Lessons Learned from Two Usability Studies of Digital Skiing Game with Elderly People in Finland and Japan

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Abstract

Physical decline is associated with old age. Engagement in regular physical exercises can help elderly people improve their physical functionalities, as well as cognitive abilities. Among modern technologies, digital games have the potential to promote elderly people's engagement in physical exercises through fun and enjoyable gameplay. Although commercial digital games show promise, most of them are not designed for elderly people. The literature also suggests that more studies need to be undertaken to understand the usability and usefulness of digital games for elderly people. Hence, in this study, we designed and developed a digital game-based Skiing activity for elderly people. Then, we evaluated it with the Finnish and Japanese elderly participants in Finland and Japan to investigate their feedback towards the usability and usefulness of the game. The findings from both studies show that the Skiing game is an easy and user-friendly game for elderly people. While digital games are promising to be used as an alternative solution for promoting the Japanese elderly participant's physical activities, the Finnish elderly participants recommend to use it when they don't have access to non-digital physical exercises. The lessons learned from this study can help researchers, designers, and practitioners gain insights into game design and development for elderly people and their physical activities.

Keywords: *Digital games, Elderly People, Usability, User Experience, Human-Computer Interaction*

1. Introduction

Physical and functional decline is associated with ageing, and it is common in old age [1]. The American Psychological Association [2] states that most elderly people experience natural and normal age-related changes, including physical and cognitive decline, social disengagement, and health decline. According to Chappell and Cooke [3], physical health declines with increasing age, and it is also related to the likelihood of disability for elderly people. Manini [4] states that elderly people are at risk for a higher level of physical disabilities due to the ageing process and associated chronic diseases.

Engagement in regular physical exercise activities can improve elderly people's physical well-being, including physical fitness, functional ability, and independent lifestyle that are indicators for their quality of life [5]. According to Bherer, Erickson, and Liu-Ambrose [6], physical exercises are effective as a non-pharmaceutical intervention for elderly people to prevent cognitive decline and neurodegenerative disease (e.g. Alzheimer's disease). The benefits of

participation in regular physical exercises can not only prevent age-related diseases but also improve their quality of life [7].

With the help of the advent of technologies, people have been helping to promote elderly people' physical well-being in terms of their participation in physical exercises, rehabilitative training, and safety (e.g. fall prevention). Of these modern technologies, digital games are promising to promote elderly people's physical fitness and their participation in regular exercises through fun and engaging gameplay. Planinc et al. [8] state that digital game-based physical exercises can offer benefits for elderly people and enable them to be physically fit through motivating gameplay that leads to improvements in mobility. Beyond fun, recreational, and entertaining purposes, digital games are utilized to increase physical and cognitive functioning in elderly people [9, 10].

To date, there have been a number of scholarly studies that investigated the usability and usefulness of digital game-based exercises for elderly people. However, this research area is still new, compared with traditional Human-Computer Interaction and Usability for other age groups (e.g. young adults). Much of existing literature has stressed on the perceived health benefits of exergames for elderly people; however, little is known about the usability aspects of digital game-based exercises for them [9]. Whitlock, McLaughlin, and Allaire [11] also highlight that relatively little is known about digital game usability for elderly people. Planinc et al. [8] state that most commercially available games are not designed for elderly people, and there is a limited study on effective game design guidelines in digital games for elderly people. Gerling et al. [12] point out that there is a lack of comprehensive information regarding interaction design for elderly people in full-body motion-based games. To bridge the gaps between existing research and the use of digital games for elderly people, in this study, we aimed at understanding the usability, user experiences, and usefulness of digital games for elderly people in doing physical exercises.

The population in the European Union countries is rapidly ageing, and Finland is one of them [13]. The Finnish government and authorities have been promoting aged care, and the use of modern technologies (e.g. digital games) is one of the solutions in promoting the quality of life for elderly people in Finland [14]. In this study, we designed and developed a digital game-based exercise called the 'Skiing Game' to promote the Finnish elderly people' physical exercise activities. We evaluated the game with 21 Finnish elderly participants in Finland to understand their feedback towards the usability of the game, their user experiences, and the usefulness of the game. According to United Nations [15], Japan is one of the countries in the world that has the highest ageing population: 33 percent were aged 60 years or over in 2015. The Japanese government has used modern technologies that offer one approach to ease the increasing burden of aged care [16]. Among these technologies, healthcare practitioners and researchers in Japan have used digital games to promote elderly people's well-being [17]. The similar demographic challenge in Japan has drawn our attention and interest to investigate the Japanese elderly people's feedback towards the usability of digital game-based exercises and their user experiences in the gameplay. Thus, in this study, we collaborated with the Japanese organization (e.g. Sendai Wellbeing Center) and evaluated the game with 24 Japanese elderly participants in Japan. The main objectives of the study are stated as follow:

1. To investigate the Finnish and Japanese elderly people's feedback towards the usability of the Skiing game,
2. To investigate their in-game and post-game user experiences, and
3. To compare the differences between the Finnish and Japanese elderly people in responding towards the usability and usefulness of digital game-based exercises.

2. Background

2.1 Gamified Solutions in Healthcare

Gamified Solutions in Healthcare (GSH) is a collaborative project between the Turku University of Applied Sciences and the University of Turku in Finland [14]. The main objective of GSH is to provide gamified services for elderly people in Finland, including socialization, rehabilitation, entertainment, and counseling services. In this study, we only focused on the rehabilitation service, which utilizes digital games to enhance elderly people's physical exercise activities. To implement game-based rehabilitative services for elderly people, we applied the user-centered design

approach, which includes requirements gathering, design and analysis, prototyping, and evaluation [18]. For requirements gathering, we conducted a number of pre-studies that include an interview and observational studies with the Finnish elderly people at the elderly service homes in Finland [14, 19], a literature review [20, 21], reviewing existing games and technologies [22, 23], pilot user testing of commercial games and existing game from Puuha Group [24, 25], and forming a research agenda [19].

In pre-studies, we investigated the requirements of the Finnish elderly people in their daily activities, their acceptance of digital games for physical exercise, the usability and usefulness of commercial and existing games, and insightful design guidelines for future game development. Based on the findings from the pre-studies, we designed and developed the interactive Skiing game for elderly people. Then, we evaluated the game with the Finnish elderly participants at one of the elderly homes in Finland called 'Ruusukortteli (Rose Square)'. We also aimed to evaluate the game with the non-Finnish elderly participants outside of Finland to understand the feedback from the non-Finnish elderly people towards the game. Therefore, we collaborated with the as Sendai City Health Promotion Center and the Sendai-Finland Wellbeing Center in Japan. By conducting the cross-country evaluation of the game, we aimed at helping not only the Finnish elderly people but also other elderly groups living in foreign countries to promote their physical fitness and participation in regular physical exercises.

2.2 Related Studies

In recent years, people have used digital games for serious purposes other than fun, recreation, and entertainment activities [26]. For instance, digital games have been used for game-based learning, exergames, games for training, and gamification for business. In the context of healthcare, professionals and practitioners have regarded the potential of digital games for improving elderly people's physical exercises and rehabilitation [27]. Digital games have the potential to improve elderly people's physical well-being. It shows promises to improve elderly people's engagement and participation in regular exercise routines [28]. In addition, it has been used for rehabilitation [10] and fall prevention for elderly people [29].

According to Sato et al. [30], low adherence rate to physical exercises is a problem among elderly people. The researchers state that digital game-based exercises that involve physical motion of players are promising to keep them active [30]. They designed and implemented Kinect-based digital exercise system for elderly people to examine the effects of the game on elderly people and their health benefits such as muscle strength and body balance. They evaluated the game with 24 healthy community-dwelling elderly people, and their findings show that digital game-based exercises were effective in improving the muscular strength of lower extremities for elderly people. Pisan et al. [31] highlight that fall is one of the leading causes of injuries and disabilities for elderly people. They point out that physical exercises can reduce the potential risk of falling by 40%. However, elderly patient's adherence rate is low [31]. To promote elderly people's adherence rate to exercises, the researchers designed a digital game-based fall prevention training for elderly people and evaluated with them [31]. Their findings suggest that game-like exercises can result in increased adherence rate among elderly people to the physical exercise routines.

Chao et al. [32] conducted a review on a total of 22 empirical studies about digital games for elderly people's physical function, and their findings show that using digital games (e.g. Nintendo Wii) show promises as an alternative intervention to improve elderly people's physical function, cognition, and psychosocial well-being. Kaufman et al. [33] conducted a survey study with 463 adults, aged 55 years and above, to identify their gameplay experiences. The results show that the use of digital games can provide innovative and engaging activities for enhancing elderly people's aging processes. To date, there are a number of studies in academic research that reported the positive impacts of digital games on elderly people' physical well-being, including digital games for their physical therapy (e.g. stroke rehabilitation), functional tasks (e.g. game-based training for driving), activities of daily living (e.g. ADL training), and recreational activities (e.g. playing games).

Katajapuu et al. [37] evaluated digital memory game with a total 92 Japanese and Finnish elderly people in individual and group settings. Their findings show that the correlation between game difficulty and game enjoyment was found in the Finnish people but not in the Japanese population. They also reported cultural differences in digital game use and attitudes towards different digital brain exercise games (e.g. game preferences). Five exergames developed by researchers from Finland, Singapore, and Japan were tested with a total of 30 participants in

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Singapore in 2016 [38]. Their findings show that digital games are useful for elderly people's physical functioning.

2.3 Research Questions

The existing literature highlights the potential of the use of digital games for promoting elderly people's physical activities. However, there is only a few cross-country study about elderly people's perceptions of digital games and its usability and usefulness. More importantly, to our knowledge, a limited number of related studies can be found in the western and eastern context. To fill the gap in this research context, we expect to evaluate the usability, user experience, and usefulness of digital game-based exercises for elderly people in Finland and Japan. We formulated the following research question in our study:

Q1. What are the Finnish and Japanese elderly people' feedback towards the usability of the Skiing game and their user experiences in the gameplay?
Q2. What are the differences in user experiences between the Finnish and Japanese elderly people?
Q3. Are digital game-based exercises useful for both the Finnish and Japanese elderly people as an alternative way of exercising?

3. Methodology

In this study, we evaluated the Skiing game with 21 Finnish elderly participants in Turku, Finland [34, 35] and 24 Japanese elderly participants in Sendai, Japan [36]. In the following sub-sections, we describe the design and gameplay of the Skiing game, followed by the design and procedures of the Finnish and Japanese usability studies, and the questionnaires we used in both studies.

3.1 The Skiing Game

The main objective of the game is to promote the Finnish elderly people's regular exercise activities by using digital game-based exercises as an alternative solution. In the Skiing game, we used a simple, easy, and age-friendly game interface, familiar game context, and real-world game task. For the game context, we chose snowy mountains and a forest, which is inspired by the popular Finnish Lapland. For the gameplay, we used a popular cross-country Skiing activity (the double pole skiing technique), which is familiar to most of the Finnish elderly people. To play the game, a player needs to continuously move both hands forward and backward to ski in the game. In addition, a player simply needs to move his or her body to the left or right to avoid obstacles in the game. With regard to user's interaction experience, we used a motion-based interaction for elderly people by adopting Xtreme Reality Technology in the game (Extreme Reality technology, 2015). To implement the game, we used the Unity3D game engine with C# programming language. Figure 1 shows screenshots from the Skiing game.

Figure 1. The Screenshot of the Skiing Game

3.2 Finnish Usability Study

The test was conducted at the elderly service home '*Ruusukortteli'* in Finland, which supports elderly-care services such as social, recreational, and physical activities. Before we conducted the usability study, we consulted a physiotherapist from the elderly center regarding the recruitment, study design and procedures, and inclusion criteria for elderly participants. For the inclusion criteria, the elderly participants should be aged between 60 and 85 years, and they should have a sound and stable health condition and cognitive ability. Furthermore, the participants should be able to tolerate for at least 10 minutes to play a digital game-based exercise. They also should have a capability of standing and walking 10 meters independently. Lastly, they should have no neurological or cognitive deficits. We also requested the consent of the individual participant to be involved in the study. We recruited a total of 21 Finnish elderly participants at the elderly service home.

Then, we conducted the usability study for two days: day one with 17 participants and day-two with four participants respectively. Three researchers from the University of Turku and Turku University of Applied Sciences were involved in the study, and they provided guidance and help for the elderly participants in the gameplay, asked questionnaires, and conducted interviews. We recorded the whole usability study with a video recorder and a notebook to observe the elderly participants' behaviour, expression, feedback, and user experiences.

3.2.1 Design and Procedure

Firstly, the pre-study interview and gameplay sessions were undertaken at one of the therapy rooms, and the post-interview session was conducted at another therapy room at the elderly service home. Before an elderly participant played the game, a researcher asked the pre-game interview questions, which include demographics, physical activities, digital gameplay experiences, their attitudes towards digital games, and physical exercises. The pre-game interview session took about 10 minutes. Then, the elderly participant went through a tutorial session, which was guided by a researcher. Then, he or she played the game for a few times, depending on their request. The gameplay session took about 5 to 10 minutes, which can be different from one elderly participant to another.

After playing the game, a researcher asked the elderly participants the post-study interview questions, including in-game and post-game user experiences, the usability of the game, the perceived usefulness, and their ease-of-use of the game. Moreover, we also asked the general interview questions regarding their feedback, opinions, and attitudes towards the digital game-based exercises. The post-interview session took about 10 minutes. The whole usability study took about 30 minutes. The study was conducted in the Finnish language. Figure 2 shows a photo of an elderly participant playing the Skiing game.

Figure 2. The Finnish Usability Study of the Skiing Game

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3.2.2 Questionnaires

In this study, we used different questionnaires to investigate the elderly participants' user experiences in playing the Skiing game. Firstly, we developed the pre-gameplay interview questions to investigate the elderly participants' demographics, physical exercise activities, and their experiences in playing digital games. These questions are generally open-ended interview questions. Regarding the elderly participants' user experiences in the gameplay, we used Game Experience Questions (GEQ) developed by IJsselsteijn et al. [39, 40]. The GEQ contains two modules: in-game and post-game to assess players' user experiences. The in-game questionnaires are used to investigate players' experience while they are playing the game. It contains seven components, including competence, competence, sensory and imaginative immersion, flow, tension, challenge, negative effect, and positive effect. There are 14 items in the in-game module.

The Post-game GEQ questionnaire is used to find out how a player feels right after the gameplay. It includes four components such as positive and negative experiences, tiredness, and returning to reality respectively. There are 17 items in the post-game module. Both in-game and post-game GEQ questionnaires used a 5-point Likert scale from "Not at all (0)" to "Extremely (4)". To investigate the usability of Skiing game, we used the System Usability Scales (SUS), which is easy and simple to understand for elderly people, and based on ten-item scales that give the subjective assessments of the usability of a particular system [33, 34]. SUS questions also used the 5-point Likert scale from "Strongly disagree (1)" to "Strongly agree (5)". We modified the SUS questionnaires to be suited for the objective of the study. For general interview questions, we developed post-interview questions based on the Senior Technology Acceptance & Adoption Model (STAM) [41].The questions include four items that investigate elderly participants' perceived usefulness, perceived ease-of-use, gerontechnology self-efficacy, and gerontechnology anxiety. These post-gameplay interview questionnaires use open-ended questions.

3.3 Japanese Usability Study

We conducted a cross-country usability study of the Skiing game with 24 Japanese elderly in Japan [42], by collaborating with the Sendai City Health Promotion Center, which is a rehabilitation center, which provides rehabilitative training for the Japanese elderly people. They are interested in adopting digital game-based intervention for the Japanese elderly people to enhance their physical exercises. We recruited the Japanese elderly participants through an advertisement at the Sendai City Health Promotion Center, and physiotherapists and nurses helped us in the recruitment process. We used the same inclusion criteria for the Japanese elderly participants that were used in the Finnish study.

3.3.1 Design and Procedure

The entire usability study took two days. Firstly, 16 elderly participants played the game and answered the questionnaires on the day-one, followed by the remaining 8 elderly participants on the day-two. The study was undertaken by five researchers: three Japanese physiotherapists from the Sendai City Health Promotion center, one project officer from the Sendai-Finland Well-being center, and one Finnish researcher from the Turku University of Applied Sciences, Finland. In this study, the Japanese language was used to communicate with the elderly participants.

The study was taken place in three different rooms. At the station one (room one), a Japanese physiotherapist from the Sendai City Health promotion center conducted the pre-study interview, which includes the elderly's demographics, their physical exercise activities and experiences in playing digital games, and their consent. It took about 5-10 minutes. At the station two (room 2), two Japanese physiotherapists from Sendai City Health Promotion center helped the elderly participants to play the Skiing game. One therapist guided the elderly participants how to play the game, and the other monitored the participants to minimize their health risks. The total time for the station two took about 20 minutes. At the station three (room 3), a project officer from the Sendai-Finland Well-being center asked the questionnaires and post-interview questions in Japanese. One student from the Sendai National College of Technology helped us in recording the whole usability study with a video recorder. Figure 3 shows a Japanese elderly playing Skiing game.

Figure 3. The Japanese Usability Study of the Skiing Game

3.3.2 Questionnaires

In this Japanese study, we used a number of questionnaires to investigate the Japanese elderly's user experiences in playing the Finnish Skiing game. We used GEQ in-game and post-game questionnaires, SUS questionnaires, and post-gameplay interview questionnaires. We have used the same questionnaires and interview questions in the Finnish usability testing of the Skiing game.

4. Analysis and Findings

After collecting the data from the Finnish and Japanese usability studies of the Skiing game, we conducted both quantitative and qualitative analyses to investigate the elderly participants' responses and feedback towards the game. We also conducted a comparative study between the Finnish and Japanese elderly groups to understand their differences in user experiences and feedback towards the game. In this section, we reported the findings from both groups, followed by the comparison.

4.1 Pre-Gameplay Interview

Based on the findings from the pre-study interview sessions of the Finnish study, we found that 13 female (62%) and 8 male (38%) Finnish elderly people participated in the study. Their average age is 71 years. All of them are retirees, and they are the regular visitors to the elderly service home. The findings from the interview show that 19 out of 21 Finnish elderly participants are active in regular physical exercises, whereas only two participants were inactive doing physical activity due to their old age: 85 and 87 respectively. Among the active Finnish elderly participants, only six elderly participants usually do daily exercises for one to two hours, whereas other active participants spend 3-4 hours per week for physical exercises. They have a positive attitude towards physical exercises that it can benefit their physical health. For the Japanese study, we found there was an equal number of male and female Japanese elderly people participated (12 male and 12 female). The average age of the Japanese participants is 72 years. All participants visit the elderly center in Japan regularly, and they are active in doing regular exercises daily and weekly. They usually do physical exercises at least 5-7 hours per week. The findings from the pre-study interview show that the Japanese elderly participants have positive attitudes towards the benefits of physical exercises. The findings from two studies show that both elderly groups have similar positive attitudes towards doing physical exercises.

Regarding the elderly participants' prior experiences in playing digital games, 18 out of 21 Finnish elderly participants (86%) did not play digital games before. They had negative views and misconceptions towards digital games. For instance, 10 Finnish elderly participants mentioned that they are not interested in playing digital games, while two Finnish elderly participants stated that it is a waste of time. One Finnish participant revealed that playing digital games is only for young people. With regard to the Japanese elderly participants' prior experiences in playing digital games, half of the Japanese participants (12 out of 24) never played digital games before, whereas the other 12 Japanese participants have played digital games. In the Japanese study, six elderly participants who played digital games had negative attitudes towards digital games, claiming that

games are difficult to play and are not interesting. The other six Japanese participants who had prior gameplay experiences enjoyed playing digital games, and they recommended that playing digital games is fun, entertaining, and beneficial for their memory. For the Japanese elderly participants who never played digital games, they had neutral attitudes and showed they're interested in playing digital games. The findings show that 18 out of 24 Japanese elderly participants (75%) had a fairly positive attitude towards digital games Based on the findings from both studies, we found that the Finnish elderly participants had more negative attitudes towards digital games, compared with the Japanese elderly participants.

4.2 Systems Usability Scale

According to the findings from the Finnish usability study, we found that there was one Finnish participant (4.76%) who responded 'Best Imaginable' to the usability of the game, while 9 Finnish elderly participants (42.86%) rated the game as 'Excellent'. Moreover, there were 6 elderly participants (28.57%) who rated the game as "OK", while 2 of them (9.52%) rated "Poor" and one (4.76%) rated "Worst Imaginable". For acceptability ranges, 16 Finnish elderly participants (76.19%) rated "Acceptable", while 2 of them (9.52%) rated "Marginal" and 3 Finnish elderly participants (14.28%) responded as "Not Acceptable". For the Japanese usability study, we found that 8 out of 24 Japanese elderly participants (33.33%) responded that the game is "Excellent", while the other 8 participants (33.33%) rated as "Good". In addition, 7 out of 24 participants (29.1%) answered that the game is "OK", and one participant (4.17%) responded "Poor". Regarding acceptability ranges, 16 out of 24 participants (66.66%) responded that the game is acceptable, while 7 participants (29.1%) accepted the game as "Marginal". Only one participant (4.17) responded that the game is "not acceptable".

The majority of the participants from both elderly groups responded positively towards the game's usability. We analyzed the difference between two elderly groups, and the findings show that the feedback from both groups was not significantly different ($t(43) = -.27$, $p = 0.7$). Both elderly groups had similar positive feedback towards the usability of the Skiing game. The following Table 1 shows the SUS scores and scales of the participants from both elderly groups.

Table 1. System Usability Scale

SUS Adjective Scales	**No. of Finnish Participants (N=21)**	**No. of Japanese Participants (N=24)**	**SUS Score**	**Acceptability Ranges**
Best Imaginable	1 (4.76%)	-	90-100	Acceptable
Excellent	9 (42.86%)	8 (33.33%)	80-89	Acceptable
Good	6 (28.57%)	8 (33.33%)	63-79	Acceptable
OK	2 (9.52%)	7 (29.1%)	47-62	Marginal
Poor	2 (9.52%)	1 (4.17%)	25-46	Not Acceptable
Worst Imaginable	1 (4.76%)	-	0-24	Not Acceptable

4.3 In-game Experience

Regarding the Finnish and Japanese participants' in-game experiences, we found that both elderly groups had a relatively high mean score ($M >= 2.9$) in "Positive Affect" in the gameplay, whereas they had a low mean score ($M <= 0.5$) in "Negative Affect". Both groups had average mean scores ($M >= 2.0$) in "Flow", "Sensory and Imaginative Immersion", and "Competence". The gameplay was relatively challenging for the Japanese elderly participants ($M=2.4$), whereas it was not the case for the Finnish elderly participants ($M=1.2$). They had a noticeable small mean score number ($M <= 0.8$) for "Tension". The following table 2 shows the GEQ scores for both elderly groups.

Table 2. In-game GEQ Scores.

In-game GEQ (Gameplay)	Finnish Participants (N=21)		Japanese Participants (N=24)	
	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)
Positive Affect	3.0	0.2	2.9	0.7
Negative Affect	0.1	0.1	0.4	0.4
Flow	2.6	0.3	3.0	1.0
Sensory and Imaginative Immersion	2.3	0.3	2.7	0.9
Competence	2.3	0.0	2.6	0.8
Challenge	1.2	0.2	2.4	1.0
Tension	0.1	0.1	0.8	0.7
* The highest Mean score (M) = 4.0				

Regarding the elderly participants' user experiences in playing the Skiing game, we compared the results of in-game positive affect between the Finnish and Japanese elderly participants, and the findings show that there is no significant difference between them ($t(43) = 0.433$, $p = 0.7$). It means that both elderly groups had similar positive affection in playing the game. For the component 'Competence', we found that there was no statistically significant difference between the Finnish and Japanese elderly participants ($t(43) = -1.1$, $p = 0.8$). It means that both elderly groups had a successful experience to play the Skiing game. Furthermore, we observed that the components 'Flow' ($t(43) = -1.29$, $p = 0.2$) and 'Sensory and Imaginative Immersion' ($t(33.8) = -1.1$, $p = 0.3$) were not significant between the Finnish and Japanese elderly groups. The results indicate that both groups were moderately absorbed and interested in the gameplay.

In contrast, we found that the elderly participants' negative affection in the gameplay was significantly different ($t(43) = -2.0$, $p = 0.05$), and it shows that the Japanese elderly participants had slightly more negative experiences, compared with the Finnish elderly participants. We also observed the similar result in the elderly participants' level of tension in the gameplay ($t(27.5) = -4.43$, $p = 0.0$). It indicates that the Japanese elderly participants had a slightly higher level of tension, compared with the Finnish elderly participants. Furthermore, we found that the Skiing gameplay was more challenging for the Japanese elderly participants than the Finnish elderly participants ($t(43) = -4.24$, $p = 0.0$).

4.4 Post-game Experience

For their post-game experiences, we found that both elderly groups had an average score in "Positive Experience" ($M >= 2.0$), whereas they had a considerably low mean score ($M <= 0.9$) in "Negative Experience". They had a low mean score in "Returning to Reality" ($M <= 0.8$), while both groups also had a very low mean score in "Tiredness" ($M <= 0.4$). The following Table 3 shows the GEQ Post-game scores of both elderly groups.

Table 3. Post-game GEQ Scores.

Post-game GEQ (After Gameplay)	Finnish Participants (N=21)		Japanese Participants (N=24)	
	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)
Positive Experience	2.0	0.3	2.1	1.0
Negative Experience	0.1	0.1	0.9	0.4
Returning to Reality	0.8	0.5	0.5	0.4
Tiredness	0.1	0.1	0.4	0.6
* The highest Mean score (M) = 4.0				

Regarding the differences in post-game user experiences for both elderly groups, we found that there was no significantly significant difference in positive experience ($t(43) = -0.25$, $p = 0.8$), indicating that both elderly groups had a positive gameplay experience after they had played the Skiing game. Similarly, their experiences to 'Returning to Reality' were not significantly different

(t (43) = -0.33, p = 0.7). It indicates that both groups had no disorientation after the gameplay. In contrast, we found that there was a significant difference in their negative experiences (t (34.5) = -4.7, p =0.0). It means that the Japanese elderly participants had slightly more negative experiences in the gameplay, compared with the Finnish elderly participants. The similar results can be also found in 'Tiredness' (t (38) = -2.57, p = 0.01), indicating that the Japanese elderly participants were slightly more tired in the gameplay than the Finnish elderly participants.

4.5 Post-Gameplay Interview

Regarding the Finnish and Japanese participants' gameplay experiences to play the Skiing game, we conducted the post-gameplay interview sessions in both studies. We compiled the participants' responses and created different categories for similar responses and feedback. Then, we analyzed the qualitative data from four different data sources, including video observations, note-taking, and interview sessions. Firstly, in each analysis, we coded and analyzed the data, followed by categorization. Then, we de-categorized them if necessary until we identified the important findings. We created different categories, including game context, user interface, gameplay, feedback, user experience, and interaction. Table 4 shows the selected quotes from the participants that we used for the analysis.

According to the categories created based on the participants' feedback towards the game system, both elderly groups recommended that they prefer digital game context, which is designed to be a real-world environment in the virtual world. For instance, in the Skiing game, a snow resort theme as a game context was designed and simulated especially for the Finnish players so that it can remind them of skiing activity in Finland. The findings from the qualitative interview also showed that the participants' responses to the game context were positive. With regard to the usability of the game, some elderly participants from both studies suggested that visual cues can be helpful for them due to their poor eyesight, as well as their lack of experiences in the digital gameplay. Furthermore, they recommended that using voice-based instructions in their own languages will be helpful for them to play more easily. Both Finnish and Japanese participants suggested that they prefer to play real-world activities and sport based gameplay such as cycling, tennis, golf, and driving.

The findings from the participants' responses, we found that negative feedback from the game can discourage them. For instance, the findings from the observations in both studies showed that the elderly participants were frustrated in the gameplay whenever they (the virtual character) fell down in the game. Moreover, in the interview session, they mentioned that negative reactions in the game can lessen their level of confidence to continue playing. We also found from the interview studies that the elderly participants revealed their concern that they may fall down in the gameplay unless they can balance their body during the gameplay. In addition, some participants revealed that they had a motion sickness to a certain extent while playing the game. We also notice that especially for the novice elderly players, they prefer the simple gameplay rather cognitively challenging activities in the game. The elderly participants suggested that low achievement in the gameplay for their first time can lead them to the abandonment of the gameplay in the future. Lastly, they recommended that playing digital games with controller-free interaction was easy and effective to play the game.

Table 4. Participants' Quotes.

Category	Finnish Participants' Quotes	Japanese Participants' Quotes
Game Context	"this game reminds me of Lapland (Northern region of Finland) and it was fun to do skiing activity in the game" (FP1)	"It was enjoyable to play a game-based skiing activity" "I felt like I was in a skiing resort" (JP3)
	"That real-world environment games are fun to play like cycling in nature" "I would like to try different types of games playing in the real-world" (FP9)	"Activity-based games are interesting" "I like to try fishing game, football, cycling, driving, etc." (JP24)
User Interface	"My eye sights are not so good. So I can't see clearly sometimes" "It will be better if the trunks in the game are highlighted so that I can avoid them". "I think the game can provide voice instruction in the Finnish language to	"I hit and fall many times in the game because I don't know that I have to avoid the fallen trunks in the game". "My eyes are tired to pay attention to this" (JP14)

	easily understand what to do" (FP8)	
Gameplay	"I like physical activities" "When I was young, I used to do skiing but not now because of my health" "It's fun to play that kind of game" (FP1)	"I would like to try other types of games like cycling, fishing, tennis, golf, etc. " (JP10)
	"Skiing is fun. It reminds me of old days" "I like to try more" (FP21)	"Skiing activity is popular in Japan" "It's exciting to play it" (JP19)
Feedback	"Whenever I fall down in the game, I was discouraged" "Instead of falling down, it should show something…[sic]" (FP10)	"I am afraid that I would fall down in the real-world when I hit the fallen trunk in the game" (JP1)
User Experiences	"I was nervous that I would fall down while playing the game"(FP6)	"The body balance is important. Otherwise, I might fall when I am off-balance in the game" (JP1)
	"I felt frustrated that I hit and fall in the game" "It discouraged me" "Other than that, it was a fun experience" (FP11)	"It was quite difficult to go upward the mountains in the game" "I felt a bit uneasy to move faster". (JP7)
	"I felt a bit giddy in the gameplay" "I am afraid of falling down if I feel motion sickness" (FP20)	"If I feel a bit shaky to see the screen, I can't see properly" (JP17)
	"It was my first-time experience" "When many fallen trunks are coming towards me, I don't know how to avoid them". (FP12)	"I tried hard to understand what to do with the gameplay" "It's a bit hard at first, but slowly I got an idea what to do next". (JP5)
	"For the first time playing digital games, I felt a bit depressed to have low scores [sic]" (FP2)	"I think my performance was poor in the gameplay because I am old [sic]" (JP8)
Interaction	"I used game controllers with buttons and they were confusing" "It's easier for me to use controller-free interaction". (FP17)	"I like to play the game without using any controllers" (JP23)
	"I think it's more natural to play the game with no buttons…[sic]" (FP6)	"Movements are easier when there is no physical controller to hold by hands" (JP13)

Regarding the participants' attitudes towards playing digital games after they had played the Skiing game, we asked the interview questions to both elderly groups. Based on the findings from the analysis of their responses, we found that both elderly groups had positive attitudes towards digital games after the gameplay. For the Finnish elderly participants, the majority of them (81%) suggested that playing digital games was fun, easy, and entertaining. 57% of the Finnish elderly participants agreed that playing digital games can be beneficial for them. 71% of the Finnish elderly participants mentioned that they would like to play it again, as well as to try other types of digital games. 67% of them revealed that they will play it regularly, while others claimed that they may not have adequate resources to play it regularly.

For the Japanese elderly participants, 96% of them claimed that playing digital games is fun, easy, and entertaining. 83% of them suggested that playing digital games can be beneficial for their physical health. 91% of them suggested that they would like to play it again in the future, and try various digital games. Similarly, 91% of the Japanese elderly participants mentioned that they will play digital games regularly if they have adequate resources in terms of devices and manpower (e.g. therapists). Lastly, we asked whether playing digital games can be an alternative solution for them to do physical exercises regularly. We found that 66% of the Finnish elderly participants suggested that playing digital games can be a second priority for them because they think that regular physical exercises are more important. They also mentioned that digital game-based solution will be useful when they do not have access to regular physical exercises. For the Japanese elderly participants, 83% of them suggested that playing digital games can be an alternative solution for them because it can provide an enjoyable way of exercising.

5. Discussion

Based on the findings from the analysis of data from both studies, we observed similarities between the Finnish and Japanese elderly participants. For instance, we found that both Finnish and Japanese elderly participants are active in doing physical exercises. Moreover, they are aware of the benefits of doing regular physical exercises activities. They have similar positive attitudes towards physical exercises. Regarding their prior experiences in playing digital games, the Japanese elderly participants had more experiences than the Finnish counterparts. In addition, we found from the pre-interview studies that prior to the gameplay session, the Japanese elderly participants had more positive attitudes towards playing digital games, while the Finnish elderly participants had relatively negative attitudes towards playing digital games. Regarding the participants' responses to the usability of the Skiing game, we found that elderly groups responded quite positively, and there is no difference between two groups. Similarly, both elderly groups had relatively positive in-game and post-game experiences except the fact that the Finnish elderly participants had slightly more positive experiences, compared with the Japanese counterparts.

With regard to the post-gameplay session, we found that both elderly groups had changed their attitudes towards the game more positively. Compared with the Finnish counterparts, the findings show that the Japanese elderly participants have more positive attitudes towards playing digital games after the gameplay. The findings also show that the Japanese elderly participants are more active to play digital games in the future. They recommended that playing digital games can be an alternative solution for them to do physical exercises. They also recommended that playing digital games can be beneficial for their physical health. In contrast, the Finnish elderly participants suggested that playing digital games can be an alternative solution for them when they do not have access to primary physical exercises, which they regularly do at elderly service homes (e.g. Physiotherapy exercises).

Based on the findings from both Finnish and Japanese usability studies of the Skiing game, we answered the research question 1 (Q1) that the Skiing game is an easy, usable, and user-friendly game for the Finnish and Japanese elderly people. With regard to their user experiences, both elderly groups had a relatively positive experience in the gameplay. Furthermore, the elderly participants who did not have prior experiences in playing digital games have become interested in playing digital games. Their attitudes towards digital games have changed positively after the gameplay. For the research question 2 (Q2), although the Finnish elderly participants had more positive experience in the gameplay, the Japanese elderly people showed more interest in playing digital games as an exercise activity in the future. Regarding the research question 3 (Q3), the Japanese elderly people are more positive towards using digital game-based exercises as an alternative solution, whereas the Finnish elderly participants recommend to use it as a second option when they don't have access to conventional physical exercises.

From both Finnish and Japanese usability studies, we have learned a number of lessons including the usability of the game, game design, user experiences, and interaction experiences. Based on the findings from the qualitative analysis of the participants' responses and feedback towards the game, we highlighted the following usability lessons learned from both studies. Frist of all, regarding game context and gameplay, we learned that the elderly participants enjoy playing digital games, which are simulated as a real-world environment (e.g. Skiing resort). We also learned that the elderly participants enjoyed playing real-world physical activities in the game (e.g. Skiing activity). Secondly, with regard to game interface, we learned that visual cues are important to be provided in the game system so that elderly participants can interact with the game more effectively. We also noted that the elderly participants also preferred voice-based instruction in the game. Thirdly, regarding game feedback, the findings suggested that the elderly participants preferred positive feedback provided by the game.

One of the important lessons learned about players' experiences is that the elderly participants were afraid of getting injuries while playing the game. Thus, we learned that minimizing their physical risks in the gameplay is important. In addition, we also learned that if the elderly participants encountered frustration in the gameplay, it would lead to their discouragement to continue playing the game. Therefore, we learned that minimizing their frustration in the gameplay is also an important factor to be taken into account in the game design. We also learned that the cognitive complexities in the game are not suitable for the elderly participants, especially for their first time experiences. We also need to be aware of the elderly participants' motion sickness in the game, and it should be taken into consideration while designing digital games especially for elderly players. We also learned that creating a sense of achievements for novice elderly participants can encourage them to play the game in the future. Lastly, regarding their interaction

experiences, we learned that the elderly participants prefer using controller-free interaction that can make them easy to play the game. The following Table 5 lists the usability lessons that we learned from both Finnish and Japanese usability studies.

In summary, from both the Finnish and Japanese usability studies of the Skiing game, we report that digital games are useful as an alternative solution for promoting elderly people's physical exercise activities. This finding also supports the existing literature [10, 11, and 12]. Although the Skiing game was designed for the Finnish elderly people, it has been accepted by the non-Finnish elderly people as a form of exercise activity. The findings also show that user-friendly digital games can positively change non-gamers elderly people' perceptions of digital games. The findings from this study can help researchers and practitioners gain insights into using digital games for promoting elderly people's physical activities. It can also help game designers and developers gain insights into usability guidelines for designing digital games for elderly people.

Table 5. Usability Lessons.

Category	Lessons Learned
Game Context	1. Real-world game context simulated in the game should be taken into account in the game design.
Game Play	2. Real-world activities designed in the game are suitable for elderly players.
Game Feedback	3. Positive game feedback should be provided in a game.
User Experiences	4. It is important to minimize physical risks of elderly players in the gameplay.
	5. It is important to minimize elderly players' frustration in the gameplay.
	6. It is important to minimize cognitive complexities in the game, especially for novice elderly players.
	7. It is important to minimize elderly players' motion sickness in the gameplay.
	8. Creating a sense of achievements for novice elderly players is important.
User Interface	9. Providing visual cues and voice-based instructions should be taken into consideration in game design for elderly players.
	10. Controller-free interaction is easy and effective for elderly players.

6. Conclusions

Finland in the European Union has been facing a challenge of demographic change and so is Japan in East Asia. The literature suggests that digital games show promises for elderly people's physical exercise activities. However, some researchers argue that more studies need to be done in order to investigate the usability and usefulness of digital games for elderly people. Hence in this study, we conducted the usability evaluation of the "*Skiing game*" with the Finnish elderly people in Finland to understand their feedback towards the game. We also conducted a cross-country usability evaluation of the game with 24 Japanese elderly participants in Japan to understand the non-Finnish elderly people' perceptions of the usability of the game. We conducted pre-study, observation in the gameplay, and post-study by using SUS and GEQ questionnaires, as well as interview questions to understand the elderly participants' responses and feedback towards the usability of the game and their gameplay experiences.

Based on the findings from both studies, we found that both elderly groups had relatively positive experiences in in-game and post-game, as well as their responses towards the usability of the game is noticeably positive. The Finnish elderly participants had a relatively negative attitude towards digital games prior to their gameplay, whereas the Japanese elderly participants were fairly positive to digital games. After the gameplay, both elderly groups' attitudes towards digital games had become positive, while the Japanese elderly participants showed more interests and positive attitudes towards digital games. Furthermore, the Japanese elderly participants recommended that playing digital games can be an alternative solution for them to do physical exercises, and it can be beneficial to their physical health. For the Finnish elderly participants, they recommended that playing digital games can be an alternative solution for them when they don't have access to conventional physical exercises. We also learned a number of usability lessons from

both studies, and we reported them in this study for researchers and practitioners to take into consideration when they design and develop digital games for elderly people.

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References

[1]Hébert, R., Functional Decline in Old Age, Canadian Medical Association Journal, Vol.157, Nr. 8, 1997, pp. 1037-1045.
[2]American Psychological Association (APA), Older adults' health and age-related changes, 2017, http://www.apa.org/pi/aging/resources/guides/older.aspx
[3]Chappell, N. L., Cooke, H. A., "Age-related disabilities - Aging and quality of life", In J. Stone & M. Blouin (Eds.), International Encyclopedia of Rehabilitation, 2010
[4]Manini, T. M., Mobility Decline in Old Age: A Time to Intervene, Exercise and Sport Sciences Reviews, Vol. 41, Nr. 1, 2014
[5]World Health Organization, "Good health adds life to years: Global brief for World Health Day", http://apps.who.int/iris/bitstream/10665/70853/1/WHO_DCO_WHD_2012.2_-eng.pdf
[6]Bherer, L., Erickson, K. I., Liu-Ambrose, T., A Review of the Effects of Physical Activity and Exercise on Cognitive and Brain Functions in Older Adults, Journal of Aging Research, 2013, doi:10.1155/2013/657508
[7]Sun, F., Norma, I. J., While, A. E., Physical Activity in Older People: A Systematic Review, BMC Public Health, Vol.13, Nr. 499, 2013, doi:10.1186/1471-2458-13-449
[8]Planinc, R., Nake, I., Kampel, M., "Exergame Design Guidelines for Enhancing Elderly's Physical and Social Activities". Paper presented at the The Third International Conference on Ambient Computing, Applications, Services and Technologies, 2013.
[9]Harrington, C. N., Hartley, J. Q., Mitzner, T. L., Rogers, W. A., "Assessing Older Adults' Usability Challenges Using Kinect-Based Exergames", In J. Zhou & G. Salvendy (Eds.), Human Aspects of IT for the Aged Population. Design for Everyday Life: First International Conference, ITAP 2015, Held as Part of HCI International 2015, Los Angeles, CA, USA, August 2-7, 2015. Proceedings, Part II (pp. 488-499). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-20913-5_45
[10]Pyae, A., Tan, B. Y., Mark, G., "Understanding stroke patients' needs for designing user-centered rehabilitative games". Proceedings of the 7th Annual International Conference on Computer Games Multimedia and Allied Technologies, 2013, pp. 151–156. https://doi.org/10.5176/2251-1679_CGAT13.36
[11]Whitlock, L. A., McLaughlin, A. C., Allaire, J. C., "Video Game Design for Older Adults: Usability Observations from an Intervention Study", the The HUMAN FACTORS and ERGONOMICS SOCIETY 55th ANNUAL MEETING, 2011.
[12]Gerling, K. M., Livingston, I. J., Nacke, L. E., Mandryk, R. L., "Full-Body Motion-Based Game Interaction for Older Adults". Paper presented at the CHI 2012, Austin, Texas. https://doi.org/10.1145/2207676.2208324
[13]Heikkilä, E., "Labour Market Participation of Immigrants in Finland and its Regions". The European Social Science History Conference, 2012.
[14]Raitoharju, R., Luimula, M., Pyae, A., Pitkäkangas, P., Smed, J., "Serious games and active healthy ageing: A pre-study". Proceedings of the International Conference on Well-being in the Information Society, WIS, 2014. https://doi.org/10.1007/978-3-319-10211-5_16
[15]United Nations, "World Population Ageing", http://www.un.org/en/development-/desa/population/publications/pdf/ageing/WPA2015_Report.pdf
[16]Dethlefs, N., Martin, B., Japanese Technology Policy for Aged Care, Science and Public Policy, Vol.33, Nr. 1, 2006, pp.45-57. https://doi.org/10.3152/147154306781779163

[17]Katajapuu, N., Granholm, P., Hiramatsu, M., Ishihara, E., Hirayama, J., Pitkakangas, P., Luimula, M., Brain trainer exercise game. Field tests in Finland and Japan. International Journal of Chemistry and Chemical Engineering Systems, Vol.1, 2016
[18]"User-Centered Design Basics", https://www.usability.gov/what-and-why/user-centered-design.html
[19]Pyae, A., Raitoharju, R., Luimula, M., Pitkäkangas, P., Smed, J., Serious Games and Active Healthy Ageing: A Pilot Usability Testing of Existing Games. International Journal of Networking and Virtual Organisations, Vol. 16, Nr. 1, 2015, doi: DOI: 10.1504/IJNVO.2016.075129
[20]Pyae, A., Luimula, M., Smed, J., "Understanding stroke patients' motivation for motivation-driven rehabilitative game design". In R. Giaffreda, R-L Vieriu, E. Pasher, G. Bendersky, A. J. Jara, & J. J. P. C. Rodrigues (Eds.), Internet of Things. User-Centric IoT, 2015, pp. 99–111. Springer International. https://doi.org/10.1007/978-3-319-19656-5_16
[21]Pyae, A., Mika, L., Smed, J., Rehabilitative Games for Stroke Patients. EAI Endorsed Transactions on Serious Games, 15(4: e2), 2015.
[22]Nakai, A., Pyae, A., Luimula, M., Hongo, S., Vuola, H., Smed, J., Investigating the Effects of Motion-based Kinect Game System on User Cognition, Journal on Multimodal User Interfaces, Vol. 9, Nr. 4, 2015, pp. 403–411. https://doi.org/10.1007/s12193-015-0197-0
[23]Pyae, A., Luimula, M., Smed, J., "Investigating the usability of interactive physical activity games for elderly: A pilot study". 6th IEEE International Conference on Cognitive Infocommunications, 2015, pp. 185–193. https://doi.org/10.1109/CogInfoCom.2015.7390588
[24]Pyae, A., Luimula, M., Smed, J., "Pre-studies on Using Digital Games for the Elderly's Physical Activities". In H. Li, P. Nykänen, R. Suomi, N. Wickramasinghe, G. Widén, & M. Zhan (Eds.), Building Sustainable Health Ecosystems: 6th International Conference on Well-Being in the Information Society, WIS 2016, Tampere, Finland, September 16-18, 2016, Proceedings (pp. 82-96). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-44672-1_8
[25]Luimula, M., Kattimeri, C., Katajapuu, N., Pitkäkangas, P., Malmivirta, H., Pyae, A., Liukkonen, T., Smed, J., Qvist, P., Gamified Solutions in Healthcare - Testing Rehabilitation Games in Finland and Asia. Acta Technica Jaurinensis, Vol.10, Nr. 1, 2017 DOI: http://dx.doi.org/10.14513/actatechjaur.v10.n1.412
[26]Breuer, J., Bente, G., Serious Games – An Overview. Eludamos, Journal for Computer Game Culture, Vol.4, Nr.1, 2007, pp. 7-24.
[27]Kato, P. M., Video Games in Health Care: Closing the Gap. Review of General Psychology, Vol.14, Nr. 2, 2010, pp.113-121. https://doi.org/10.1037/a0019441
[28]Taylor, M. J. D., McCormick, D., Shawis, T., Impson, R., Griffin, M., Activity-promoting gaming systems in exercise and rehabilitation, Journal of Rehabilitation Research & Development, Vol.48, Nr.10, 2011, pp.1171-1186. https://doi.org/10.1682/JRRD.2010.09.0171
[29]Santos, A., Guimarães, V., Matos, N., Cevada, J., Ferreira, C., Sousa, I., "Multi-sensor exercise-based interactive games for fall prevention and rehabilitation". The Proceedings of the 9th International Conference on Pervasive Computing Technologies for Healthcare, 2015, Istanbul, Turkey. https://doi.org/10.4108/icst.pervasivehealth.2015.259115
[30]Sato, K., Kuroki, K., Saiki, S., Nagatomi, R., The effects of exercise intervention using KinectTM on healthy elderly individuals: A quasi-experimental study. Open Journal of Therapy and Rehabilitation, Vol.2, Nr. 1, 2014, pp.38-44 https://doi.org/10.4236/ojtr.2014.21008
[31]Pisan, Y., Marin, J. G., Navarro, K. F., "Improving Lives: Using Microsoft Kinect to Predict the Loss of Balance for Elderly Users under Cognitive Load". The Australasian Conference on Interactive Entertainment, 2013. https://doi.org/10.1145/2513002.2513026
[32]Chao, Y.-Y., Scherer, Y. K., Montgomery, C. A., Effects of using Nintendo Wii Exergames in Older Adults: A Review of the literature. Journal of Aging and Health, Vol.27, Nr. 3, 2015, pp. 379-402. https://doi.org/10.1177/0898264314551171
[33]Kaufman, D., Sauv, L., Renaud, L., Sixsmith, A., Mortenson, B., Older Adults' Digital Gameplay. Simul. Gaming, Vol.47, Nr. 4, 2016, pp.465-489. doi:10.1177/1046878116645736
[34]Pyae, A., Liukkonen, T. N., Luimula, M., Kattimeri, C., Smed, J, Investigating the Finnish elderly people's user experiences in playing digital game-based skiing exercise: A usability study. Gerontechnology, Vol.16, Nr. 2, 2017, pp.65-80 https://doi.org/10.4017/gt.2017.16.2.002.00

[35]Pyae et al., Investigating the Finnish Elderly People's Attitudes and Motivation towards Digital Game-Based Physical Exercises. Finnish Journal of eHealth and eWelfare, 2017.
[36]Pyae, A., Liukkonen, T. N., Saarenpää, T., Luimula, M., Granholm, P., Smed, J., When Japanese Elderly People Play a Finnish Physical Exercise Game: A Usability Study. Journal of Usability Studies, 11(4), 2016, pp.131–152.
[37]Katajapuu, N et al., Brain trainer exercise game. Field tests in Finland and Japan. International Journal of Chemistry and Chemical Engineering Systems, Vol. 1, 2016.
[38]Katajapuu, N et al., Benefits of Exergame Exercise on Physical Functioning of Elderly People. 8th IEEE International Conference on Cognitive InfoCommunications, 2017.
[39]IJsselsteijn, W.A., de Kort, Y.A.W., Poels, K., Development of the Game Experience Questionnaire (GEQ). Manuscript in preparation.
[40]IJsselsteijn, W.A., de Kort, Y.A.W., & Poels, K., The game experience questionnaire: Development of a self-report measure to assess the psychological impact of digital games. Manuscript in preparation.
[41]Renaud, K., van Biljon, J., "Predicting technology acceptance and adoption by the elderly: A qualitative study". Proceedings of the SAICSIT 2008, Wilderness Beach Hotel, Wilderness, South Africa. https://doi.org/10.1145/1456659.1456684
[42]Pyae, A., Liukkonen, T. N., Saarenpää, T., Luimula, M., Granholm, P., Smed, J. When Japanese Elderly People Play a Finnish Physical Exercise Game: A Usability Study. Journal of Usability Studies, Vol.11, Nr. 4, 2016, pp.131–152.