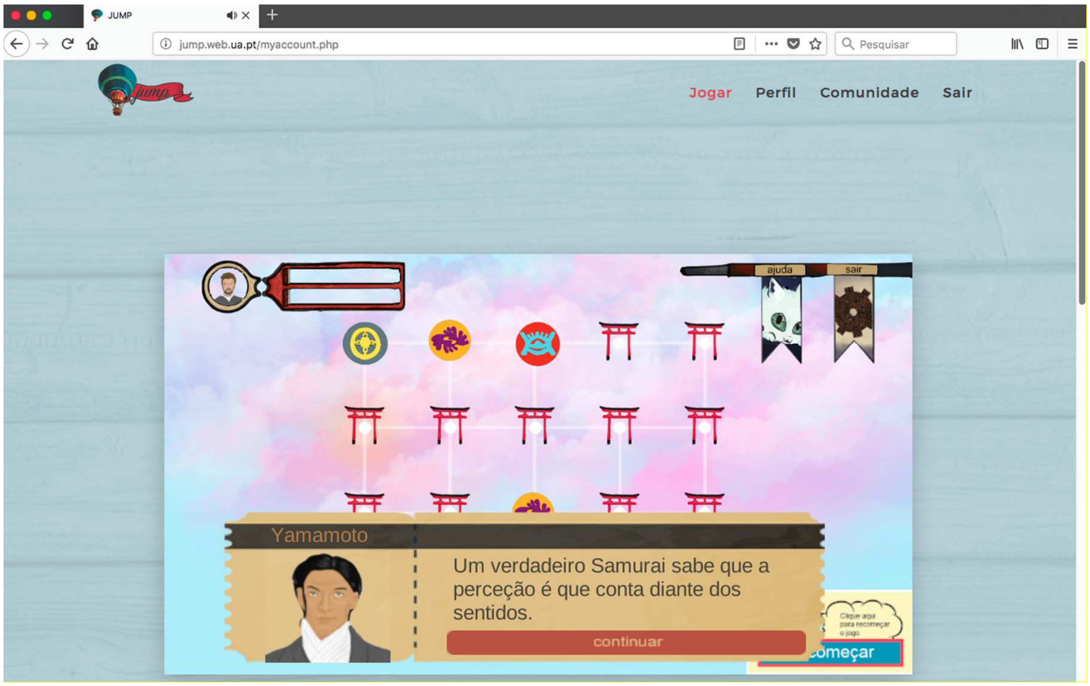

Figure 2. Game missions related with Cognitive Activity

In the computer-assisted learning platform (CAP), the end-user can watch videos related with the benefits of physical activity, biological effects of the ageing process and fall prevention (Figure 3).

Figure 3. Computer-assisted platform – Physical activity

If the user enrols in the course 'Cognitive Activity', the videos cover the brain and the ageing process, the mechanisms of sensation, perception and attention and the memory and the learning process (Figure 4).

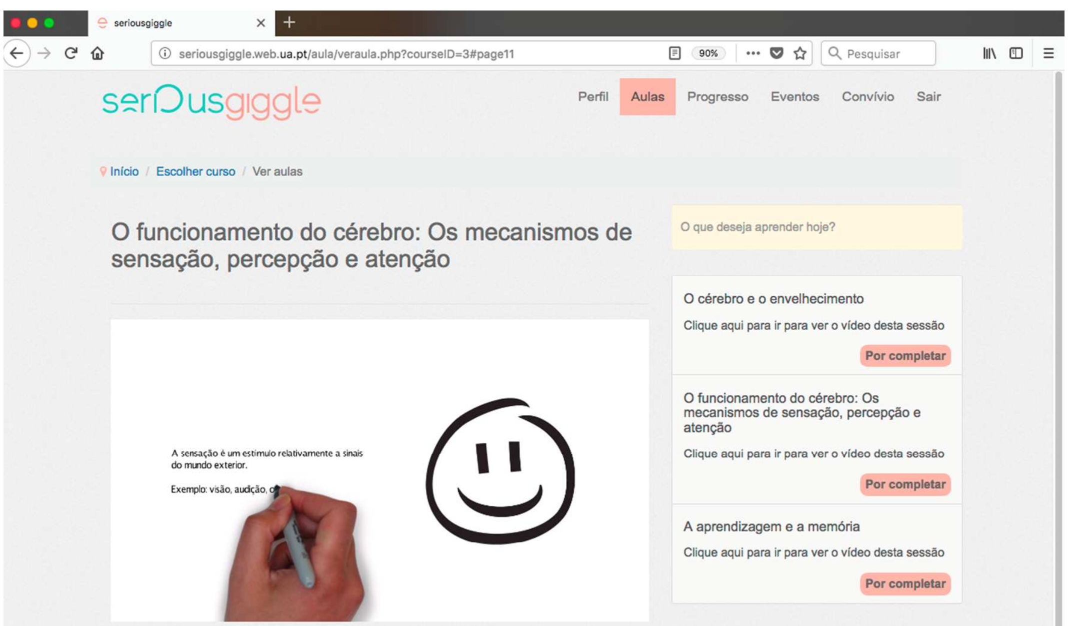

Figure 4. Computer-assisted platform – Cognitive activity

When learning about nutrition through GBLP, the players can have access to the factors that can influence nutrition and the differences between the Mediterranean food, Asian diet and vegetarianism in their time travelling experience to Hizen, 1709. They can have further missions about the use of macronutrients, micronutrients and experience some scenarios of malnutrition in a time travelling experience to London, 1895. In this level, the player is asked to talk with the non-player character Thomas Richard Allinson about the reasons for the malnutrition of poor children, working in factories. The main goal is to find food rich in a certain vitamin (Figure 5), aiming at producing the best medicines to 'help vision and cell growth', 'function of the nervous system, blood, muscles and heart', 'prevent cataracts and relieve eye strain', 'repair DNA', 'help to alleviate anxiety and depression', among other scenarios.

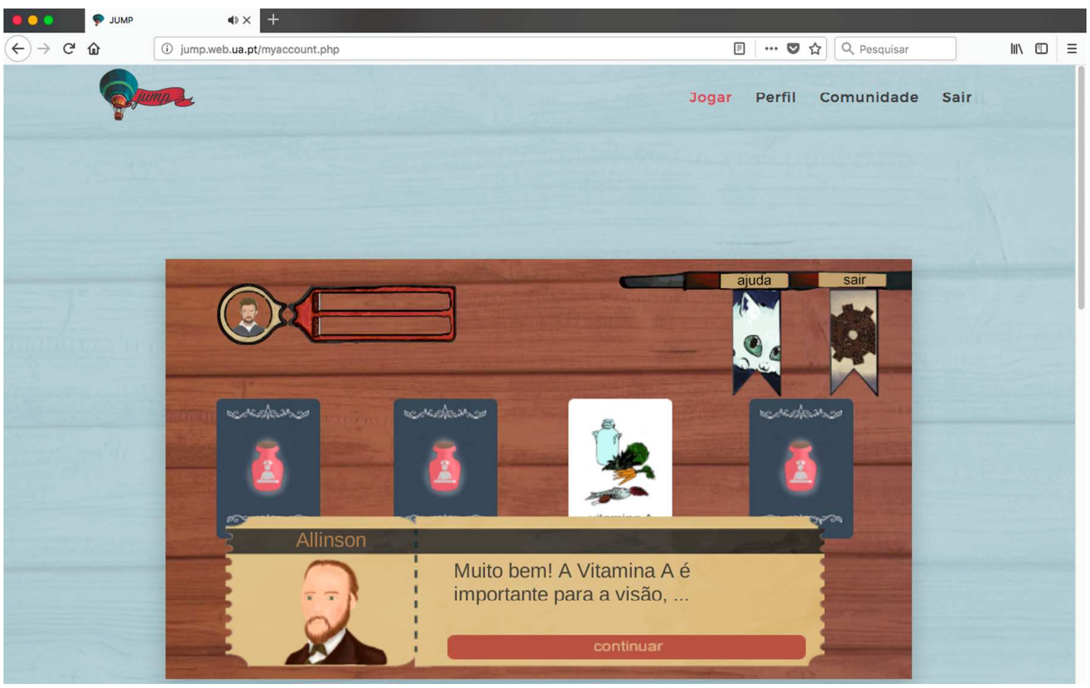

Figure 5. Game missions related with Nutrition

In the computer-assisted learning platform (CAP) (Figure 6), the user can watch videos relative to the factors that can influence nutrition, the differences between the Mediterranean food, Asian diet and vegetarianism; the concepts of macronutrients and micronutrients; and the consequences of malnutrition.

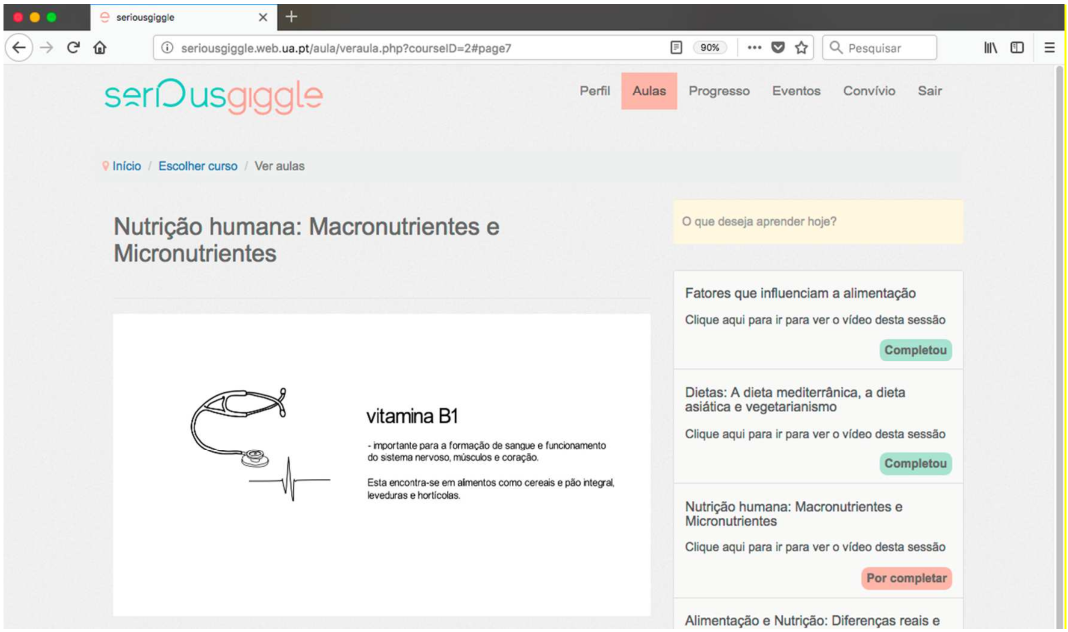

Figure 6. Computer-assisted platform – Nutrition

Finally, the players can learn about the sense of security and participation in society when choosing the scenario of Paris, 1948. This era was chosen in order to create awareness of the role of institutions in the Universal Declaration of Human Rights. The different types of threats to Human Security are covered in a Word Soup mini-game and the different Human Rights are displayed in a quiz. The players are also invited to participate for a cause related with the Millennium Development goals in the section about daily-life missions (Figure 8).

In terms of the CAP, the end-users watch videos about different types of Human Security, the Human Rights and polices for Human development and education.

In addition, the end-users can share their progress, manage learning events, share information and their doubts about the different modules in the CAP whereas in the game they can check their progress and daily-life missions and post a message in the web platform.

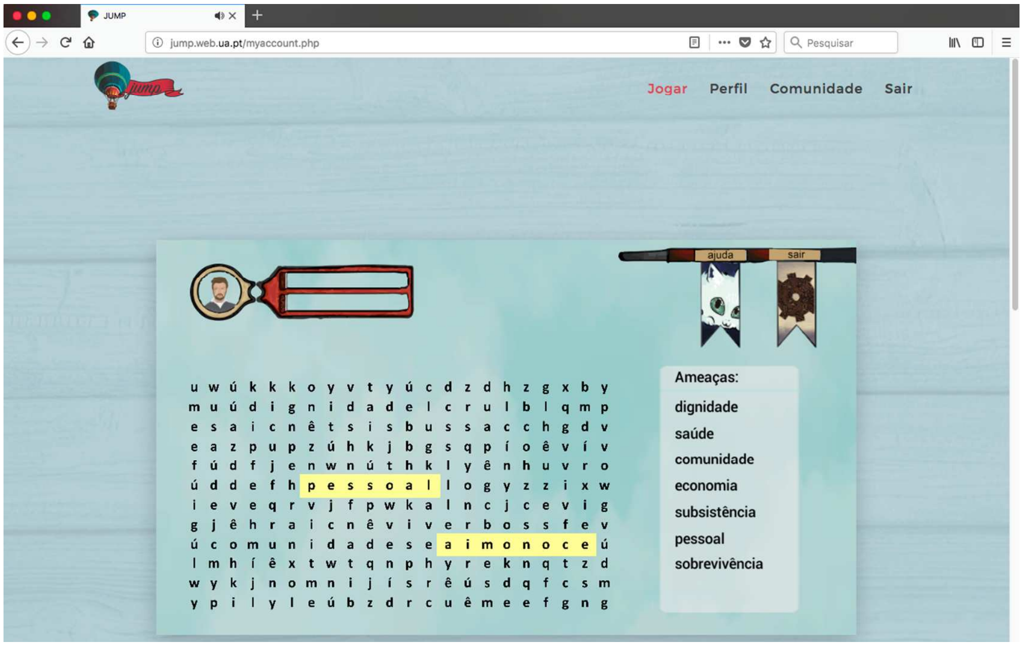

Figure 7. Game missions related with Human Security

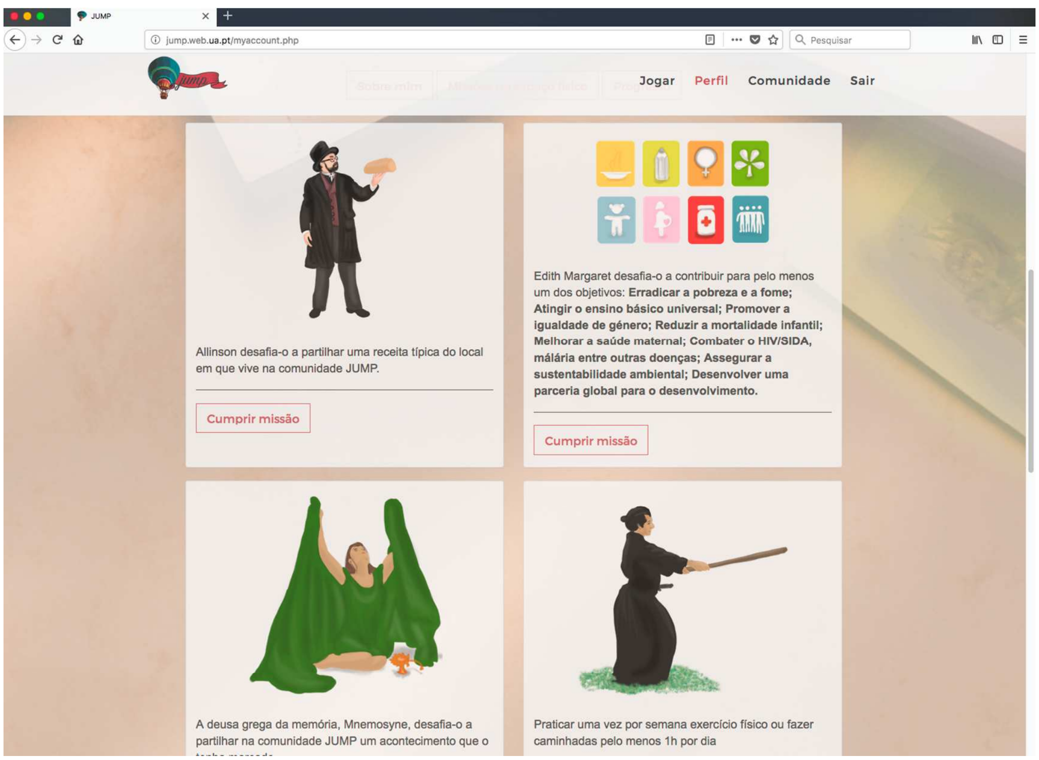

Figure 8. Game missions related with Participation in Society

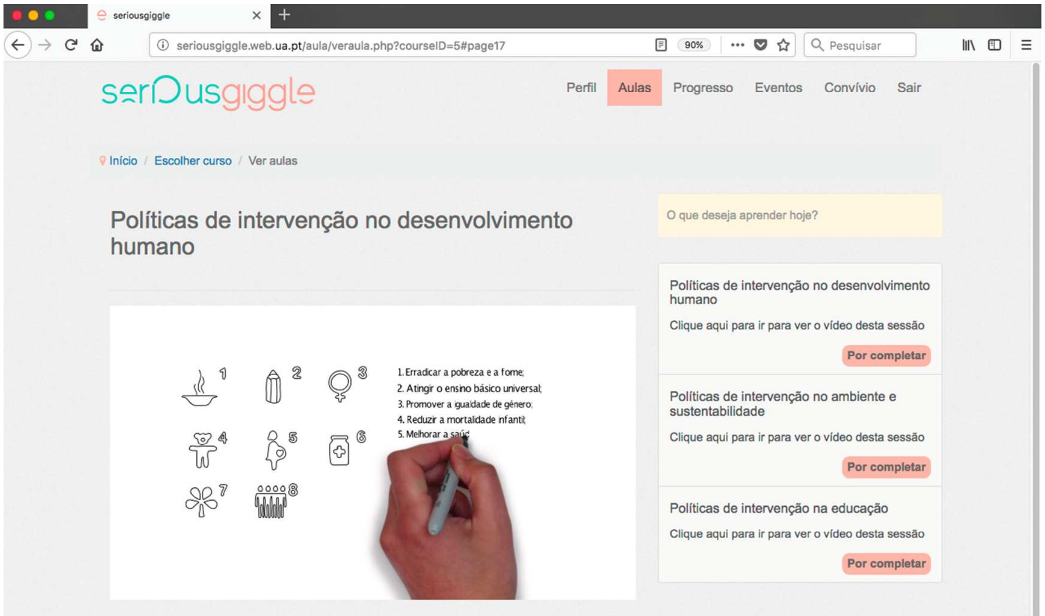

Figure 9. Computer-assisted platform – Participation in Society

PHASE 2 – The Quantitative Experimental Research

A two-treatment counterbalanced design with a control group was conducted in order to test whether there were significant differences between the type of experiment undertaken (the use of game-based learning or the computer assisted platform) (Table 1). In addition, the main psychosocial variables that game designers should take into account when designing and assessing games for active ageing were explored.

Sixty (60) adult learners at four Universities of Third Age were enrolled in the study. They were randomly assigned to three different groups: The Experimental group (G1), who tested firstly a game-based learning platform (GBLP) and then a computer assisted platform (CAP); The Comparison group (G2), who tested firstly the CAP and then the GBLP and the Control group (G3) that did not take part in the intervention. Participants were then assessed on their perception of health-related wellbeing and quality of life, using the SF36- v2 and WHOQOL-BREF scales before and after each experiment.

Participants and Procedures

The participants were sixty adult learners at four Portuguese Universities of Third Age enrolled in the study. Twenty participants (50% males, 50% females; M= 73 years old, SD=5.93) tested firstly a game-based learning platform (GBLP) and then a computer-assisted platform (CAP) (experimental group – G1); twenty participants (40% males, 60% females; M= 69 years old, SD=6.35) tested firstly the CAP and then the GBLP (group of comparison – G2); and twenty participants (G3) did not take part in the intervention (35% males, 65% females; M= 69 years old, SD= 7.16).

In terms of these participants' education level, 38.3% (N=23) had a University Degree, 21.7% (N=13) had 1-4 years of schooling, 16.7% (N=10) had 7-9 years of schooling; 11.7% (N=7) had 10-12 years of schooling; 8.3% (N=5) had 5-6 years of schooling and 3.3% (N=2) had a Post-graduate degree. There were not significant statistical differences between the three sample groups regarding their age (F=.728, p=.487), gender (x2(2) =2.19, p>.05) and their education level (x2(10) =7.28, p>.50). The inclusion criteria for this convenience sample were the following: (i) being 50 or older; (ii) know how to read and write; (iii) voluntary participation; and (iv) interest in learning. Data from participants were gathered between March 2017 and June 2017. A two-treatment counterbalanced design with a control group was conducted and it involved three assessment phases. Table 1 illustrates the main activities carried out during a 6-week session experiment (3-week sessions devoted to game testing and 3-week sessions devoted to video-based online course).

All experimental sessions were conducted in groups and *in loco*. Data collection was based on the application of the scales, direct observation and group discussions.

Table 1. Activities carried out during the 6-week session experiment

Session number	Activities
1	The researcher greeted the participants and explained the research objectives, procedures, benefits, risks and rights of the participants. Questions and Answers (Q&A) followed and consent was obtained from the participants.
2	The session begun with the self-administered surveys: WHOQOL-BREF and SF36v2 (Baseline). The Experimental Group (G1) tested the Game-based learning Platform whereas the Comparison Group (G2) tested the Computer-Assisted Platform. Participants were given an activity guide for each activity and at the end of the session, the main strengths and weaknesses of both platforms were discussed.
3	The Experimental Group (G1) tested the game-based learning platform and then the computer-assisted platform whereas the Comparison Group (G2) tested firstly the computer-assisted platform and then the game-based learning platform. Participants were given an activity guide for each activity and at the end of the session, the main strengths and weaknesses of both platforms were discussed.
4	The session begun with self-administered surveys: WHOQOL-BREF and SF36v2 (Midpoint). The Experimental Group (G1) tested the computer-assisted platform whereas the Comparison Group (G2) tested game-based learning platform. Participants were given an activity guide for each activity and at the end of the session, the main strengths and weaknesses of both platforms were discussed.
5	The Experimental Group (G1) tested the computer-assisted platform whereas the Comparison Group (G2) tested the game-based learning platform. Participants were given an activity guide for each activity and at the end of the session the main strengths and weaknesses of both platforms were discussed.
6	This session was completed with self-administered surveys WHOQOL-BREF and SF36v2 (Posttest).

Measures and analysis

The instruments used in this study were the SF36v2 short form and the WHOQOL-BREF. The SF36v2 form aims to assess the perception on health-related wellbeing and comprises of two health component summary measures (physical and mental) and the following eight health domains: physical functioning, role participation with physical health problems (role-physical), bodily pain, general health, vitality, social functioning, role participation with emotional health problems (role-emotional) and mental health. In this study, the perceived changes in health status were assessed relative to a 1-week recall and the Permission to use SF36v2 was given by Quality Metric. The answers provided by the participants for each of the three data collection sessions were very consistent (The Response Consistency Index ranged from 0.133 to 0.883), level of completeness was 100% and the Cronbach's Alpha was .967. This scale met the purpose of assessing health-related wellbeing and has been previously applied to the older adult population (e.g. Lee, Chan & Mok, 2010).

The WHOQOL-BREF is a 26-item scale that has the purpose of assessing the perception on quality of life. The level of completeness was 98.93% and the Cronbach's Alpha was .919.

The WHOQOL-BREF scale seems to meet the purpose of this study in terms of assessing the predictors of the individuals' perception of their quality of life. It encompasses the four dimensions proposed by the World Health Organizations' definition of quality of life (WHOQOL group, 1998): (1) the position of the physical condition; (2) the perception on the emotional and cognitive condition; (3) the perception on the number and quality of social relationships; and (4) the perception of own context and environment. This scale is available and validated in English and Portuguese, being also used in geriatric patients, dementia and Parkinson's disease.

The participants were also asked to share their opinions on the main strengths and weaknesses of both of the platforms used during the experiments. Data analysis was performed using SPSS Statistics 23 and QualityMetric's Health Outcomes Scoring Software 5.0.

PHASE 3 – Cooperative evaluation of the prototypes with G1 and G2.

After the co-design process and the prototype development, a cooperative evaluation with 40 adult learners (Experimental Group - G1 and Group of Comparison - G2) was followed. This evaluation had the purpose of identifying the main strengths and problems when experiencing the co-designed game platform, and understanding the way the game-based learning tool could encourage active ageing and healthy lifestyles. Therefore, the participants were asked about the main strengths, weaknesses, and suggestions for improvement in the game as well as the way the game platform could encourage active ageing.

Ethical considerations

This study is part of the research project SeriousGiggle (SFRH/BD/101042/2014), which has been approved by the Ethics Committee of the University of Aveiro (Resolution n. 3/2015) that safeguards, among other things: (a) the informed consent of the participants aged 50 and over; (b) voluntary participation; (c) involvement of the research team in the process; and (d) that the risks of participating in the study do not outweigh the risks associated with the participants' daily lives.

Results

In order to assess the psychosocial variables that game designers should take into account when designing and assessing games for active ageing, repeated ANOVA tests were used. Although no significant differences between the type of experiment undertaken by each group and their perception of wellbeing and quality of life were found, there were differences between the group type and their perception on mental health ($F(2,57) = 3.771$, $p=.029$) and general health-related wellbeing ($F(2,57) = 5.231$, $p=.008$), in which the game experiment showed improvements relative to the computer-assisted learning platform.

The participants have reported that games could be effective in encouraging active ageing by fostering confidence to solve daily problems, motivating participation in the community, reducing the fear of ageing and improving the capacity to find solutions to problems. For each recommendation, they also rated its importance from 0 to 4. We then performed Pearson's correlations between these recommendations and the different domains of wellbeing and quality of life.

In terms of quality of life, the environment domain seems to be correlated with the participants' confidence to solve daily problems (G1: r=.514, p=.02; G2: r=.489, p=.03), motivation to Participate in Society (G1: r=.554, p=.01), Decrease in Ageing Bias (G2: r=-.678, p< .01), and Finding solutions to Problems (G2: r=.509, p=.02). The psychological domain seems to be correlated with the Decrease in Ageing Bias (G2: r=-.49, p=0.03).

In regards to health-related wellbeing, the mental health domain seems to be correlated with the confidence to solve daily problems (G2: r=.524, p=.02) and motivation to participate in the community (G2: r=.583, p< .01). In addition, the general health, vitality and social functioning seem to be correlated with the participants' confidence to solve daily problems (G2: r=.59, p< .01; r=.624, p< .01; r=.481, p= .03) and motivation to participate in the community (G2: r=.79, p< .01; r=.49, p= .03; r=.476, p= .03). Finally, the role-functioning also seems to be correlated with the decrease in ageing bias (r=-4.73, p=.04).

The participants' perspectives on the strengths and weaknesses of both prototypes (Game-based Learning and Computer-Assisted Learning Platforms) were also outlined.

In the case of the game-based learning platform, the participants liked the game graphics, narrative and found it easier to interact with the mouse cursor. The idea of travelling throughout time during the gameplay and the game music were seen as an added plus, enabling the participants to re-create sensory perception of different stimuli ('sense of being there'). For example, these were some of the participants' quotes:

> "Wow, I'm impressed. The idea of travelling in time and exploring different cities and historical facts in a game was very good."

> "Thank God there is no need to use the keyboard in order to play the game. This is simple."

> "This music is very good."

> "This looks familiar... It is like I've been here [...] When travelling to one place, it could link the information of the game with the historical archive from the past until now [...]"

In addition, strategy and memory mini-games were types of games that were well accepted by the subjects, as can be illustrated in the following participant's statement:

> "I like these types of games: Word Soup, Sudoku, Word Games... and this game that you presented is the type of game that I'd play but as I use the computer only when I need it, I regret that I wouldn't even try [...]"

Finally, another aspect that the participants highlighted was the fact that they were very interested in checking the food that contained a certain type of vitamin and they were also motivated to repeat and progress in the game with the use of such immediate messages as 'Congratulations' and end-screens for each level with the points obtained.

As for the game weaknesses, the mini games did not enable the players to retrieve the information at any time of the game-playing, forcing the player to replay in order to have access to that information. The exercises could also be more diversified with different difficult levels and bio notes should be provided. As one of the participants pointed out:

> "[…] I need to be remembered of the story [...] Ok, it was presented in the beginning but I almost forgot: it was something about time travelling but it is all that I can remember though."

The game could also have reinforced the interlink between the game challenges and the context (either indoors or outdoors):

> "If the game could be incorporated in my daily life and entertain me during my trips and invite me going outside – that would be nice" "[...] For example, a challenge that enables us to link the information that was given to us with our daily life."

> "We could have done these and other exercises outside."

In a nutshell, these were the main aspects that the end-users stated that the game could improve: (a) Provide a way to retrieve information without the need to replay the game; (b) Present the bios of the characters and history-related facts; and (d) Reinforce the link established between games and daily life activities.

Regarding the computer-assisted learning platform, the videos were perceived as simple and easier to understand, being informative and simple. For example, this fact can be illustrated in the following participants' statement:

> "I think that these videos get my attention. Adding colour to the drawings would be more appellative, though."

Furthermore, the video subtitles helped one of the participants, who had problems with the sound. The participants have also outlined that the functionality of marking doubts relative to a specific moment of the video encouraged them to associate a piece of information shared in a specific moment to the learning content as the doubt of other users could also be their own doubts.

Relative to the progress area, most of the participants competed with their colleagues based on the ranking. Nevertheless, they stated that they would use the platform in order to obtain further information about a topic and not for the purpose of interacting with colleagues.

The profile area was also relevant as it interconnected the learning activity to the end- users' identity and the information retrieval was easier when interacting with the platform rather than with the game.

In terms of the weaknesses of the video-based learning and suggestions for improvement, some of the participants have expressed their concern towards some of the learning areas as it was a bit confusing to distinguish between their profile and colleagues' profile. In fact, the profile area showed too much information and the users' progress per module should be visible, instead of the overall progress. As one of the participants points out:

> "Who are these people? I am not this guy. Where is my profile?"
>
> "I finished the module of Cognitive Activity and my progress is low in my profile [...]"
>
> "The same happened to me [...] Ah, I think it should be per Module, then."

The subjects also stated that video-based lessons should be interlinked with social media as their contacts could answer their doubts and interact with them within the platform. The exercises should be context-based, aiming at giving the opportunity to apply the knowledge obtained to the videos and reinforcing the link with social networks, locations and photos. These are some of their statements:

> "Who will answer to my doubt? My friends on Facebook? But they can if I send it to them, right?"
>
> "How do I share this on Facebook?"
>
> "What about trying these different diets in a lunch/dinner meeting?"

Rewards and video feedback could also be improved. For example, feedback on whether the video has been watched and giving the option to watch it again or the next video should be provided. As the participants note:

> "At the end of each video, present the information that the video has been watched and give the option to watch it again or watch the next video."

> "Has this video already been finished? [...] Where do I click to move to the next one?"

> "It stopped. Shouldn't it reproduce the 5 videos?"

Badges were not so appealing to the participants and a recommendation for incorporating them in the learning process would be through interactive videos (after task- based videos). In addition, other end-users' doubts could be embedded in the video as they could be a challenge to other users and, therefore, be awarded with points (community rating to validate the answers given).

In view of all that has been mentioned so far, one may suppose the next step would be to apply the knowledge given in their own context (progression dependent on daily events, community and strengthened link with social networks/communities...). One way to meet this challenge would be through the use of mobile technology and smart devices to monitor and share the information between multiple platforms.

Discussion

This paper has presented the main factors to be taken into account when designing games for active ageing, well-being and quality of life. Findings have suggested that the Game-based learning platform (GBLP) showed slightly improvements in terms of mental health ($F(2,57) = 3.771$, $p = .029$) and general health-related wellbeing ($F(2,57) = 5.231$, $p = .008$) in comparison with the Computer-assisted learning Platform (CAP). The fact that no significant differences were found between the two groups relative to the total of wellbeing and quality of life may reveal that both media can be complementary in order to transmit the information and multimodality can be the key to reinforce the interlink between the information in daily life and its representation in the digital environment.

Based on the correlations of the psychological variables with the perceived benefits of both platforms that were outlined by the participants in this study, one may suppose that the following quality of life and health-related domains are relevant to build an instrument for designing and assessing the effectiveness of a technology-mediated programme for wellbeing and quality of life: Environment, Mental Health, Social Functioning and Vitality.

In addition, the participants' quotes and the researchers' observations in the field were essential to determine the following design recommendations:

- Encourage actions and changes in behaviour by giving it a purpose through storytelling;
- Adapt the game challenges to the context and interlink the information presented with daily life activities;
- Bring people together in both physical and digital environment;
- Provide immediate feedback towards an action and re-create sensory perception of different stimuli and 'the sense of being there';
- Provide information about the bios and places visited in the game in order to provide meaning to the exploration and the player experience;

In a nutshell, the findings from this study extend current knowledge on the use of games for active ageing, wellbeing and quality of life, giving a noteworthy contribution to the main factors to consider when designing and assessing digital games that go beyond the entertainment purposes. In addition, the prototypes that were developed take into account the different dimensions active ageing, going beyond illness recovery or the maintenance of cognitive or physical capacities. However, it has some limitations and the results need to be interpreted with caution. For example, the study used a convenience sample, so attempts to generalize beyond these respondents are not warranted. In addition, it is a small sample and therefore the number of participants per group should be increased for future work. We are currently carrying out a set of interviews with a group of experts in game design and psychology/ageing studies, aiming at discussing in what way the challenges observed and the recommendations provided based on the participants' context can be met by current trends and solutions in the game market.

Future work lies in extending this experience to other Universities of Third Age from different countries, testing the impact of mediating factors between the use of the digitally-mediated platforms and wellbeing and quality of life as well as building an instrument for assessing the effectiveness of games in encouraging active ageing, wellbeing and quality of life.

Acknowledgements

The research reported in this publication was supported by FCT and ESF under Community Support Framework III – SFRH/BD/101042/2014, the project SEDUCE 2.0 nr. 31696 and the EU under the H2020 Beaconing project, Grant Agreement nr. 687676. The authors wish to thank the WHOQOL Group, Quality Metric, Sigma Maths and Stats Support at the Coventry University for helping us with the analysis of data and to the group of experts, who validated the content to be used during the co-design sessions. A special thank to Prof. Hélder Caixinha and the sTIC team (specially to Alex Angélico). To André Pereira, Mário Jader and Marina Leitão, students who embarked with us on this project. Our gratitude is also extended to Universidade Sénior Gafanha da Nazaré, Academia de Saberes de Aveiro, Universidade Sénior de Oliveira de Azeméis and Universidade Sénior de Águeda.

References

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), 1302–1306. doi: 10.1016/j.chb.2013.01.014

Amichai-Hamburger, Y., & Barak, A. (2009). Technology and Psychological Well-being. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/CBO9780511635373

Baranowski, T., Buday, R., Thompson, D. I., & Baranowski, J. (2008). Playing for Real. Video Games and Stories for Health-Related Behavior Change. *American Journal of Preventive Medicine*, 34(1), p. 74-82. doi: https://doi.org/10.1016/j.amepre.2007.09.027

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. Psychological Bulletin, 56(2), 81. doi: http://dx.doi.org/10.1037/h0046016

Ceranoglu, T. A. (2010). Video games in psychotherapy. *Review of General Psychology*, *14*(2), 141–146. https://doi.org/10.1037/a0019439

Cohen, L., Manion, L., & Morrison, K. (2013). The ethics of educational and social research. In *Research methods in education*, 7th ed., London, UK: Routledge, 99-128

Costa, L. V., & Veloso, A. I. (2017). Co-Designing a Game Based Learning Platform for Active Ageing: The Case of "Jump." In J. Kehoe (2017) *GAME-ON'2017, 18th Annual Conference on Simulation and AI in Computer Games*. Institute of Technology Carlow, Carlow, Ireland, September 6-8, 2017.

Costa, L. V., & Veloso, A. I. (2017a). "Game-based psychotherapy" for active ageing: A game design proposal in non-game context. In *ProceedingsTISHW 2016 - 1st International Conference on Technology and Innovation in Sports, Health and Wellbeing,* Vila Real, PT: TISHW 2016, IEEE, December 1-3, 2016. doi: https://doi.org/10.1109/TISHW.2016.7847788

Costa, L. V., & Veloso, A. I. (2017b). Demystifying Ageing Bias Through Learning. In D. Beck, C. Allison, L. Morgado, J. Pirker, F. Khosmood, J. Richter, & C. Gütl (Eds.), *Proceedings Immersive Learning Research Network: Third International Conference, iLRN 2017, Coimbra, Portugal,* June 26--29, 2017, Cham: Springer International Publishing, 201–213. https://doi.org/10.1007/978-3-319-60633-0_17

Costa, L. V., Veloso, A. I., & Mealha, Ó. (2017). A Review of Proxemics in "Smart

Game-Playing.” In Ó.Mealha, M.Divitini, M.Rehm (eds.) *Citizen, Territory and Technologies: Smart Learning Contexts and Practices, Smart Innovation, Systems and Technologies*, SLERD 2017, Smart Innovation, Systems and Technologies, *Vol. 80*, Spinger, Cham, 219–226. https://doi.org/10.1007/978-3-319-61322-2_22

Costa, L. V., & Veloso, A. I. (2016). Factors influencing the adoption of video games in late adulthood: A survey of older adult gamers. *International Journal of Technology and Human Interaction*, *12*(1). https://doi.org/10.4018/IJTHI.2016010103

Costa, L., & Veloso, A. (2015). The gamer’s soul never dies: Review of digital games for an active ageing. In *CISTI 20152015 10th Iberian Conference on Information Systems and Technologies,*. Áveiro, PT: CISTI 2015, IEEE https://doi.org/10.1109/CISTI.2015.7170614

Derboven, J., Van Gils, M., & De Grooff, D. (2012). Designing for collaboration: a study in intergenerational social game design. U*niversal Access in the Information Society*, 11(1), 57-65.Springer- Verlag, https://doi.org/10.1007/s10209-011-0233-0

De Schutter, B., & Vanden Abeele, V. (2008). Meaningful play in elderly life. *Annual Meeting of the International Communication Association*. Canada

DeSmet, A., Van Ryckeghem, D., Compernolle, S., Baranowski, T., Thompson, D., Crombez, G., … De Bourdeaudhuij, I. (2014). A meta-analysis of serious digital games for healthy lifestyle promotion. *Preventive Medicine*., p. 95-107. doi: https://doi.org/10.1016/j.ypmed.2014.08.026

Eichenberg, C., & Schott, M. (2017). Serious Games for Psychotherapy: A Systematic Review. *Games for Health Journal*, *6*(3), 127–135. doi: https://doi.org/10.1089/g4h.2016.0068

Fang, K., Lin, Y.-C., & Chuang, T.-L. (2009). Why do internet users play massively multiplayer online role-playing games? A mixed method. Management Decision, 47(8), 1245–1260. https://doi.org/10.1108/00251740910984523

Ferreira S., Torres A., Mealha Ó. & Veloso A. I. (2014) Training effects on older people in Information and Communication Technologies considering psychosocial variables. Educational Gerontology 41(7) 482-493 doi: http://dx.doi.org/10.1080/03601277.2014.994351

Ferrini, R. L., Edelstein, S. L., & Barrett-Connor, E. (1994). Factors associated with health behavior change among residents 50 to 96 years of age in Rancho Bernardo, California. *American journal of preventive medicine*, *10*(1), 26-30. doi: https://doi.org/10.1016/S0749-3797(18)30643-3

Glanz, K., Rimer, B. K., & Viswanath, K. (Eds.). (2008). *Health behavior and health education: theory, research, and practice*. San Francisco, CA:John Wiley & Sons.

Hall, A. K., Chavarria, E., Maneeratana, V., Chaney, B. H., & Bernhardt, J. M. (2012). Health Benefits of Digital Videogames for Older Adults: A Systematic Review of the Literature. *Games for Health Journal*, *1*(6), 402–410. doi: https://doi.org/10.1089/g4h.2012.0046

Hart, P. D., Kang, M., Weatherby, N. L., Lee, Y. S., & Brinthaupt, T. M. (2015). Systematic review of health-related quality of life assessments in physical activity research. *World J Prev Med*, *3*(2), 28-39. doi: 10.12691/jpm-3-2-3

Jenkins, C.D. (2003). Building Better Health A Handbook of Behavioral Change. Scientific and Technical Publication No. 590. World Health Organization. Washington D.C., USA: PAHO

Law, E. L., & Sun, X. (2012). Evaluating user experience of adaptive digital educational games with Activity Theory. International Journal of Human-Computer Studies, 70(7), 478–497. doi: https://doi.org/10.1016/j.ijhcs.2012.01.007

Lee, P.L., Lan, W., & Yen, T.-W. (2011). Aging successfully: A four-factor model. *Educational Gerontology*, 37(3), 210–227. doi: 10.1080/03601277.2010.487759

Leinonen, M., Koivisto, A., Sirkka, A., & Kiili, K. (2012). Designing games for well-being; Exergames for elderly people. In *Proceedings of the 6th European Conference on Games-based Learning*, *ECGBL 2012,* Cork, Ireland, October 4-5, 2012, 635–640. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-84897789689&partnerID=tZOtx3y1

McGuire, F. A. (1984). Improving the quality of life for residents of long term care facilities through video games. Activities, Adaptation & Aging, 6(1), 1–7. doi: https://doi.org/10.1300/J016v06n01_01

Namioka, A., & Schuler, D. (1993). *Participatory design: Principles and practices. Hillsdale, Lawrence Earlbaum, NJ.* New Jersey, USA: Lawrence Erlbaum Associates Publishers.

Pannese, L., Wortley, D., & Ascolese, A. (2016). Gamified wellbeing for all ages - How technology and gamification can support physical and mental wellbeing in the ageing society. In Kyriacou E., Christofides S., Pattichis C. (eds.) XIV Mediterranean Conference on Medical and Biological Engineering and Computing 2016, IFMBE Proceedings, vol. 57, 1281–1285. Springer, Cham. https://doi.org/10.1007/978-3-319-32703-7_246

Potempa, K. M., Butterworth, S. W., Flaherty-Robb, M. K., & Gaynor, W. L. (2010). The healthy ageing model: Health behaviour change for older adults. *Collegian*, *17*(2), 51-55.doi: https://doi.org/10.1016/j.colegn.2010.04.008

Siegel, C., & Dorner, T. E. (2017). Information technologies for active and assisted living—Influences to the quality of life of an ageing society. *International journal of medical informatics*, *100*, 32-45. doi:https://doi.org/10.1016/j.ijmedinf.2017.01.012

Shahrestani, A., Van Gorp, P., Le Blanc, P., Greidanus, F., de Groot, K., & Leermakers, J. (2017, July). Unified health gamification can significantly improve well-being in corporate environments. In *39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2017*, 4507-4511, Seogwipo, South Korea: EMBC, IEEE. doi: 10.1109/EMBC.2017.8037858

Sixsmith, A., Gutman, G. (2013). Introductions. In *Technologies for Active Aging*, 1–5. Boston, MA: Springer. https://doi.org/10.1007/978-1-4419-8348-0

Torres, A. C. S. (2011). Cognitive effects of video games on old people. *International Journal on Disability and Human Development*, *10*(1), 55-58. doi: https://doi.org/10.1515/ijdhd.2011.003

Vargheese, J. P., Sripada, S., Masthoff, J., & Oren, N. (2016). Persuasive strategies for encouraging social interaction for older adults. *International Journal of Human-Computer Interaction*, 32(3), 190-214. doi: https://doi.org/10.1080/10447318.2016.1136176

Veloso, A. I., & Costa, L. V. (2017). Heuristics for designing digital games in assistive environments: Applying the guidelines to an ageing society. In *Proceedings TISHW 2016 - 1st International Conference on Technology and Innovation in Sports, Health and Wellbeing,* Vila Real, PT: TISHW 2016, IEEE, December 1-3, 2016. doi: https://doi.org/10.1109/TISHW.2016.7847789

Veloso, A., & Costa, L. (2015). Social network games in an ageing society: Co-designing online games with adults aged 50 and over. *CISTI 20152015 10th Iberian Conference on Information Systems and Technologies,*. Áveiro, PT: CISTI 2015, IEEE . doi: https://doi.org/10.1109/CISTI.2015.7170613

Von Steinbüchel, N., Lischetzke, T., Gurny, M., & Eid, M. (2006). Assessing quality of life in older people: psychometric properties of the WHOQOL-BREF. *European Journal of Ageing*, *3*(2), 116-122. doi: https://doi.org/10.1007/s10433-006-0024-2

Wiemeyer, J., & Kliem, A. (2012). Serious games in prevention and rehabilitation-a new panacea for elderly people? *European Review of Aging and Physical Activity*, p.41-50, doi: https://doi.org/10.1007/s11556-011-0093-x

Whitlock, L. A., McLaughlin, A. C., & Allaire, J.C. (2012). Individual differences in response to cognitive training: Using a multi-modal, attentionally demanding game-based intervention for older adults. Computers in Human Behavior, 29 (4), p. 1091-1096.

WHO -World Health Organization. (2002). *Active ageing: A policy framework*. Geneva: World Health Organization.

WHOQOL Group. (1998). Development of the World Health Organization WHOQOL-BREF quality of life assessment. The WHOQOL Group. Psychological Medicine, 28, 551–558.

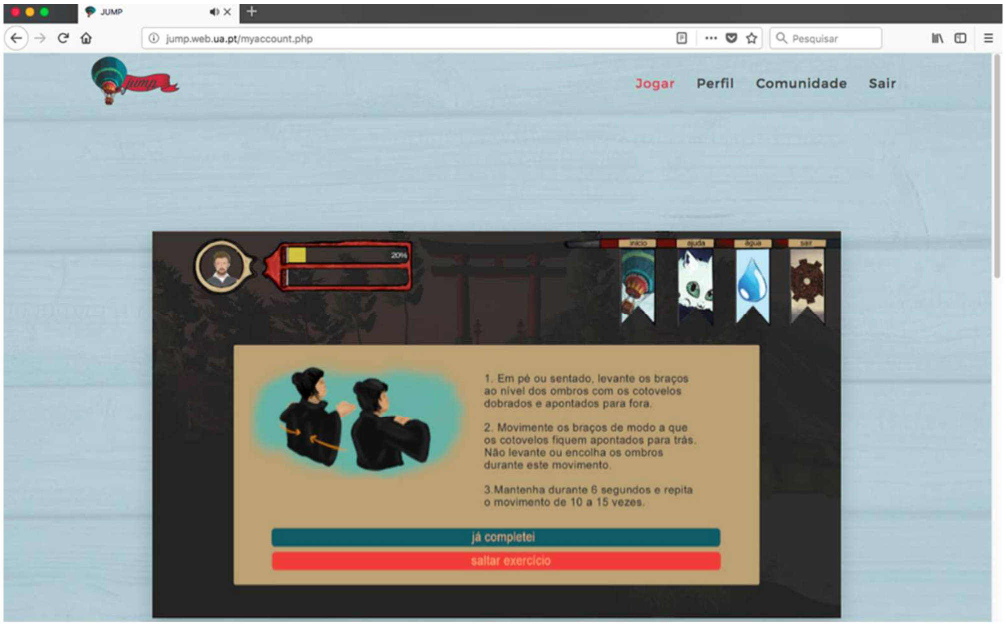

Figure 1. Game missions related with Physical Activity

333x206mm (72 x 72 DPI)

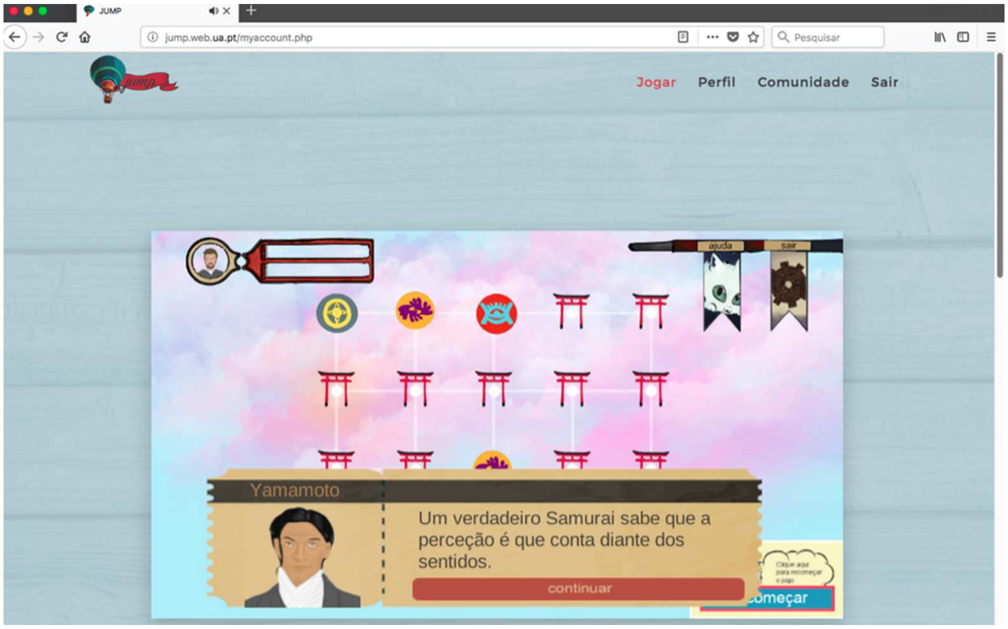

Figure 2. Game missions related with Cognitive Activity

340x211mm (72 x 72 DPI)

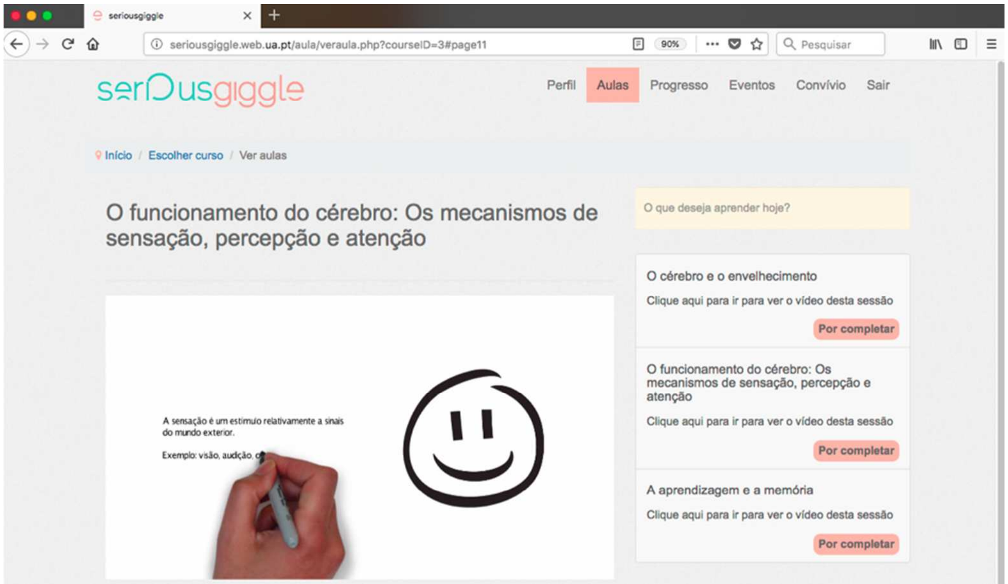

Figure 4. Computer-assisted platform – Cognitive activity

333x194mm (72 x 72 DPI)

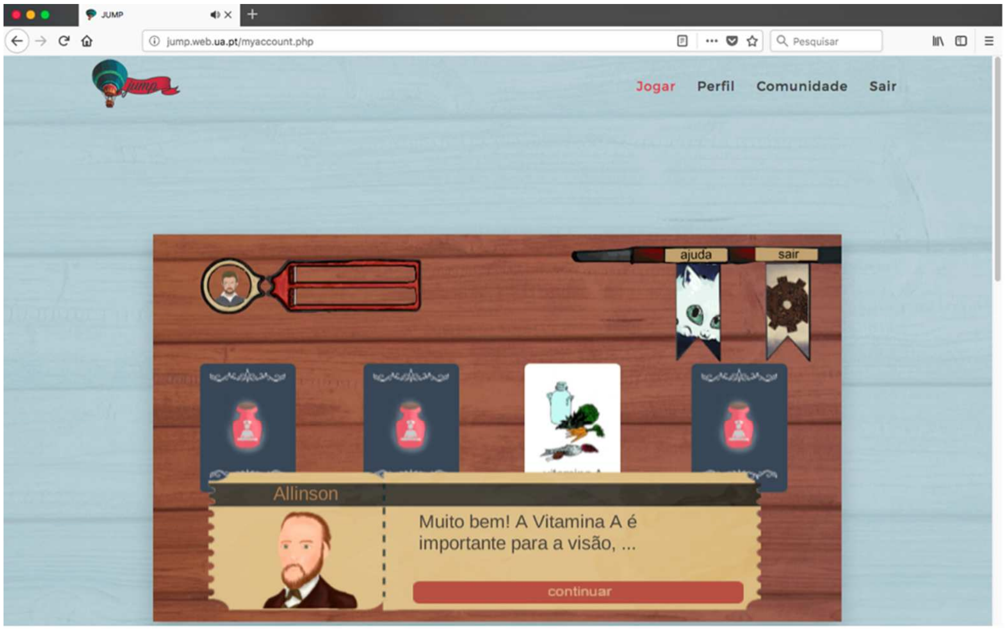

Figure 5. Game missions related with Nutrition

341x213mm (72 x 72 DPI)

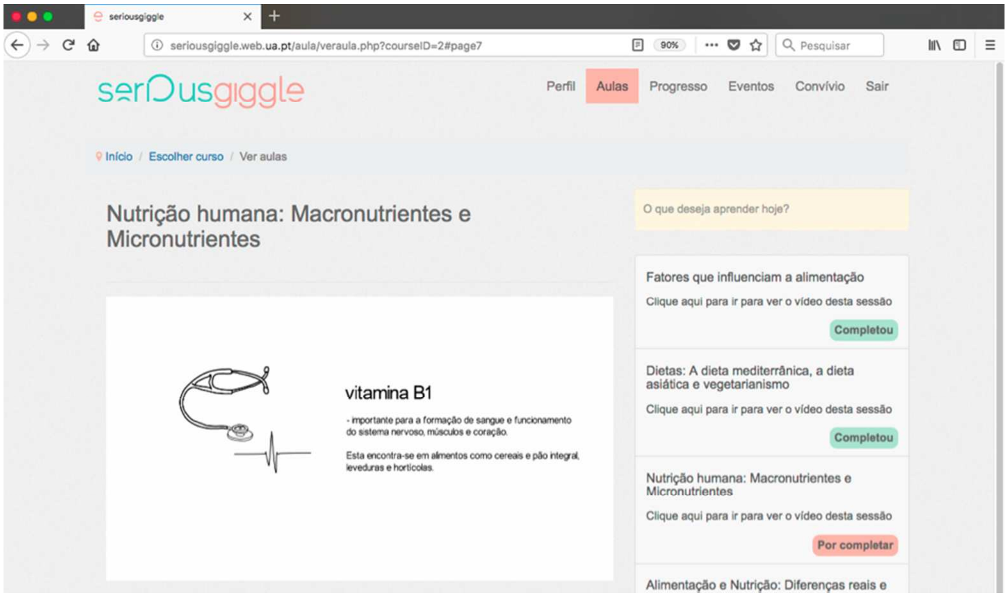

Figure 6. Computer-assisted platform – Nutrition

333x196mm (72 x 72 DPI)

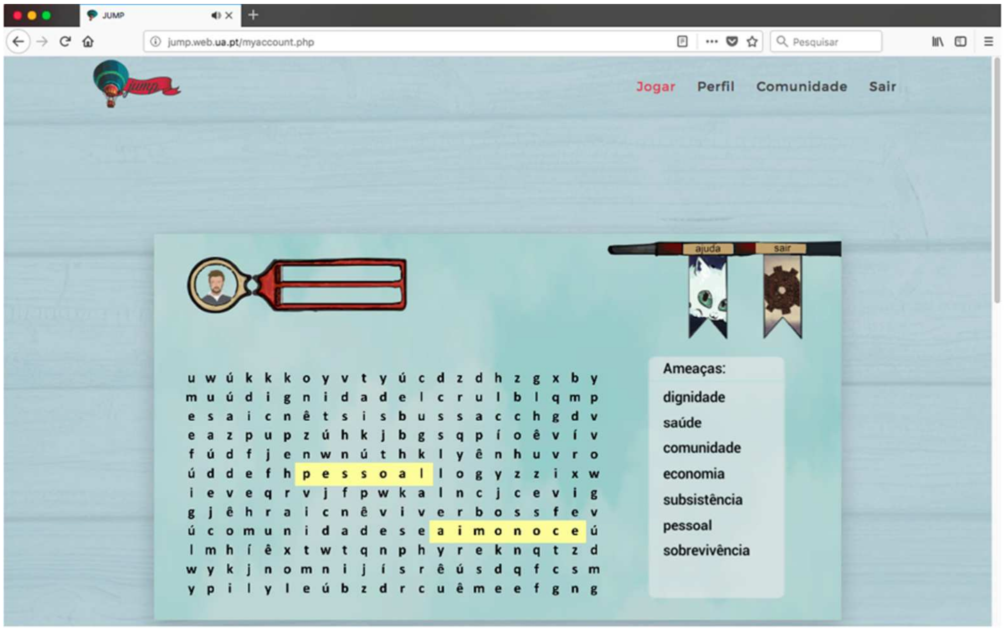

Figure 7. Game missions related with Human Security

320x200mm (72 x 72 DPI)

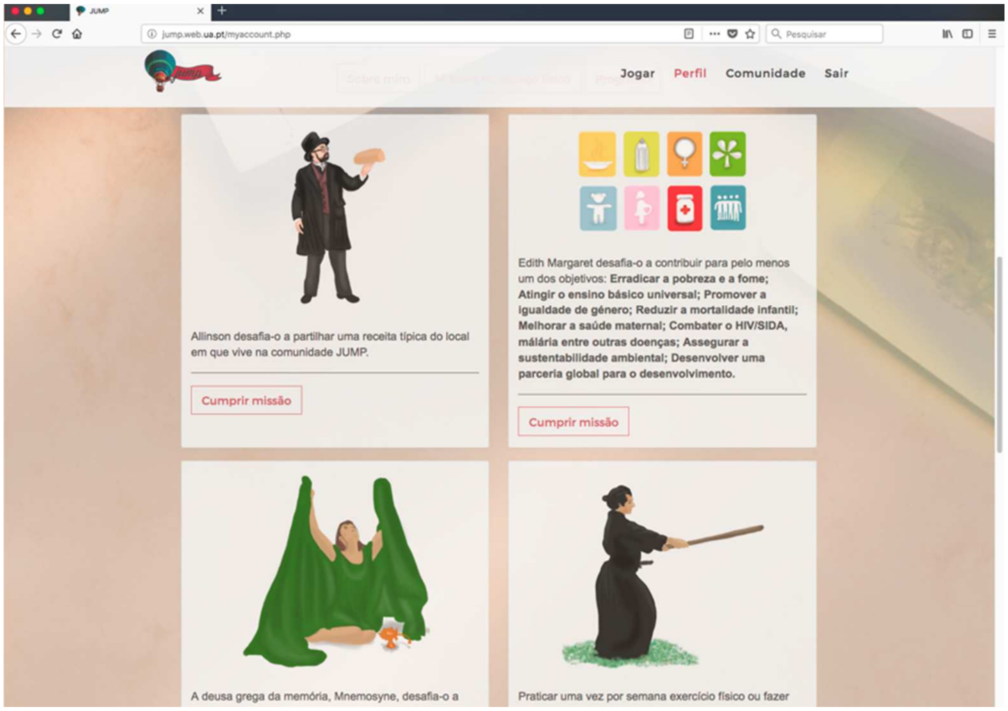

Figure 8. Game missions related with Participation in Society

302x212mm (72 x 72 DPI)

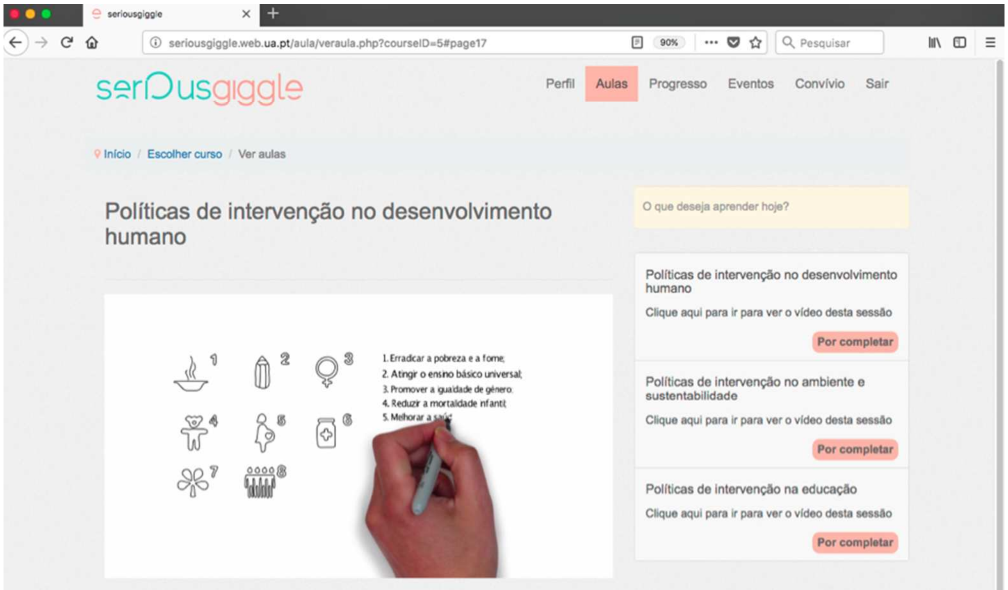

Figure 9. Computer-assisted platform – Participation in Society

335x197mm (72 x 72 DPI)

Table 1. Activities carried out during the 6-week session experiment

Session number	Activities
1	The researcher greeted the participants and explained the research objectives, procedures, benefits, risks and rights of the participants. Questions and Answers (Q&A) followed and consent was obtained from the participants.
2	The session begun with the self-administered surveys: WHOQOL-BREF and SF36v2 (Baseline). The Experimental Group (G1) tested the Game-based learning Platform whereas the Comparison Group (G2) tested the Computer-Assisted Platform. Participants were given an activity guide for each activity and at the end of the session, the main strengths and weaknesses of both platforms were discussed.
3	The Experimental Group (G1) tested the game-based learning platform and then the computer-assisted platform whereas the Comparison Group (G2) tested firstly the computer-assisted platform and then the game-based learning platform. Participants were given an activity guide for each activity and at the end of the session, the main strengths and weaknesses of both platforms were discussed.
4	The session begun with self-administered surveys: WHOQOL-BREF and SF36v2 (Midpoint). The Experimental Group (G1) tested the computer-assisted platform whereas the Comparison Group (G2) tested game-based learning platform. Participants were given an activity guide for each activity and at the end of the session, the main strengths and weaknesses of both platforms were discussed.
5	The Experimental Group (G1) tested the computer-assisted platform whereas the Comparison Group (G2) tested the game-based learning platform. Participants were given an activity guide for each activity and at the end of the session the main strengths and weaknesses of both platforms were discussed.
6	This session was completed with self-administered surveys WHOQOL-BREF and SF36v2 (Posttest).