Article

"What a mobility-limited world": Design Requirements of an Age-friendly Playable City

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Abstract: A key concern in an ageing society is citizens' mobility. As populations age, disability impairments can affect active ageing, health-related wellbeing and quality of life. In this paper, we present the on-going research project SeriousGiggle – Game-based learning for triggering active ageing. Its goal is to assess the potential of game-based learning for active ageing and contribute to a sense of wellbeing and quality of life. It also seeks to improve the mobility of older adults by creating a set of journey plans with route guidance that are rated in terms of safety, community support, environment and age-friendliness. Drawn on our field work with 33 co-designers, 40 end users and 10 semi-structured interviews with Subject Matter Experts, we identify a set of necessary design requirements to an Age-friendly Playable City. This study recommends the use of gamification and playful techniques to engage the end-users to provide information about local traffic signs, pavement conditions, wayfinding and, therefore, help to create route guidance and walking assistance that are personalized to older adults' context in terms of location, travel fitness, mobility impairments and motivations.

Keywords: Playable City; Age-friendly environments; Games; Mobility; Active ageing

1. Introduction

Mobility and physical activity play a vital role in the individuals' daily-life activities, wellbeing and quality of life [1, 2]. The ageing process is a personal trajectory built over the years [3] and, therefore, creating awareness about dietary intake and fostering safe physical activities are essential in order to both prevent sarcopenia [4] and the risk of certain diseases – *e.g.* hypertension, diabetes and cholesterol [4, 5, 6, 7]. Furthermore, physical activity can be beneficial by (a) strengthening the muscles [8, 9] (p.25); (b) improving agility, posture, stress tolerance, sleep and mood [8, 9]; (c) preventing excessive weight gain and reducing the risk of fracture and frequency of falls [8, 9]; (d) improving cognitive function and confidence [8, 9]; and (e) reducing depression and anxiety [8, 9].

According to the International Classification of Functioning, Disability and Health [10], mobility impairments can occur at different stages: Changing and maintaining body position;

47 Carrying, moving and handling objects; Walking and moving; and Moving around transportation.
48 These impairments do not only challenge the interface design in urban, mobile and home spaces but
49 also open up a set of opportunities to rebuild the cities in terms of safety, community support,
50 environment and age-friendliness.
51   Although there has been an increasing interest in the use of game strategies and elements
52 applied to physical exercise [11, 12, 13], there has been little published data on its use for
53 encouraging active ageing through mental and emotional representations of player-citizens in their
54 environment [11], and encompassing equally important dimensions, other than health, – i.e. security
55 and participation in society [12]. The playable city movements, in which the inherited services,
56 stories and places are determined by own citizens [11, 12, 13], have also reinvented the way people
57 interact and move within the city [11, 12, 13]. However, building playable cities, which are equally
58 age-friendly and inclusive seems to be unconsidered in both literature review and/or current social
59 policies.
60   The aim of this paper is to identify a set of necessary design requirements for designing an
61 Age-friendly Playable City. Specifically, we (a) identify a set of recommendations for designing
62 age-friendly environments, and (b) discuss in what way these can be applied for engaging
63 individuals in a Playable City that is more accessible in terms of journey plans and route guidance.

64 **2. Materials and Methods**

65   The purpose of this research project **SeriousGiggle** is to assess the potential of game-based
66 learning for active ageing and contribute to a sense of wellbeing and quality of life. It also seeks to
67 improve the mobility of older adults by creating a set of journey plans with route guidance that are
68 rated in terms of safety, community support, environment and age-friendliness.
69   This exploratory mixed-method research is divided into the following three phases: PHASE 1 –
70 The Participatory Action Qualitative Research, in which a group of 33 adult learners at a University
71 of Third Age were involved in the design process of a game-based (GBLP) and computer-assisted
72 learning programs (CALP); PHASE 2 – The Quantitative Experimental Research, in which two
73 treatment counterbalanced groups tested a game-based and a computer-assisted learning program
74 and assessed these in terms of their perceived health-related wellbeing and quality of life before and
75 after each experiment (SF36v2 and WHOQOL-BREF); and PHASE 3 – The Mixed-Method Approach,
76 in which groups discuss pros and cons of each experiment and then proceeding to a set of interviews
77 with a group of experts in order to propose a set of recommendations for designing such
78 digitally-mediated and age-friendly environments.
79   This paper will focus on PHASE 3 – The Mixed-Method as this paper is an extension of the
80 conference paper presented at SEGAH 2018- *Breaking barriers to game-based learning for active ageing*
81 *and lifestyles: A qualitative interview study with experts in the field* [14] and further information about the
82 process and other phases are described in the following papers: *Games for active ageing, well-being and*
83 *quality of life: a pilot study* [15], *Co-designing a Game-based Learning Platform for Active Ageing: The Case of*
84 *'Jump'* [16], and *Demystifying Ageing BiasThrough Learning: Co-designing an Online Course about 'Ageing*
85 *Well'* [17].

86 *2.1. Previous assessment of the perceived benefits and motivations to Physical Exercise with the co-design*
87 *group*

88   A group of 33 adult learners at a University of Third Age were assessed in terms of their context
89 and involved in the design of the GBLP and CAP (48.5% male and 51.5% female, M = 67 years old,
90 minimum = 55; maximum=82) and data were collected from March 2015 to December 2016.
91   Concerning Physical Exercise, the participants were asked whether they practiced any Physical
92 Exercise and about the reason for doing or not doing it. The participants were, therefore, given a list
93 of statements based on the World Health Organization's potential benefits for practicing Physical
94 Exercise [8] and [9] to rate from 1 to 5 their level of (dis) agreement:
95   • 'Doing exercise with people of the same age is good for socializing';

96   • 'Doing exercise in a balanced way is essential to good health';
97   • 'Doing exercise helps me to relieve anxiety and cope with emotions';
98   • 'Doing physical exercise in groups is more fun than individual exercises';
99   • 'Physical exercise is important to general health.'
100   After showing some examples of the use of Technology in Physical Exercise and discussing the
101   role of technologies in Health, they were asked about the main functionalities that they would like to
102   have in a learning program related to Physical Exercise. The following options based on those
103   examples and discussion were provided:
104   • 'Creation of events related to Physical Exercise';
105   • 'Schedule Physical Exercises';
106   • 'Creation of a plan of Physical Exercise';
107   • 'Share the progress of Physical Exercise';
108   • 'Compare the progress of Physical Exercise with friends';
109   • 'Associate a reward system to Physical Exercise';
110   • 'Audio-visual tutorials related with exercises to practice'
111   • 'Simulations on exercises to practice';
112   • 'Other.'

113   *2.2. Game design relative to physical exercise*

114   Based on the definition of active ageing presented by the WHO [12] and the participants'
115   context a game-based learning program was developed. The game plot is the following: "Sul, the
116   fisherman is tired of getting stuck to a routine that he never got used to. Depressed and isolated, Sul
117   has to face the storyteller Nubel, who forces him to a time travel experience, in order to recover
118   values and have a significant meaning to his own life."
119   In the game missions, a set of challenges related with Physical Exercise were also included (i.e.
120   Strength, Flexibility, and Equilibrium exercises) that can be performed both indoor and outdoor
121   (Figure 1 and Figure 2).
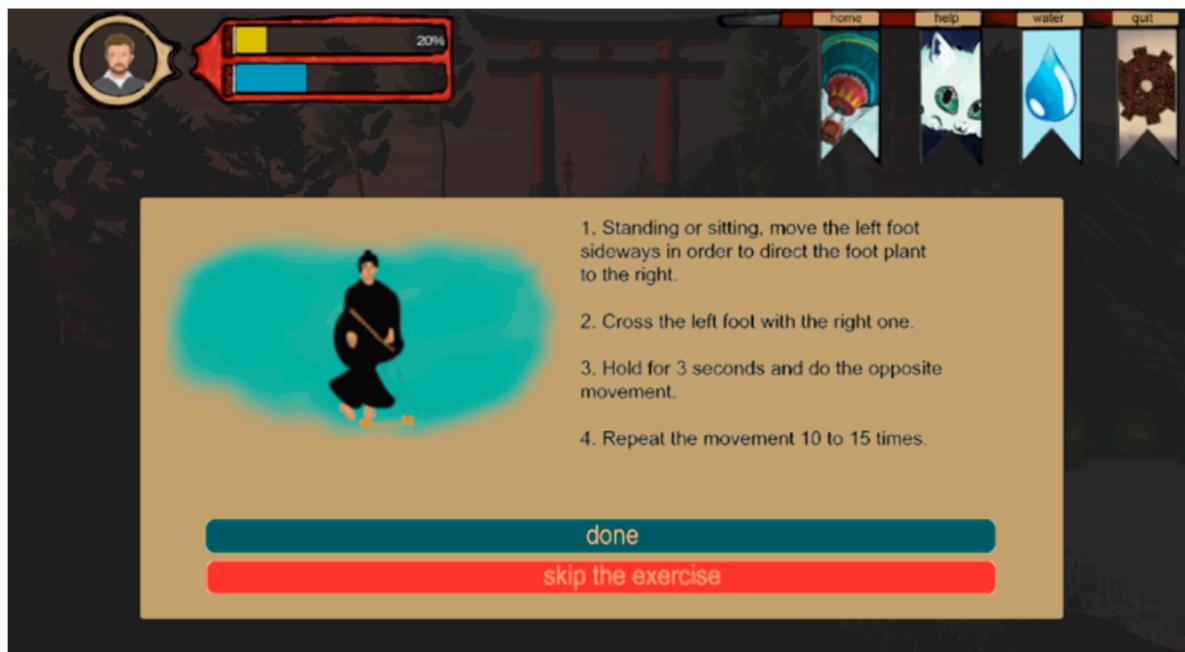
122
123   **Figure 1.** In-game missions related to Physical Exercise
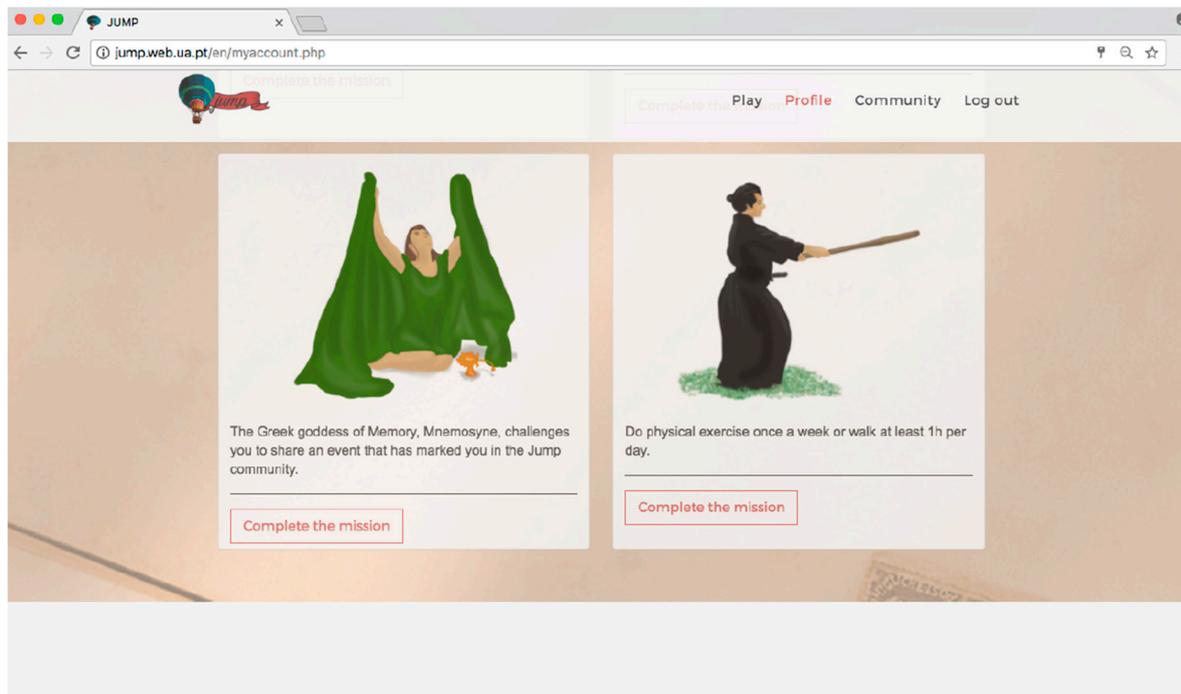
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125   **Figure 2.** Off-game missions related to Physical Exercise

126   These missions are embedded in the game plot, in which the character Sul travels to the Hizen
127   Province, 1709 to meet the history-based and non-player character (NPC) – the Samurai Yamamoto
128   Tsunetomo, who encourages the player to do the exercises by giving his practical and advices on
129   how to be a Samurai warrior (published in the book 'Hagakure'). The player can also find
130   information about the benefits of physical activity, the biological effects of ageing and
131   recommendations on fall prevention. The same contents were covered in an online video-based
132   course (Figure 3), aiming at comparing its effectiveness with the game [17].
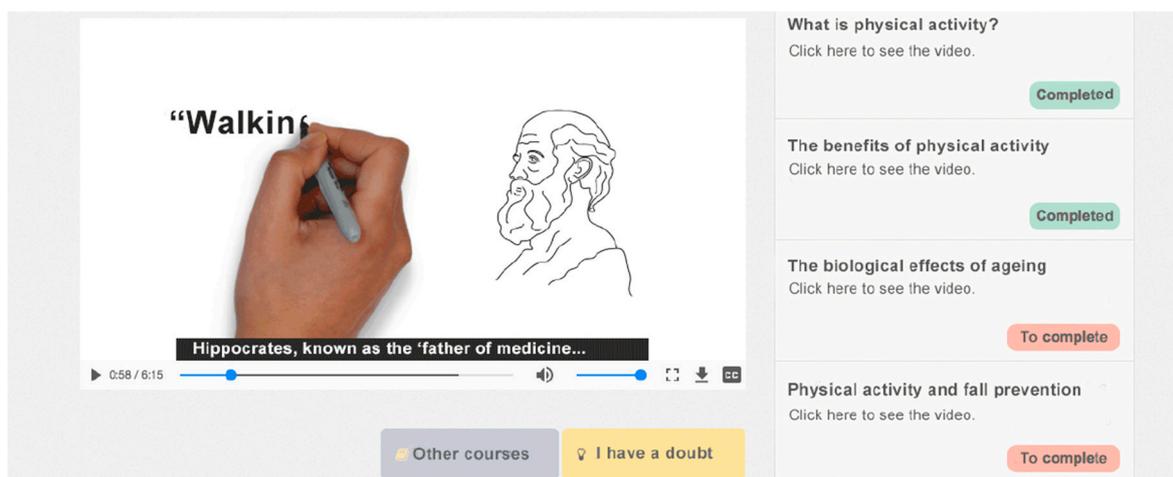
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134   **Figure 3.** Off-game missions related to Physical Exercise

135   *2.3. Cooperative evaluation*

136   After the co-design process and game development (PHASE 1 and 2), a cooperative evaluation
137   with 40 adult learners was performed. This cooperative evaluation aimed to identify the main
138   strengths and problems of the platforms to encourage active ageing and healthy lifestyles.

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140   *2.4. Interview with Subject Matter Experts*

141   A group of experts (N=10) in the fields of Games, Human-Computer Interaction, Psychology,
142   Marketing and Ageing Studies were interviewed. These experts met the following selection criteria:
143   (a) voluntary participation; and (b) being familiar with games, or/and learning and changes in
144   behaviour, or/and age-friendly environments. Out of the 53 invitations sent, there were 10
145   acceptances, 2 refusals and 40 no answers.
146   The purpose of the interviews was twofold: (a) acquire the experts' perspective on the use of
147   games in learning and changes in behaviours; and (b) understand the role of digitally-mediated
148   approaches to meet the challenges of the ageing process. As such, audio recorded semi-structured
149   individual interviews were held between July and October 2017 with 10 interviewees (8 males and 2
150   females), researchers and practioneers in the game industry (Table 1). Face-to-face interviews took
151   place at Coventry University and others were conducted on teleconference, videoconference or
152   e-mail, being audiotaped and transcribed.
153
154   **Table 1.** The Interviewees' general information

ID	Context	Description
1	Educational Sector	Researcher in User Experience and Information Architecture. Professor in Computer Science with a vast experience in joint academia-joint academia-industry projects (e.g. Microsoft, Nokia)
2	Both	Freelance game designer, consultant and lecturer. Experience in game development and previous involvement in such game projects as the ones carried out by Bullfrog Productions or Madden NFL Football.
3	Industry	Vast experience in the game industry and consultant in monetization, videogames and gamification. Relevant game projects: Smashy City, Batman and The Flash: Hero Run, Jelly Jiggle and Farm All Day.
4	Educational Sector	Research Associate at the Disruptive Media Learning Lab. Background in Psychology with the following research interests: identities in online communities, learning practices and games.
5	Industry	Vast experience in the tabletop games industry and involvement in various game projects (i.e. triple A console MMOs and free-to-play games).
6	Industry	Vast experience in game design. Relevant game projects included SEGA Rally Revo and Colin McRar: DiRT Rally.
7	Educational Sector	Professor and Researcher with expertise in 'silver gaming' and the use of old and new media by older adults.
8	Educational Sector	Research fellow for the Behaviour and Interventions Research Group (Coventry University) and Public Health Warwickshire with the following research interests: evidence informed making, social marketing, health behavior change and eHealth.
9	Educational Sector	Researcher in Educational Technology and Learning Design at Simon Fraser University with a focus on ageing and technology. Research interests: digital games and digital storytelling with older adults and intergenerational relationships.
10	Educational Sector	Senior lecturer and researcher with background in Artificial Intelligence, in-game learning, computer games development and digital media. Research interests: Virtual reality and applications for learning and training.

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156   A convenient time was arranged for both the interviewee and the interviewer and a protocol
157   was used to conduct the interviews and analyse the data. This protocol was divided into the

158 following steps: 1. Introduction/Instructions and Standards Procedures; 2. Ice-breaker questions; 3.
159 Four/five questions; and 4. A Thank-you statement.
160   Whereas Table 2 presents the questions used to interview Subject Matter Experts in the fields of
161 Games/Human-Computer Interaction, Table 3 shows the ones posed to the experts in Psychology,
162 Marketing or Ageing Studies.
163   The verbatim transcriptions were reread, coded using NVIVO and analysed by identifying and
164 highlighting patterns in the interviewee's statements. The codes used in this paper were:
165 Recommendations for designing age-friendly environments and Designing for learning and
166 behaviour change.

167 **Table 2.** Overview of the questions used to interview experts in the fields of games/human-computer
168 interaction

Data Collection Questions	Data Analysis Questions
1. How can we attract the player's attention to the information transmitted and changes in behavior through a game-based approach?	What are the main factors that can foster learning and changes in behavior?
2. In your opinion, what could be a pervasive game scenario for motivating active ageing and healthy lifestyles?	
3. Do you see gamification as a players' mind-set solution or a game designer's product? Why?	What's the role of game designers in gamification?/What's the role of players' mind-set in gamification?
4. Can a gamified system work by extending actions that occur in the physical space to the digital one? What is your view on that?	
5. How can games generate a culture of care and prevention outside of the medical system?	What are the main factors that can generate a culture of care and prevention outside of the medical system?
6. In your perspective, what role can informational literacy perform in order to overcome the commercial war that can occur between changing or manipulating behaviors?	What are the main strategies that can be adopted in order to avoid manipulation of behaviors in *gamification*?
7. What are the main misconceptions or drawbacks of these game-based approaches that game designers should take into account?	What are the drawbacks/challenges of the game-based approaches for learning and changes in behaviors?
8. What are the opportunities for gamification and serious games?	What are the opportunities for gamification and serious games?
9. In your opinion, what the future holds for serious games and gamification?	

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Table 3. Overview of the questions used to interview experts in the fields of psychology and ageing studies

Data Collection Questions	Data Analysis Questions
1. What drives Human behaviors?	What are the main factors that can foster learning and changes in behavior?
2. In your opinion, can technologies trigger changes in behavior? If so, in what way?	What are the key technological features that can influence changes in behaviors?
3. How can we transform Human behaviors into daily routines?	What are the main factors that lead Human behaviors into habits/routines?
4. In your opinion, how can we create environments that are better places for encouraging active ageing?	What are the main features of an age-friendly environment?
5. In your perspective, what could the technology industry do to contribute to age-friendly contexts?	What are the opportunities for age-friendly technologies?
6. What challenges do you foresee in the new approaches to create age-friendly environments?	What are the challenges for age-friendly technologies?

173   *3.5. Ethical considerations*

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

179   **3. Results**

180   *3.1. Previous assessment of the perceived benefits and motivations to Physical Exercise with the co-design*
181   *group*

182   When surveying the participants whether they practiced Physical Exercise, 54.5% (n=18)
183   revealed that they do physical exercise at least 3 times per week due to the following reasons:
184   Improve agility and posture (n=20; 60.6%); Prevent health problems (n=17; 51.5%); and Maintain and
185   improve mobility (n=15; 45.5%). Six participants did not practice any physical exercise and pointed
186   out the 'lack of motivation/interest' as being the main reason.
187   Results have also shown that most of the participants agreed that doing exercise with people of
188   the same age was good for socializing (n=31; 94%). They also recognized that doing it in a balanced
189   way was essential to good health (n=33; 100%) and helped them to relieve anxiety and to cope with
190   emotions (n=31; 94%), being more fun in groups rather than individual exercises (n=32; 99%).
191   Overall, Physical Exercise was stated to be important to general health n=32; 99%).
192   Table 4 shows the functionalities of a digitally-mediated program to encourage physical
193   exercise.

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Table 4. Functionalities of a digitally-mediated program to encourage physical exercise

Functionalities	No important		Neutral		Important		No answer	
	N	(%)	N	(%)	N	(%)	N	(%)
Creation of events related to physical exercise	7	21.2	9	27.3	11	33.3	6	18.2
Schedule physical exercises	3	9.1	8	24.3	19	57.6	3	9
Creation of a plan of physical exercise	4	12.1	9	27.3	18	54.6	2	6
Share the progress of physical exercise	7	21.2	6	18.2	19	57.6	1	3
Compare the progress of physical exercise with friends	5	15.2	16	48.5	9	27.3	3	9
Associate a reward system to physical exercise	13	39.4	7	21.2	8	24.2	5	15.2
Audio-visual tutorials related with exercises to practice	9	27.3	11	33.3	9	27.3	4	12.1
Simulations on exercises to practice	7	21.2	6	18.2	15	45.4	5	15.2

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196 As shown in Table 4, the main functionalities that the participants chose were: schedule
197 physical exercises (n=19, 57.6%), share the progress of physical exercise (n=19, 57.6%), and
198 simulations on exercises to practice (n=15, 45.5%).

199 *3.2. Cooperative evaluation of the game design relative to physical exercise*

200 In terms of the main strengths and weaknesses of the game that was developed, the
201 participants have revealed that the game challenges should be interlinked with the participants'
202 context (indoors and outdoors). For example, some participants stated: "If the game could be
203 incorporated in my daily life and entertain me during my trips and invite me going outside – that
204 would be nice", "[…] For example, a challenge that enables us to link the information that was
205 given to us with our daily life", and "We could have done these and other exercises outside."
206 Bringing the players in both physical and digital (phygital) environments is, therefore, an essential
207 aspect to consider when designing an age-friendly playable city and for ensuring the outdoor
208 safety, information about local traffic signs, pavement conditions and wayfinding could help to
209 create route guidance and walking assistance that are personalized to the older adult's context in
210 terms of location, travel fitness, mobility conditions and motivations.

211 Another highlighted aspect was the need to get immediate feedback towards action. Indeed,
212 the participants were motivated to repeat and progress in the game with the use of immediate
213 messages. For example, one of the participants argued: "You see? Congratulations, you won! I want
214 to repeat it!" Similarly, social networks and the use of Key Performance Indicators were also
215 relevant. As the participants point out: "I think that it is very important to check our performance –
216 if we learn the information that is given. For example, a challenge that enables us to link the
217 information that was given to us with our daily life." and "I would like to see my grade and how
218 well I did when compared with others […] But how can I see what I was missing and in which
219 areas I performed better in comparison with my colleagues?"

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223   *3.3. Interview with Subject Matter Experts*

224   In terms of the interviews with Subject Matter Experts, their perspectives on Recommendations
225   for designing age-friendly environments and Designing for learning and behavior change were
226   outlined.
227   According to the interviewees, age-friendly environments should: (a) foster social
228   connectedness and demystify ageing bias; (b) take into account different age-cohorts when
229   addressing products to this target group; (c) not focus on age-related difficulties or illness
230   prevention; (d) train skills through cognitive challenges and foster life-long learning, establishing a
231   strong with everyday life; and (e) make the participants familiar with the interfaces.
232   The following is some of the interviewees statements:
233   "[…] increasing social connectedness, reducing ageism and contributing to life-long
234   learning. These aspects are very important to encourage active ageing […] The other is
235   not only focus on the disease or age-related difficulties, but to make designs that also
236   focus on the positive aspects of ageing […] risk of seeing older adults as their age-related
237   difficulties, and having approaches only focus on reducing this, or increasing that. It is
238   important that the person is respected as something beyond their age-related
239   conditions."- Interviewee 9
240   "If you take somebody they understand TV, they understand the computer with Internet
241   connection and they might be coerced to interact with a fitness band. Anything else, I
242   think that it will be a struggle […]"- Interviewee 1
243   "I think that we should really try to involve them because I think that older people is a
244   diverse group including women, men, younger-old, old-old, higher educated and
245   non-higher educated […] Connect to their everyday life."- Interviewee 7
246   The interviewees also outlined the following recommendations to design for behavior change:
247   (a) reinforce the presence if the player in the environment; (b) stimulate the players' subconscious
248   by overweighting internal motivations (i.e. skills, beliefs, self-efficacy) and external elements that
249   lead to Human behaviors; (c) use social elements, scenario building and changes in the game plot;
250   (d) interlink between cognitive and affective dimensions; (e) strengthen the dialogue between both
251   the game-design and the subject area; and (f) establish a link between games and outdoor activities
252   and rely heavily on notifications. However, the interviewees drew our attention to the problem of
253   manipulation of behaviors and too much focus on PBLs (Points, Badges and Leaderboards), in
254   which information literacy can have an important role. As the interviewees state:
255   "Technologies can most definitely trigger changes in our behaviors at both the conscious and
256   unconscious levels. For example, simple reminders on our phones can be helpful for
257   medication adherence levels. For example, simple reminders on our phones can be helpful
258   for medication adherence behavior. Technologies can also target our unconscious processes
259   by releasing smells to trigger certain behaviors like eating."- Interviewee 8
260   "[…] a cognitive dimension and an emotional/affective dimension. I think that these two
261   need to be interconnected but then need to think about the information from the start and
262   the relational, emotional things are also important. It is a point I'd recommend that we look
263   at when talking about behaviors – not only the cognitive dimension but also the affective
264   one"- Interviewee 7
265   "I see some problems with using games and gamification to shape behavior, of course –

266   there is a huge ethical discussion even when using it for a good reason […] All the
267   techniques that we developed that can shape behavior could be caught by the army,
268   advertisement or insurance. What I see in many gamification and serious games applications
269   is a very behaviorist approach to human motivation, so you do something – you get a reward
270   – you do something – you get a reward –you do something - you get a reward, which I think
271   it can work in a short-term but I don't think it can go very far – you can't change behaviors in
272   short-term but you can change mind-sets."- Interviewee 4
273   "Information literacy can assist in the changing of behavior as it encourages people to
274   identify the need for information, locate it, evaluate it, and apply it to assist in changing of
275   behavior. The information being sort has a role to play on the effectiveness of informational
276   literacy. For example, health information can be activity pursued or avoided in order to delay
277   the acquisition of the information. The pursuit of information in the case of health may
278   depend on a variety of factors, such as an individual's traits and confidence"- Interviewee 10

4. Discussion

280   The aim of this paper was to identify a set of necessary design requirements for designing an
281 Age-friendly Playable City. Specifically, we identified a set of recommendations for designing
282 age-friendly environments. Based on the previous assessment of the perceived benefits and
283 motivations to physical exercise and the cooperative evaluation of the game design relative to
284 physical exercise, the following design requirements were suggested: (a) enable the participants to
285 schedule their activities and share their progress; (b) use Key Performance Indicators (KPI) (e.g. time
286 frequency, accuracy of the exercises) and (c) reinforce social support networks.
287   The additional requirements were added based on semi-structured interviews with Subject
288 Matter Experts: (a) take into account different age-cohorts, when addressing products to this target
289 group; (b) do not focus on age-related difficulties or illness prevention; (c) establish a strong link
290 with everyday life and familiarize the participants with the interface; (d) stimulate the players'
291 subconscious by overweighting internal motivations (i.e. skills, beliefs, self-efficacy) and external
292 elements that lead to Human behaviors; and (e) establish a link between games and outdoor
293 activities. This interrelationship between indoor and outdoor activities suggests the potential of
294 gamification and playful techniques to engage the end-users to provide information about local
295 traffic signs, pavement conditions, wayfinding and, therefore, to help create route guidance and
296 walking assistance personalized to the older adults' context in terms of location, travel fitness,
297 mobility conditions and motivations.
298   A limitation of this study was the use of a convenience sample and further work needs to be
299 conducted as attempts to generalize are not warranted and results should be interpreted with
300 caution. Further efforts are being made to both extend the sample and integrating a set of missions
301 that are personalized to the end-user context (location, travel fitness, mobility condition,
302 motivations) and that take into account the social activities, information about local traffic signs,
303 wayfinding, pavement conditions and time schedule through the use of gamification and playful
304 techniques.
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