LANCASTER UNIVERSITY

Design characteristics of fitness games in a Learning Disabilities context

Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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31/06/2017

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Abstract

Motivating people with learning disabilities (LD) to carry out physical exercise is a difficult task. Adapted fitness games can address this problem. Yet the design characteristics of the fitness games for this particular user group have not been studied before. Combining game design guidelines and inclusive design principles, this research explores the design characteristics in six categories: purposes, user requirements study, mechanics, technology, motivations and types. A mixed-method approach has been adopted. Firstly, a case study of the development of a fitness game for LD users was conducted through 10 interviews and 3 observations, gathering insights of game designers and end users about the general design characteristics of LD fitness games. Based on the qualitative findings and a literature review, a questionnaire was generated addressing the important design characteristics in six categories. The questionnaire surveyed 235 people from both game and healthcare industries to assess their agreement to the design characteristics. By identifying critical design characteristics in each aspect, this research contextualizes and clarifies general game design literature including game development process models, fitness game design guidelines and motivation theories. The findings of the research conceptually enrich the seven inclusive design principles and clarify each principle in a context of designing for LD users. The study provides an example on how to combine qualitative and quantitative methods for comprehensive data collection in research on fitness game design. With the recognition of a large population of relevant experts, the design characteristics proposed provide game designers with a structured approach to make fitness games for LD users.

Acknowledgements

My most sincere gratitude goes to my three supervisors Professor Monideepa Tarafdar, Dr. Patrick Stacey and Dr. Nikos Kourentzes. I could not thank them enough for their continuous support of my research and for their guidance for me to grow as a research scientist. Their advice on research and my career has been priceless.

I would like to thank the game studios and care homes that allowed me access to collect empirical data. Without the input of the 10 interviewees and 235 survey participants it would not be possible to conduct this research.

Lancaster University Management Science department supported my PhD journey by providing funding, facilities and connections. I would like to thank admin team members Ms. Gay Bentinck and Ms. Lindsay Newby for their help.

A very special thanks to my family and friends who have offered me unconditional support. I am grateful for their continuous encouragement and invaluable advice.

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1. Chapter One: Introduction

The research topic for this thesis is the design characteristics of fitness games that are targeted at users with learning disabilities (LD). The thesis contains eight chapters presenting the literature review, data collection, data analysis and the findings of the research. To introduce the thesis briefly, this chapter discusses the research overview, motivations, contributions, research design and thesis structure.

1.1 Overview

People with LD often lack physical exercise due to their impairments (Messent, et al., 1998). To change this situation, fitness games can be helpful. Literature has shown that fitness games are effective in a healthcare context generally (McCallum, 2012). However, to the best of my knowledge, there is very little research that studies fitness games within a more specific healthcare context of LD. Nor are there studies that examine detailed design characteristics of such games (Lotan, et al., 2009 and Cai and Kornspan, 2012). Given the fact that people with LD often suffer from problems associated with obesity and physical activity (Robertson, et al., 2000), it is important to generate alternative tools, such as games, that can support and improve the quality of life for LD users. Thus, the objective of this thesis is to study the detailed design characteristics of fitness games for LD users.

A mixed-method research design has been adopted for this research. Firstly, interviews and observations were conducted with game designers and end users of a fitness game. Based on the qualitative findings and literature review, a questionnaire was generated addressing the important design characteristics. The questionnaire surveyed 235 people from both game design industry (114 game designers from various game studios) and healthcare industry (131 healthcare professionals from different care homes) to assess their agreement to the design characteristics.

To study the design characteristics of fitness games in the LD domain, this study explores fitness game design from six categories: purposes, types, user requirements study, mechanics, technology and motivations. By identifying critical design characteristics in each aspect, this dissertation provides guidance for an inclusive and nuanced approach to designing games for LD users. It identifies concepts in fitness games that intrinsically motivate physical activities.

1.2 Research motivations and objectives

The primary motivation for this research is the reality that there is an absence of design guidelines for designing fitness games that are targeted at LD users. Identifying design characteristics for fitness games in an LD context would fill this research gap and accelerate fitness game development.

In general, people with LD exhibit poor fitness performance in terms of strength, endurance, and motor coordination (Golubović, et al., 2012). Research has shown that this low performance is associated with limited motor development, sedentary lifestyle, mental impairments and short attention span (Golubović, et al., 2012). Lack of motivation is also a cause for low levels of fitness (Halle, et al., 1999). Previous study has found that that an increase of moderate intensity physical activity has a positive result in improving health (Robertson, et al., 2000). Particularly for disabled populations, performing specifically adapted exercise can change their current physical inactive situation (Pate, et al., 1995).

However, conventional fitness training programs are not always useful or appropriate for meeting the needs of LD users (Lotan, et al., 2009) because of the physical and intellectual restrictions that LD users face. To promote physical exercise, fitness programs with motivational factors are recommended (Rogers-Wallgren, et al., 1992). Fitness games have been tested to be effective in promoting physical exercise for adults with LD (Lotan, et al., 2009). When fitness games are designed for LD, they encourage users to repeat daily movements and help them improve in an enjoyable and virtual simulated environment (Campbell, et al., 2008).

The research objective is to discover the key design characteristics of fitness games that are targeted at LD users. More specifically, the research explores special elements that differentiate designing for LD users from other user groups. To carry out the research in detail, this thesis discusses the fitness design from six categories: purposes, types, user requirements study, mechanics, technology and motivations. The research objective is addressed by drawing from concepts in both game design literature and inclusive design literature. This is used to establish theoretical links between game design literature and inclusive design literature. The study aims to clarify the design pitfalls in the fitness game industry. It outlines the key design concepts of a successful fitness game and potentially contributes to a better quality of life for LD users. The games that are produced following these design characteristics have the potential to make a change to the poor physical conditions faced by LD users.

1.3 Research significance and contributions

The research contributes to both theory and practice. In terms of enriching literature, this research expands both game design and inclusive design principles. In a practical sense, the findings of the research provide guidance to game designers to make more suitable fitness games which would help LD users to engage in fitness activities and thus improve their quality of life.

This research contributes to three types of game design literature: game design process models, fitness game design guidelines, and motivational aspects of game design. The findings of the research further clarify and expand Rouse III (2010)'s three-step process model and make it more applicable to the LD domain. The research integrates prior fitness game design guidelines and expands them in six categories: game purposes, game types, user requirements study, game mechanics, game technology and game motivations. By integrating Self-Determination Theory (Deci and Ryan, 2002) with game design guidelines, the research introduces ways in which intrinsic motivation can be assessed and encouraged during gameplay.

With regards to the contributions of the research in industry, it addresses previously identified pitfalls for fitness game designers, namely the limitations in existing game design guidelines that might result in development of games which are not wholly suitable for LD users. With a more structured approach to make fitness games specifically for LD users, the games can potentially improve the LD end user's problems associated with obesity and physical activity. Additionally, this research attempts to focus on collaboration between researchers, commercial game designers and healthcare professionals for game design and research purposes.

1.4 Research design

To collect rich and triangulated data for developing the design guidelines, a mixed-method research design is chosen for this study. The case study explores the initial design characteristics through interviewing and observing game designers and LD game users as they had first-hand experience developing and testing a fitness game targeted at LD users. The survey confirms and clarifies the initial findings from a larger and differentiated set of industrial experts' opinions about design characteristics. Industrial experts include game designers with years of experience developing games and healthcare professionals who work with LD users. Due to their work experience, their insights of design characteristics are valuable.

The research starts with a qualitative case study based on interviews and observations of developing a fitness game named Somability. The case study was conducted in collaboration with the game studio Cariad Interactive (based in Cardiff) and Cardiff Metropolitan University. The interviewees are ten people who were actively involved in the development of Somability. Three natural observations included one of the game designers developing the game in the game studio and two of the beta testing activities that were accomplished by game designers in collaboration with end users from a day care centre. The case study provides insights into the perspectives of both the game designers and the end users. After analysing the qualitative data, it was discovered that the design characteristics suggested that the literature needed to be further clarified in a context of designing fitness games for LD users.

To complement and extend the qualitative findings and to confirm the results with a broader base of relevant stakeholders that are interested in, contribute to, and benefit from games for LD users, the second phase of the study uses a quantitative questionnaire-based method to understand the details of each design characteristic. The questionnaire is designed using qualitative findings and literature. This consists of 114 game designers from various studios and 131 healthcare professionals who worked with LD users. The survey respondents provide their perception of appropriate design characteristics for fitness games.

Overall, a combination of methods enables the study to access richer data and provides a basis for a detailed and comprehensive analysis of fitness game design characteristics. By assessing industrial experts' agreement on design characteristics through interviews, observations and surveys, the research findings gained a generable ground. The game designers and end users involved in the case study had first-hand experience developing and testing a fitness game that was targeted at LD users; the game designers and healthcare professionals who participated in the survey had experience developing games or working with LD users. Therefore, their insight of fitness game design is valuable and credible. Design characteristics found through experts' agreements can be applied to the game design industry with reasonable confidence. The design characteristics discovered through the first-stage case study are tested empirically as they emerge through the development of a successful fitness game: Somability. Other characteristics proposed in the second stage survey study came from existing design literature. The combination of the experts' agreement, success of Somability and prior literature helps define the design characteristic proposed in this study and are well recognized in the game design industry. End user input is observed during the case study and their reactions are interpreted. LD user input was excluded during the survey stage due to their vulnerability in social settings and other communication barriers. People of LD tend to have difficulty talking to strangers. It would not be feasible to access a large group of LD users efficiently without using questionnaires as many of them would not be able to read or answer.

1.5 Summary and thesis structure

In order to present the research about fitness games, this thesis is organized in ten chapters: Chapter 1 Introduction, Chapter 2 Literature Review, Chapter 3 Methodology, Chapter 4 Study One: Case Study, Chapter 5 Updated Literature Review, Chapter 6 Study Two: Questionnaire Survey Study, Chapter 7 Discussion, Chapter 8 Conclusion, Chapter 9 References and Chapter 10 Appendices.

Chapter 2 starts by defining what a fitness game is and introduces prior research about the applications and limitations of fitness games. It introduces the adoption of fitness games in an LD context and discusses existing design guidelines such as inclusive design principles, practice-based fitness games design guidelines and the process model for designing fitness games.

Chapter 3 presents the mixed-method research design. To justify the reasons for choosing this research design, the chapter explains the research philosophy and rationale for combined methods. The details of the first case study are presented as follows: definition, case description, data collection methods and data analysis techniques. Similarly, the second survey is introduced in this chapter with the following sections: questionnaire development, selection of survey participants, data collection methods and data analysis techniques.

Chapter 4 introduces Study one, the case study. The data is presented and analysed following a three-step sequence: opening coding, axial coding and selective coding. The findings of the data analysis have been summarised into six design categories.

Chapter 5 provides additional literature review concerning the six design categories identified from the qualitative study in the previous chapter. The existing literature on game design and inclusive design provides a theoretical background for the follow-up questionnaire design.

Chapter 6 presents Study two, the questionnaire survey study. This section validates the choice of the questions and choice of measurement items and the survey itself. All participants were asked the same questions so that the study could identify differences and similarities in the answers of the participants. The design characteristics of fitness games are concluded from the quantitative analysis.

Chapter 7 draws conclusions from the results of both the qualitative and the quantitative studies. Additionally, the chapter presents the contributions of this research for literature in three areas: game design, inclusive design and intrinsic motivation in games. The contributions to the game design industry are presented here.

Chapter 8 summarises the thesis and points out the research limitations, future research and critical reflections.

Chapter 9 lists all the references that are used in the thesis in Harvard referencing style.

Chapter 10 contains the appendices, which include the consent form for interviewees, the two sets of questionnaires, and an example of qualitative data analysis using NVivo.

2. Chapter Two: Initial Literature Review

In order to evaluate a design strategy for fitness games in the LD domain, it is important to review the literature concerning LD users in terms of application of fitness games. This chapter provides a theoretical foundation for this research.

2.1 Introduction to fitness games

To study fitness games, the first section of literature review defines what fitness games are and demonstrates what they are currently used for and the limitations they have.

2.1.1 Definition

A fitness game is a video game that is used as a component to promote physical activities (Sinclair, et al, 2007). It is also called exergaming or exer-gaming (Sinclair, et al, 2007). In the healthcare industry, a fitness game can be defined as a video game that requires physical movements including strength, balance, and flexibility activities (Oh and Yang, 2010). Examples of some successful commercial games for mainstream use include: Wii Fit, Just Dance, Zumba Fitness, My Fitness Coach, Kinect Sports and Zombie, Run! (McCallum, 2012). Fitness games are used in various sites. For instance, games such as Just Dance are played in a room while games like Zombie, Run! are played outdoor (Kankaanranta and Neittaanmäki, 2008). For the purpose of this research, fitness games that are designed to play in a room are studied.

Most fitness games are gesture-controlled. These gestures include movements of hand, body, fingers, head, and often associated with voice. Gesture-based games are typically easier to use as participation in these types of game allows play regardless of age. They also overcome issues with physical and mental ability. Technology required for gesture-controlled games used to require a combination of worn sensors, camera sensors and infrared signals. Improved camera technology, image processing software and game tools have lowered the sensor requirements. In addition to the decrease in cost, usability has also become more natural and intuitive. Therefore, it is widely used in a variety of different industries such as entertainment, training (in a working environment), education (schools/universities), artificial intelligence, simulation, healthcare (e.g. elderly), and tele-health. (Bhuiyan and Picking, 2009)

2.1.2 Applications of fitness games in the healthcare industry

Fitness games, ranging from traditional games such as Wii Fit to simulators for training like Virtual-U, have already been introduced to many areas of healthcare industry (McCallum, 2012). These fitness games have been used for therapy, fitness tracking, education and data collection (McCallum, 2012). In the therapy domain alone, fitness game can be harnessed for cognitive improvement (e.g. Brain Age), social networking (e.g. Nintendo Wii), mental well-being (Fleming, et al, 2011) and fitness improvements (McCallum, 2012).

Fitness games have been applied to end users of all ages including children (e.g., Graf et al, 2009; Unnithan et al., 2006), teenagers (e.g., Staiano and Calvert, 2011), young adults (e.g., Douris et al., 2012; Graves et al, 2010), middle-age adults (e.g., Guderian et al., 2010) and elderly adults (e.g., Planinc et al., 2013; Gerling et al., 2012). Prior research has proven that fitness games are effective in terms of increasing physical fitness and mobility.

2.1.3 Limitations of fitness games

There are a few limitations of fitness games. Some games are less portable because the exertion interfaces are attached to computers. For example, some games on the Nintendo Wii are fixed to a specific location because they require projection-based solutions and specific sensor placement (e.g. Lightspace Play floor and DigiWall). Some games such as GPS-based games are less suitable for children due to safety reasons (Bekker, et al, 2008). On the other side, end users of fitness games have different levels of acceptance in terms of the technology used. Disabled users and elderly users are less comfortable when using new technology (Planinc, 2013).

2.2 Introduction to learning disabilities

A learning disability can be defined as 'a significant reduced ability to understand new or complex information or to learn new skills, a reduced ability to cope independently, and an impairment that started before adulthood, with a lasting effect on development' (Martin, 2001).

Although the UK is the only country that uses the term 'learning disabilities', other English speaking countries such as USA use the term 'intellectual disability'. In the UK, the terms 'learning disabilities' and 'learning difficulties' are often interchangeable in a healthcare context. (Hardie and Tilly, 2012)

2.2.1 Physical and intellectual restrictions of different levels of learning disabilities

According to Hardie and Tilly (2012), there are four levels of learning disabilities. In order of severity from highest to lowest, they are: profound, severe, moderate and mild.

Mild LD refers to slight sensory or motor defects. Most of the people in this group are never diagnosed and are able to live independently. They might need help with employment and housing or when under unusual stress. (Bouras et al., 1995)

People in the moderate LD group can talk and care for themselves under supervision, sometimes undertaking paid work. (Bouras et al., 1995)

People with severe LD have a slow pace of learning (Bouras et al., 1995). They may be able to communicate in a simple way (Bouras et al., 1995). They can perform easy tasks and only engage in limited social interaction (Bouras et al., 1995). However, they often need help with daily activities and need to live under close supervision (Hardie and Tilly, 2012).

A person with profound LD usually has a number of disabilities which could include impairments to hearing, movement and vision. This can also include conditions such as epilepsy and autism (Hardie and Tilly, 2012). People with severe LD often need help with daily activities (Hardie and Tilly, 2012). Their behaviours could be challenging for others (Ware, 2004). They find it with great difficulty to communicate with others (Ware, 2004). As a consequence, this group of people has been neglected and excluded from the society and there is need to increase meaningful social interaction (Sheehy and Nind, 2005). Additionally, people with profound LD typically do not partake in physical exercise activities due to their impairments.

In general, people with LD show poor fitness performance in terms of strength, endurance, and motor coordination (Golubović et al., 2012). Research has shown that the poor performance is associated with limited motor development, sedentary lifestyle, mental impairments and short attention span (Golubović et al., 2012). Lack of motivation is also a cause for low levels of fitness (Halle et al., 1999). Physical performance is influenced by the level of LD, for example, athletes with lower LD level perform better in motor coordination tests (Guideti et al., 2010).

In terms of their mental conditions, people with LD generally struggle from mental health difficulties more than the general populations (Lacey and Oyvry, 2013). They often withdraw themselves from their environments and engage in obsessive or compulsive behaviours that would stop them from participating in everyday activities such as physical exercise and have low self-esteem (Lacey and Oyvry, 2013).

Overall, all levels of LD struggle with physical movements, adverse mental conditions and have an impaired ability to learn. Therefore, a questionnaire is designed to study users at all four levels of the LD spectrum. To distinguish different levels of LD, caregivers who participated in the survey are asked to answer the questions accordingly for each level of LD they have experience with.

2.2.2 Poor living quality of people with LD

People with LD have been reported to have poor health conditions, both physically and mentally (Cortiella and Horowitz, 2014). Other literature suggests that people with LD often face problems that are associated with diet, obesity and physical activities (Robertson, et al., 2000).

The reasons for their poor health condition can be genetic with biological bases, influenced by lifestyle factors and accessibility to healthcare (Emerson and Hatton, 2007). Fitness games can help change this situation.

2.2.3 The difficulties of designing games for people with LD

Due to the conditions of LD users, there are many challenges when designing a game for them. Their demands may be very special and little may be known about them. They may find it difficult to communicate their thoughts and therefore, designers cannot easily gather feedback. It is difficult to conduct market research because the buyers of games may not be the people with disabilities. (Newell and Gregor, 2000)

For LD specifically, challenges in the design process are mainly about communication. Depending on the LD level, game designers are challenged in various ways. Language barriers, memory problems hinder progress. For people with severe and profound LD, the main challenge is understanding and quantifying their subjective experiences and needs. Getting feedback from those with mild or moderate LD is generally a lot more straightforward. (Ross and Oliver, 2003)

2.3 Identified fitness games design framework

Considering the special conditions faced by LD users, there are restrictions and guidelines to follow when designing games for them. Combining the restrictions and guidelines, this research discusses the design characteristics of various aspects of fitness game design.

Previous literature points to particular frameworks that have had success in the past.

2.3.1 Reasons to study design characteristics of fitness games

Previous research about interactive games design has focused on providing broad and theoretical frameworks (for example, Benford et al, 2012 and Benford et al., 2005). There have also been studies that examine how games have been designed before (Fullerton et al., 2004; Schell, 2014). To connect the theoretical frameworks and the design practice closer, there were alternative design studies carried out in the format of design cards (Mueller et al., 2014). These practice-oriented approaches have been proven to be supportive for the design process (Hornecker, 2010).

Even though these studies provide sufficient theoretical ground, they mostly focus on interactive system or games in general instead of fitness games. Fitness game design is different from designing button-press games (Mueller et al., 2011). Previous research has attempted to study challenges and opportunities that were faced by designers of fitness games (for example, Gerling et al., 2012 and Sweller, 1994). However, most studies concentrated on offering either abstract frameworks (Loke et al, 2007; Mueller et al., 2011) or emphasizing individual aspects of fitness games such as health benefits (Berkovsky et al., 2010), social benefits (Lindley et al., 2008) and effective responses (Bianchi-Berthouze 2013; Isbister et al., 2011). To provide a comprehensive understanding of how to design fitness games, Mueller and Isbister (2014) presented a set of practice-based design guidelines. However, research has not been done to study fitness games targeted at the LD group. Considering the special conditions of LD users, fitness games have to be designed to specifically meet their needs. Therefore, this study discusses various aspects of fitness games in the LD domain.

The design characteristics discussed in this study include the objectives of fitness games, types of games, user requirements study, mechanics, technology and motivations. This set of characteristics provides a comprehensive understanding of how to design fitness games in the LD domain. These characteristics provide a basis for a more structured approach for game designers.

Before establishing new design characteristics, the identified design guidelines are studied. The inclusive design principles are discussed first as commonly used guidelines for all products designed for disabled users. Later on, a set of design guidelines for fitness games is presented. There are two sets of design guidelines for fitness games targeted at less abled users such as the elderly. Additionally, the process model of fitness game design is presented.

2.3.2 Inclusive design principles

Inclusive design principles are the most commonly adopted design guidelines for making products targeted at disabled customers (Normie, 2005). For the inclusive design process, a group of professionals identified seven general principles. The authors of the principles are architects, product designers, engineers and researchers (Mace, 1997). Products or services that made following inclusive design principles should be able to accommodate users with a wide variety of characteristics and disability is one of them (Mace, 1997). The seven principles are:

1. Equitable use: the design is useful and marketable to people with diverse abilities.
2. Flexibility in use: the design accommodates a wide range of individual preferences and abilities.
3. Simple and intuitive use: use of the product is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.
4. Perceptible information: the design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.
5. Tolerance for error: the design minimizes hazards and the adverse consequences of accidental or unintended actions.
6. Low physical effort: the design can be used efficiently and comfortably with minimum fatigue.
7. Size and space for approach and use: appropriate size and space is provided for approach, reach, manipulation and use regardless of user's body size, posture or mobility.

2.3.3 Practice-based fitness games design guidelines

The inclusive design principles are useful when discussing designing for disabled people in general. When it comes to fitness games in particular, Mueller and Isbister (2014) proposed the following practice-based design guidelines:

1. Embrace ambiguity: designers should be aware of the sensitivity of the devices and use them to create ambiguity in fitness games. This is because end users enjoy exploring uncertainty and dislike forced precision.

2. Celebrate movement articulation: designers need to give end users frequent and accurate interactive feedback.
3. Consider movement's cognitive load: designers should try to avoid overloading users with too much feedback as too much feedback requires a high-level of mental capacity especially when users are learning something new.
4. Focus on the body: to keep the end user's attention on the body instead of on the screen, designers need to provide other forms of feedback other than screen-based, for example, audio and haptics feedback. Opinions from other end users are also important.
5. Consider fatigue: designers should carefully consider fatigue in fitness games. They can minimize fatigue through short game cycles, varying movements and distractions such as music.
6. Exploit fear of risk: LD users may feel uncomfortable with the game experience and associate it with a sense of risk. Designers can convey this as a sense of thrill with a positive benefit to the game experience. Additionally, they need to consider risks in the environment as well as in games.
7. Map imaginatively: designers can add virtual features to help end users perform movements that are not possible in real life.
8. Highlight rhythm: designers can use music to make interaction easier. They can also visualize upcoming movements to help users identify rhythm in their movements.
9. Support self-expression: designers can encourage end users to perform different movements and show result of self-expression, for example, in forms of photos.
10. Facilitate social fun: designers can introduce the multi-player mode because moving with others is fun. Designers can make the game easy to learn by observing in order to encourage bystanders to play.

The aforementioned design guidelines proposed by Mueller and Isbister (2014) are for all fitness games in general. To study fitness games for LD users, it is important to look at existing design guidelines for other less abled users. Elderly users and LD users share many things in common, for example, limited cognitive and physical conditions. There is some research about fitness games applied for the elderly and two design guidelines were proposed.

Considering the limited cognitive and physical abilities of elderly users, Gerling et al. (2010) proposes the following design guidelines of fitness games targeted at this user group:

1. The games should be designed to enable elderly end users to play sitting and standing.
2. The games should be designed without extensive or sudden movements.
3. The games should be designed to enable elderly end users to adjust the level of difficulty individually.
4. The games should be designed with constructive feedback to avoid frustration.

Planinc et al. (2013) also proposes a set of design guidelines for fitness games target elderly people. These guidelines include:

1. The games should be mindful of the end user's physical conditions.
2. The games should use appropriate gestures for learning and reminding the users of their progress at learning.
3. The games should avoid small or fast-moving objects.
4. The games should provide positive visual and audio feedback to avoid resulting low self-esteem and frustration.
5. The games should be able to adjust the difficulty dynamically to accommodate end users with all abilities.
6. The games should use a clear interface.
7. The games should choose a suitable topic. Elderly end users prefer games that are related to real life such as gardening and pets. They like games with educational or cultural benefits.
8. The games should encourage social interaction among elder people as well as their interaction with grandchildren.

2.3.4 Process model for designing fitness games

Other studies focus on a 'process model' approach to game design and development. Examples include Boomerang (Stacey and Nandhakumar, 2008) and prototyping (Baba and Tschang, 2001), as well as a variety of design techniques such that use scenarios, body storming, paper prototyping, rapid prototyping, theatrical techniques of improvisation (Clanton, 1998; Bjork et al., 2002; Johnson and Wiles, 2003), simulation (Kanev and Sugiyama, 1998), cuisinart (Rouse III, 2010), and play environments such as mixed reality (Cheok et al., 2002).

To discuss design characteristics of fitness games, this research draws from a typical game design process (Rouse III, 2010), which focuses on three phases: conceptual outline, implementation and outcome (Figure 1). The reason to choose Rouse's process model is that it is highly user-centred. A 'user-centred design' means end-users influence how a product takes shapes in the design process (Abras, et al., 2004). Rouse's process model emphasizes the input of users in order to provide more appropriate conditions for fitness game participation. The design process of the fitness game that is observed and analysed in this study map well with Rouse's model, which is another reason to choose this framework.

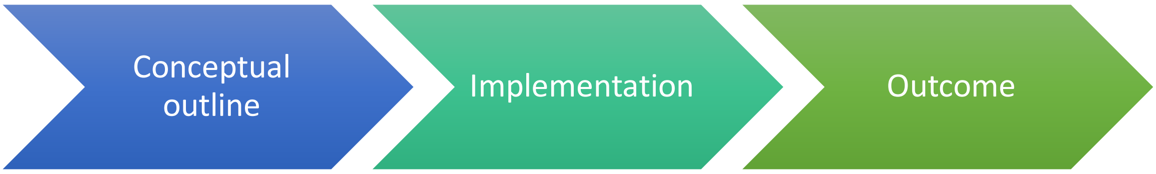

Figure 1. Rouse III's (2010) game design process model

In the conceptual outline phase, game designers should focus on learning about user requirements and make games accordingly. Designers have to decide the challenges in a game and the virtual environment to match these challenges. It is also important to recognize the correct pace of the game that is most appropriate for the user. Moreover, the rewards for end users also need to be considered. (Rouse III, 2010)

In the implementation phase, designers firstly need to build a game architecture to satisfy the aims proposed in the first phase (Rouse III, 2010). The next step is to design game mechanics and refine them until they are fun (Rouse III, 2010). Designers also need to choose the right form for interaction with the virtual environment (Rouse III, 2010). With regards to human-computer interaction, the emphasis is on game interface design and visual adaptability (Czaja and Lee, 2008,). When a game is finished, playtesting is required to collect feedback for further improvements (Rouse III, 2010).

In the outcome phase, a game is expected to engage end users by providing them with joy, challenges, social interaction, emotional experiences and fantasies (Rouse III, 2010). This research focuses on the intrinsic value that fitness games can bring. Such outcomes are long-lasting when it comes to motivating end users to continue playing.

This section summarises some frameworks for fitness games design. However, there is not much research with regards to designing fitness games for LD users. To fill this research gap, the Chapter 5 discusses how to go about adopting fitness games in an LD context.

2.4 Research questions and objectives

In summary, people with LD are in need of an effective method to encourage physical exercise. Fitness games with motivating factors could potentially address this need. Considering the special conditions of LD users, fitness games are required to be designed with certain characteristics to enable enjoyable gameplay and exercise. Existing design literature has proposed abstract frameworks, theoretical guidelines and design cards for fitness game design. As for designing games for LD users, there is only one general set of game design principles that fit the guide for the target group. To achieve a comprehensive understanding of designing fitness games in the LD domain, this research links the fitness game design with LD design.

The main research question is 'what are the design characteristics of fitness games in the LD domain?'. Additionally, the research explores the importance of each design characteristic in detail.

3. Chapter Three: Research Design and Methods

This research adopts a mixed-method research design. This chapter explains the overall research design and describes the research methods. This section firstly introduces the general research philosophies of qualitative and quantitative methods. The next section explains the particular research design for this study. Next, the case study method and the questionnaire survey method are explained in detail in two separate sections, together with the analysis strategies adopted.

3.1 Research philosophy

This section explains general research methods and philosophical approaches. It points out the positions for qualitative and quantitative approaches within this specific study.

3.1.1 Research paradigms: interpretivism and positivism

Interpretivism views the world with a subjective position and believes that reality is subjective and internal. Furthermore, they view reality as socially constructible and could be given meaning by its people. One form of interpretivism is social constructivism which focuses on discovering people's meanings and interpretations, and requires a researcher to reflect on his own theories. By investigating conversations and languages, social constructionism research aims to analyse the way people achieve sensemaking and interpretations. In summary, this particular research paradigm is often used to develop hypotheses or theories through the exploration of phenomena. Because of the subjective nature of interpretivism, it is helpful when learning content. (Easterby-Smith et al, 2012)

Positivism views the world externally and believes that observations from researchers should not have any impact or interpretation of reality (Arbnor and Bjerke, 2008). With the analytical view of the reality, positivism assumes that researchers are independent from knowledge which can be obtained in an objective manner (Arbnor and Bjerke, 2008). One of the criticisms about positivism is that it does not adequately account for this research context (Denzin and Lincoln, 2000: 106).

Taking into consideration the content of research and the nature of the two research paradigms, this study adopts research methods that reflect both interpretivism and positivism: a qualitative case study at first to gather subjective insights in an interpretive vein followed by a survey study to confirm the initial findings from a positivist point of view.

3.1.2 Qualitative and quantitative research approaches

The epistemological orientation of qualitative approaches is often interpretivism (Easterby-Smith et al, 2012). The common qualitative methodologies include action research and cooperative inquiry, ethnography and narrative methods, case studies and grounded theory (Easterby-Smith et al, 2012). Qualitative approaches emphasize the interaction between social actions as being the primary research objectives. It is especially helpful when trying to understand and interpret social actors in special situations (Swanson and Holton, 2005: 19). In this study of fitness games, qualitative methods are appropriate at the first-stage. Qualitative approaches contribute to disclosing the richness of data within a specific context (Bonoma, 1985).

Quantitative research often incorporates positivism as the epistemological orientation (Bryman and Bell, 2015). Quantitative research assumes that social factors are objective and that variables can be identified and measured (Bryman and Bell, 2015). With the capacity to handle large amounts of data, the survey methods are able to cover a wide range of situations quickly and economically (Easterby-Smith and Lyles, 2011: 32). A survey research is often conducted to test pre-established findings from qualitative studies (Lin, 1998). It is particularly useful when informed by a case study because it tends to have a better chance to ask the right questions (Lin, 1998). The quantitative approach further identifies and confirms the phenomena being studied in a prior case study. In this study, quantitative methods are used in the second stage to test the findings discovered from the qualitative research stage with a broader audience.

Given the characteristics of the two research approaches and the research objectives of this study, both qualitative and quantitative approaches and techniques are used to accomplish the research objectives for this study. Therefore, a mixed-method research design is adopted.

3.1.3 Research design approach: explanatory, exploratory and triangulation

There are four typical types of mixed methods research design: explanatory, exploratory, triangulation and embedded (Creswell and Clark, 2007). Each research type differs according to the theoretical lens adopted, the qualitative or quantitative methods used, and the data analysis techniques chosen (Creswell and Clark, 2007). For the purpose of this study, three research types are discussed, namely explanatory, exploratory and triangulation. Each of the three means contributes to answering different types of research questions.

Explanatory

Explanatory research describes an issue and explains the reason for its existence and changes (Creswell and Clark, 2007). The typical results of such studies are a loose model that is often explained in quantitative terms (Aken, 2004). With regards to the philosophy stance, explanatory studies tend to have a positivistic perspective (Punch, 2013: 17).

Exploratory

The exploratory approach is a systemic and accurate method to represent social reality because of its open, flexible and practical nature. Qualitative methods are mostly chosen to conduct exploratory studies. In comparison to quantitative studies that seek to confirm knowledge through rule-bound processes, qualitative methods explore social issues from a more open point of view. (Stebbins, 2001)

Triangulation

Denzin (1973) classifies four types of triangulation: data, investigator, theory and methodological triangulation. Briefly, data triangulation enhances the validity and reliability of data; investigator triangulation reduces the bias caused by a single interviewee; theory triangulation approaches the data with different theoretical perspectives and hypotheses; methodological triangulation adopts more than one research method in a study (Denzin, 1973).

For this study triangulation the methodological triangulation research is chosen. Qualitative and quantitative methods have been collectively used in a wide range of principles. They are highly prevalent in mixed-method research (Jick, 1979). This combination is undertaken because each method complements each other and leads to more valid results (Jick, 1979). As an example of sequence, the order of conducting case studies first and following up with surveys is common in social science disciplines. The case study builds a theory or a theoretical explanation, or understands the description of a phenomenon, and the survey tests the theory on a sample of appropriate population (s) (Jick, 1979). This sequence is mostly applied to modify, extend or confirm a theoretical framework (Voss et al., 2002).

3.1.4 Characteristics of induction and deduction

In general, qualitative research is inductive and quantitative research is deductive. An inductive research process generates thoughts, ideas and hypotheses from the data collected (Merriam, 1998: 7). On the other hand, a deductive research process has pre-existing hypotheses and aims to test them by collecting data (Swanson and Holton, 2005: 164). The inductive approach is useful when conducting exploratory research or when there is little existing theory; while the deductive approach is often used to test a theory and assure content validity (Swanson and Holton, 2005: 164).

This research combines both qualitative and quantitative methods. Induction is conducted in the case study while deduction is used for the survey. The back and forth between both of the research approaches is pivotal during research design, data collection and data analysis (Swanson and Holton, 2005: 165).

3.2 Empirical research design

After discussing the general philosophy of research design, this section explains the research strategy used to study the fitness game in this particular research.

3.2.1. Selection of the mix-method research

Combining qualitative and quantitative methods in this study is appropriate because of the complexity involved (Strauss and Corbin, 1994). By combining both methods, researchers can: confirm and corroborate each method's findings via interplay, discover greater details that develop the theories, generate new ways of thinking, and expand the depth and scope of the study (Miles and Huberman, 1994).

3.2.2. Rationales of combined methods

There are two reasons to combine the qualitative and quantitative research methods: research objectives and limited resources.

Reason 1: Research objectives

The main research objective is to identify the design characteristics of fitness games. The characteristics are identified firstly during the case study and further explored for triangulation in the survey phase.

Qualitative methods including interviews and observations are adopted first to learn the design characteristics of fitness games. The initial findings are drawn from the insights of game designers and the end users. The qualitative methods enabled the study to reveal rich data within a LD fitness game design context.

To study the importance of each design characteristic in more detail, the quantitative method is used. The initial findings are grouped into six design categories and formed six survey questions with many sub-questions. By surveying participants' opinion on each design characteristic, the initial findings are further qualified and generalized.

Reason 2: limited number of game companies that design for LD users

Researchers often have to switch research methods due to different conditions - there might be limitations on data collection techniques, available population, costs, language barriers, or shortages of time (Strauss and Corbin, 1994).

In the context of this study, there are very few game studios that produce fitness games targeted at the LD group. This makes it more difficult to find qualified game designers to conduct sufficient interviews or observations. If the research solely adopted the qualitative method, the findings would not be qualified to generalize. In addition, former literature explored fitness games design frameworks and inclusive design principles, but failed to establish the link between the two design areas. In particular, there is not much literature discussing fitness games design for LD users. Therefore, the resources for qualitative research are limited.

To form a generalizable grounding for the research findings, quantitative methods are used in the second stage. Questionnaires are used to access experts' opinion about fitness game design. The experts included game designers who are familiar with fitness game design and healthcare professionals who work with LD users on a daily basis. This quantitative method makes up for the limited number of game companies that are involved in the qualitative study.

3.2.3. The sequence of the two research methods

When choosing combined research methods, researchers should bear in mind the sequence of qualitative and quantitative methods (Strauss and Corbin, 1994). Instead of simply stating that 'they supplement each other' or 'they complement each other', researchers should be precise about which method to be used during which step because data collection and analysis could adopt both methods and in many combinations (Strauss and Corbin, 1994). For this research, the qualitative method is used first because of its exploratory nature. The quantitative method comes after because it is used to further confirm and expand on the findings from the qualitative study.

This research uses the following sequence of studies (Miles and Huberman, 1994):

QUALITATIVE → QUANTITATIVE

(case study) (questionnaire)

3.3 Study one: case study

Given that the case study methodology is chosen for the first-stage of the study, this section explains this research methodology in general, before describing its application in this study.

3.3.1 Definition of case studies

A case study is a commonly used research strategy to understand complicated phenomena in order to provide a meaningful view of real-life events in the social science discipline (Yin, 2013).

Case study research can either contain a single case or multiple cases (Yin, 2013). While conducting multiple cases of research enables cross-analysis, it requires extensive resources and access to other cases which may not be accessible to independent researchers (Ulkuniemi, 2003: 84-85). This is one of the reasons that this particular research goes with a single case study. Also, there are very few companies working on fitness games for LD. Yin (2013) argues that a single case study is suitable when the case can test, confirm, extend or challenge a well-formulated theory. The case in this research, the fitness game Somability, represents a typical fitness game and its development process is applicable to others. The case study extends the existing game design frameworks with an emphasis on disabled consumers.

3.3.2 Selection and description of the case

This section provides the selection procedures with a description of the case.

Selection of the case

When choosing the case for this research, the focus was to gather people's opinions about how best to develop games for LD users. There are three criteria for choosing a particular case: access to resources, time availability and the extent to which it would answer research questions (Silverman, 2013). This research identifies a case following the aforementioned criteria.

The single case chosen as Somability which was a fitness game developed specifically for

LD users. Studying this game is a good fit for this research because it answered the primary research questions about design characteristics of such fitness games. The primary data that influenced the design characteristics of this research are identified via communication with Somability's game designers. Observations of the user tests highlighted reactions to these design characteristics. Full access to the game studio and testing sites meant that observation could be undertaken throughout the development process and also during the product's launch. This also opened the door to interviews with Somability's game designers and third-parties that were involved with the project. The whole case study was finished within four months.

Description of the case

Somability is an application that was produced by Cardiff Metropolitan University in partnership with Cariad Interactive. It gives users affordable access to recreational activities through technology. Their product uses music and rhythm to promote dynamic movements with three components called reach, balance and flow, as well as three modes: mirror, skeleton tracking and colourful shadows.

As mentioned previously, Somability has three main components: reach, balance and flow. Reach is a game that encourages users to reach high with their reflections to touch the shapes on the screen. The balance game requires users to open their arms and to balance as many digital balls as possible. Flow is a task-free game that allows users to perform any movements they like. Each one has three different interaction modes called mirror, skeleton tracking and shadow. The mirror mode shows users' original reflection on the screen, skeleton tracking shows a digital image of the user as colourful skeletons and shadow mode turns the digital images into colourful shadows and attaches beautiful lines to the user's digital image. Users can choose any mode within the three games.

3.3.3 Data collection

Data is collected through ten interviews and observations.

Interviews

Because the original drive for interviews is the desire to know more about people and their views of the world, interviewing is the most effective method when the aim of the research is to gain a subjective understanding of the people (Seidman, 2013). Ten interviews were undertaken in 45-minute timeslots. Interviewees have the following occupation in relation to their influence on Somability: programmer, graphic designer, manager, researcher, dancing instructor, facilitator and caregiver. Table 1 illustrates the interviewees' positions and organizations.

Table 1. Information of interviewees

Participant number	Name	Position	Organizations
1	Wendy	Managing director and project manager	Cariad Interactive
2	Joel	Lead programmer	Cariad Interactive
3	Pete	Art Director	Cariad Interactive
4	Leah	Research assistant of Wendy	Cardiff Metropolitan University
5	Zoe	Dancing instructor	Artis Community
6	Dave	Facilitator	Rhondda Cynon Taf Skills for Independence
7	Florence	Carer	Gladys Resource Centre

Cariad Interactive has four main partners: Wendy, Joel, Pete and Marek. Each partner played a different role in the development of Somability. During the development of Somability, Cariad Interactive partnered with 'Rhondda Cynon Taf Skills for Independence' and 'Artis Community' and did beta tests with 'Gladys Resource Centre' in Aberdare. Interviews with these parties helped understand how to design fitness game as a whole. The details of each interviewee and interview questions are explained in Table 2.

Table 2. Interview questions

Dates	Names (Position)	Sites	Questions
31/01/2014	Pete (Art Director)	Game studio	1. Could you please describe your role in the development of Somability? 2. How did you come up with the initial design objectives and how did you narrow down the scope of the project? 3. Can you explain the free space in the game? 4. Was there a particular challenge that you had to fix? 5. Can you tell me briefly about the new app (not Somability) you are developing?
31/01/2014	Joel (Programmer)	Game studio	1. Could you please describe your role in the development of Somability? 2. How did you conduct testing for Somability? 3. Can you explain the 'free space' in the game? 4. Was there a particular challenge that you had to fix? 5. Is the final version of Somability different from what you expected?
11/11/2014	Wendy (Director)	Cardiff Millennium Centre	1. Can you tell me how Somability was developed? 2. What was the biggest surprise that you faced during development of Somability? 3. Did you have any trouble talking to the end users? 4. What else challenged you? 5. What do you think of the free space in the game?
11/11/2014	Florence (Caregiver)	Cardiff Millennium Centre	1. Can you tell me your role in the design of Somability? 2. Who came up with the game concept? 3. Were you surprised at the user's reactions? 4. What do you think of the free space in the game?
11/11/2014	Dave (Facilitator)	Cardiff Millennium Centre	1. Can you tell me your role in the design of Somability? 2. Were you surprised at the user's reactions? 3. What do you think of the free space in the game?
18/11/2014	Lean (Research assistant)	Phone	1. Could you please describe your role in the development of Somability? 2. How did you get to know the users? 3. What is special when designing for this group of users? 4. Is the final version of Somability different from what you expected?
19/11/2014	Zoe (Dancing instructor)	Phone	1. Could you please describe your role in the development of Somability? 2. Were you familiar with your end users? 3. There are three game modes in the final app, whose idea is that? 4. Were you surprised with the end user's movements with the help of Somability? 5. What do you think of the free spaces that were left for users?
13/01/2015	Wendy and Joel	Skype	1. At what stage of development is Somability in now? 2. How did the beta tests go?
08/02/2015	Wendy and Pete	Arts Depot, London	1. Can you tell me the reasons to introduce the platform 'Raspberry Pi'? 2. What movements were the end users able to achieve with the assistance of Somability? 3. How does iterative development work for Somability?
21/02/2015	Joel (Programmer)	Arts Depot, London	1. What adjustments did you make to Somability during development? 2. How did the end users react to the game?

Observations

Three natural observations were taken to learn how the development team designed the product. The first involved making observation of the game designers during the development of the game. The remaining observations focused on beta testing once the product was in a functional state. Designers collaborated with the intended user base to perfect the product. The users' responses to the game helped analyse the design process. Table 3 outlines the observations of the 53 people involved.

Table 3. Details of the three observations

Dates	People involved	Sites	Observations
11/11/2014	Users: 18 Caregivers: 6 Dancing instructors: 2 Design team: 4	Cardiff Millennium Centre	1. The way users interacted with Somability 2. The role of caregivers 3. The design team recorded and reflected on the user interaction
08/02/2015	Users: 8 Design team: 3	Arts Depot, London	1. The design team planned the testing session 2. Users played with the game 3. The design team adjusted the code during the session 4. Every user was encouraged to express their opinion at the end of the session
21/02/2015	Users: 9 Design team: 3	Arts Depot, London	1. The users played with the game 2. The design team adjusted the code during the session 3. The parents of the users were happy with the game too

3.3.4 Methods of analysis

Transcriptions of the interviews and observations were taken throughout the entirety of this phase of the study. In order to identify and refine concepts in the data, 'three-step coding' was conducted to construct themes and patterns. The coding procedure is introduced in the following chapter.

3.4 Study two: survey study

The second phase of the research is carried out following a quantitative methodology: survey. This section explains the survey method in general and its application to this research.

3.4.1 Questionnaire development

This research follows Malhotra and Grover's (1998) steps to conduct a survey study.

The first step in this process is to develop a suitable questionnaire. A questionnaire comprises of questions, also called items, and it seeks objective or perceptual information from the respondent (Malhotra and Grover, 1998). There are six questions in the questionnaire. Each question contained five to ten items. The six questions selected are concerned with the design characteristics from the following categories: purpose, type, user requirements study, mechanics, technology and motivation for use. Items for each category are based on previous literature and the qualitative findings from the Study One. Each question was revised multiple times to find the most relevant, succinct and easy-to-follow wording.

When developing the questionnaire, the type of scaling is decided with careful thought. The scale choice is made depending on the ease with which the respondents could answer and the analysis could be done. The questionnaire in this study uses a five-point Likert scale because it is able to gather the respondent's opinion with regards to design characteristics from 'least disagree' to 'most agree' without taking up too much time.

The content validity (Hinkin, 1998) of the questionnaire is ensured through literature review and the evaluation of an expert panel. The literature review formed the basis for the initial set of survey items. Subsequently, the survey content is validated by five experts to improve validity, identify ambiguous items and to improve the questionnaire structure. Obtaining feedback about the structure of the questionnaire is achieved through individual interviews with the expert panel. This is because qualitative methods such as interviews have proven to be effective for survey studies (Lynn et al, 1999). These experts include a game designer, a questionnaire design expert and a healthcare professional who all have more than 10 years' experience of working in their field. Other experts are industry-recognised academics in the healthcare field. The contributions of each interviewee are as follows.

The first interviewee is a questionnaire design expert with over 10 years' experience working in the healthcare industry. He made several suggestions for rephrasing the language to clarify the questionnaire for a broad audience. Specifically, he suggested including explanations for some items. The table below shows all amendments that were made following his suggestions.

Table 4. Examples of the amended survey items

Questionnaire items	Original	Revised
1b	Such games should allow users to express something in movements.	Such games should allow users to express something in movements (e.g. feelings, emotions, joy).
2b	Education games.	Education games that teach daily skills for independent living.
2c	Cognitive games.	Cognitive games that enhance memory, visual sensitivity, numeric, etc.
3c	Designers learn from design theories.	Designers learn from theories such as game design theories and inclusive design theories for disabled users.
6d	During gameplay, users feel empowered.	During gameplay, users feel empowered because they are in control.
6e	During gameplay, users become more independent from social workers.	During gameplay, users become more independent from people who give assistance.

Next, a game designer was interviewed. One of his children has LD which made him familiar with the survey content. He suggested adding more questions in the Personal Information part to learn about respondents' background. Therefore, amendments were made in the first section of the questionnaire: the job roles were enriched by adding roles including general practitioner, primary caregiver, teacher, parent, guardian, teaching assistant, SENCO, charitable help. Question 3 was added to the survey which is concerned with the type of LD that respondents mostly deal with. Two more survey items were included: 3a game designers should learn from the users; 5d technology providing non-tactile support such as eye movement recognition. Suggestions also included rephrasing three survey questions and splitting Question 3 (user requirements study) into two parts: conduits and methods, which clarifies the ambiguity in the original survey. The table below explains the amendments made to the three questions. A change from the five-point Likert scale measurement to a ranking format was suggested. After careful consideration, the five-point Likert scale measure is left untouched due to the accuracy it provides.

Table 5. Amended survey questions

Questions	Original	Revised
2	Apart from fitness games, learning disabilities users might have needs for other types of games. Please indicate the extent to which the following games would benefit users.	Apart from fitness games, users with learning disabilities may require other types of games. Please indicate the extent to which the following games would benefit users.
3	To understand user requirements of a fitness game for learning disabilities, please indicate the usefulness of the following methods.	To understand the requirements of users with learning disabilities, please indicate the usefulness of the following methods. 3 a) To understand user requirements, designers should involve 3 b) To understand user requirements, designers should learn from
4	Considering the user's limited ability, a fitness game has to be both fun and simple. Please indicate the extent to which you agree with the following methods to simplify a fitness game.	Considering the ability level of the user, a fitness game has to be both fun and simple. Please indicate the extent to which you agree with the following methods to simplify a fitness game.

The third interviewee is a healthcare professional with years of experience working with different care homes and dealing with a range of disabilities. With his help, one new attribute was added: item 2e games that require group-play. His years of practice in this field were extremely useful when it came to designing the questionnaire for healthcare professionals.

The fourth and fifth interviewees are both academics in the Lancaster University Health Research Centre. They rephrased some sentences and straightened up the flow of the survey. Their contribution improved the level of understanding of the survey and ensured that it answered the research questions of the study.

In summary, the participation of five experts helped revise the questionnaire into a more suitable format. They improved content validity and identified ambiguous items that were then modified.

3.4.2 Selection of survey participants

To access industrial experts with various backgrounds, the survey is carried out among both game designers and healthcare professionals. This is because there are few game design companies working on fitness games for LD users. Only surveying game designers from such companies would not provide solid data for further analysis. Instead, I surveyed game designers with fitness game design experience and healthcare professionals who worked with LD people.

Game designers were the obvious initial choice because of their familiarity with designing games and the experiences they could share when adapting to fitness games. Questionnaires were distributed during two game events where game designers from various game studios gathered. Participants included game writers, graphic designers, game producers and games studio managers.

Healthcare professionals were involved because of their close association with people who have LD. Because many LD users have trouble with communication, they are not directly surveyed. Instead, the survey targeted healthcare professionals who had lots of experience working with the LD demographic. Most participants were caregivers who worked in care homes that specialized in LD. 30 care homes were visited to collect questionnaire responses. Occupations in this sector included nurses, caregivers, social workers and care homes managers. In addition to this, healthcare professionals such as school teachers, council workers, charity organization employees and researchers in this discipline were also involved.

After observing some end users of the game Somability in the case study stage, first-hand data was collected about their interpretation of a fitness games. Considering their vulnerability and communication barriers, they were not included in the second stage of the study. Surveying a large group of LD users might be troublesome because of their low ability to read and write, and potentially trigger breakouts for the people that have mental conditions. Instead, healthcare professionals were surveyed to represent the opinions of LD users about their requirements, conditions and preferences.

3.4.3 Data collection

Altogether, there were 245 responses and the response rate was 41.8% (245/586). 114 responses came from game designers and 131 responses came from healthcare professionals. This generated a response rate of 44.7% (114/255) and 39.6% (131/331) respectively. 10 surveys were deleted during response screening due to missing values of more than 50%, leaving 235 samples.

Survey for game designers

To collect feedback from game designers, I attended two game events: Code Mesh and Adventure-X. I set up tables at the events to explain the research and distributed questionnaires. I brought 100 questionnaires to each game event. I acquired a 60% response rate at the Code Mesh event (3rd November 2015) and a 49% response rate at the Adventure-X event (12th December 2015). I advertised the questionnaire via email, Twitter and Facebook with 3 people responding making a response rate of 6%. Additionally, I contacted other people familiar with the game design and healthcare fields. 2 people filled up the survey and the response rate was 10%.

In terms of the job roles of the respondents, there were 58 programmers, 11 graphic designers, 11 managers, 7 producers and 27 others. There were 12 people who filled up this section as 'other' mentioning that they worked as game designers. The rest of respondents included students, gamers, professors, artists, sound designers and sales.

When asked about the types of game companies the respondents worked for, 4 people answered gaming system constructors, 34 were from game studios, 10 worked for publishers, 3 worked for test labs and 63 chose the other company type. The other companies included app companies, digital studios, hardware suppliers for games, E-commerce, mobile systems, media and technical consultancy companies. 5 people mentioned that they were freelancers.

With regards to the 'work duration' of the respondents in their respective industries, 27 answered that their work duration was 2 years or less, 36 had a work duration between 3 and 5 years, 18 had a work duration between 6 to 9 years and 33 people had a work duration of 10 years or more.

Table 6 shows demographic information for the game design respondents.

Table 6. Demographic information of the game design survey respondents

Demographics		Respondents	Percentages
Survey locations	Code Mesh event	60	52.6%
	Adventure-X event	49	43%
	Emails, twitter and Facebook	3	2.6%
	Personal contacts	2	1.8%
Job Roles	Programmer	58	50.9%
	Graphic designer	11	9.6%
	Manager	11	9.6%
	Producer	7	6.1%
	Other	27	23.7%
Company types	Gaming system constructors	4	3.5%
	Game studios	34	29.8%
	Publishers	10	8.8%
	Test labs	3	2.6%
	Other	63	55.3%
Years of working	2 years or less	27	23.7%
	3-5 years	36	31.6%
	6-9 years	18	15.8%
	10 years or more	33	28.9%

Survey for healthcare professionals

To survey healthcare professionals, I visited 20 care homes in Lancashire and London during October to December 2015. I paid two visits to each care home. The first to introduce the research and hand out questionnaires. The second one was two weeks later to collect the responses. In total, I collected 123 surveys with a response rate of 46.2%. I also tried other avenues to collect questionnaire responses. I tried contacting healthcare organizations such as Optimo Care via emails, Twitter and Facebook. 5 people responded online, generating a response rate of 20%. I also contacted a research organization named Centre for Disability Research (CeDR) which is a disability research group based in Lancaster University. Three people (1 manager and 2 researchers) responded and the response rate was 30%. In addition, I contacted charities, government organizations and local councils. Unfortunately, I did not get any respondents through these channels. Table 7 shows the demographics for healthcare respondents.

In terms of the jobs roles of the respondents, the survey included 106 support workers, 6 nurses, 2 primary caregivers, 1 psychologist, 5 social workers, 1 teacher, 1 teaching assistant, 2 researchers and 7 managers.

The LD severity level breakdown consists of the following: 14 mostly dealt with people with mild LD, 81 worked with people with moderate LD, 26 worked with severe LD and the remaining 10 worked with the profound group. In total, there were 131 respondents.

With regards to the question concerning the respondents' 'work duration', 31 people answered 2 years or less, 53 people answered between 3 to 5 years, 22 answered between 6 to 9 years and 43 people have worked 10 years or more.

Table 7 shows demographic information for healthcare respondents.

Table 7. Demographic information of the healthcare survey respondents

Demographics		Respondents	Frequencies
Survey locations	Care home	123	93.9%
	Emails, twitter and Facebook	5	3.8%
	Centre for Disability Research	3	2.3%
Job Roles	Support worker	106	80.9%
	Nurse	6	4.6%
	Primary caregiver	2	1.5%
	Psychologist	1	0.8%
	Social worker	5	3.8%
	Teacher	1	0.8%
	Teaching assistant	1	0.8%
	Researcher	2	1.5%
	Manager healthcare services	7	5.3%
LD types	Mild	14	10.7%
	Moderate	81	61.8%
	Severe	26	19.8%
	Profound	10	7.6%
Years of working	2 years or less	31	23.7%
	3-5 years	35	26.7%
	6-9 years	22	16.8%
	10 years or more	43	32.8%

Data cleaning

Two criteria were used to clean the dataset.

The first criterion is missing data. Responses with more than 50% unanswered questions were excluded. To make the most of the responses without losing any valid information, some questionnaires that had less or equal to 50% unanswered questions were used for analysis. For each response that was used, the survey questions that were not answered were left blank and treated as system missing values in the SPSS analysis (referring to the book by George and Mallery (2016) Chapter 4, Section 4.2.1). When analysing each survey question through statistical tests such as the one-sample Wilcoxon Signed Rank tests and the Mann-Whitney U tests, the blank answers were not replaced but excluded from calculations automatically.

The second criterion is invalid responses. Some respondents may have answered the questions without careful thinking and thus their answers were the same for all questions. Therefore, the questionnaires with the same answer for each question were deleted from the data. This kind of invalid response was deleted case by case.

In total, 10 responses were removed and the corresponding surveys were deleted.

3.4.4 Methods of analysis

After collecting survey responses, data was manually entered into SPSS and analysed using statistical methods. The statistical methods adopted for analysis is presented in Chapter 6.

3.5 Methods summary

This research adopts a mixed-method approach that combines qualitative and quantitative methods. This research design was determined by the research objectives and the limited number of suitable game studios. The first qualitative case study is exploratory, aiming to discover the insights of game designers and end users with regards to the general design characteristics of LD fitness games. The qualitative methods included interviews and observations. To confirm and expand the exploratory findings, the second phase of the study used a quantitative questionnaire-based method to understand the details of each design characteristic. The questionnaire surveyed both game designers and healthcare professionals. The respondents confirmed the qualitative findings and further provided perceptions of the importance of each design characteristic. Combining qualitative interviews and quantitative questionnaires enabled me to take advantage of both methods to identify design characteristics.

4. Chapter Four: Study One- Case Study

Having reviewed the game design literature and explained the methodology, this chapter presents the empirical case study data analysis procedure of the development of a fitness game (Somability) that was targeted at LD users. Due to the large amount and richness of the data collected, the analysis was carried out in a three-step coding procedure: open coding, axial coding and selective coding (Strauss and Corbin, 1994).

4.1 Open coding

Open coding breaks down the data and generates initial categories of information for the phenomenon being studied (Strauss & Corbin, 1994). During the open coding stage, 'indicators' including words, phrases, statements and observations from the data are compared with each other to identify new insights until theoretical saturation is reached (Strauss & Corbin, 1994). Table 8 provides a detailed list of the indicators identified from the 10 interviews and 3 observations.

Table 8. List of initial indicators and concepts from interviews and observations

Challenges when designing	Functions of games	Future developmen t	Inspiration	Intrinsic motivation	Irresistible and expressive movements
Funding application	Paper prototype	Graphic sketches	Story board	User observations	Collect user feedback
Ongoing iteration	Surprises in the game	Technical expectations	Unexpected results	Visual expectations	Detecting the small movements
Expand the user group	Gamificatio n	Leaving free space	The level of participation	Motivating the staff	Physical improvement s
Improving the game	Design documents	Engaging with the outer environmen t	Visual appearance	Conduits to communicate	Daily movements
Design for disabilities	Differences from autism	Differences from school environmen t	Designers' former experience	Knowing the users	Learning disabilities
Let users discover	Caregivers	Dancing instructors	Graphic designers	Manager	Programmers
Research assistant	Touch trust	Working as a group	Users' previous physical performance s	Users' reactions to the game	Mental improvement s
Users communicatin g with the technology	Competition between users	Confidence	Social connections	Users' current physical performance s	

4.2 Axial coding

Axial coding refers to the analysis practice that takes place around the axis of one category at a time. During this stage, further coding is conducted within a category by analysing paradigm conditions; relationships between categories are analysed. (Strauss, 1987)

To better understand the development of Somability, some categories were generated after carefully comparing and organizing the indicators identified. I analysed each person's description and looked for similarities, oppositions, resonances in conversation and underlying connections. As concepts and meanings emerged from the data, four categories were formed: design process, stakeholders' involvement and contributions, user requirements study, and user responses. Table 9 shows the four categories and their indicators from axial coding.

Table 9. List of categories generated during axial coding

Categories	Indicators		
Design process	Challenges when designing	Functions of games	Future development
	Inspiration	Intrinsic motivation	Irresistible and expressive movements
	Improving the game	Funding application	Paper prototype
	Graphic sketches	Story board	User observations
	User observations	Design documents	Ongoing iteration
	Technical expectations	Surprises in the game	Unexpected results
	Visual expectations	Detecting the small movements	Engaging with the outer environment
	Expand the user group	Gamification	Leaving free space
	The level of participation	Motivating the staff	Physical improvements
	Visual appearance		
Stakeholders' involvement and contributions	Caregivers	Dancing instructors	Graphic designers
	Manager	Programmers	Research assistant
	Touch trust	Working as a group	
User requirements study	Conduits to communicate	Daily movements	Design for disabilities
	Differences from autism	Differences from school environment	Designers' former experience
	Knowing the users	Learning disabilities	Let users discover
User responses	Users' previous physical performances	Users' reactions to the game	Mental improvements
	Users communicating with the technology	Competition between users	Confidence
	Users' current physical performances	Social connections	

4.2.1 The design process of Somability

To study the design characteristics of Somability, its design process is summarised first. Figure 2 describes the design process.

Figure 2. The design process of Somability

Step 1: Decide the product objective through brainstorming workshops

The primary objective of a fitness game like Somability is to promote physical exercise. Somability also aims to break physical activity boundaries to overcome the restrictions LD people face in their daily lives. Eventually this would mean training them enough so that they could live their life normally and engage in all activities without the restrictions often associated with having a LD. Somability focuses on repetitive daily movements to make fitness games more suitable for the physical and intellectual attributes of the LD users. After careful research, discussions and try-outs, the 'reach', 'balance' and 'flow' components of the game were created to simulate every day movements.

Brainstorming workshops, paper prototypes and graphic sketches

Brainstorming workshops and paper prototypes were used to determine the game's objectives. During the two workshops, people from various organizations brainstormed game objectives and functions of Somability. The initial ideas were presented via paper prototypes. Later, people were invited to interact with the prototypes, during which time their movements were videoed and translated into graphical sketches. After careful discussion and numerous try-outs, the game design team decided to set the game's primary goal as daily exercise using the concept of repetitive movements.

> 'By using paper prototyping, we were able to really draw attention to the facts of movements that are in everyday life and we were able to think about how to emphasize it into more of a performance.'
>
> --- Participant 1, project manager, Cariad Interactive

The brainstorming workshops were extremely effective at narrowing down the functions of Somability from ten functions to three. The initial ten functions included click, fight, raise, walk, jump, repeat, clap, reach, balance and flow. After evaluating the user preferences and the technology's capacity, the design team narrowed the functions down to three: 'reach', 'balance' and 'flow'. According to interviewees, this was a fun process that encouraged the group to talk and to express their feelings in a supportive way. Meanwhile, the paper prototyping helped explore ideas without wasting resources developing something that would not be used.

Stakeholder involvement

The brainstorming workshops involved many people with different expertise: game designers, researchers, caregivers, facilitators and dancing instructors. They brought their professional knowledge to the design process. The brainstorming workshop provided an opportunity for experts in their field to exchange ideas and identify the best features of Somability.

The project manager had many years' experience working with people with special needs. She came up with the initial idea of introducing fitness games to LD users. To make it happen, she brought together game designers and caregivers. She encouraged everyone to speak up and make their points heard during the brainstorming workshops. During the brainstorming workshops, she introduced a dancing theory, Rudolf Laban's fundamentals (von Laban, 1975) which drew attention to basic daily movements.

The game designers' main contribution to the brainstorming workshops was looking at the technical possibilities.

The researchers videotaped every session and kept a detailed record of the entire process. They also helped liaise and coordinate all parties involved in the development of Somability.

The caregivers, facilitators and dancing instructors gave advice about which type of game would work and which would not. Their biggest concern of Somability was that LD users were all different and they did not want anyone to be left out when exercising.

> 'So we told them if they could have something that would involve everyone to participate in the activities, which would be really brilliant.'
>
> --- Participant 7, caregiver, Gladys Resource Centre

Getting everybody's input was extremely valuable in terms of the development of the overall product. Positive feedback inspired all stakeholders involved which accelerated the development of Somability.

Step 2: Determine user interaction via storyboards

Based on sketches that were generated in the previous step, storyboards were created. The storyboards contained the types of interaction that game designers proposed to achieve the game objectives. Additionally, it looked at the movement sequence and special properties in the environment. It helped visualize concepts into a clearer design document for implementation in the next stage.

Stakeholder involvement

Game designers were the main stakeholders in this step. They created the storyboards according to the feedback collected in the first step.

Step 3: Implement the game mechanics and interface

To achieve the game objectives, the team implement the game mechanics. Technical challenges were split among the designers who worked separately before combining the whole product to test.

The game mechanics

As mentioned previously, the Somability game has three components: 'reach', 'balance' and 'flow'. All three games adopt simple game mechanics using full-body motion. Firstly, the 'reach' game only requires users to reach high for digital balls on the screen. The aim of 'Balance' is to balance virtual balls on the user's arms. The 'flow' game type is different in that there are no goals and the user is free to do as they please and interact with the virtual environment via motion. It was important to strike a balance between overcomplicating the mechanics of the game and providing an interesting and enjoyable experience. The game designers intentionally picked simple and common movements to satisfy the primary game objective which was to enable users with all levels of ability to participate and benefit from exercise.

Some unexpected mechanics popped up during testing, for example, the skeleton mode in Somability.

> 'Very early on, programmers needed to be able to pick up what is moving in space. They placed the skeletons in the bodies to check where they were. They found out users were very interested in and playful with the skeletons.'

--- Participant 2, lead programmer, Cariad Interactive

The game interface

During the implementation phase, caregivers gave their initial thoughts on the product and communicated ideas about how the interface should look. This included the colour scheme and the shapes on the interface. According to the art director, the interface of Somability was designed to be 'simple, clear, not too intricate'. To achieve satisfactory visualization of the interface, careful attention to detail was required.

> 'Because humans are very visual animals and we can't help looking into detail if it's there. But there is that balance between distraction and being very explicit and how you've visualized someone's body movements'
>
> --- Participant 3, art director, Cariad Interactive

Stakeholder involvement

Game designers and caregivers were involved in this phase.

Step 4: Refine the product through beta testing

Beta tests were used to collect feedback about the first functional version of Somability. This time period provides some flexibility in terms of the implementation of the game so that users can provide final input before launch.

> 'Each time we were trying out a prototype, we were observing the service users' performance and engagements. Not so worried about what the software was looking like, but more about what people were doing with it. That really let them finalize the proper positions in the interface.'
>
> --- Participant 1, project manager, Cariad Interactive

Based on user interaction with the game, alterations were made. On the technical side, programmers fixed any bugs that were found during beta-testing. Some slight adjustments were also made to items on the game's interface.

Methods

People with LD often face trouble with verbal communication. As a result, game designers gauged feedback by interpreting the user's enjoyment based on the time they spent playing it, the level of involvement and their willingness to overcome challenges.

Moreover, the caregivers and the facilitators acted as a conduit for communication between the LD users and game designers trying to interpret their behaviour. To make this happen, a mutual trust between the design team and caregivers was built first. Therefore, the caregivers were encouraged to speak out because their knowledge and input was appreciated. In this way, the caregivers and facilitators were able to explain the idiosyncrasy about user behaviour.

> 'So we can design, we know how to design, it is our job. But actually having the motivation to really respond to what individual people want to do with something and how their everyday environment affects them. Having that kind of insight is really special and I think right at the start that was surprising for us'
>
> --- Participant 1, project manager, Cariad Interactive

Stakeholder involvement

People from all parties were involved during the bate test phase. The game designers monitored the tests and used the user feedback to adjust the game. The caregivers, facilitators and dancing instructors organized LD users to try out the game and interpret their feelings based on their reactions. Most importantly, the end users were involved and provided vital feedback for the game under development. Most of their opinions about the game were identified through their physical and emotional responses during gameplay. Some users with less severe LD also communicated their feedback verbally.

Step 5: Ongoing iteration

There were two iterations: during the development and after.

During the development, the game was amended many times according to users' feedback (explained in Step 4).

When the game was released to market, adjustments were needed for individual copies of the game to suit customer's needs. For example, to customize the game for users with different levels of LD, the difficulty and sensitivity of the game were adjusted. Meanwhile, the designers have been working on making the product more affordable and more accessible to everyone.

Stakeholder involvement

The stakeholders that were involved the most in this stage were the game designers. Having users available at this stage meant that the game designers had a constant and iterative feedback loop with which they could use to iron out any bugs or make minor adjustments to the game.

4.2.2 The stakeholders' involvement and contributions

Table 10 summarises the different stakeholders' involvement and contributions in each development stage.

Table 10. Each party's contributions in every development stage

Stakeholders	1: product objective	2: user interaction	3. implementation	4. refine	5. iteration
Manager	Coordination; Previous design experience; Professional knowledge	Coordination; Design documents	Coordination; Guidance of the development process	Coordination; Beta testing on the sites	Coordination; Business prospects
Programmers	Brainstorm	Design documents	Programed	Beta testing on the sites; Game mechanics adjustments	Game mechanics adjustments; Technical improvements
Art directors	Brainstorm	Design documents	Graphic design	Visualization	Visualization
Research assistant	Assisted the manager	Documented the design process	Documented the design process	Gathered users' feedback	
Dancing instructors	Movement knowledge			Feedback about the prototypes	
Caregivers	Knowledge of the users		Knowledge of the users	Users feedback	Users feedback
Facilitators	Knowledge of the users			Users feedback	Users feedback
End users				Beta testing	

At least one of each type of stakeholder was interviewed to talk about their particular contribution in the design of Somability. Table 11 presents their domain of their specialization and interview times.

Table 11. Each stakeholder's domain of specialization

Stakeholders	Domain of specialization	Interview times
Manager	1. Coordinate the design team; 2. Liaise different parties; 3. Professional knowledge of game design for people; with special needs; 4. Beta testing on the sites; 5. Strengthening the business prospects.	1 solo; 1 joint with the programmers; 1 joint with the art directors
Programmers	1. Game programming; 2. Beta tests and make adjustments.	1 solo; 1 joint with the manager
Art directors	1. Graphic design; 2. Refine the visualization according to feedback.	1; 1 joint with the manager
Research assistant	1. Assist the manager; 2. Keep documents of the design process.	1
Dancing instructors	1. Provide movement knowledge and dancing theories; 2. Give opinion about the prototypes.	1
Caregivers	1. Provide knowledge of the users; 2. Provide users feedback.	1
Facilitators	1. Provide knowledge of the users; 2. Provide users feedback.	1
End users	1. Participant in the beta testing; 2. Provide feedback about the game	0

4.2.3 The user requirements study of Somability

Learning about user requirements is vital in any game development. Traditionally, game designers conduct a user requirements study to explore various aspects of a game including the gameplay, the story, the mechanics and the game interface (Desurvire, et al., 2004). This is typically done by playability sessions where end users are asked to play the game, answer probing questions and fill out a questionnaire (Desurvire, et al., 2004). In an LD context, there are some special considerations for the study of users.

Methods to carry out a user requirements study: observations and conduits

When facing LD users, the traditional methods to approach the users become less feasible due to difficulty in verbal communication. In the Somability team, the users' feedback about the game was mainly collected through observation. To make this happen, the design team made frequent interaction with the LD users for beta testing.

> 'It was very important that we get to know our service users and then we could maintain contact with them for a long period of time so that they felt comfortable

around us.'

--- Participant 4, research assistant of the project manager, Cardiff Metropolitan University

From the very beginning of the game design process, the users' daily movements were observed. These movements were then transcribed into basic movements which constructed the game's framework. Their opinion was valued highly.

'We listened to the needs of service users from the very beginning and there was no designer or thought process undertaking until we had got some feedback on what they wanted and then what they needed.'

--- Participant 4, research assistant of the project manager, Cardiff Metropolitan University

During beta-testing, end users were again involved so that their reactions to the game could be observed and game designers could make adjustments accordingly.

The caregivers were involved from the start of the design process and they were encouraged to speak up about their knowledge of the users. In the beta testing stage, they were invited to play the game along with the users. In this way, they could share their own experience and their interpretation of LD user reaction to the game. Because of their familiarity with the users, they could easily interpret LD user behaviour when interacting with Somability.

Features of the LD user group

The Somability design team had experience working with users with other disabilities such as autism. From their experience, designing for LD users has some special characteristics.

This user group has physical disabilities which have to be considered in a game design.

'This audience is slightly different; having the added complicity of physical disabilities, say wheelchair users and so on.'

---Participant 1, project manager, Cariad Interactive

The caregivers and facilitators were very cooperative, which accelerated the design process.

'What is really great about this is that people are really up for anything that they can try. Because something went up straight away, it appeared straight away and service users were enjoying it, the atmosphere that they were enjoying was quite pervasive.'

---Participant 1, project manager, Cariad Interactive

Results from the user requirements study: keep the design simple

The primary result coming from Somability user requirements study was the necessity to keep the design simple.

'The best way to design is to design as simply as you possibly can. And dig later, and allow the service users to add their own complexities.'

--- Participant 1, project manager, Cariad Interactive

The design team emphasized the user-centred principle in design. This reflects the keep-it-simple principle and focuses on the users' needs instead of overcomplicating the game mechanics.

'…but that is your pre-conserved expression of what interaction is about, what we find by designing so simply is that interaction is about people and it is not about software.'

--- Participant 1, project manager, Cariad Interactive

4.2.4 The user responses

Somability turned out to be a huge success among LD users. It motivated them to carry out physical exercise regularly. Additionally, Somability improved users' mental states. This section summarises the results of Somability.

Improvements of user fitness

Somability is a fun and encouraging game that improved the users' physical condition. It created an inclusive gameplay process and drew end users into the moment, which motivated them to exercise regularly. Users have been observed to break their own perceived physical limitations.

'There were some users who didn't want to move. With Somability, it's just like a

> game in a way, movements became irresistible. Everyone wants to have a go.'
>
> ----Participant 5, dancing instructor, Artis Community

To involve users with all levels of LD, Somability provides a lot of freedom in the game. The game was designed with few rules and restrictions. As a result, the game engaged everyone.

> 'So you find that service users, even the ones with restricted movements, they would say 'look, it is doing what I am doing'. They saw their bodies on the screen, it was a reflective and positive response. It encouraged them. No one was really left out, even the ones in wheelchairs. They were really involved because they could see themselves on the screen.'
>
> --- Participant 7, caregiver, Gladys Resource Centre

This technology makes even the smallest amount of movement appear big on a screen. As a result, it brings enjoyment from movement for those who do not have high-level of mobility in their lives, for example, people in wheelchairs.

Changes in users' emotional state

Somability made doing physical exercise easy and enjoyable. Users were reported to repetitively come back to the game simply because it was fun. While playing the game, the users' emotional state was improved.

During gameplay, users had increased confidence levels. The confidence was not only reflected on the physical aspects of gameplay, but also on their emotional state as they were able to control the game progress. For instance, there was a noticeable increase in physical aspects of their confidence levels demonstrated by the fact that users were more and more willing to perform movements that they initially felt uncomfortable doing.

> 'We tried to build our software so that there was an element of simplicity to it. There is a mechanism that is immediately obvious within the interaction. But that mechanism could be interpreted by your imagination in any way you like. We purposely left as much space as we could to allow the imagination of any individual to occupy that space between what we have made and what they think it was, there was lots of room.'
>
> --- Participant 3, art director, Cariad Interactive

As the game progressed, users benefited from the experience of controlling the game, so that they became more and more independent. The increase of independence impacted other aspects of the users' life: their caregivers saw them live with less support from others since the launch of the game.

> 'As you can see it from today, how confident and exploratory the service users were without any need from myself to be involved or any prompting needed from an adult. That in itself, is really important because it is about independence.'
>
> --- Participant 1, project manager, Cariad Interactive

Users gained empowerment from the game, as they were controlling the game process by themselves. The chance to control a situation is rare for LD users. Therefore, Somability provided a precious opportunity for them to experience this.

> 'I think a lot of the caregivers had expectations about what the users would do and would not do. But actually, when they were using the software and playing within the environment, they started doing stuff. It is because the participants were controlling for themselves.'
>
> --- Participant 3, art director, Cariad Interactive

Somability was a channel for users to express themselves via movement. Traditionally, people with LD struggle with expressing themselves verbally. With Somability, they could show their emotional feelings such as joy and anger through movement.

> 'We look at the fact that we reach for things when we need them, how can we make that reach more dynamic? So instead of reaching for something, it is reaching to express something. In that process of expressive movement, we are actually physically moving more. Movements have become irresistible.'
>
> --- Participant 1, project manager, Cariad Interactive

Some users were triggered by the competition in Somability. The caregivers had expressed that the competition was kept within a certain level and it was motivating. On the other hand, some interviewees thought it might be too stressful for some users.

> 'There is competition for all users now: there is one game in Somability that the more you clap, the more flowers you get. So you find that the service users, some of them would say 'look, I have more flowers'. There was competition and it was

really fun. Not only that, even the staff, we were like 'look, I am doing well'. The more you get flowers, it motivates you.'

--- Participant 7, caregiver, Gladys Resource Centre

As a matter of fact, almost all of the emotional triggers were intentionally planted in Somability to intrinsically reward users.

'Instead of having a target, why don't you have a self-reward. So it is not extrinsic, it is more intrinsic. I think the centre of intrinsic motivation is to get feedback of what you do, so you get a sense of your progress and that progress is naturally paced at your own pace. There are lots of opportunities for repetition. With the game-like experience, too much repetition can be negative. But in a non-competitive environment, more repetition allows improvement. I think if you allow people to repeat themselves until they feel comfortable, you can avoid potential failure.'

--- Participant 1, project manager, Cariad Interactive

Alteration of users' social interaction

Playing the game have brought users closer, users have interacted more with other users and with other people around them. This extra social interaction helps create bonds and trust among peers.

'I was working with an LD boy and I was moving with him. When he moved to the other side, I stopped and slowing slipped away. He pulled me back because he wanted to work with me. I thought that was really nice because the game encouraged partnership and people working together.'

--- Participant 6, facilitator, Rhondda Cynon Taf Skills for Independence

Meanwhile, users have shown an increase of social responsibility. They were able to participate in group tasks and organise group performances.

'Karen had been unable to collaborate with anyone else, but now she was organising group performances herself.'

--- Participant 1, project manager, Cariad Interactive

In addition to connecting with other people, the users of Somability started to interact with the technology and other aspects in their environment.

> 'When we first started using the software, the users were copying me. I would be making movements such as a breathing exercise. They would be copying me but they would not relate themselves to the computer image. Eventually they started to see themselves on the screen and related the image to themselves. This is interesting because communicating with technology is something the users did not understand.'
>
> --- A Participant 6, facilitator, Rhondda Cynon Taf Skills for Independence

4.3 Selective coding

Selective coding focuses on analysing the core categories or variables that are identified in the axial coding phase. The core categories and variables are the centre of analysis and guides further theoretical sampling. (Strauss, 1987)

Having provided and examined the four themes identified in axial coding, this section refines the core variables in these themes and organizes the design characteristics into five design categories. Emerging from the qualitative data, these five design categories are the key steps in a game design process that differentiate the LD targeted fitness game design from generic game design. The first step in the game design process is deciding the purposes of the game. The second step is conducting user requirements study. The third step is designing game mechanics. The fourth step is adopting suitable technologies. The fifth and final step is selecting appropriate motivation for playing the game. Therefore, five design categories emerged from the qualitative data: game purposes, user requirements study, game mechanics, technology and motivations. These five categories are the foundation for the questionnaire in the next stage survey study.

4.3.1 Purposes of Somability

The purpose of Somability was not decided solely by the game designers but during their discussions with healthcare professionals. Through brainstorming workshops and paper prototype try-outs, the primary objective of Somability was decided as follows: to make movements easy and interesting. To achieve this objective, the team set several design guidelines.

To make movements easy and engage users with all levels of LD, Somability simulates the basic daily movements 'reach', 'balance' and 'flow'. The design team intentionally chose only essential movements and set minimal rules in the game, so that there was free space for the users to repeat movements and to make improvements at their own pace.

To make movements interesting, intrinsic motivation was encouraged by the design team. They aimed to provide self-rewards to the users so that they were motivated to come back to the game. Emotional and social rewards were attempted: the game encouraged users to express their feelings through movements and to build social connections with others.

> 'We are about creative dance and personal expression. The game allowed the users moving the way they wanted to and expressing themselves the way they wanted to.'
>
> --- Participant 6, facilitator, Rhondda Cynon Taf Skills for Independence

4.3.2 User requirements study for Somability

To study LD users, the Somability team took input from the users themselves as well as their caregivers.

The users' feedback about the game was mainly collected through observations. The observations happened in the beta testing stage (stage 4). By observing the users when they played the game prototypes, the game designers recorded their behaviours such as their movements, attitude, level of involvement and time spent. These behaviours were discussed with the caregivers and analysed to make further amendments to the game.

The caregivers were involved in the user requirements study of Somability because of their expertise in the LD domain. The caregivers contributed in two stages: deciding the product objective (stage 1) and testing prototypes (stage 4). They were able to tell the game designers about the potential users' expectations of a fitness game and their physical limitations, and they helped translate daily movements into paper prototypes which kicked off the game design process. During the testing stage, the caregivers assisted users and interpreted their reactions. Because of their familiarity with the users and their healthcare knowledge, their opinion was more valid. Their cooperation accelerated the development process.

In addition to learning from the end users and their caregivers, the Somability team used other sources to study user requirements: their former design experience and some design guidelines. Prior to the Somability game, the design team developed other games for people with special needs. Therefore, they were able to transfer some knowledge into this project. In terms of design guidelines, the inclusive design principles (Mace, 1997) and the dancing theory 'Rudolf Laban's fundamentals' (von Laban, 1975) were used in the early stages of the design process.

4.3.3 Mechanics of Somability

When deciding the mechanics in Somability, the design team only considered the simplest game rules to encourage users to repeat the most common daily movements. Three components 'reach', 'balance' and 'flow' were chosen after carefully evaluating user requirements and the availability of technology.

The game mechanics of Somability were designed with loose-ends and the game encourages free movements that go beyond the original three movements 'reach', 'balance' and 'flow'. Without the limitation of strict game rules, users are allowed to make mistakes and to play repetitively. In this way, the game provides LD users a less stressful gameplay experience. As a result, the users exercised at their own pace and gradually made improvements.

> 'So that space leaves the narratives open. I think it's the narrative, whether it's a physical narrative or a mental narrative or an orderable narrative. That is whether the meaning sets. Because you put yourself at the centre.'
>
> --- Participant 3, art director, Cariad Interactive

The free space in the game rules enables the users to choose the level of difficulty during the gameplay. Meanwhile, the game's interface included different modes to accommodate various preferences of users. Originally, two modes 'mirror' and 'shadow' were included in the early prototypes. From testing, the design team noticed that the users were interested in see the 'skeleton' which was intended to track their movements by the sensor. Thus, the team introduced a new mode with the focus of 'skeleton'.

Even though the interface of Somability had three different settings to satisfy users with various preferences, it was designed to be 'simple, clear and not too intricate'. It maximizes the user experience for LD users.

4.3.4 Technology in Somability

Somability requires a PC and Microsoft Kinect to play. In general, fitness games need an input device to capture movements in addition to a PC. When designing for LD users, the devices need to be more sensitive but forgiving at the same time.

Technology of Somability provided clear and responsive feedback to the users. There were two types of feedback: pictorial and verbal. The interface of Somability was clear and responsive in terms of mirroring the user movements. Additionally, Somability used the clapping sound to reward a user when he makes an excellent movement. This real-time feedback encouraged the users. The responsive technology avoided some frustration.

> 'Say when you try to pop that bubble and if technology failed which we have seen all the time, that can be infuriating. For somebody who maybe has a lower level of tolerance, that can be really infuriating and it can turn him off from that.'
>
> --- Participant 6, facilitator, Rhondda Cynon Taf Skills for Independence

While the design team increased the sensitivity of the technology, they intentionally did not include too many features in the game. The designers planned to incorporate the real-world interaction with the game world.

> 'There is so much stuff that has too many in-built features, so everything all happens in one space which makes you not able to engage with the world around you. All our software encourages people to engage with the world around them in real time.'
>
> --- Participant 1, project manager, Cariad Interactive

In order to make the best use of the technology in Somability, the team provided training for the caregivers in the care homes that purchased the software. Consequently, the caregivers could assist the end users and solve some technology problems on-site. For other fitness games that target LD users, training could be provided for parents, teachers and nurses.

The cost of devices is another concern of the Somability team and they are working to lower the costs. Currently the game is built on Microsoft Kinect but the team is transferring it to the Raspberry Pi platform which is more accessible and cheaper.

4.3.5 Motivations in Somability

Somability was designed to intrinsically motivate users to play. The users were driven by the self-rewards which included the improvements in physical, emotional and social aspects.

The biggest achievement for the users from the game was that they could have fun while exercising. On top of that, the users gained empowerment because they were in control of the game. Gradually, confidence was built not only in the game world but also in other aspects of their real lives. As a result, the users have been reported to live more independently.

> 'Everyone wants to have a go. It's been lovely to see that confidence in them.'
>
> --- Participant 5, dancing instructor, Artis Community

On the social aspect, playing the game was an occasion to interact with other people. The users started playing with others with similar conditions, as well as their caregivers and parents. It helped changing the isolation issues LD users face. The social interaction made the game even more interesting and motivating. However, it has been pointed out that people with more severe LD tend to enjoy the social interaction less than the people with mild LD. This is because of their habit of living alone as well as their vulnerable emotional state.

A controversial motivation in Somability is about competition. Some caregivers encouraged the users to compete and they thought it helped them exercise. However, other caregivers held their own opinion against introducing the competition in games.

> 'I think the competition is really fun. But for some clients the competition may not be such a good thing because there was continuous arguing.'
>
> --- Participant 6, facilitator, Rhondda Cynon Taf Skills for Independence

4.4 Case study summary

This chapter presents the exploratory case study that was conducted in the first-stage of the research. The design process of Somability suggested five design categories that differ from generic game design: game purposes, user requirements study, game mechanics, technology and motivations.

Fitness games in an LD context and the traditional fitness games share the common game goal which is to promote physical exercise. When designed for LD users, fitness games should allow users to express feelings through movement, improve social interaction and encourage free movement.

When conducting a user requirements study, general game design resources can be used including beta testing, previous experience in game design, existing design theories and human movement theories. In an LD context, the end users should be observed rather than talked to; healthcare professionals should be involved when the end users are not accessible.

The mechanics of fitness games should be designed as simply as possible to offer a clear interface and ability to accommodate user preferences. Considering the special conditions of LD users, the mechanics should have minimal rules and allow mistakes.

The technology in fitness games should aim to be low cost and feature pictorial feedback, verbal feedback. These are generic features of successful games. When designed for LD users, it is important that adequate training is provided for the caregivers so that they can fully use the technology and be able to assist LD users. The technology should be able to incorporate real-world interaction into the game world.

To motivate users to carry on playing, the fitness games can adopt general game motivations such as fun and competition. To intrinsically engage LD users, games should be able to empower users with achievements, encourage social interaction and train users to live independently.

This research builds on existing knowledge of fitness game design. The extra enhancement is that it introduces other game types that are beneficial to LD users. Examples of such games include cognitive games, education games and group-play games. There were concerns shown in the interviews that fitness games can be developed further by including extra functions. The features of such games can inspire the design of fitness games and might help generate ideas for future development.

The table below summarises the key findings from the case study.

Table 12. Main findings from the case study

Design categories	Generic design guidelines	Specific characteristics is an LD context
Purposes of fitness games	1. Promote physical exercise	2. Allow users to express feelings through movements 3. Accelerate social interaction 4. Encourage free movements
The study of user requirements	1. Conduct beta testing 2. Adopt former design experience 3. Use game design theories 4. Learn from human movement theories	5. Learn from observing the end users instead of talking to them 6. Involve healthcare professionals in the design process
Mechanics of fitness games	1. Offer a clear and interactive interface 2. Accommodate user preference	3. Set up minimal rules or restrictions 4. Allow mistakes and repetitive play
Technology in fitness games	1. Offer pictorial features 2. Offer verbal features 3. Lower the cost for the additional devices	4. Provide training for the caregivers 5. Incorporate the real-world interaction with the game world
Motivations in fitness games	1. Make the experience fun 2. Allow uses to compete in the game	3. Empower users with their achievements 4. Encourage social interaction 5. Gradually train users to live independently
Other types of games	1. Cognitive games 2. Education games 3. Group-play games	

In order to carry out more in-depth study of the aforementioned six design categories, additional literature review is conducted. Combining the qualitative data findings with the existing literature, a survey was generated to assess industrial experts' opinion about the fitness game design characteristics. The experts included game designers and healthcare professionals.

5. Chapter Five: Updated Literature Review

Having identified the six core design categories that differentiate LD design from generic game design practice, this chapter presents additional literature that pertains to these categories. The general design characteristics of fitness games for each of the identified design categories are presented in the first section. Adoption of fitness game design characteristics in an LD context is discussed in the second section. The literature describes the design characteristics in the six categories and reveals that many of the current design principles or guidelines require further clarification in an LD context. It thus provides additional sources for the questionnaire design.

5.1 Design characteristics of fitness games by category

To understand the design characteristics of fitness games, this section discusses the existing literature on game design from six design categories.

5.1.1 Purposes of fitness games

The primary purpose of fitness games is to motivate exercise. Maintaining regular physical exercise has been recognized as an important part of a healthy lifestyle (Pate et al., 1995). Research has proven that moderately intense physical activity has a positive result on health (Robertson et al., 2000; Stanish et al., 2006).

Doing physical exercise not only helps people with fitness, but also contributes to decreasing anxiety and depression (Franklin et al., 2000). Successfully completing tasks in fitness games also improves self-esteem and confidence (Hutzler and Korsensky, 2010). Moreover, research indicates that physical exercise helps decrease inappropriate behaviours (Bachman and Sluyter, 1988).

In addition, fitness games have positive socio-emotional benefits including increased engagement and social interaction (Márquez, et al., 2013). The physical performative aspect of fitness games creates a playful social context (Márqsuez, et al., 2013). In the meantime, some co-located social fitness games encourage interaction between end users by bringing them together (Márquez, et al., 2013). Social play provides similar benefits to physical play, for example, higher engagement and positive emotions (Ravaja et al., 2006).

5.1.2 Other types of games for LD users

In addition to fitness games, there are other types of computer games that might be beneficial to the LD community. Studying these other types of games can provide potential functions that fitness games could work on.

Research has shown that computer games have educational usages (Lanyi and Brown, 2010). In an LD context, education games have three applications: general education curriculum, academic achievement and prosocial behaviours (Maccini et al, 2002). For example, Lanyi and Brown (2010) developed a game that taught students with LD how to do fractions and percentages. Games can develop LD people's cognitive abilities such as problem-solving and thus have long-term impact on their lives (Standen and Brown, 2005).

Computer games can also be used to teach LD users about life-skills (Standen and Brown, 2005). In response to this, Lanyi and Brown (2010) made games to teach end users everyday morning tasks. For physically injured end users, rehabilitation games can help them recover from injuries and live a new life with a positive attitude (McCallum, 2012). In terms of tackling isolation that LD people often suffer from, group games offer a chance for them to form social relationships (McCallum, 2012).

5.1.3 User requirements study for fitness games

All fitness games should be designed to be challenging and entertaining with the goal of creating meaningful play (Ermi and Mäyrä, 2005). If a game can meet end user requirements, it can provide effectiveness, efficiency as well as a pleasant user experience (Korhonen, et al., 2009). To achieve this, the designers must identify the end user requirements through a user requirements study.

Every end user is different which means each has a preference for the pace and style of gameplay, and each end user focuses on different techniques to complete challenges in games (Charles, et al., 2005). A thorough study of potential end users of the game can help identify design goals, moderate the challenge levels and adapt gameplay more appropriately to the end users' requirements and preferences (Charles, et al., 2005).

This section discusses previous methods used to conduct user requirements studies. User requirements studies in fitness game design adapt methods from computer systems design: observing end users and/or asking them a series of questions (Charles, et al., 2005). In addition, game designers learn about the end user requirements through literature research (for example, Yim and Graham, 2007), a designer's former experience and statistical data (Ermi and Mäyrä, 2005).

5.1.4 Mechanics of fitness games

The mechanics in fitness games refer to the actions, behaviours and control offered to the end users (Hunicke, et al., 2004). Adjusting the mechanics helps smooth the gameplay experience (Hunicke, et al., 2004). Depending on the game types, there are corresponding mechanics.

The first type of fitness game was a stationary bicycle connected to a game console in the 1980s. In the late 1990s, foot-operated pads made fitness games more cost-effective and commercially successful. The third generation of fitness games adopted motion sensor technology that used a camera interface or a controller device to transfer end user movements to a screen. Recently, fitness games can track full-body movements in three dimensions: reaction time, movement speed and power (Staiano and Calvert, 2011).

Bogost (2005) summarises five types of fitness games:

1. Running games: games that are contests of running speed or endurance.
2. Agility games: games that interrupt the sprint mechanic with an orthogonal activity to enforce a transition in physical activity. Examples of agility games can be seen in aerobic exercise.
3. Reflex game: games that require time-sensitive physical responses.
4. Training game: games that transfer traditional workout methods into videogame form.
5. Impulsion game: games that contains gestures that are specifically designed to elicit a physical response from the end user.

5.1.5 Technology in fitness games

The digital devices used in fitness games have some technological challenges to be considered. These challenges include digitally capturing, interpreting and communicating body movements (Mueller et al., 2011). To solve these challenges, fitness games require additional input devices, for example, motion sensors, foot operated pads and exercise bikes (Planinc et al., 2013).

In terms of motion input devices, there are generally two types (Planinc et al., 2013). The first type is a controller which tracks the movements of the end user, such as the Nintendo Wii Remote (Planinc et al., 2013). During this type of gameplay, users need to move the controller or press buttons on the controller, or do both at the same time (Planinc et al., 2013). Another type of motion input does not require a controller, but these fitness games are controlled by motion sensors that track body movements directly (Planinc et al., 2013). In addition to powerful sensing mechanisms, commercial fitness games require complex calculations embedded in the platform (Márquez, et al., 2013). Examples of these fitness games include the Sony PlayStation II EyeToy and the Microsoft Kinect. The latter type of motion input device allows end users to forget about any extra controller and to interact with the game more directly (Planinc et al., 2013).

Motion sensors used in the latter type of motion input device use computer vision as well as data gloves, infra-red sensors, video-based recognition, touch or pressure-sensitive devices, mobile phone sensors and radio frequency identification (RFID) (Loke et al., 2007). Motion sensor technology kicked off with the pressure activated mat in Dance Dance Revolution. This was followed by the web camera in the EyeToy, the sophisticated infrared camera integrated within the Kinect, the Sony PlayStation Move and the Wii nunchucks (Márquez, et al., 2013).

To enable fitness games to function properly and provide end users with an enjoyable gameplay experience, motion sensor technology must be precise when tracking body movements. Advancements in motion sensor technology that are incorporated in games consoles have fuelled the growth of fitness games (Mueller and Isbister, 2014). However, the current technology is not ready for this responsibility in many cases, for example Microsoft Kinect admitted their technical limitations (Márquez, et al., 2013). One of the trends for fitness games is integrating mobile devices with GPS to record and promote physical exercise. Examples include Nike+, FitBit, RunKeeper and Garmin Connect (McCallum, 2012). On the other hand, the problem associated with precise motion sensor technology and visual feedback is more severe for fitness games that use with mobile devices (Márquez, et al., 2013). This is because of differences in form factor; smaller devices have stricter hardware and software constraints (Márquez, et al., 2013).

On the other side, motion sensor technology that requires too much precision can frustrate the users if there is very little room for error (Márquez, et al., 2013). In addition to this, excessive movements such as gestures during gameplay may not be detected by the sensors (Simon, 2009). To encourage improvisation and self-expression, it is important that motion sensor technology is not too precise (Simon, 2009). A relaxed game environment also enhances corporeal emotions and social play (Isbister et al., 2011). Games that provide more freedom of movement are more enjoyable than task-focused games that require small gestures (Isbister et al., 2011).

5.1.6 Motivations in fitness games

Fitness games are effective at motivating users to perform repetitive physical exercise (Marin et al., 2011). People are motivated in two ways: extrinsically and intrinsically (Deci and Ryan, 2002). Extrinsic motivation use external rewards and lead people to achieve a positive result, even though this motivation is separate from the activity itself (Deci and Ryan, 2002). While extrinsic motivation place emphasis on instrumental reasons to perform activities, intrinsic motivation drive people to behave in a particular way, out of internal interest and enjoyment (Deci and Ryan, 2002). In comparison to extrinsic motivation, intrinsic motivation are more effective at changing people's behaviours long-term (Garris, et al., 2002).

Traditionally, fitness games tend to adopt extrinsic motivation such as rewards and points (Macvean and Robertson, 2013). However, there are several criticisms of the overuse of extrinsic rewards. Researchers are concerned that they might lose their effects once removed (Zichermann and Cunningham, 2011). Extrinsic game mechanics are not appropriate methods for changing user behaviour in the long-term because people tend to lose interest in extrinsic rewards (Nicholson, 2012). The application of extrinsic rewards could be risky since they are very different from real life and there are few cases where people use them to disconnect with real life (Nicholson, 2012). Intrinsic motivation can be damaged by extrinsic rewards, especially when users find tasks interesting and advantageous (Deci, et al, 1999).

These criticisms point out that games could be improved by motivating users in a more intrinsic way. To motivate users intrinsically, the research refers to Self-Determination Theory (SDT) which believes that the more control someone has over their decisions, the better chance he will be internally motivated to perform it. The three core facilitators in SDT are autonomy, competence and relatedness. Autonomy could be improved by offering alternatives to choose from, utilizing positive feedback and providing flexible instructions. Competence needs can be satisfied by providing a chance to acquire new knowledge or skills. Relatedness is strengthened by making the connection between people more secure, frequent and robust. When an event meets any of the three needs, people find it interesting and enjoyable, and thus carry out activities unconditionally. The SDT theory has been proven to be effective. (Deci and Ryan, 2002)

5.2 Adoption of fitness games in an LD context

Having reviewed existing literature on fitness game design, this section discusses prior research on the adoption of fitness games in an LD context. Based on the findings of the case study, specific design characteristics in six categories are identified in design literature, providing a theoretical background for the questionnaire development.

5.2.1 Benefits of fitness games in an LD context

Originally, a combination of exercise and computer games created a sense of immersion and motivation during training sessions (Mokka et al., 2003). When fitness games are designed for LD, they encourage end users to repeat daily movements and help them improve in an enjoyable virtually simulated environment (Campbell et al., 2008). Fitness games were tested to be effective in promoting physical exercise for adults with LD (Lotan et al., 2009). For schoolchildren with LD, fitness games can be used for physical education (Cai and Kornspan, 2012).

Playing fitness games can help users build self-esteem and confidence (Grimes et al., 2010). By finishing tasks in fitness games, the users gradually gain empowerment and confidence (Hutzler and Korsensky, 2010).

Group-play in fitness games also connect users (Yim and Graham, 2007) and can potentially alter the socially isolated situation that LD users tend to have. Additionally, regular physical activity promotes social inclusion and a sense of belonging (Temple and Walkley, 2007). The more active a user is, the higher level of engagement he or she will achieve (Márquez, et al., 2013). Further research has shown that the engagement increases with movement are related to 'easy fun' (Lazzaro, 2004) which focuses on intrigue and curiosity rather than winning (Bianchi-Berthouze, 2013).

Fitness games promote body movements which helps users communicate their feelings. Through body movements, LD users can communicate their feelings to others (Biddle et al., 2003) which they would normally struggle to do verbally.

In summary, fitness games can help LD users conduct physical exercise, build confidence, make social connections as well as communicate feelings.

5.2.2 Types of games in an LD context

Other than fitness games, there are other types of games that benefit LD users. Studying these game types help identifies additional requirements for this specific group. Fitness games can be designed more comprehensively by understanding these requirements and adding more features accordingly.

The first type of game that is beneficial in the LD domain is education games (Maccini et al, 2002). LD users especially appreciate games that can teach useful life-skills (Standen and Brown, 2005). This can make them more independent and less reliant on others to live.

Cognitive games can contribute to their long-term quality of life (Standen and Brown, 2005). Rehabilitation training games can also help users recover from injuries (McCallum, 2012).

Group-play games bring end users together and build social relationships during gameplay (McCallum, 2012). For LD users, a supervised group-play game provides a safe and relaxed environment to bond.

5.2.3 User requirements study for fitness games in an LD context

Traditionally, communication between end users and designers has been poor. For instance, game designers often only refer to previous research about end user types and design games without talking to any potential end users. Even if there is an attempt to conduct a user requirements study, it is mostly done through observing their performance during testing or verbal feedback. When facing LD users, the designers have to adopt special techniques to access the users. (Ermi and Mäyrä, 2005)

When designing for LD users, this research proposes four groups of people to be involved in the user requirements study process: potential LD users, their family members, healthcare professionals and education professionals. These groups are chosen with careful consideration of the user group's features and related design literature.

As the actual users of fitness games, their requirements are best expressed by the users themselves. In a game design process, there are some effective ways for them to be involved: Hutzler and Korsensky (2010) proposed a cross-group; peer-based modelling, Newell et al. (2011) suggested that user panel and evaluating prototypes are good methods to access user needs. Nicolle and Abascal (2001) argued that designers should observe users interacting with technology in their real environment.

However, because LD users often struggle to express their opinions about games, it would be wise for the game designers to seek help from others: family members (Kafai and Kafai, 1995), healthcare professionals (Hutzler and Korsensky, 2010) and education professionals (Annetta, 2010). In order to encourage them to contribute to the user requirements study, Newell et al. (2011) point out that when social support workers such as caregivers are involved, they should be introduced to the motivation and methodologies of the game design process.

In addition to relying on other people's knowledge and feedback, game designers can study the end user requirements through several different sources: research game design literature, designers' own previous experiences or vision, end user research and statistical data (Ermi and Mäyrä, 2005).

5.2.4 Mechanics of fitness games in an LD context

The mechanics of fitness games refer to the actions, behaviours and control mechanisms of the game itself (Hunicke, et al., 2004). As discussed before, there are different mechanics for each type of fitness game. Normal fitness games can use mechanics such as fast running, agile turning or fast reactions (Bogost, 2005). These mechanics require the end users to have high-level of visual-spatial skills, hand-eye or foot-eye coordination and quick reaction times (Staiano and Calvert, 2011). However, LD users often lack these skills. Therefore, the mechanics of fitness games must be designed specifically.

To match the ability of the users, the actions and rules of fitness games have to be easy to understand and follow. Among all the game behaviours, 'easy fun' should be encouraged other than 'hard fun', 'altered states' and 'people factor' because it is about experiencing rather than winning (Lazzaro, 2004).

To make the game easy to play, the control mechanism in fitness games should only convey necessary information (Mace, 1997). Repetitive play should be encouraged because LD users need more repetition than others to absorb the information (Coles, et al, 2007).

Meanwhile, fitness games should contain different levels and settings to accommodate the user preferences. For LD users, the virtual environment should be adjustable to adapt to the user capability (Yalon-Chamovitz and Weiss, 2008).

5.2.5 Technology in fitness games in an LD context

The availability of assistive technologies for LD users has increased dramatically over the last few years (Raskind and Higgins, 1999). Assistive technology refers to 'any item, piece of equipment, or product system, whether acquired commercially off-the-shelf, modified, or customized, that is used to increase, maintain or improve the functional capabilities of individuals with disabilities' (Bryant and Seay, 1998). In a context of LD users, assistive technology can further be described as any technology that helps LD users to compensate for specific insufficiencies (Raskind and Higgins, 1999). Some technology is used to assist or augment performance with regards to a certain disability, for instance, a hearing aid. Others are used to circumvent or bypass specific disabilities entirely, for example, wheelchairs (Raskind and Higgins, 1999). There is also technology that compensates for weaknesses by enhancing an individual's strength (Raskind and Higgins, 1999). In an LD context, technology does not intend to remediate or instruct (Raskind and Higgins, 1999).

The technology in fitness games should provide pictorial, verbal and tactile supports (Nicolle and Abascal, 2001). It should be able to offer clear and immediate feedback (Werbach and Hunter, 2012: 94-97). For users with limited mobility, fitness games that have tactile support are helpful (Chen and Downing, 2006). In addition, to benefit LD users, technology in the virtual world should help users to generalize what they have learned in the real-world (Coles, et al, 2007). Besides, specific training should be provided to instructors to assist the gameplay (Hutzler and Korsensky, 2010). In an LD context, caregivers and family members should be offered training sessions.

5.2.6 Motivations in fitness games in an LD context

To promote physical exercise, fitness programs with motivational factors are recommended (Rogers-Wallgren et al., 1992). This research emphasizes the intrinsic motivation in fitness games. When the users are intrinsically motivated and actively involved in a game, they can learn more effectively (Rankin, et al., 2008).

Borrowing Deci and Ryan's (2002) Self-Determination Theory, the research explores how fitness games meet the user's autonomy and relatedness needs so as to intrinsically motivate play.

The autonomy in fitness games can be achieved through the process of generating confidence and independence. Fitness games allow the users to create a sense of control during gameplay (McCallum, 2012) which helps build confidence and empowerment. The users of fitness games can make independent choices about when and how they play. In this way, the user's autonomy needs are met through offering them alternatives to choose from, utilizing positive feedback and providing flexible instructions (Deci and Ryan, 2002). Prior research has shown that games help people with disabilities improve confidence, self-esteem and enjoyment (Yalon-Chamovitz and Weiss, 2008).

The relatedness factor can be satisfied by group-play fitness games. During gameplay, fitness games can bring LD users closer to their caregivers and parents. In an LD context, interaction and collaboration should be highly encouraged (Hutzler and Korsensky, 2010). Strengthening the frequency and robustness of connections between people triggers relatedness.

In addition to the autonomy and relatedness factors, this research discusses the importance of competition when it comes to intrinsic motivation. All games have a sense of competition because end users compete with each other or against a game system (Salen and Zimmerman, 2004).

5.3 Summary

This chapter discusses previous literature of fitness game design from six different design categories. Although the literature provides a solid theoretical foundation for the research findings, some of the design characteristics or guidelines have not been tested to be effective in an LD context. Similarly, the findings of the single case study need a more generalizable ground. A questionnaire was developed combining both findings from the literature review and the case study with the hope to survey a large amount people from relative industries to help confirm, expand and generate the findings.

6. Chapter Six: Study Two - Questionnaire Survey Study

Following the qualitative study, this chapter discusses the utilization of a questionnaire survey research method to investigate the extent to which industry experts agree on the initial findings, to expand the research to a more generalizable ground. Combining the qualitative study findings and literature research results, the questionnaire was generated with the objective to confirm the first-stage findings with a broader audience. 245 experts from the game design industry and healthcare industry responded to the survey. Analysing the survey data revealed the design characteristics of fitness games that people from both industries valued. When compared this result with qualitative case study findings, the research explores the conflicts in opinion with regards to designing fitness games.

6.1 Design of the questionnaire

There were two primary sources for developing the survey. Firstly, findings from the qualitative study were used to generate the domain of questions and initial measurement items. Secondly, a literature review was used to refine the measurement items. Literature helps conceptualize questions and define variables (Churchill Jr, 1979). In addition to these, a pre-test was carried out with five experts to improve the survey. Interviews of these experts were conducted separately to obtain sufficient domain knowledge (Churchill Jr, 1979).

This section explains the qualitative findings and literature research results that were used to create questionnaire questions and measurement items.

6.1.1 Sources for the questionnaire content

In this section, the sources that were used to design each question in questionnaire are explained. Some questions came from either qualitative findings or the literature, while other questions were generated after combining both sources.

6.1.1.1 Purposes of fitness games

The first question concerns the purposes of fitness games and it is defined as the purposes of a fitness game that healthcare professionals and game designers would expect to fulfil. This survey question aims to study the design objectives of fitness games. For game designer respondents, their answers indicated the functions of fitness games that they would try to achieve when designing for LD users. For healthcare professional respondents, their answers showed their expectations for fitness games.

The first question in the survey is phased as: 'considering a fitness game for LD users, please indicate the extent to which you agree with the following purposes'. There are seven measurement items in this question:

Item 1a: Games should help users to make movements freely. This was the main design target of Somability. Designers and caregivers wanted a game to motivate users to live their full lives and to be engaged in all activities. For any fitness game, movements carried out by users should be smooth and free, and users should not have any limitations caused by technology.

Item 1b: Games should allow users to express feelings and emotions in movements (e.g. anger, joy). Somability wanted users to express their emotions and feelings through movements because these users do not usually communicate verbally. Struggling to express verbally is common for people with severe or profound LD, therefore a game that allow them to express through other means would be helpful.

Item 1c: Games should improve users' muscle function. Fitness games help users be more active which leads to muscle function improvements (Lotan, et al, 2009). When users are more physically active, they exercise more and build strength which decreases the risks of disease (Lotan, et al, 2009).

Item 1d: Games should motivate users to carry out physical exercise. LD users often lack physical exercise because they are intellectually and physically challenged. A fitness game should be able to motivate them to exercise willingly and effectively.

Item 1e: Games should decrease users' anxiety and depression. Fitness games improve the mental condition of users because they make users happier, healthier, and more open to others (Lotan, et al, 2009).

Item 1f: Games should help users to improve self-esteem. Fitness games involve users in various tasks and by performing these tasks successfully, users gradually build self-esteem and confidence (Hutzler and Korsensky, 2010).

Item 1g: Games should help users build social connections. This was the second design goal of Somability. Designers noticed that LD users were sometimes isolated from each other and they wanted to change that. Fitness games often encourage group-play which contributes to social relationship of users. This social connection is also an important accelerator for improving the mental conditions of users.

6.1.1.2 Other types of games

In order to identify the types of games that are useful in this context, the second question of the survey is formed and defined as other types of games LD users may require. Responses to this question indicate the additional requirements that did not appear in general fitness games design to better inform the game design process. The source of this question was only literature research because the case study only focused on one fitness game.

The question in the survey is: 'Apart from fitness games, LD users may require other types of games. Please indicate the extent to which the following games would benefit users.' This question contains five measurement items:

Item 2a: Games that support learning abilities for academic studies such as math or literature. In an LD context, education games can be used in three specific areas: general education curriculum, academic achievement and prosocial behaviours (Maccini et al, 2002).

Item 2b: Games that teach life-skills for independent living. LD users often lack essential knowledge and they need to rely on others to live, but an education game could try to teach them useful skills that they could use in real life (Standen and Brown, 2005).

Item 2c: Games that enhance other cognitive abilities such as memory and numeracy. Cognitive games contribute to a healthier mind. Studying cognitive knowledge would have long-term impact on LD users (Standen and Brown, 2005).

Item 2d: Games that help rehabilitation from injuries. Well-designed rehabilitation games can help users recover from injuries and live life with a positive attitude (McCallum, 2012).

Item 2e: Games that require group-play. LD people are often observed to be isolated. Group-play games would offer a chance for them to form social relationships (McCallum, 2012).

6.1.1.3 User requirements study for fitness games

Fitness games have to be designed to meet user requirements. The 'user requirements study' in the questionnaire is defined as methods to understand user requirements. By marking the measurement items in this question, game designers indicated their preferred user requirements study methods for fitness games. Healthcare professionals expressed their opinions about the best ways for games designers to learn about user requirements.

There are two parts to this question. The first part intends to identify the people that game designers should take inputs from. There are four measurement items:

Item 3a: potential game LD users. Somability involved users in prototype testing. Hutzler and Korsensky (2010) agreed with it and argued that users should be regularly involved in cross-group and peer-based modelling in game design. Newell and Gregor (2000) also thought that a user panel and evaluating prototypes were good methods to access user needs. In particular, designers should observe users when they are interacting with technology in their real environment (Nicolle and Abascal, 2001).

Item 3b: family members. Family members live with users every day and they know their needs. They are easy to communicate with especially when users themselves have multiple disabilities. It is valuable to take input from them. (Kafai and Kafai, 1995)

Item 3c: health and social care professionals. The Somability team relied on caregivers a lot and based the design largely on their insights and feedback. Hutzler and Korsensky (2010) pointed out that social support frameworks including family members and carers should be involved when designing physical aspects of the game. However, people from a social support background should be introduced to the motivation and methodologies of game design process, which are different from their normal work (Newell and Gregor, 2000). If not, social supporters and designers might not understand each other which ends up in fraught with difficulties (Newell and Gregor, 2000).

Item 3d: education professionals. For children who are still in school, their teachers work with them and are familiar with their needs. Education professionals' input would help to improve the product and make it more effective (Annetta, 2010).

The second part of the question 'user requirements study' is about resources that game designers should learn from. There are six measurement items in this part:

Item 3e: Designers learn from theories about human movements such as walking and running. Designers, programmers, caregivers and dancing instructors all sat down and analysed users' daily movements. The three functions of the product 'reach', 'balance' and 'flow' all came from everyday movements. Learning from biochemistry theories would help game designers better understand how human move to design more suitable fitness games.

Item 3f: Designers learn from computer game design theories. There are some design guidelines such as Ferrara (2012) and Werbach and Hunter (2012). Designers could borrow some of these concepts.

Item 3g: Designers learn from inclusive design theories for disabled users. As discussed before, there are seven inclusive design principles that can guide designing games for people with disabilities. Fitness game designers can borrow some elements from them.

Item 3h: Designers learn from their own game development experience. Carrying out case studies of former game design experience is effective to learn about user requirements (Newell and Gregor, 2000).

Item 3i: Designers learn from observations of potential game users in daily life. During the development of Somability, the users were observed during the prototype testing stage. Observing real end user reactions to help improve the game.

Item 3j: Designers learn from testing prototypes. As discussed above, Somability made some adjustments according to user feedback. Evaluation of prototypes has proven to be a valid method to collect user requirements (Newell and Gregor, 2000).

6.1.1.4 Mechanics of fitness games

The fourth part of the survey intends to identify the characteristics of game mechanics that would make a fitness game simple and easy enough to use. This question, 'mechanics', is defined as the mechanics in fitness games that make the gameplay simple and fun.

The question in the survey is: 'Considering the ability level of the user, a fitness game has to be both fun and simple. Please indicate the extent to which you agree with the following methods to simplify a fitness game'. There are six measurement items:

Item 4a: Designers should make the rules of a game easy. Somability is a game that is simple and easy to play, and freedom within the game inspires users to explore. Computer games should match the skills of the end user to keep them engaged (McCallum, 2012). They should allow end users to start from very easy to avoid failure at their first trial (Zicherman and Cunningham 2011: 59-63). As for inclusive design principles, the first two guidelines are 'simple and intuitive use' and 'flexibility in use' which call for a simple design that can be used by anyone (Mace, 1997).

Item 4b: Designers should make games so that they only convey necessary information to users. As one of the inclusive design principles, the design should communicate perceptible information to users taking into account their sensory abilities (Mace, 1997).

Item 4c: Designers should make games that allow mistakes. Somability designers wanted users to have a chance to make mistakes without being punished. This encourages them to move freely within the game and achieve more than they could previously.

Item 4d: Designers should make games that allow repetitive play. Theoretically, LD users need more repetition than others to understand the information (Coles, et al, 2007). Games designed for LD users should allow them to progress at their own pace and to repeat actions whenever they want (Coles, et al, 2007).

Item 4e: Designers should make games that accommodate user preferences. Somability has three game modes: skeleton, mirror and shadow. For LD users, virtual environments should be adjustable to adapt to the user capability (Yalon-Chamovitz and Weiss, 2008). Flexible virtual environments should provide multimodal feedback which contributes to meaningful play (Ijsselsteijn, et al, 2007).

Item 4f: Designers should make game interfaces clear. A clear and colourful interface attracts the attention of the user and it is also helpful for users with visual challenges.

6.1.1.5 Technology in fitness games

When adopting technology in fitness games, special adjustments need to be made for LD users because of their conditions. The aim of this section of the survey is to identify the features of technology in fitness games. The question 'technology' is defined as features of technology that a fitness game should obtain.

In the survey, the question is: 'Considering a fitness game for LD users, please indicate the extent to which you agree with the following items with regards to technology'. There are seven measurement items:

Item 5a: Technology providing pictorial support for clear feedback. Somability provides instant feedback which helps users engage with the game. The technology is very sensitive and is able to pick up the smallest movements so that users are encouraged by their own progress. Nicolle and Abascal (2001) agree that technology should provide pictorial, verbal and tactile support. Clear and immediate feedback is a key element for the design of any game design (Werbach and Hunter, 2012: 94-97).

Item 5b: Technology providing verbal features such as music and sound (clapping). Somability asks users to clap to create flowers on the screen. Users get excited when seeing flowers on the screen and consequently are encouraged to continue clapping. The verbal features in fitness games can act as a guidance and an accelerator for users.

Item 5c: Technology providing tactile support such as touch screen. Tactile support is very important for users with limited mobility (Chen and Downing, 2006). They can easily be integrated in games that only require them to sit down which is suitable for wheelchair users.

Item 5d: Technology providing non-tactile features such as eye movement recognition. Some LD users are not able to move freely and non-tactile features allow them to get involved easily.

Item 5e: Technology that incorporates real-world interaction into the game world. The game must use movements from real life so that the LD users can benefit from progress made in the virtual world (De Freitas, 2006). It is important that users generalize what they learned in the virtual world to the real-world (Coles, et al, 2007).

Item 5f: Technology providing specific training for caregivers, teachers and family members. Somability provides training for care homes that bought the product. Hutzler and Korsensky (2010) supported this opinion and argued that specific training should be provided to instructors so that they can help support physical activities.

Item 5g: Technology that has low cost. Somability requires a laptop and Kinect. To lower the cost, Cariad Interactive is developing a new product with similar functionality. It uses a Rasberry Pi which is very cheap and portable. More affordable fitness games can benefit a wider audience of users.

6.1.1.6 Motivations in fitness games

Fitness games work best when they can motivate users to perform physical exercise intrinsically.

This survey question aims to explain the characteristic of intrinsic motivation that are provided in fitness games. This question 'motivations' is defined as 'motivations that a fitness game should bring to users'. Game designers and healthcare professionals expressed their opinion about the likelihood of motivational events happening during gameplay. The result may explain the characteristics of fitness games that need to be reformed to motivate users intrinsically.

The question asked in the survey is: ‘Considering a fitness game for LD users, please indicate the extent to which you agree with each statement that describes events that happen during the course of a game’. There are seven measurement items:

Item 6a: During gameplay, users compete with each other. When playing Somability, users compete to create more flowers on the screen which encourages the users to be more physically active. All games are competitive because end users compete with each other or against a game system (Salen and Zimmerman, 2004).

Item 6b: During gameplay, users start to play with other users, caregivers, staff and parents. Relatedness is a facilitator in SDT theory, it is strengthened by making the connection between people more secure, frequent and robust (Deci and Ryan, 2002). Somability witnessed the fact that users bond with each other. The game also broke down barriers between users and caregivers, and helped build trust. In an LD context, collaboration should be more encouraged than competition (Hutzler and Korsensky, 2010).

Item 6c: During gameplay, users meet new people with similar conditions. Somability gathered users to play in a group, some of these users had not met before. It is also a good opportunity for parents to talk to other parents. Fitness games should provide a chance for users to meet others both online and offline.

Item 6d: During gameplay, users feel empowered because they are in control. Autonomy is another facilitator in SDT theory and it could be improved by offering alternatives to choose from, utilizing positive feedback and providing flexible instructions (Deci and Ryan, 2002). When playing Somability, users gain empowerment through instant feedback that tracks their progress. This gives the users a sense of control when they play the game. This sense of control is one of the primary motivators in computer games (McCallum, 2012). Users also receive a sense of empowerment because they can make their own decisions.

Item 6e: During gameplay, users become more independent from people who give assistance. Somability gradually helped the users to become more independent during gameplay. Being able to live without assistance is a massive improvement for LD users because it means they can start to live a life without support from caregivers or family.

Item 6f: During gameplay, users build confidence as the game progresses. Users of Somability became braver after playing for a while. A lot of them can perform in front of others without feeling uncomfortable. Research shows that leisure games can improve confidence, self-esteem and enjoyment (Yalon-Chamovitz and Weiss, 2008).

Item 6g: During gameplay, users feel happier. Somability has created fun among users and the ones who used to struggle from either physical or mental conditions became happier. Fitness games should be fun and enjoyable.

6.1.2 Questions and measurement items

Overall, there are six questions in this research which cover the following categories in fitness games design: purposes, types, user requirements study, mechanics, technology and motivations. The Table 13 below lists the questions, question definitions, measurement items and sources.

Table 13. Questions and measurement items

Question and definitions	Measurement items (means)	Sources
Purposes: the objectives of fitness games	Fitness games should: 1a: encourage free movements. (4.09) 1b: allow users to express feelings. (3.96) 1d: motivate physical exercise. (4.17) 1g: encourage social connections. (3.97)	Qualitative study findings
	1c: improve muscle functions. (4.18) 1e: decrease anxiety. (4.13) 1f: improve self-esteem. (4.16)	Lotan, et al, 2009; Hutzler and Korsensky, 2010.
Types: other types of games that LD users may require	Market also welcomes games that: 2a: support academic studies. (3.73) 2b: teach life-skills. (4.17) 2c: enhance cognitive abilities. (4.05) 2d: help rehabilitation. (3.85) 2e: require group-play. (3.82)	Maccini et al, 2002; Standen and Brown, 2005; McCallum, 2012.
User requirements study: methods to understand user requirements	Game designers should learn from: 3a: potential game users. (4.40) 3c: healthcare professionals. (4.14) 3e: human movement theories. (3.97) 3g: inclusive design principles. (4.24) 3i: user observations. (4.21) 3j: testing prototypes. (4.14)	Qualitative study findings
	3b: family members. (3.83) 3d: education professionals. (3.90) 3f: game design theories. (3.83) 3h: previous personal experiences. (3.84)	Hutzler and Korsensky, 2010; Newell and Gregor, 2000; Ferrara, 2012; Werbach and Hunter, 2012; Newell and Gregor, 2000;
Mechanics: the mechanics in fitness games that make the gameplay simple	Fitness games could be simplified through: 4a: easy rules. (4.32) 4c: allowing mistakes. (4.11) 4f: clear interface. (4.41)	Qualitative study findings
	4b: conveying only necessary information. (3.96) 4d: repetitive play. (3.97) 4e: accommodating user preferences. (4.22)	Mace, 1997; Coles, et al, 2007; Yalon-Chamovitz and Weiss, 2008; Ijsselsteijn, et al, 2007.
Technology: features of technology in fitness games	Technology should be able to: 5b: provide verbal features. (4.22) 5d: provide non-tactile features. (3.68) 5f: specific life-skill. (4.08) 5g: cost low. (3.97)	Qualitative study findings
	5a: provide pictorial support. (4.24) 5c: provide tactile features. (3.96) 5e: incorporate real-world interaction. (3.86)	Nicolle and Abascal, 2001; Werbach and Hunter, 2012: 94-97; Coles, et al, 2007; De Freitas, 2006.
Motivations: motivations that fitness	During game paly, users should: 6a: compete. (3.02) 6b: play with others. (3.93) 6c: meet new people. (3.94)	Qualitative study findings

games should bring to users	6e: become more independent. (4.28) 6g: feel happier. (4.59)	
	6d: feel empowered. (4.26) 6f: gain confidence. (4.41)	Deci and Ryan, 2002; McCallum, 2012; Yalon-Chamovitz and Weiss, 2008

6.2 Analysis of each survey item

To identify survey respondents' opinions about the design characteristics, the response of each survey item was compared with midpoint of 3 (neutral). All survey items came from qualitative findings and literature research which meant positive feedback was expected from survey participants. Considering that there were two participant groups, the similarity between both groups was tested first with Mann-Whitney U Tests. This test was used because the answers of all questions were right-skewed instead of normally distributed. Another reason to choose Mann-Whitney U Tests over Wilcoxon Signed Rank Tests is due to the independence of two sample groups. For the items that received similar answers from both groups (Mann-Whitney U Tests' results were 'Yes': p-values greater than .05, i.e. there was no statistically significant evidence that both groups differed), both groups' answers were combined. The median of the combined answer was compared with 3, which is the neutral baseline, using one-sample Wilcoxon Signed Rank Tests. If the p-value was smaller than .05 then there was enough evidence to support that an item was significantly more positive than 3. Regarding the items that received different answers from both groups (Mann-Whitney U Tests' results were 'No': p-value smaller than .05), the median of each group was tested separately against a value of 3 with one-sample Wilcoxon Signed Rank Tests.

In this section, each item in every question is analysed to identify the importance of certain design characteristics when making fitness games for LD users. To reveal the significance of each design characteristic in detail, the means of each question are reported because they are able to demonstrate people's varied evaluation.

6.2.1 Purposes of fitness games

The first question is 'purposes' which intends to discover the functions of fitness games that game designers and healthcare professionals would expect. Table 14 and 15 summarise all response attributes for this question.

Table 14. Items that have similar answers across groups (Purposes)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Combined
1a) Make movements freely	4.13	4.04	4.09	Yes p=.333	Yes P<.01
1d) physical exercise	4.26	4.06	4.17	Yes P=.075	Yes P<.01
1e) decrease anxiety and depression	4.11	4.15	4.13	Yes P=.874	Yes P<.01
1f) improve self-esteem	4.26	4.05	4.16	Yes P=.132	Yes P<.01

*The significance level is .05

Table 15. Items that have different answers across groups (Purposes)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Healthcare	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Game
1b) express feelings and emotions	4.14	3.75	3.96	No p=.003	Yes P<.01	Yes P<.01
1c) muscle functions	4.38	3.96	4.18	No P<.001	Yes P<.01	Yes P<.01
1g) build social connections	4.38	3.50	3.97	No P<.001	Yes P<.01	Yes P<.01

*The significance level is .05

As can been seen in this two tables, all items in the first question regarding 'purposes of fitness games' have p-values of less than .01 in the one-sample Wilcoxon Signed Rank test regardless of the group difference. In other words, for fitness games that target LD users, there is significant evidence that supports the idea that all purposes receive positive feedback. These purposes include physical goals such as 'motivating users to carry out physical exercise' and 'helping users to make movements freely' as well as emotional purposes that 'decrease user anxiety and depression' and 'help users build social connections'. This indicates that both game designers and healthcare professionals agreed on the suggested physical and emotional 'purposes'. The data suggests that game designers would satisfy these purposes when designing fitness games for LD.

Given significant evidence to show that the proposed 'purposes' are positive, grouping survey items with similar content can be used to further understand fitness game design from a high-level perspective. Two main groups were created after merging items with similar content. This grouping reveals the underlying relationships between the survey items and shows that fitness games have physical and emotional objectives. Grouping the items also enables analysis towards a single item as well as each group's average score, the range and the different responses from the two types of respondents. By comparing and contrasting both groups, the research suggests that despite the usefulness of emotional objectives, the physical functions are more valued in fitness game design.

According to the contents of the survey items, the seven game purposes can be grouped into two categories: physical objectives (1a, 1c, 2d) and emotional objectives (1b, 1e, 1f, 1g). The average score for the physical objectives is 4.15 and the average for the emotional objectives is 4.05. This shows that overall, respondents favour physical objectives of fitness games more than emotional objectives. This is an expected result because traditional fitness games are used to promote exercise and a healthy lifestyle (Sinclair, et al, 2007). Although prior research has shown that fitness games bring emotional benefits such as decreased anxiety and depression (Franklin et al., 2000), the survey results reveal that industrial experts put less emphasis on the emotional objectives when designing games.

Looking at the range of responses within both groups: the group 'physical objectives' has the highest response of 4.18 (1c) and lowest of 4.09 (1a) making the range 0.09; the group 'emotional objectives' has the highest response of 4.16 (1f) and the lowest 3.96 (1b), a range of 0.2. This result further reveals that items concerning physical objectives have more positive and less divided feedback when compared to emotional objectives.

In terms of the differences between both respondent groups, the difference of emphasis is especially obvious in the game designer respondent group. When compared to healthcare professionals, game designers did not respond as positively for the emotional objectives including 'allowing users to express feelings and emotions in movements (1b)' and 'helping users build social connections (1g)'. Unlike game designers, the healthcare professionals not only gave high scores in the questionnaire responses, they also spoke highly of these 'purposes' during the former case study. Besides, emotional and social support offered by fitness games could meet users' autonomy and relatedness needs, so as to intrinsically motivate them (Deci and Ryan, 2002). The survey result of Question 6 further supports the positive effects of emotional motivation in fitness games. The results suggest that game designers seem to have neglected these emotional 'purposes' to some extent, and they should pay special attention to them when designing fitness games for LD.

In summary, grouping the items provides further evidence to support the hypotheses and confirms that the seven game purposes are valid in practice. Both groups have raised two main areas that fitness games should aim to provide: physical exercise and emotional improvements. The survey data revealed that emotional motivation is not as valued as physical motivation in fitness game design, even though it has been verified to be effective.

After ranking the items, the top ones chosen by healthcare professionals are 'improve muscle function' (4.38), 'build social connections' (4.38), 'carry out physical activities' (4.26) and 'improve self-esteem' (4.26). As for game designers, the top three answers are 'decrease anxiety and depression' (4.15), 'carry out physical activities' (4.06) and 'improve self-esteem' (4.05). After combining both groups, the three most favoured options are 'improve muscle function' (4.18), 'carry out physical activities' (4.17) and 'improve self-esteem' (4.16). In conclusion, both groups agreed that 'carry out physical activities' and 'improve self-esteem' were important. The research also suggests that healthcare professionals called for emotional purposes in fitness games. Game designers should try to satisfy this need.

The survey left some space for participants to make additional comments. Some participants proposed other purposes for fitness games. These include 'maintain the blood sugar levels in their bodies, 'maintain a healthy lifestyle', 'help with physiotherapy', 'release energy and tension', 'enable clients to feel better about themselves', 'enable self-exploration and self-expression' and 'maintain their mental well-being. Many participants mentioned that different games or game customization should be implemented to accommodate various levels of LD. Others argued that 'it's important not to force learning upon them but to ensure there isn't too much freedom'.

To further understand the survey responses, each item in this question is further analysed in turn.

Item 1a: Games should help users to make movements freely.

Feedback from healthcare professionals and game designers has proven to be similar. After combining the answers of both groups, the score is significantly higher than 3. This provides strong evidence that this item holds.

Item 1b: Games should allow users to express feelings and emotions in movements (e.g. anger, joy).

The answers from both groups had significant difference. Therefore, the medians of each group were tested separately and compared with the midpoint (3). Both medians were more than 3 which provides evidence to support this item.

Specifically, healthcare professionals (average 4.14) ranked this purpose higher than game designers (average 3.75). Careful attention needs to be paid to this conflict in opinion since LD users often need a means to express themselves other than verbal communication. Fitness games should provide functionality that is more than just physical exercise. During interviews, caregivers often mentioned that playing Somability helped users 'express their happiness as well as anger'. However, one game designer commented on the questionnaire stating that 'expressing feelings is fine, but stuff like anger can be tricky. Releasing anger to release frustration is fine, as long it is contained to reasonable levels so that we can avoid a sort of addiction to anger'.

The relationship between the purpose 'allow users to express feelings and emotions in movements' and 'feel happier' in Question 6 is strong. There is a significant correlation between both items. This means that respondents believe that when users express feelings and emotions, they are likely to feel happier.

Item 1c: Games should improve users' muscle function.

The answers from both groups differed for this item. However, the medians of each group exceeded a value of 3. Therefore, this item has been tested to be true.

Item 1d: Games should motivate users to carry out physical exercise.

Both groups gave similar answers and the combined answer was significantly higher than 3. Therefore, the evidence strongly supports the fact that this item is true.

Item 1e: Games should decrease users' anxiety and depression.

Both groups had similar feedback for this item. Also, the median of overall answers was significantly greater than 3. Therefore, the evidence strongly supports the fact that this item is true.

Item 1f: Games should help users to improve self-esteem.

Both groups had similar feedback for this item. The median of overall answers was significantly greater than 3. Thus, the evidence provides strong support for the truth of this item.

According to Self-Determination Theory, autonomy is one of the intrinsic facilitators (Deci and Ryan, 2002). In order to improve self-esteem, fitness games should provide empowerment (Question 6, Item 6d), independence (Question 6, Item 6e), confidence (Question 6, Item 6f) and happiness (Question 6, Item 6g). The correlation between 'helping users improve self-esteem' and the other four items are all significantly positive. This means fitness games should be able to fill this purpose so that users can gain empowerment, independence, confidence and happiness through gameplay.

Item 1g: Games should help users build social connections.

Both groups gave different answers for this item. Therefore, the median of each group was compared to the midpoint value of 3, where the p-values were less than .01 for both groups. This evidence provides strong support for the truth of this item.

Both groups responded with significant difference to this question. Healthcare professionals gave an average score of 4.38 while game designers only scored 3.5. This difference between groups was the largest within this question. Figure 3 contains two histograms demonstrating the response frequencies for both respondent groups. As shown on Figure 3, most game designers voted 'neutral'. One game designer expressed their concerns by commenting: 'beware of internet connections, vulnerable disabled people could be hurt (e.g. if people ask them to meet and take their money)'.

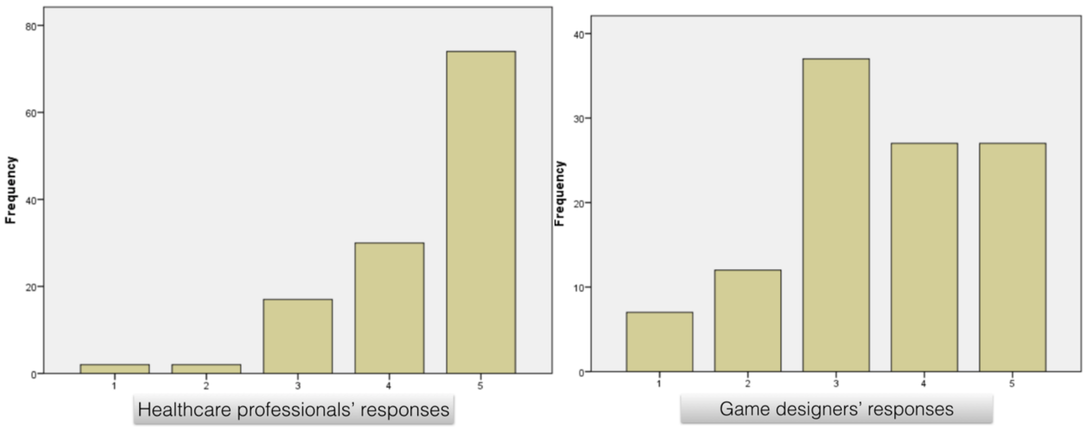

Figure 3. Distributions of both groups' answers (Purposes)

However, healthcare professionals were mostly positive in both questionnaires and interviews. Right from the very beginning of Somability's design, caregivers from different care homes expressed concerns that LD users were sometimes isolated from each other and they wanted to change that through the game. Therefore, Somability encourages group-play as a method to bring users together.

The correlation between this item and Question 6 is strong. There are significant correlations between the purpose 'help users build social connections' and competition (Question 6, Item 6a), interaction with others (Question 6, Item 6b), meeting new people (Question 6, Item 6c), independence (Question 6, Item 6e) and happiness (Question 6, Item 6g). Some game designers did not like the idea of users competing and that might be a reason for a low score. On the other hand, building social connections helps with the mental conditions of users in different ways. It also contributes to the relatedness of humans which is one of the facilitators in Self-Determination Theory (Deci and Ryan, 2002).

6.2.2 Types of games

The second question, 'types', intended to study other types of games that may be useful to LD users. Game designers can improve fitness games by adopting the features of other games. Table 16 and 17 describe the responses for this question.

Table 16. Items that have similar answers across groups (Types)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3) * Combined
2b) life-skills for independent living	4.20	4.13	4.17	Yes p=.332	Yes P<.01

*The significance level is .05

Table 17. Items that have different answers across groups (Types)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3) * Healthcare	One-sample Wilcoxon Signed Rank Tests (compared to 3) * Game
2a) academic studies	3.54	3.95	3.73	No p=.037	Yes P<.01	Yes P<.01
2c) cognitive abilities	3.89	4.23	4.05	No P=.012	Yes P<.01	Yes P<.01
2d) rehabilitation from injuries	3.98	3.71	3.85	No P=.017	Yes P<.01	Yes P<.01
2e) group-play	4.02	3.60	3.82	No P=.002	Yes P<.01	Yes P<.01

*The significance level is .05

There is significant evidence here that all items are welcomed by the market since they received p-values of less than .01 in One-sample Wilcoxon Signed Rank Test. Both healthcare professionals and game designers agreed that LD users would benefit from games that support academic studies, teach life-skills, enhance cognitive abilities, help rehabilitation and promote group interaction. The results of this survey question inspire fitness games to include extra functionality that helps users gain independent life-skills and acquire knowledge.

Although the five game types emphasize various skills and can inspire fitness game design from different aspects. Similar items can be grouped into two broader categories to give an idea of the big picture for game designers to borrow ideas from. These broader categories are: games that help users gain independent life-skills (2b, 2d, 2e) and games that help knowledge acquisition (2a, 2c). The average score for the first category is 3.95 and the average score for the second category is 3.89, indicating that life-skills training games are more welcomed by the market when compared to the knowledge acquisition games.

In terms of the range of responses in both categories: 'life-skills training games' category has a high score of 4.17 (2b) and low score of 3.82 (2e) leaving a range of 0.35; 'knowledge teaching games' has a high score of 4.05 (2c) and low score of 3.73 (2a) leaving a range of 0.32. Although the differences are small, this result shows that the life-skills games received more positive feedback.

When comparing the differences between both respondent groups, healthcare professional favoured the former category whereas the game designers favoured the latter. Games that 'help rehabilitation (2d)' and 'promote group interaction (2e)' were more valued by healthcare professionals than game designers. On the contrary, game designers gave higher scores for games that 'develop independent life-skills (2b)', 'support learning abilities (2a)' and 'enhance cognitive abilities (2c)'. From my observations, caregivers who take care of LD users always have a heavy workload because of the users' physical conditions. They desperately require games that help improve the users' physical conditions. They also would like users to be more interactive with others because users lack the motivation to break through their communication barriers (McCallum, 2012). These two areas in the market call for more attention from game developers.

To summarise, the positive feedback of all five game types answers the hypotheses and inspires fitness games to adopt additional functionality. After grouping the five survey items into two categories, it became clear that fitness games could borrow concepts from either life-skills training games or knowledge games. The survey data highlights the fact that game designers valued knowledge games higher, whereas healthcare professionals favoured life-skills training games. Attention should be distributed between both game types.

Survey respondents from both groups also persistently commented that the games must cater to individual disability characteristics. With higher levels of disability, game developers could concentrate on daily living skills. On the other hand, for users with lower levels of LD, additional games could be made to address academic and cognitive skills.

The top three items for healthcare professionals are 'life-skills for independent living' (4.2), 'group-play' (4.02) and 'rehabilitation from injuries' (3.98). Game designers picked 'cognitive abilities' (4.23), 'life-skills for independent living' (4.13) and 'learning abilities for academic studies' (3.95). After combining data from both groups, the top three items are 'life-skills for independent living' (4.17), 'cognitive abilities' (4.05) and 'rehabilitation from injuries' (3.85). The item that gained favour from both groups is 'games that teach life-skills for independent living'. Healthcare professionals favoured games that contributed to practical living skills such as rehabilitation, whereas game designers emphasized cognitive skills and academic skills. This disagreement indicates that game designers should communicate more with the end users and their support workers.

Survey participants suggested other types of game that they would like to see in this market. Extra comments in the survey suggests the game should 'teach users about social responsibility', 'enhance attention span', 'artistic skill or creative engagement', 'transform board games to a technology format like *snakes and ladders*' and 'develop communication skills, e.g. assisted communication systems and sign languages'.

The analysis for each item in the question is as follows:

> **Item 2a:** Games that support learning abilities for academic studies such as math or literature.

This type of game had the lowest overall score (3.73) out of the five types and the second lowest score throughout the entire survey. Since both groups of respondents had significantly different answers, the medians of each group were tested against the midpoint value of 3. Both results were significantly higher than 3 which provided sufficient evidence to say that participants responded to this item positively. In conclusion, this type of game is required by the LD market, but not urgently.

> **Item 2b:** Games that teach life-skills for independent living.

Two groups of respondents gave similar answers to this item. The combined score was the highest among all five items (4.17). LD users have a reduced ability to cope independently which results in their reliability on others. Games could help them learn life-skills and improve independence. Survey respondents pointed out that these skills could include 'ability to make decisions independently', 'ability to recognise when they are being bullied' and 'ability to understand nature and objects'. The game should attempt to teach skills that can be used in both the real-world experience and virtual environment.

> **Item 2c:** Games that enhance other cognitive abilities such as memory and numeracy.

This item had the second highest score (4.05). Both groups also had similar feedback for this item. The median of overall answers was significantly greater than 3. Thus, the evidence provides strong support for this item holding true.

One survey respondent commented 'games to improve memory and concentration are important as they are the basis of all interaction with the external world'. Another survey participant suggested that 'cognitive learning from games is a really interesting area. There is a small niche of education games but the majority are focused on children rather than adults'. Fitness game designers can use get ideas from these games to improve the end product.

Item 2d: Games that help rehabilitation from injuries.

Both groups' answers differed for this item. The medians of each group were tested separately and compared to the midpoint value of 3. Because both groups had a median significantly higher than 3, this item has been tested to be true.

Item 2e: Games that require group-play.

The overall score of this item was 3.82. Both groups had different answers and both scores significantly higher than 3. During the prior case study, interviewees commented that group-play was very important for users to meet new friends and develop social skills. Relatedness, one of the three facilitators in Self-Determination Theory (Deci and Ryan, 2002) would be enhanced by group-play games.

Survey participants agreed with this item. One participant mentioned that 'group-play will enhance their social relationships and communication skills as well as relief from the metal pressure'. Another participant said that group-play games would 'increase service users' awareness of other's feeling'. An additional benefit that group-play teaches users is the ability to 'see things from another's perspective'. Another participant mentioned that they would like to see games that 'caregivers and patients can play together'. However, another participant also pointed out that 'group-play is good as long as the user's preferences are respected'.

6.2.3 User requirements study of fitness games

The third question discusses the means to conduct a user requirements study for fitness games. Table 18 and 19 summarise the survey participants' insights of the suggested methods.

Table 18. Items that have similar answers (User requirements study)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Combined
3c) inputs from healthcare professionals	4.14	4.15	4.14	Yes p=.757	Yes P<.01
3f) game design theories	3.86	3.80	3.83	Yes p=.638	Yes P<.01
3g) inclusive design principles	4.12	4.38	4.24	Yes P=.163	Yes P<.01
3h) previous design experiences	3.95	3.73	3.84	Yes p=.070	Yes P<.01
3i) user observation	4.10	4.34	4.21	Yes p=.230	Yes P<.01

*The significance level is .05

Table 19. Items that have different answers (User requirements study)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Healthcare	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Game
3a) inputs from users	4.24	4.58	4.4	No p=.002	Yes P<.01	Yes P<.01
3b) inputs from family members	3.99	3.64	3.83	No p=.023	Yes P<.01	Yes P<.01
3d) inputs from education professionals	4.00	3.79	3.9	No p=.028	Yes P<.01	Yes P<.01
3e) theory on human movements	4.08	3.85	3.97	No p=.018	Yes P<.01	Yes P<.01
3j) testing prototypes	3.95	4.35	4.14	No P=.011	Yes P<.01	Yes P<.01

*The significance level is .05

After conducting One-sample Wilcoxon Signed Rank Tests, all Question 3 items have p-values of less than .01. Therefore, it is safe to say that there is significant evidence to support that all the suggested means are effective to study user requirements. Survey respondents thought that ‘potential users’ and ‘health and social care professionals’ were the best people to take inputs from. In terms of means to study user requirements, respondents ranked the top three as ‘inclusive design theories’, ‘observations of potential users’ and ‘testing game prototypes’.

For 3A, both groups were asked which parties should be involved in the user requirements gathering stage. Even though all four items had positive responses, significant differences were shown between both respondent groups. The item with the highest score was ‘potential users (3a)’. Game designers gave a very high score of 4.58 and healthcare professionals gave a score of 4.24. This difference in scores indicates that although healthcare professionals acknowledged the importance of user involvement, they were more worried about the difficulty in practice. Similarly, the items regarding taking inputs from ‘family members (3b)’ and ‘education professionals (3d)’ had less positive feedback from game designers, indicating that the game designers might have ignored the importance of using conduits to conduct a user requirements study. On the positive side, both respondent groups have agreed upon the importance of the inputs from healthcare professionals (3c). Interestingly, both respondent groups ranked all items in the same order: 3a, 3c, 3d followed by 3b. This indicates that despite the differences in scores, both healthcare professionals and game designers agree that they would adopt the four useful sources to collect user requirements in the sequence of: potential users, healthcare professionals, education professionals and family members.

3B studies the methods used to conduct the user requirements study. Items from this part of the question are grouped by similarity. This demonstrates the three main sources required to conduct the user requirements study. The items were grouped as followed: former experience (3h), design theories (3e, 3f, 3g) and design practice (3i, 3j). The first group’s averaged at 3.84, the second at 4.01 and the third at 4.18. This result indicates that rather than relying on textbook theories or previous experience, fitness games design should collect user requirements during the design process so the game can be adjusted based on user feedback.

In terms of the score ranges, the first group ‘former experience’ only has one item with an average of 3.84. The second group ‘design theories’ has a high of 4.24 (3g), and a low of 3.83 (3f), giving a range of 0.41. The third group ‘design practice’ has a high score of 4.21 (3i) with a lowest score of 4.14 (3j), giving a range of 0.07. Item 3g (inclusive design principles) is ranked second which indicates that although design theories may not be the best source to collect user requirements, the inclusive design principles are a useful source when making games for LD users. The most recognized source to conduct a user requirements study is 'design practice' with both methods being the highest rated.

Looking at both respondent groups, the item 'learn from previous design experience (3h)' had a relatively low score (3.84 average) especially from the game designers (3.73), indicating that designing fitness games for LD users is a very niche and challenging practice. Fortunately, there are design theories that game designers can follow including game design theories (3f), inclusive design principles (3g) and human movement theories (3e). Among the three theory sources, inclusive design principles are highly recognized by both game designers and healthcare professionals (4.24 average). The third category to conduct user requirements study contains two design practices: user observation (3i) and testing prototypes (3j). These two methods received high scores from survey respondents, especially the game designers, indicating that learning from game design practice is an effective way to study user requirements.

In summary, the feedback of all survey items provides a positive answer to the hypotheses. The most useful source to study user requirements is potential users. After grouping the second part of this question, it became clear that the most effective source to collect user requirements is game design practice. Excluding inclusive design principles, existing design theory and former experience are not as useful.

To discuss the item rankings of question 3, 3A and 3B are ranked separately. 3A is concerned with the people that provide input gathering user requirements. For healthcare professionals, the top two answers are 'potential users' (4.24) and 'health and social care professionals' (4.14). Game designers answered with 'potential users' (4.58) and 'health and social care professionals' (4.15). 3B is concerned with the methods used to study user requirements. Healthcare professionals thought the top three important items are 'inclusive design principles' (4.12), 'user observation' (4.1) and 'human movements theory' (4.08). Game designers gave the highest scores for 'inclusive design principles' (4.38), 'testing prototypes' (4.35) and 'user observation' (4.34). Overall, the top three are 'inclusive design principles' (4.24), 'user observation' (4.21) and 'testing prototypes' (4.14).

To put this into practice, the best ways for game designers to study user requirements are through inclusive design principles, user observations and prototype testing. It would be very useful to involve potential users in the whole process but it would be too difficult to achieve. Instead, involving healthcare professionals would be an easy and effective method.

Survey respondents suggested other guidelines that game designers should consider including cognitive theory, childhood development theory and ergonomics theory. Another survey participant suggested taking input from psychology experts.

To go into more detail of each item in this question, the following analysis is conducted.

Item 3a: Designers learn from potential game users with LD.

Healthcare professionals gave an average of 4.24 for this item while game designers gave an average score of 4.58. Both groups' answers were significantly different, therefore the medians of each group were tested and compared with a midpoint value of 3. Both groups had a score significantly higher than 3. Thus, the evidence provides strong support that this item holds true.

Many survey respondents commented positively about this item. One said 'it is very important to collaborate with potential users at all stages'. Another respondent pointed out that it is vital to personalize: 'talking directly to potential users is very important, especially for LD users, to learn what is helpful to the individual'. Instead of talking to LD users in care homes, one survey participant advised that it would be useful to 'speak to designers and developers who have disabilities'.

Item 3b: Designers learn from family members.

The feedback from healthcare professionals and game designers also showed differences. As a result, the median of each group was used and ended being significantly higher than the midpoint value. This evidence provides strong support that this item holds true.

Item 3c: Designers learn from health and social care professionals.

This item had the second highest score out of the four types of people to take inputs from. Healthcare professionals marked this 4.14 and game designers 4.15. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

One survey respondent commented that 'the valuable suggestions from the other professionals help the game designers understand things more deeply'.

Item 3d: Designers learn from education professionals.

Healthcare professionals gave an average of score 4.0 while game designers gave an average score of 3.79. The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

Item 3e: Designers learn from theory on human movements such as walking and running.

The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

Item 3f: Designers learn from computer game design theories.

This item has the lowest overall score of 3.83. Scores from both groups were also the lowest in each respondent group (3.86 for healthcare professionals and 3.80 for game designers). Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

One respondent said, 'game design theories are not as developed, useful and used as they may be'. This indicates that game designers tend to make products based on their practical experience rather than existing design literature. There is a need to advance game design guidelines to better support product development. This research has a potential to improve game design guidelines in terms of designing fitness games for LD.

Item 3g: Designers learn from inclusive design theories for disabled users.

This item has the highest score (overall 4.24, healthcare professionals 4.12 and game designers 4.38). Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Item 3h: Designers learn from their own game development experience.

Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

One participant commented 'game designers can only work from their own resources but the scope of their own resources differ from each other, for example, one's contacts, experience and software etc.'

Item 3i: Designers learn from observations of potential game users in daily life.

This item has the second highest score. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Item 3j: Designers learn from testing prototypes.

This item has the third highest score. The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

Potential users and healthcare professionals should be involved in prototype testing. One respondent said, 'healthcare professionals are aware of medical restrictions'. Another respondent suggested game design should 'beta test many small and simple ideas. Create model systems that allow for complexity to be added but start with the simplest iteration'. On the other hand, the difficulty here has been pointed out as 'focused testing with groups of disabled end users should be more widely used by game designers but often the pressure of deadlines leaves little time to do this'.

6.2.4 Mechanics of fitness games

This next question which is referred to as 'mechanics' discusses the features of game mechanics. Table 20 and Table 21 describe the average scores of each item in the question.

Table 20. Items that have similar answers across groups (Mechanics)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Combined
4a) make the rules easy	4.42	4.21	4.32	Yes p=.065	Yes P<.01
4d) repetitive play	4.03	3.90	3.97	Yes p=.110	Yes P<.01

*The significance level is .05

Table 21. Items that have different answers across groups (Mechanics)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Healthcare	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Game
4b) convey necessary information	4.06	3.83	3.96	No p=.029	Yes P<.01	Yes P<.01
4c) allow mistakes	3.89	4.35	4.11	No P=.024	Yes P<.01	Yes P<.01
4e) accommodate user preferences	4.35	4.06	4.22	No P=.003	Yes P<.01	Yes P<.01
4f) offer clear interface	4.20	4.65	4.41	No P<.01	Yes P<.01	Yes P<.01

*The significance level is .05

In summary, all items have p-values of less than .01 in the One-sample Signed Rank Tests. This is significant evidence that all methods used to simplify fitness games had positive feedback. The three items with highest scores are 'clear interface', 'easy rules' and 'accommodate user preference'. Both survey participant groups agreed on one of the three items, 'easy rules'. However, even though the other two items have different opinions, all the answers are significantly higher than 3. To cater to the needs of the users, fitness games should be simple and easy. To do that, the rules of games must be easy and forgiving. The interface should be clear and responsive. Additionally, fitness games should be adapted to different user preferences and abilities.

To better understand the features of game mechanics when designing fitness games, the six survey items are grouped into two categories: game rules (4a, 4b, 4c, 4d, 4e) and interface (4f). This grouping is conducted according to the contents of the items. The average score for the first category is 4.12 and the average score for the second category is 4.41. This result shows that when designing fitness games for LD users, there are two aspects that help simplify games: its rules and the interface. This research reveals that adjusting the game interface is more effective and feasible than changing the game rules.

The first category has a high score of 4.32 (4a) and low score of 3.97 (4d), giving a range of 0.35. The second category only has one item (4f) with a score of 4.41. This shows that the game interface is a very important aspect of game mechanics and highly affects the delivery of fitness games.

When comparing the responses from both survey respondent groups, both game designers and healthcare professionals agreed that the most important feature of game mechanics is 'easy rules (4a)'. Other than the 'repetitive play (4d)' feature, both respondent groups had diversified opinions: healthcare professionals gave their highest score to 'easy rules' (4.42) and game designers marked 'clear interface' highest (4.65). This means that when deciding on the mechanics in fitness games, healthcare professionals mostly considered the limited ability of the users and their demands. On the other hand, game designers intended to do this by offering a clear interface. When put into practice, both aspects are vital. The second highest scores in each group are 'accommodate user preferences' by healthcare professionals (4.35) and 'allowing mistakes' by game designers (4.35). This indicates that healthcare professionals thought it was necessary to adapt games based on ability. Game designers should make games that allow users to make mistakes to encourage physical exercise and decrease stress.

In conclusion, the positive survey results have tested the hypotheses to be true. All features of game mechanics proposed have been tested to be effective. The grouping of the survey items reveals that an adjusted game interface is the most important feature of fitness games. The diversified feedback from healthcare professionals and game designers indicated that the game rules should be easy and forgiving.

The top three items that healthcare professionals value are 'easy rules' (4.42), 'accommodate user preferences' (4.35) and 'clear interface' (4.20). For game designers, the top three choices are 'clear interface' (4.65), 'allow mistakes' (4.35) and 'easy rules' (4.21). The difference between both respondent groups is 'accommodate user preferences' and 'allow mistakes'. Game designers should consider this feedback and make fitness games more adaptable and forgiving.

Other contributions from the survey respondents about the mechanics of fitness games are ‘make games that do not require a long attention span’ and ‘provide performance feedback’.

Item 4a: Designers should make the rules of a game easy.

This item has the second highest overall score 4.32. The scores from both groups were also very high: healthcare professionals scored 4.32 and game designers scored 4.21. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Survey respondents pointed out that making the rules of a game easy would require ‘easy to understand, clear instructions’. Because ‘LD users vary in their capacity of processing daily events. Making things easy help them understand clearly and deeply’. One participant mentioned that ‘nobody likes a game that is stressful, unforgiving or forces them to keep restarting’. Another participant argued that the games should ‘still be a little challenging’.

Item 4b: Designers should make games so that they only convey necessary information to users.

This item has the lowest score among all six items, the overall score was 3.96: healthcare professionals 4.06 and game designers 3.83. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Participants commented that ‘all information available should be easy to understand to allow personal development and advancement’ and ‘it can be nice to perhaps have a relatable character with a bit of a story’. Game designers felt that games would need some background.

Item 4c: Designers should make games that allow mistakes.

The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

Item 4d: Designers should make games that allow repetitive play.

The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

One respondent mentioned that ‘repetitive play might only be interesting to strengthen certain neuronal inputs without being too boring’.

Item 4e: Designers should make games that accommodate user preferences.

The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

Many survey respondents commented on customization. ‘Games should be simple to understand and build difficulty as the user improves and learns’ and ‘someone with a mild LD may find a simple game childish and not challenging enough. Offering games which appeal to adults with different levels of LD would be beneficial as this would enable individuals to have a game which suits them’. Another comment was that ‘giving users choices would encourage self-determination’. Another suggested adding ‘easily accessible tutorials in case they need reminders’.

Item 4f: Designers should make game interfaces clear.

The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

According to the survey respondents’ comments, the interface should have ‘simple large graphics and colours’ and ‘visual instructions’. The interface should also be ‘forgiving, for instance if you miss-click a button by a little, it should still register.

6.2.5 Technology in fitness games

This question ‘technology’ studies the electronic devices used in fitness games and the adoption required for LD users. The survey results are described in Table 22 and 23.

Table 22. Items that have similar answers across groups (Technology)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Combined
5a) pictorial support	4.30	4.17	4.24	Yes p=.068	Yes P<.01
5d) non-tactile features	3.75	3.60	3.68	Yes p=.115	Yes P<.01
5e) real-world interaction	3.94	3.77	3.86	Yes p=.088	Yes P<.01

*The significance level is .05

Table 23. Items that have different answers across groups (Technology)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Healthcare	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Game
5b) verbal features	4.35	4.06	4.22	No P=.001	Yes P<.01	Yes P<.01
5c) tactile features	4.13	3.76	3.96	No P=.004	Yes P<.01	Yes P<.01
5f) training for caregivers	4.27	3.86	4.08	No P<.01	Yes P<.01	Yes P<.01
5g) low cost	4.11	3.81	3.97	No p=.009	Yes P<.01	Yes P<.01

*The significance level is .05

Given that all the items in Question 5 have p-values of less than .05, there is significant evidence to suggest all aspects of technology mentioned in the survey are important to the respondents. The three items with the highest overall scores are 'pictorial support' (4.24), 'verbal support' (4.22) and 'training for caregivers, teachers and family members' (4.08). These items are also the top three choices for both groups when analysed separately. Out of the three items, healthcare professionals and game designers agreed on 'pictorial support'. This suggests that fitness games should have simple graphics and a colourful, clear and forgiving interface.

In order to understand the features of technology in fitness games from a high-level perspective, the seven survey items are grouped into three categories: technology features

(5a, 5b, 5c, 5d, 5e), life-skills (5f) and cost (5g). The grouping is conducted according to the meaning of each survey item. The average score of the first category is 3.93, the average of the second category is 4.08 and the average of the third category is 3.97. This research shows that technology in fitness games requires responsive features, sufficient life-skills support and have a low cost.

The range of scores is wide in the first category: the highest item (5a) is 4.24 and the lowest item is 3.68 (5d). The item 5b in the first category also has a very high score of 4.22. Because the second and third categories only have one item in each, the ranges are not discussed. The scores suggest the most important features of technology in fitness games are pictorial support, verbal features, teaching life-skills and low cost.

Among the five technology features, 'pictorial support' (4.24) and 'verbal support' (4.22) had much higher scores. These items were the only ones that game designers scored higher than 4. This result reveals that they thought these two features were most effective as well as the easiest to implement. Meanwhile, healthcare professionals emphasized life-skills and the cost of fitness games, pointing out the pictorial issue of adopting such games. Interestingly, healthcare professionals outranked game designers in every item in this survey question. Given that all the answers are significantly more than 3, two groups of people saw the importance of such technology features and both parties intended to put them into practice.

Overall, the hypotheses raised towards technology features have been tested to be true. From the survey data analysis, pictorial and verbal features of technology have been reviewed as most effective for fitness games whereas life-skills and low costs are highly valued by the healthcare professionals.

A survey respondent suggested that the games could 'have an alarm to call caregivers if users need help'. Another respondent asked for a feature that added 'colour changes for those who may also be colour blind'. Many survey respondents said that technologies should be chosen 'depending on the aim of the game and the needs of the player'. Game designers should 'keep all disabilities in mind'. Participants suggested that games should have 'customisable assistance tailored to specific genres of disability'.

Item 5a: Technology providing pictorial support for clear feedback.

This item has the highest combined score of 4.24. Healthcare professionals gave similar responses to game designers, 4.30 and 4.17 respectively. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Item 5b: Technology providing verbal features such as music and sound (clapping).

This item has a combined score of 4.22 which was the second highest overall. Healthcare professionals scored this at 4.35 and game designers at 4.06. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Item 5c: Technology providing tactile support such as touch screen.

For this item, the combined score was 3.96. Healthcare professionals scored 4.13 and game designers scored 3.76. The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

Item 5d: Technology providing non-tactile features such as eye movement recognition.

For this item, the combined score was 3.68. Healthcare professionals scored 3.75 and game designers scored 3.60. This item has the lowest scores overall. However, non-tactile technology has been used by many big companies such as Kinect and Wii, and it has proven to be successful in terms of encouraging users to carry out more physical activities.

Item 5e: Technology that incorporates real-world interaction into the game world.

The combined score of this item is 3.86. Healthcare professionals scored this at 3.94 and game designers at 3.77. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

One respondent mentioned that 'involving staff and parents with games would be good'.

Item 5f: Technology providing specific training for caregivers, teachers and family members.

This item has the third highest combined score of 4.08. Healthcare professionals scored 4.27 and game designers scored 3.86. The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

One respondent said that 'family and healthcare professional training should be a separate application or product'.

Item 5g: Technology that has low cost.

The combined score for this item was 3.97. Healthcare professionals scored 4.11 and game designers scored 3.81. The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

One participant commented that 'it should be accessible to everyone, so low cost is important'. Similarly, another participated suggested that 'cost is quite important to these families but it shouldn't be too much of a limitation'.

6.2.6 Motivations of fitness games

The last question 'motivation' discusses the intrinsic motivation that is provided by fitness games. Table 24 and Table 25 summarise the survey results.

Table 24. Items that have similar answers across groups (Motivations)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Combined
6b) play with others	3.90	3.96	3.93	Yes p=.535	Yes P<.01
6c) meet new people	3.93	3.95	3.94	Yes p=.345	Yes P<.01
6e) independence	4.28	4.27	4.28	Yes p=.627	Yes P<.01
6f) confidence	4.35	4.47	4.41	Yes p=.609	Yes P<.01

*The significance level is .05

Table 25. Items that have different answers across groups (Motivations)

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined	Mann-Whitney U Tests *	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Healthcare	One-sample Wilcoxon Signed Rank Tests (compared to 3)* Game
6a) compete with each other	3.30	2.71	3.02	No P<.001	Yes P=.028	Yes P=.019 Lower than 3
6d) empowered	4.07	4.46	4.26	No P=.018	Yes P<.01	Yes P<.01
6g) happiness	4.48	4.73	4.59	No P=.012	Yes P<.01	Yes P<.01

*The significance level is .05

When comparing the average score of every item to 3, only one of seven items scored significantly lower than 3. Game designers scored ‘competition between players’ significantly lower than 3. This suggests that game designers are against competition in fitness games. However, the feedback from healthcare professionals averaged at 3.30 which was significantly higher than 3. Healthcare professionals thought that competition was positive in fitness games. On the other hand, 3.30 is still the lowest score that healthcare professionals gave in the entire survey. Thus, even though they thought competition is not a bad thing, it needs to be handled carefully and may not be encouraged as much. In conclusion, competition in fitness game for LD is debatable and should be considered carefully.

The other six items had p-values less than .01 in the One-sample Wilcoxon Signed Rank Test. Survey participants are positive about the benefits in fitness games and they think these results should be encouraged in the development process. The three items with the highest combined scores are ‘happiness’ (4.59), ‘build confidence’ (4.41) and ‘become more independent’ (4.28). All these benefits are examples of intrinsic motivation and were expected to be positive in the survey. Survey respondents agreed with the intentions of using intrinsic motivation in practice.

To understand the different aspects of motivation in fitness games, the seven survey items are grouped into two categories: emotional motivation (6d, 6e, 6f, 6g) and social motivation (6a, 6b, 6c). This grouping is conducted according to the contents and meanings of the items. The average score of the first category is 4.39 and the average of the second is 3.63. The results reveal both main motivation types that fitness games can adopt. The big difference in the average scores indicates that emotional motivation is more encouraged than social motivation.

The score range of the first category is 0.33 with a high score of 4.59 (6g) and a low score of 4.26 (6d). The score range of the second category is 0.92 with a high score of 3.94 (6c) and low score of 3.02 (6a). This result further shows that emotional motivation in fitness games is more effective and less debatable to adopt than social motivation.

All emotional motivation was positively received by both respondent groups. 'Happiness (6g)' received the highest score among all survey items. The other emotional motivations 'empowerment (6d)', 'independence (6e)' and 'confidence (6f)' all had high scores from both survey groups. This result reveals that both game designers and healthcare professionals agree on the emotional effects of fitness games and intend to design such games to help the users become happier, more confident and independent through gameplay.

In terms of the social motivation, there were concerns about 'competition (6a)' in games. Game designers thought that competition might add a negative effect. The other social motivations, 'play with others (4b)' and 'meet new people (4c)', received positive feedback from both groups. This indicates that healthcare professionals and game designers thought it was beneficial for users to interact with others during gameplay. However, the three survey items concerning social motivation had lower scores compared to emotional motivation. This reveals the concern towards exposing vulnerable LD users when introducing group-play games. Supervision from healthcare professionals or family members should be provided, especially when game users have more severe LD (Bouras et al., 1995).

In summary, all but one survey hypothesis tested to be true. Competition in fitness games received doubts from both game designers and healthcare professionals. Other motivation factors in games were viewed as positive and effective. The grouping analysis of the survey items indicates that fitness games should be designed to promote physical exercise as well as emotional benefits including happiness, empowerment, independence and confidence. Social motivation can be adopted to help LD users meet and play with others. However, intense social interaction such as competition should be supervised and only promoted among the users with less severe LD.

The most popular items for healthcare professionals are 'feel happier' (4.59), 'build confidence' (4.41) and 'become more independent' (4.28). Game designers' top choices are 'feel happier' (4.73), 'build confidence' (4.47) and 'feel empowered' (4.46).

One survey respondent gave further support for intrinsic motivation in fitness games by saying 'fitness is best achieved when the participants are subconsciously engaged. The majority of things mentioned in the survey, including exercise, should encourage interaction'.

Item 6a: During gameplay, users compete with each other.

The only item that scored significantly less than 3 was given by game designers. There is no evidence to suggest people reacted positively to this question and the overall opinion is neutral due to the answers given by health professionals.

Some participants commented that they 'like everyone to be a winner so no one gets disappointed and resents using the game' and 'competition should be kept to a no-pressure level'. Although this has some importance and winners are always motivated to carry on playing, this does not necessarily mean that losers are discouraged completely. Vansteenkiste and Deci (2003) suggest the idea that losers of games can in fact be intrinsically motivated if they were offered positive feedback. With that said, fitness games could apply the idea of providing positive responses such as the sounds of applause when users make progress. In addition, users should be encouraged to compete against themselves but not against others. Overall, the survey results suggest that it is best for fitness games to avoid unhealthy competition. However, adding positive feedback in fitness games can help motivate both winners and losers. Because of the special mental conditions of LD users, competition may cause unwanted stress. When users play with others, caregivers or family need to be present to help them avoid unhealthy competition.

Item 6b: During gameplay, users start to play with other users, caregivers, staff and parents.

The combined score of this item was 3.93. Healthcare professionals scored 3.90 and game designers scored 3.96. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

One respondent said end users should 'share their experience of gameplay with family, friends and other service users'.

Item 6c: During gameplay, users meet new people with similar conditions.

The combined score of this item was 3.94. Healthcare professionals scored 3.93 and game designers scored 3.95. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Survey respondents also suggested that ‘connecting with other disabled people is very important’, but ‘it should be optional as they may create more stress’. One expressed concerns that they are ‘not sure how you could allow people to meet other LD people, but that would be good’. Connecting people could be done offline or online. In care homes, fitness games would bring everyone to play together and it is a perfect occasion to get familiar with each other. Fitness games could be set up at playcentres which would allow them to meet new people as a result of the game. For users with mild LD, they could meet others by playing online fitness games.

Item 6d: During gameplay, users feel empowered because they are in control.

The combined score of this item was 4.26. Healthcare professionals scored 4.07 and game designers scored 4.46. The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

To help users feel empowered, one survey respondent suggested ‘creating a sense of freedom and control for a sense of self mastery’. Another said, ‘some people may never be independent, but they should definitely feel empowered and confident as a person’.

Item 6e: During gameplay, users become more independent from people who give assistance.

This is the third highest scoring item with a combined score of 4.28. Healthcare professionals scored 4.28 and game designers scored 4.27. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Item 6f: During gameplay, users build confidence as the game progresses.

This is the second highest item with a combined score of 4.41. Healthcare professionals scored 4.35 and game designers scored 4.47. Both scores are similar so the groups were combined and compared against the midpoint. The result was significantly higher than 3. This evidence provides strong support that this item holds true.

Item 6g: During gameplay, users feel happier.

Throughout the survey, this item had the highest combined score of 4.59. Healthcare professionals scored 4.48 and game designers scored 4.73. The feedback from healthcare professionals and game designers were different and therefore compared to the midpoint value separately. Since each was higher than the midpoint, there is strong enough evidence to support the truth of this item.

6.3 Summary of all items' responses

Looking at the survey items as a whole, the average score was 4.05 which was significantly higher than the midpoint value of 3. This indicates that the design characteristics proposed in this research were received positively by industry professionals. Healthcare professionals generally gave higher scores than game designers. This section discusses the scores given for each item and analyses the survey items as a whole to discuss any correlations.

6.3.1 Average scores and outstanding items

This section discusses the differences and similarities between the average scores of both respondent groups.

Average scores for the individual survey question

The questionnaire addresses each design category with questions and subsections (items). To look at the big picture of game design, the average scores of each question are summarised in Table 26.

Table 26. The average scores of both survey groups for each survey question

	Average scores	The higher group	The lower group	Highest item	Lowest item
Q1	4.09	Healthcare 4.24	Game design 3.93	1c: muscle functions 4.18	1b: express feelings 3.96
Q2	3.92	Healthcare 3.93	Game design 3.92	2b: independent living 4.17	2a: academic skills 3.73
Q3	4.05	Game design 4.06	Healthcare 4.04	3a: users 4.4	3b: family members 3f: design theories 3.83
Q4	4.17	Game design 4.17	Healthcare 4.16	4f: clear interface 4.41	4b: only necessary information 3.96
Q5	4.00	Healthcare 4.12	Game design 3.86	5a: pictorial support 4.24	5d: non-tactile support 3.68
Q6	4.06	Game design 4.08	Healthcare 4.04	6g: happier 4.59	6a: competition 3.02

The average scores reveal the items that each respondent group emphasised with regards to six design categories. Question 4 (mechanics) had the highest average score 4.17, followed by Question 1 (game goals) scoring 4.09, Question 6 (motivations) scoring 4.06, Question 3 (user requirements study) scoring 4.05, Question 5 (technology) scoring 4.0 and Question 2 (types of games) scoring 3.92.

Differences between the survey groups

Table 27 describes the highest and lowest items of each survey question for both survey groups.

Healthcare professionals gave higher average scores for half the survey questions and the other half were scored higher by game designers. The difference between the average scores amongst all four design categories was not significant. However, both groups responded differently to Question 1 and 5. This difference suggests that both groups have some differences in opinion and further communication is required.

In each question, both respondent groups had various opinions about the items with highest and lowest weights. Interestingly, the responses for Question 1 were completely different which indicates that the game producers and end users might have contradictory expectations of fitness games. Question 5 and 6 had the exact same responses from both groups which confirms the design characteristics proposed in this research.

Table 27. The highest and lowest items of each survey question for both survey groups

	The higher group	The lower group	Highest item in healthcare	Highest item in game design	Lowest item in healthcare	Lowest item in game design
Q1	Healthcare 4.24	Game design 3.93	1c: muscle functions 1g: social connections 4.38	1e: decrease anxiety 4.15	1e: decrease anxiety 4.11	1g: social connections 3.5
Q2	Healthcare 3.93	Game design 3.92	2b: independent skills 4.2	2c: cognitive abilities 4.23	2a: academic skills 3.54	2e: group-play 3.6
Q3	Game design 4.06	Healthcare 4.04	3a: users 4.24	3a: users 4.58	3f: design theories 3.86	3b: family 3.64
Q4	Game design 4.17	Healthcare 4.16	4e: accommodate preferences 4.35	4f: clear interface 4.65	4c: allow mistakes 3.89	4d: repetitive play 3.9
Q5	Healthcare 4.12	Game design 3.86	5a: pictorial support 4.3	5a: pictorial support 4.17	5d: non-tactile support 3.75	5d: non-tactile support 3.6
Q6	Game design 4.08	Healthcare 4.04	6g: happier 4.48	6g: happier 4.73	6a: competition 3.3	6a: competition 2.71

6.3.2 Items that had similar responses from both survey groups

Both survey groups gave similar responses to 19 items. This agreement means that the design characteristics based on these items can be applied to game design practice with reasonable confidence.

Table 28 presents the items with similar responses from both survey groups.

Question 1: both groups of experts came to an agreement that such games should have physical as well as emotional benefits.

Question 2: games that train LD users with life-skills should be explored.

Question 3: end users and conduits should be involved in the beta-testing phase.

Question 4: easy rules and repetitive game mechanics are helpful.

Question 5: pictorial support, non-tactile features and real-world interaction should be beneficial.

Question 6: social motivation and autonomy motivation appeal to LD users.

Table 28. Items that had similar responses from both survey groups

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined
Question 1			
1a) Make movement freely	4.13	4.04	4.09
1d) physical exercise	4.26	4.06	4.17
1e) decrease anxiety and depression	4.11	4.15	4.13
1f) improve self-esteem	4.26	4.05	4.16
Question 2			
2b) life-skills for independent living	4.20	4.13	4.17
Question 3			
3c) inputs from healthcare professionals	4.14	4.15	4.14
3f) game design theories	3.86	3.80	3.83
3g) inclusive design principles	4.12	4.38	4.24
3h) previous design experiences	3.95	3.73	3.84
3i) user observation	4.10	4.34	4.21
Question 4			
4a) make the rules easy	4.42	4.21	4.32
4d) repetitive play	4.03	3.90	3.97
Question 5			
5a) pictorial support	4.30	4.17	4.24
5d) non-tactile features	3.75	3.60	3.68
5e) real-world interaction	3.94	3.77	3.86
Question 6			
6b) play with others	3.90	3.96	3.93
6c) meet new people	3.93	3.95	3.94
6e) independence	4.28	4.27	4.28
6f) confidence	4.35	4.47	4.41

6.3.3 Items that had different responses from both survey groups

Both survey groups had different responses to 23 items. This is slightly more than the amount of items with similar responses. Because the healthcare professionals' opinions can reflect the needs of LD users, the disagreement between them and the game designers indicates that the needs of LD users (i.e. the market expectations) and the game designer's visions are divided. More communication is needed to make the games more suitable. However, almost all items have positive feedback which means these design characteristics are beneficial and can be used in practice.

Table 29 describes the items with different responses from both survey groups.

Question 1's responses show that healthcare professionals value the emotional and social benefits of fitness games more than game designers. This difference in opinion indicates that game designers should communicate more with potential buyers before developing products.

Question 2 indicates that the market and product makers have not come to an agreement about potential games that would be good for LD users. More research is required in this field.

Question 3 reveals that game designers expected to have direct contact with the end users whereas healthcare professionals recommended using conduits such as family members and teachers. In practice, this is a case by case problem which needs to be dealt with depending on the user's conditions. Game designers should consider alternative means to communicate with end users, like using a proxy as suggested by the healthcare professionals.

Question 4 had four items with different responses from the experts. All four items had high scores, it can be interpreted that these characteristics of fitness games will be implemented with good results. On the other hand, game designers might have overlooked the ability to modify the game according to user preferences.

Question 5 reveals the fact that healthcare professionals emphasized verbal and tactile features of fitness games. They also pointed out that additional training should be provided to caregivers and family members.

Question 6 emphasizes the split opinions with regards to the use of competition in fitness games. Healthcare professionals thought it could be a good thing under careful management whereas most game designers thought it would be best to completely avoid competition.

Table 29. Items that had different responses from both survey groups

Item	Mean of Healthcare	Mean of Game	Mean of both groups combined
Question 1			
1b) express feelings and emotions	4.14	3.75	3.96
1c) muscle functions	4.38	3.96	4.18
1g) build social connections	4.38	3.50	3.97
Question 2			
2a) academic studies	3.54	3.95	3.73
2c) cognitive abilities	3.89	4.23	4.05
2d) rehabilitation from injuries	3.98	3.71	3.85
2e) group-play	4.02	3.60	3.82
Question 3			
3a) inputs from users	4.24	4.58	4.4
3b) inputs from family members	3.99	3.64	3.83
3d) inputs from education professionals	4.00	3.79	3.9
3e) theory on human movements	4.08	3.85	3.97
3j) testing prototypes	3.95	4.35	4.14
Question 4			
4b) convey necessary information	4.06	3.83	3.96
4c) allow mistakes	3.89	4.35	4.11
4e) accommodate user preferences	4.35	4.06	4.22
4f) offer clear interface	4.20	4.65	4.41
Question 5			
5b) verbal features	4.35	4.06	4.22
5c) tactile features	4.13	3.76	3.96
5f) training for caregivers	4.27	3.86	4.08
5g) low cost	4.11	3.81	3.97
Question 6			
6a) compete with each other	3.30	2.71	3.02
6d) empowered	4.07	4.46	4.26
6g) happiness	4.48	4.73	4.59

6.3.4 Correlation between items

Some correlations can be seen between the items across all six questions. The correlations between items were evaluated using the Spearman Rank-Order Correlation Coefficient test. If the p-value was smaller than .05, there was enough evidence to support a significant correlation between two items. This test was chosen because the survey data was not normally distributed.

Question 1 item 'allow users to express feelings and emotions in movements' and Question 6 item 'feel happier' are correlated. This means the survey respondents thought emotional benefits of fitness games is helpful to make users feel happier.

Question 1 includes a purpose of fitness games: increasing the 'self-esteem' of the users. In order to achieve this, Question 6 items: empowerment (6d), independence (6e), confidence (6f) and happiness (6g), were strongly correlated. The results of the Spearman Rank-order Correlation Coefficient test are shown in Table 30 below. This suggests game designers should work on the intrinsic benefits of fitness games in order to trigger the autonomy need of the users.

Table 30. Correlations between increased self-esteem and other motivations

	6d	6e	6f	6g
Correlation Coefficient	.262**	.240**	.232**	.291**
Sig. (2-tailed)	0	0	0	0
** Correlation is significant at the 0.01 level (2-tailed).				

Another purpose of fitness games that is discussed in Question 1 is 'help users build social connections'. The survey results show that this is significantly correlated with competition (Question 6, Item 6a), interaction with others (Question 6, Item 6b), meeting new people (Question 6, Item 6c), independence (Question 6, Item 6e) and happiness (Question 6, Item 6g). Table 31 contains the correlation coefficient and significance values of these items. It can be interpreted from this result that competition is an essential part of social interaction as it can bring satisfactory results.

Table 31. Correlations between 'building social connections' and other motivations

	6a	6b	6c	6e	6g
Correlation Coefficient	.191**	.135*	.210**	.187**	.135**
Sig. (2-tailed)	0.003	0.039	0.001	0.004	0.019
* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).					

Overall, the survey data has provided evidence that emotional and social effects of fitness games are important to intrinsically motivate users. Game designers intend to build self-esteem, independence and empowerment for users through gameplay. Group-play and healthy competition are proposed to be added to fitness games to increase social interaction.

6.3.5 Correlation between the answers and user LD levels

For the purposes of this study, the LD spectrum has been categories into four levels of severity from least to most: mild, moderate, severe and profound. During the survey, healthcare professionals identified the LD severity level they are most familiar with and answered the survey accordingly. To study whether the game end users with different levels of LD would require different characteristics in games, the Spearman Rank-order Correlation Coefficient test was used.

The Spearman Correlation test suggested that no correlation exists between answers and LD levels. Table 32 provides an example of how no correlations exist between LD levels and survey responses for Question 1. This result shows that the design characteristics that are discovered in this research are applicable to all levels of LD.

Table 32. Correlations between the LD level with other survey answers

	1a	1b	1c	1d	1e	1f	1g
Correlation Coefficient	-.014	.039	.042	-.047	.023	-.028	.0.024
Sig. (2-tailed)	0.877	0.675	0.651	0.610	0.800	0.756	0.792

6.3.6 Correlation of the answers with respondent backgrounds

At the start of the survey, respondents were asked to fill in some personal information that may influence their answers. The questionnaires that were distributed to the healthcare and game design industry had slightly different questions about the personal information.

Healthcare professionals were asked to identify their job role from the following options: general practitioner, nurse, psychologist, physical therapist, occupational therapist, support worker, primary caregiver, social worker, parent, guardian, teacher, teaching assistant, SENCO, researcher, charitable help or manager of health care services. Next, they were asked about the duration that they had worked in that role: 2 years or less, 3-5 years, 6-9 years or 10 years or more. Lastly, they were asked about the level of LD they mostly work with: mild, moderate, severe or profound.

Game designers were asked different background questions. Like healthcare professionals, they were asked about the duration they have worked in the industry and their job titles. They could choose from: programmer, graphic designer, manager or producer. Additionally, they needed to choose the type of game company they worked for: gaming system constructor, game developers (studios), publishers or test labs.

Correlation between the respondents' industries and their answers

The Spearman Rank-order Correlation Coefficient test was conducted to find correlations between the respondents' sectors and their answers to each question.

In Question 1 (Table 33), all three correlations are negative, implying that the respondents from the game design industry marked items 1b, 1c and 1g higher than the healthcare professionals.

Table 33. The items with correlations in Question 1

	1b	1c	1g
Correlation Coefficient	-.198**	-.259**	-.402**
Sig. (2-tailed)	0.002	0	0
** Correlation is significant at the 0.01 level (2-tailed).			

As seen in the tables below (Table 34, Table 35, Table 36, Table 37 and Table 38), some items have either positive or negative correlations. The only exception exists in Question 5 where the correlations are all negative. Like Question 1, the healthcare professionals thought less of those design characteristics that are associated with technology in the fitness games. Overall, there is no pattern between the respondents' industries and their answers.

Table 34. The items with correlations in Question 2

	2a	2c	2d	2e
Correlation Coefficient	.136*	.165*	-.157*	-.206**
Sig. (2-tailed)	0.037	0.012	0.016	0.002
* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).				

Table 35. The items with correlations in Question 3

	3a	3b	3d	3e	3h	3g
Correlation Coefficient	.202**	-.149*	-.144*	-.155*	-0.119	.167*
Sig. (2-tailed)	0.002	0.022	0.028	0.018	0.07	0.011
** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).						

Table 36. The items with correlations in Question 4

	4b	4c	4e	4f
Correlation Coefficient	-.143*	.148*	-.193**	.250**
Sig. (2-tailed)	0.028	0.023	0.003	0
* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).				

Table 37. The items with correlations in Question 5

	5b	5c	5f	5g
Correlation Coefficient	-.211**	-.192**	-.262**	-.172**
Sig. (2-tailed)	0.001	0.003	0	0.009
** Correlation is significant at the 0.01 level (2-tailed).				

Table 38. The items with correlations in Question 6

	6a	6d	6g
Correlation Coefficient	-.264**	.156*	.165*
Sig. (2-tailed)	0	0.017	0.011
** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).			

Correlation between the respondents' work duration and their answers

The survey respondents were asked to choose the duration they have worked in their respective industry from the following options: 2 years or less, 3-5 years, 6-9 years or 10 years or more. The Spearman Rank-order Correlation Coefficient test was used to identify any correlation between their work duration and answers.

After testing the respondents' years of working with their answers, no correlation could be found throughout the entire survey. Therefore, tenure within respective industries had no significant impact on their answers.

6.3.7 Potential biased data

Looking at the entire dataset, some anomalies were identified. Out of 114 game designers, only 5 people were recruited outside of game events. Out of 131 healthcare professionals, only 8 were approached outside of care homes. Analysing this data alongside the rest of the dataset could cause bias (Rubin, 1997).

At the beginning of the analysis, these anomalies were included in the whole dataset for statistical analysis presented in the thesis. However, to remove any bias, the anomalies were removed before reanalysing the rest of the dataset. However, no significant difference was shown between the before and after analysis results. On the other hand, the same statistical tests were carried out for the anomalies alone and did not show any significant difference between these responses from the rest of the dataset. This indicates that the data analysis findings presented in this chapter are generalizable.

6.4 Analysis findings: key characteristics

Combining the analysis of the survey data, this research reveals the design characteristics of fitness games for the LD market. This section summarises the findings from the survey results focused on the six categories of fitness games design: purpose, types, user requirements study, mechanics, technology and motivation. The differences between two respondent groups are highlighted in this section.

6.4.1 Design characteristics of fitness games in six categories

The design characteristics of fitness games are discovered after analysing the survey feedback from 245 respondents. Almost all the design characteristics proposed in the questionnaire were approved by both game designers and healthcare professionals. The data indicates that game designers would satisfy these characteristics when designing fitness games for LD.

The purposes of fitness games

For fitness games targeted at LD users, there is significant evidence to support all the proposed purposes. These purposes include physical goals such as 'motivate users to carry out physical exercise' and 'help users to make movements freely' as well as emotional purposes 'decrease user anxiety and depression' and 'help users build social connections'.

Other types of games for LD

The data has provided evidence that all the game types in the questionnaire are welcomed by the market. Both healthcare professionals and game designers agreed that LD users would benefit from games that support learning abilities, teach life-skills, enhance cognitive abilities, help rehabilitation and promote group interaction.

However, the scores for the items in this question are lower in comparison to other questions. This means that the survey respondents might have some concern about the game types, indicating that more research is needed about the types of game that the LD market might require.

User requirements study of fitness games

All the methods proposed to conduct a user requirements study were effective. Survey respondents thought that 'potential users' and 'health and social care professionals' are the best people to take inputs from. The highest ranked user requirements were 'inclusive design theories', 'observations of potential users' and 'testing game prototypes'.

Mechanics of fitness games

All the features of the game mechanics had positive feedback. The three items with highest scores are 'a clear interface', 'easy rules' and 'settings that accommodate user preferences'.

Technology of fitness games

All the aspects of technology mentioned in the survey are important to the respondents. The three items with highest overall scores are 'pictorial support', 'verbal support' and 'training for caregivers, teachers and family members'.

Motivations in fitness games

There is one design characteristic that was not approved by the experts. The item 'competition' scored 2.71 by game designers, indicating that game designers were against competition in fitness games. Therefore, competition in fitness game for LD is debatable and should be considered carefully.

Other types of motivation in fitness games had positive feedback from the experts. The three items with highest combined scores were 'feel happier' (4.59), 'build confidence' (4.41) and 'become more independent' (4.28). Both groups of participants also gave high scores for these three items. All these benefits have intrinsic motivation.

6.4.2 Comparison between both survey respondent groups

Looking at the survey data from both respondent groups, 23 survey items had different answers while the other 19 had similar answers. The differences tend to be about the emotional and social effects of fitness games. This divided opinion between both groups of experts indicates that more communication is required: the game designers need to listen to the requirements of potential buyers; and the healthcare professionals need to be more supportive and realistic about the products.

The purposes of fitness games

There are some survey items that game designers did not respond as positively to as the healthcare professionals. These include the emotional purpose to 'allow users to express feelings and emotions in movements' and social purpose to 'help users build social connections'. Game designers seem to have neglected the emotional and social purposes to some extent which need to be taken into account when designing fitness games for LD.

Other types of games for LD

Games that 'help rehabilitation' and 'promote group interaction' were valued more by healthcare professionals than game designers. On the contrary, game designers gave higher scores for games that 'support learning abilities' and 'enhance cognitive abilities'.

User requirements study of fitness games

In terms of the people that should be involved in the user requirements study, game designers and healthcare professionals gave scores of 4.58 and 4.24 respectively for getting input from 'potential users'. This indicates that although healthcare professionals acknowledge the importance of user involvement, they are more aware of the difficulty in practice. The best ways for game designers to study user requirements should be through inclusive design principles, user observations and prototype testing.

Mechanics of fitness games

Healthcare professionals gave their highest score to 'easy rules' and game designers marked 'clear interface' highest. This means that when considering the features of game mechanics, healthcare professionals emphasized simplicity with the rules whereas game designers favoured emphasis on clear interfaces.

Technology of fitness games

Opinions on technology used were more unified. Both respondent groups gave the highest scores for the three items (5a, 5b, 5f). On the other hand, out of the three items, they only gave a similar answer to one item (5a). Looking at the seven items in this question, healthcare professionals outranked game designers in every item.

Motivations in fitness games

In terms of motivation in fitness games, both sets of experts had similar opinions. Four out of seven motivations were agreed by both respondent groups. Both groups of participants also gave highest scores for the same three items.

6.5 Summary

This chapter presents the questionnaire-based survey study and its analysis results. 245 game designers and healthcare professionals took part in the survey and shared their opinions about fitness game design by answering a questionnaire. After analysing the survey results, this research reveals the design characteristics of fitness games from six categories: purposes, types, user requirements study, mechanics, technology and motivation. These research findings are applicable to all levels of LD because no correlation could be found between the LD levels the respondents referred to and their answers.

7. Chapter Seven: Discussion

This chapter discusses the findings from the analysis of the qualitative and quantitative datasets. The discussion includes the links between qualitative and quantitative studies, as well as contribution of this research to theory and practice.

7.1 Integration of the qualitative and quantitative findings

After comparing the findings from qualitative and quantitative analysis, it became clear that most of the quantitative data supported the qualitative findings. Almost all survey items that originated from qualitative findings had positive responses from the participants. This result shows that the findings from both stages complement one another, and the design characteristics proposed in this research can be applied with reasonable confidence to the design of fitness games for LD users.

Perhaps the greatest difference between the qualitative and quantitative findings was the aspect of competition. Somability encouraged users to compete in a game to produce flowers on the screen by clapping their hands; the user with louder clapping would product more flowers. Somability demonstrated a successful attempt at applying competition to motivate users to partake in physical activity. However, survey respondents, in particular game designers, thought that competition among LD users should be limited. One survey respondent commented on the questionnaire saying 'I like everyone to be a winner. So no one gets disappointed when playing the game'. This worry is reasonable because research has shown that competition in games drives end users to more goal-oriented behaviour, which has been tested to have a negative effect on social and physical engagement (Bianchi-Berthouze, et al., 2007). Besides, an end user who is behind in an unbalanced competition might quit when the other person's lead is overwhelming (Campbell, et al., 2008).

Although winners are always motivated to carry on playing, this does not necessarily mean that losers are discouraged completely. The losers of games can be intrinsically motivated if they were offered positive feedback (Vansteenkiste and Deci, 2003). With that said, fitness games could apply the idea of providing positive responses such as the sounds of applause when users make a progress. Users should be encouraged to compete against themselves but not against others. In addition, designers can motivate users to play the game by using methods other than competition, for example, the enjoyable experience of freely exploring the virtual game environment (Mokka, et al., 2003).

Overall, the research suggests that it is best for fitness games to avoid unhealthy competition. However, adding positive feedback in fitness games can motivate both winners and losers. A user with LD should be guided to compete with him/herself.

7.2 Theoretical contribution to the literature

With an emphasis on designing for LD users, this research contributes to literature by making a theoretical connection between fitness game design and inclusive design. This section explains the study's contribution to literature in both areas.

7.2.1 Contribution to the literature on game design

This research identifies and describes six key design categories for fitness games that are critical for designing fitness games targeted at LD users. The design characteristics are initially identified after an empirical case study through which the insights of game designers and end users were collected. These characteristics along with the design guidelines in existing literature were combined to develop a survey. This survey was then administered to game designers and healthcare professionals. The design characteristics proposed in this study have brought together game design literature and inclusive design principles. This shows the importance of contextualization and clarification of general game design principles when designing for LD users. In particular, the findings have implications for literature on game design process models, fitness game design guidelines and motivation theories.

7.2.1.1 Fitness game design process model for LD users

Even though Rouse III (2010)'s three-step process model is a practical guideline for traditional game design, it does not specify how this can be adapted to fitness game design, specifically to the LD domain. The findings of this research clarifies this process model in an LD context.

In the conceptual outline phase, Rouse III (2010) points out that game designers should learn about the end user requirements and thus decide a game's pace, challenges and rewards. For fitness games in an LD context, the primary user requirements are: 'motivate users to carry out physical exercise', 'help users to make movements freely', 'decrease user anxiety and depression' and 'help users build social connections'. To dig deeper into the user requirements and make fitness games more suitable for individual cases, this research proposes conducting a user requirements study through the involvement of 'potential users' and 'health and social care professionals'. Additionally, the study identifies the three most efficient ways to learn user requirements are via 'inclusive design theories', 'observations of potential users' and 'testing game prototypes'.

In the implementation phase, designers choose the most suitable mechanics and technology to provide meaningful play (Rouse III, 2010). Taking into consideration the abilities of LD users, this study offers guidance to design meaningful fitness games that require minimum input. Amongst all the design characteristics that help simplify fitness games, the top three are 'a clear interface', 'easy rules' and 'settings that accommodate user preferences'. In terms of technology, fitness games should come with 'pictorial support', 'verbal support' and 'training for caregivers, teachers and family members'.

In the outcome phase, a game brings end users joy, challenges, social interaction and emotional experiences (Rouse III, 2010). This research focuses on the outcomes in fitness games that trigger users intrinsically and benefit them in the long-term. The findings reveal that 'happiness', 'confidence', 'independence' and 'social connections' are the most desired outcomes in fitness games.

7.2.1.2 Fitness game design guidelines in an LD context

By comparing this study's findings with the literature discussed in Chapters Two and Five, we note that this dissertation expands the existing game design guidelines into six design areas by theoretically clarifying what they mean in an LD context.

In terms of the purposes of fitness games in an LD context, the literature emphasizes motivating physical exercise (Lotan, et al, 2009), decreasing anxiety levels (Lotan, et al, 2009) and improving self-esteem (Hutzler and Korsensky, 2010). This research discovers that game designers and healthcare workers expect functionality that gives the end users freedom within the game. This allows the users to build social connections and express emotions. The findings of the research reveal the importance and effectiveness of the emotional benefits of fitness games and point out the fact that these emotional benefits might have been neglected by game designers. The findings enrich the existing game design guidelines by introducing beneficial emotional fitness game objectives that include improving self-esteem, encouraging emotional expressions and building social connections.

With regards to other types of games that are effective in an LD context, this research verifies five types of games: academic (Maccini et al, 2002), life-skills training (Standen and Brown, 2005), cognitive (Standen and Brown, 2005), rehabilitative (McCallum, 2012) and group-play (McCallum, 2012). Experts agree that fitness games can borrow concepts from these games and enrich the design. The current game design guideline literature is enhanced by the introduction of additional functions including essential life-skills training and academic knowledge training.

Literature identifies that the following suitable user groups for user requirements studies: potential end users (Hutzler and Korsensky, 2010; Newell, et al., 2011; Nicolle and Abascal, 2001), family members (Kafai and Kafai, 1995), healthcare professionals (Hutzler and Korsensky, 2010; Newell, et al., 2011) and education professionals (Annetta, 2010). This research confirms the effectiveness of these sources and points out the importance of including the end users in all stages of the game's development. This can be done via interviews, observations and prototype testing. This research also suggests that the absence of LD user input can be replaced by input from social support workers such as caregivers and school teachers. In terms of the means to study user requirements, the literature identifies video game design theory (Werbach and Hunter, 2012), designer's previous experience (Newell, et al., 2011) and prototype testing (Newell, et al., 2011). This study enriches the user requirements study sources including physical movement, inclusive design principles and observations of potential end users in their daily lives. The inclusive design principles are a particularly useful source for the game designers as making games for LD users is a very niche and challenging task. Borrowing concepts from inclusive design practice can help game designers avoid potential pitfalls by adjusting games to suit the needs of the users. Section 7.2.2 discusses a combination of inclusive design principles and game design guidelines.

When it comes to the mechanics used in fitness games, the literature proposes making the game rules easy (McCallum, 2012), making games only convey necessary information (Mace, 1997), allowing repetitive play (Coles, et al, 2007) and accommodating user preferences (Yalon-Chamovitz and Weiss, 2008). This research confirms the effectiveness of these mechanics. The research further propose that the rules of fitness games should be easy and forgiving so that they allow users to make mistakes. The game interface should be clear and colourful. The game design literature is further enhanced by clarifying the difficulty level of the game rules and the interface layout.

With regards to technology that is associated with fitness games, the literature suggests that technology should provide pictorial support (Nicolle and Abascal, 2001), tactile support (Chen and Downing, 2006) and additional training (Hutzler and Korsensky, 2010). Literature also suggests incorporation of real-world interaction into the game world

(Coles, et al, 2007). This research additionally verifies that technology offering verbal features, non-tactile features and low cost is welcomed in industry. This research enhances the literature and confirms that pictorial and verbal features are most effective for fitness games when it comes to assisting LD users. The literature is complemented by stressing the importance of additional training and low cost for fitness games.

In terms of fitness game motivation, the literature points out that games bring people together (Hutzler and Korsensky, 2010), make end users feel empowered (McCallum, 2012) and build a user's confidence (Yalon-Chamovitz and Weiss, 2008). This research adds a further point which is that fitness games can help LD users be more independent. In addition to this, the research points out that competition in fitness games comes with both positive and negative effects and should be handled with caution. Game design literature is enhanced by clarifying the usage of social interaction depending on the user's conditions. People with less severe LD can be encouraged to carry out group-play and competitive games; people with more severe LD should be supervised when interacting with other players. More importantly, this research links these gameplay results with the Self-Determination Theory (Deci and Ryan, 2002) and provides guidance to design fitness games that trigger an end user's intrinsic motivation.

In conclusion, the research findings expand existing design characteristics and identify new ones. In the survey findings, these design characteristics are first analysed individually to understand their effectiveness. They are then combined to reveal meaningful groups of similar design characteristics that highlight the positive design characteristics that have been neglected. These include, for example, the emotional benefits of fitness games and the adoption of inclusive design principles. This grouping also helps identify the main directions for improvement in each of the six design categories, for example, the two additional game functions that fitness games can draw concepts from. The aggregate exploration allows comparison between the design characteristics within the same group as well as among the groups within each design category, revealing the design characteristics with less positive scores. For example, social motivation in games had lower scores when compared to emotional motivation. Comparing this with the data from the experts who participated in the interviews and observations, it is possible to suggest that the adoption of social motivation might have negative effects under certain conditions, such as the severity of LD. Because the quantitative data (see section 4.3.5) reveals that the adoption of social motivation might result in negative outcomes, and the qualitative data (see section 6.2.6) suggests that social activities tend to be less beneficial to people with more severe LD, it can be concluded that social motivation needs to be adjusted according to the users' LD level, such that they should be more restricted as the user's LD become more severe.

7.2.1.3 Motivations in fitness games in an LD context

The research introduces the concept of intrinsic motivation in fitness games for LD users. It does so by drawing from Self-Determination Theory (Deci and Ryan, 2002), motivation theories and game design guidelines to suggest ways in which intrinsic motivation can be assessed during gameplay. With regards to intrinsic motivation, the findings highlight the important and sensitive topic of the use of competition in fitness games and point out that it should be handled with caution.

In contrast to traditional fitness games that often apply extrinsic motivation such as points and rewards, this research highlights the functions of intrinsic motivation in games. From the case study and the survey, experts have recognized the importance of providing happiness, independence, confidence and social connections in fitness games. According to Self-Determination Theory (Deci and Ryan, 2002), these gameplay results would meet end users' autonomy and relatedness needs to intrinsically motivate them to carry on playing. In comparison to extrinsic motivation, intrinsic motivation has been tested to be more long-lasting and meaningful (Deci and Ryan, 2002).

This research highlights the effects of intrinsic motivation on end users. By exercising in a relaxed and assistive environment, LD users can become healthier and more confident. In terms of social benefits, fitness games can accelerate interaction between end users by adding a group-play option. In this way, LD users can interact with other LD users, family and friends.

This research also highlights the uncertain role of competition in fitness games, in contradiction to literature. Based on the survey data, there were differences in opinion between game designers and healthcare professionals with regards to the importance of competition. Game designers were against competition while healthcare professionals thought competition was not a bad thing. However, both groups of experts gave the item concerning competition the lowest scores in the entire survey. Therefore, when targeting LD users, competition in games is a debatable topic and should be implemented carefully.

In the earlier interviews, some caregivers showed a positive attitude towards competition in Somability because they saw the users being motivated. Similarly, healthcare professionals that participated in the survey marked the 'competition' item 21.8% higher than the game designers. Looking at the survey, healthcare professionals marked higher than game designers in 26 out of 43 items. Therefore, there was a slight tendency that healthcare professionals would give a higher score for the competition item. However, they only marked 7.4% higher on average than game designers for the other survey items. The difference in this item shows that the opinion is somewhat divided between both respondent groups.

Generally, competition in games brings end users higher enjoyment (Vorderer, et al., 2003). On the other hand, winners tend to have higher levels of intrinsic motivation than losers (Vallerand, et al., 1986). Everyone has a different level of competitiveness and the higher that level is, the more that individual would favour fitness games in a competitive setting (Song, et al, 2013). Therefore, the inclusion of competition factors in fitness games should be carried out after carefully considering the users' backgrounds. This is especially important when designing for users with low ability or low self-efficacy because competition in games is likely to be stressful and do more damage than good (Macvean and Robertson, 2013).

Other literature suggests that cooperative fitness games are more effective than competitive ones when it comes to weight control (Staiano, et al., 2013). Peng and Hsieh's (2012) research pointed out that cooperative games lead to greater effort put into a game than competitive games. Cooperative games are more effective when playing with friends with regards to goal commitment (Peng and Hsieh, 2012). Especially in an LD context, group-play games should have more positive effects as they can change the isolated situation that LD people face (McCallum, 2012).

In summary, fitness games provide intrinsic motivation to LD users by meeting their autonomy and relatedness needs. The competition in games can intrinsically motivate the users but this depends on their background. The more a person favours competition, the more likely they will enjoy this setting (Song, et al, 2012). To make a game motivating, both the winners and losers should be offered positive feedback (Vansteenkiste and Deci, 2003).

7.2.2 Contribution to the literature on inclusive design principles

The seven inclusive design principles are the most commonly adopted design guidelines for making products that target disabled customers (Normie, 2005). The findings of this research conceptually enrich these inclusive design principles and clarify each principle in the context of designing for LD users.

Principle 1: Equitable use - the design is useful and marketable to people with diverse abilities.

Fitness games are effective when promoting physical exercise for LD users. This study reveals that experts from game design industry and healthcare industry have recognized the importance of fitness games for this purpose. When designed properly, fitness games can be fun and easy to use. Additionally, the technologies associated with body sensors and virtual reality are developing rapidly which makes fitness games more accurate and affordable. Therefore, fitness games are marketable in the LD domain.

Principle 2: Flexibility in use - the design accommodates a wide range of individual preferences and abilities.

LD include four distinctive levels and sometimes are associated with other diseases such as epilepsy and autism (Hardie and Tilly, 2012). To accommodate the users' various abilities, fitness games should be designed with the option to change the difficulty level. In addition, the freestyle mode is a good opportunity for the end users with high mobility. In terms of accommodating the end users' preferences, this research suggests that fitness games should be able to change the game interface.

Principle 3: Simple and intuitive use - use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

LD users have varied ability to understand and undergo physical exercise. Designing for this user group should start from conducting a thorough user requirements study. This research suggests the methods to design for this user group by focused on their specific requirements. For instance, the research results emphasize simplifying fitness games. The findings suggest that fitness games with minimum rules, clear interfaces and assistive technology would be easy to use, especially for LD users.

Principle 4: Effective delivery of information - the design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

This research provides evidence that it is important for fitness games to have a clear interface and assistive technology. The game interface should have bright colours to catch the attention of the user and have large icons that are easy to interact with. The assistive technology in games should provide external support such as voice and touch, as well as training for caregivers or family members. Another feature of technology that should be adopted in an LD context is to distinguish human movements from machine movements. This is because some end users use wheelchairs or other equipment to help with movement. Meanwhile, the technology should be sensitive enough to detect user's interactions, but also be forgiving for their mistakes.

Principle 5: Tolerance for error - the design minimizes hazards and the adverse consequences of accidental or unintended actions.

Fitness games should always be played with other people on site to keep them safe. This is also a good opportunity for the end users to bond with their family and caregivers. Besides, some survey respondents pointed out that an alarm is necessary for fitness games. The end users can send messages to others when there is potential danger.

Principle 6: Low physical effort - the design can be used efficiently and comfortably with minimum fatigue.

The biggest objective of fitness games is to promote physical exercise. However, this needs to be done in a comfortable way to reduce fatigue as a result of repetitive movements. This research identifies design guidelines that make games easy to use. Fitness games that match these characteristics are expected to help LD users exercise in an efficient and comfortable way.

Principle 7: Size and space for approach and use - appropriate size and space is provided for approach, reach, manipulation and use regardless of user's body size, posture, or mobility.

Fitness games must be played in front of a screen and inside a big enough room. The room must have open space for LD users to perform any movement as they wish and be safe at the same time. The requirements of the play space should be mentioned during the fitness game training sessions for the caregivers and family members.

7.3 Contribution to practice

In a practical sense, this research outlines the key design characteristics of a successful fitness game that can help game designers avoid previously identified pitfalls. The research discusses the six categories of fitness game design: purposes, types, user requirements study, mechanics, technology and motivations. Each aspect covers a wide range of design topics. With the recognition of a large population of relevant experts, the design characteristics proposed provide designers with a structured approach to make fitness games for LD users.

This research can potentially contribute to the quality of life of LD users. Fitness games designed for LD users can bring physical, mental and social benefits as well as entertainment opportunities (Isbister, et al., 2011). The findings of this research indicate that specifically designed fitness games can motivate LD users to carry out physical exercise, as well as provide emotional benefits during gameplay. When applying the design characteristics to the fitness games industry, the findings of this research have the potential to influence the solution to specific problems common to LD users, such as obesity and lack of physical activity (Robertson, et al., 2000).

Researchers are encouraged to collaborate with expert practitioners when developing design guidelines to make conceptual theories more applicable to the targeted field. In return, practitioners are recommended to be involved in the design and development stages to provide domain knowledge. This research emphasizes the involvement of expert practitioners such as game designers, caregivers and other healthcare professionals in evaluating the usefulness of design guidelines in this context. In contrast to only engaging the end users in evaluating design as has been common in past research (Isbister, et al., 2011), practitioners such as healthcare professionals are equally important and provide critical perspectives on the design evaluation.

To summarise, this research contributes to practice by establishing the key design characteristics of a successful fitness game targeted at LD users. Fitness games that are developed following these design characteristics have the potential to improve the quality of life of LD users. Additionally, this research demonstrates the successful involvement of expert practitioners in the evaluation of game design guidelines.

7.4 Summary

In summary, this research makes a contribution to both literature and industry. It enriches existing game design literature in three areas: game design process models, fitness game design guidelines and motivation theories. Additionally, the research clarifies the seven inclusive design principles in an LD context. In a practical sense, this research provides design guidance for a successful fitness game.

8. Chapter Eight: Conclusions and Critical Reflections

The final part of this thesis summarises the findings of the research, describes its limitations and suggests areas of future research.

8.1 Conclusions of the thesis

This research discusses the key design characteristics of fitness games for LD users. Drawn from the analysis of both qualitative and quantitative data, the key characteristics can be summarised into six categories of the fitness game design: purposes, user requirements study, mechanics, technology, motivations and types.

The first step to making a fitness game is to decide on the objectives. The research identifies the primary goal of such games should be to motivate users to carry out physical exercise. Emotional objectives should also be encouraged such as to decrease anxiety and to help users build social connections. Fitness games can also improve self-esteem, muscle function and expression of emotions.

The research provides evidence to support the idea that a user requirements study can be improved by taking inputs from potential users and healthcare professionals. This information can be extracted by observing potential users, testing game prototypes and learning from existing design guidelines. Other useful conduits for studying LD users are family members and education professionals. In addition, resources including the developer's former game design experience, general game design guidelines and human movements theories are helpful when it comes to investigating user requirements.

The mechanics in fitness games are tested to work best when they come with easy rules, settings that accommodate user preferences and clear interfaces. Game mechanics should also allow mistakes and repetitive play.

To make games more user-friendly and assistive, the technology in fitness games should provide pictorial support, verbal support and training to caregivers, teachers and family members. This research points out that technology should be featured with real-world interaction, tactile and non-tactile options.

Fitness games are found to intrinsically motivate users by making them happier, more confident and more independent. Besides, fitness games are expected to bring people closer, which would intrinsically motivate them to continue playing as a group. The research highlights competition as a debatable motivation factor in fitness games. It points out that competition should be implemented carefully based on the severity of LD of the intended audience.

This research explores other types of games that can be applied to the LD domain. It identifies games that can be used to support learning abilities, teach life-skills, enhance cognitive abilities, help rehabilitation and promote group interaction. This research also gives suggestions with regards to additional features that can be added to future or existing fitness games.

8.2 Research limitations

Due to restricted access to data and time limitations, there are many aspects in this research that can be improved upon.

The data collected and used for this thesis was very focused: the interviewees were from one game studio and the survey responses were obtained from care homes and game studios only from London and Lancaster. Collecting data from more games companies and care homes in different locations would help understand fitness game design from a bigger picture, particularly given that responses to the questionnaires were based on their experiences so far. A wider sample would allow experts with different experiences of working with LD users or in games design to contribute. Naturally, experts in the games industry and healthcare industry from outside the UK might have different views on how to design fitness games, due to the ways they practice. The range of professional roles of the respondents can also be expanded to achieve similar benefits. More game designers and healthcare professionals with different roles could also be included in future, to provide wider insights in a practical sense. Currently, most healthcare professionals who participated in the interviews and survey were caregivers who worked at private care homes. Including more nurses, school teachers, parents and social workers could be helpful. Many of the game designers who answered the survey were from game studios that did not specify that they have worked on fitness games before. Collecting data from game designers with first-hand experience in the development of fitness games would be suitable for future research.

Similarly, there was little information directly collected from the fitness game's end users: LD users. They often have difficulty with verbal communication which is the reason why observations were used. Having additional sources of data collected directly from the LD users would help gain insights in terms of their requirements for fitness games, feedback of the prototypes and suggestions to improve their long-term well-being in general. Input from other sources would allow us to better evaluate of the success of the methodology used to identify design characteristics. This would also allow a better contrast between the views of designers and healthcare professionals with the LD users. Interviewing LD users has its own complications which makes it unfeasible to do on a large scale. Verifying consistency between the views of both professionals and LD users may have simplified future research by demonstrating points of agreement and disagreement with the end users. To do this, different research techniques can be adopted for people with various LD levels. For instance, people with mild and moderate LD can be interviewed with the assistance of their caregivers or parents. As for people with severe and profound LD, more in-depth studies could be carried out by observing prototype testing and gameplay to better interpret behaviours.

Collecting and analysing data of people with various LD levels would help understand the game requirements of users with different conditions to improve the inclusivity of fitness games. This is because the accessibility to fitness games by people with increased LD is more limited, compared to people with less severe LD. For example, a person with mild LD might enjoy a fitness game with slightly complicated rules whereas a person with severe LD would be uncomfortable with the extra complexity. Even though the data used in this research has suggested that people with four LD levels did not result in diverging views from professionals, this might be due to the limited sample from some LD levels. The questionnaire was not designed and deployed with this aspect in mind, but it could be an interesting extension to the existing set of responses. Therefore, more data collected from all four LD levels would be beneficial, as it would provide adequate evidence of similarities (or not) between the groups, providing the grounding for further similar studies.

In terms of the methodology adopted in the research, surveys have a potential limitation due to the nature of the responses, given the accuracy and the depth of the respondents' answers. More follow-up studies could be carried out to gather further insights using complementary methodologies. Respondents might have answered the questions without relating to the full context of the situation or thinking thoroughly; therefore, it would be helpful to conduct some follow-up interviews to gather insights of their further thoughts on fitness game design.

With regards to the research design, the findings of this study are not implemented in the games industry to empirically test the research outcomes. As a design study, this research proposed many design characteristics of fitness games. However, due to limited resources, these characteristics were not implemented by games studios. Even though the findings in the study were generated through the participation of a large population of relevant experts, an empirical test that examines the use and effects by LD users of a game that actually incorporates the design principles would be helpful to further improve the validity of the findings. A fitness game developed with the characteristics proposed in the research would be beneficial for LD users and improve their physical health.

8.3 Future research

Although there are many interesting findings generated from this research, the exploration journey does not stop here. Future research can focus on detailing the characteristics of each LD category and further clarifying fitness game design for relevant user groups. Although this research did not identify any significant differences between the groups, a targeted study would permit validation. The design characteristics of fitness games could be differentiated and refined by exploring the different levels of LD: mild, moderate, severe and profound. This could advance the existing literature on game design and LD studies to fill the research gap between game development and inclusive design. It will also accelerate the development of fitness games and guide game designers to make more suitable fitness games for users with different demands. With more fitness games launched, LD users will benefit both physically and emotionally.

There are many aspects of fitness game design that require further exploration. In terms of the game design process, this study proposed an adopted model based on Rouse III (2010)'s three-step process model. Even though it was suitable in a context of developing a relatively simple fitness game by a small game studio, further research can explore the possibilities of adopting other design process models, such as Stacey and Nandhakumar (2008) and Baba and Tschang (2001), to study the design process in more detail and in other contexts. When adopting Stacey and Nandhakumar (2008)'s model, further research can explore the development of fitness games following the Agile style. Following this model, fitness games can be developed in an iterative manner which contains continuous planning and feedback to ensure that the initial requirements proposed by the end users are fulfilled by the end product. This is particularly useful when designing for the less-able group as their requirements are specific and a game that could not meet the proposed requirements would not be accepted by the users. Baba and Tschang (2001)'s research inspires further research on developing fitness games that are specifically played on TV. As an assessable and reliable facility, TV is often used as an output interface for fitness games. Further research about Baba and Tschang (2001)'s model would provide a guideline for fitness game designers with regards to integrating fitness games with TV, in particular, following an originality-oriented model in which significant revisions in design might be possible after the completion of an initial prototyping cycle. This allows fitness games design to be more creative and customized which would better satisfy user demands.

The competition factor in fitness games can be clarified in future research. This research reveals the contradictory opinions about competition in games that are targeted at LD users. The game designers thought it is best to avoid competition to lower the end user's stress level. However, the healthcare professionals have witnessed the benefits of competition among the LD users. Further research can be carried out towards the usefulness of competition in games for LD users. To reveal how and when to introduce competition in fitness games, future research can focus on the application of different competition mechanics such as scores and leader boards to identify the extent to which they should be adopted. Depending on the user's LD levels, further research can try to identify the competition mechanics that would be suitable for each group. In this way, fitness game design can be advanced by ensuring the amount of competitive elements that are beneficial for LD users and knowing the competition mechanics that are appropriate for LD users with various conditions, if such a differentiation is necessary.

The research findings can inspire further exploration into seven inclusive design principles (Mace, 1997), in terms of adapting the principles for digital game design. As the most adopted set of design guidelines for making products targeted at disabled customers (Normie, 2005), these inclusive design principles are well adopted in many areas such as architecture and product design. However, they need contextualization when used to guide digital game design. This research clarifies the adaptation of the seven principles for LD users when designing fitness games. Future research can examine the adaptation these principles for the design of other digital games, considering the user's various restrictions. Adapting inclusive design principles in general game design can help make more suitable and beneficial games for the less-abled group.

Similarly, this research can be expanded to other relevant game user groups, such as wheelchair users. LD are sometimes associated with impairments to hearing, movement and vision. When researching LD design features, many impairments were considered to come up with the design characteristics that are suitable for users with various LD levels. Therefore, the design characteristics proposed in this research can be adapted to other fitness game user groups. For example, some design characteristics associated with technology proposed in this study are applicable to people with movement restrictions.

Wheelchair users would benefit from fitness games with technology that are able to distinguish human movements from the movements of assistive equipment. Future research can be built on current findings and expand to similar user groups.

Further research can explore ways to advance the communication between game designers and end users to design more desired games for people in need. This research collected opinions from game designers and healthcare professionals and analysis of the data revealed divided opinions in many design aspects such as the competition factor in games. The divided opinions might be the result of lack of communication between the game designers and the end users. To help game designers better understand the end user requirements and conditions, further research can be carried out towards improvements in communication between the designers and the users. In this research, game designers have proposed means of communication including observations and play-testing. Future research can explore the possibility of encouraging LD users to get involved more closely. For people with mild LD, research can be focused on the ways to encourage them to speak up directly and accurately. As for people with more severe LD, research can be carried to improve the accuracy of using healthcare professionals or parents as conduits to obtain information from end users.

As identified in the limitations above, the findings of this research can be further verified by producing actual fitness games following the design characteristics proposed. By monitoring the game development process and evaluating customer feedback, the success of the game can be measured to verify the usefulness of the proposed design characteristics. Further improvements of the design characteristics can be carried out depending on the feedback from participated game designers and end users. Additionally, it is the hope that by building on the findings of this study, more people with special needs can benefit.

9. Chapter Nine: References

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10. Chapter Ten: Appendices

This chapter summarises the documents used to collect data for the research, including the consent form for interviewees and the two sets of questionnaires. An example of qualitative data analysis using NVivo is included in this chapter too. The two conference papers that were based on this research are included.

Appendix 1: Participant information form and consent form for interviewees

For ethical reasons, before the interview each interviewee was provided with the participant information form to brief him or her with the research objects, interview guideline, participant's rights and confidentiality. Following up, the interviewee was asked to sign the consent form. These two documents are displayed in this section.

Participant information sheet

Researcher

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Second point of contact

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Research title

The pursuit of meaning in gamification design – a sensemaking approach.

Research subject and purpose

The proposed research is for the researcher's PhD degree only and aims to understand the meanings in gamification design. Gamification has introduced game elements in various industries, and the mechanics it adopts has expanded from extrinsic to intrinsic. The concept of gamification 2.0 is raised in this research to explain a new generation of gamification that attempts to intrinsically motivate people by helping them find meaning. However, meaning in gamification has not been studied before and there is a misunderstanding between designers and users, which could potentially lead to unsatisfactory gamification products. In fact, Burke (2013) predicted that 80 percent of gamified products are going to fail by 2014 and this is because design cannot meet business objectives. This proposed research is going to study meaning in gamification from a sensemaking perspective. Sensemaking is the process of constructing social cognition and is notoriously hard in multidisciplinary contexts such as game development (e.g. Brown, Stacey et al, 2008). Gamification, a form of game design, is no exception. It could potentially make theoretical contribution to gamification and sensemaking, and practical contributions to gamification in industry.

On view of the above, if I was permitted to conduct this study with Somability, I would ideally like to interview a mixture of designer, developers and scientists. Additionally, I would like to observe the working process with service users and collect data for performance analysis.

The research has been approved by the Lancaster University Research Ethics Committee.

Result usage

The research results will be used for the researcher's PhD thesis. The thesis will be printed and stored in Lancaster University library. The data could also be drawn on in the writing of publishable journal or conference papers. This can be discussed with yourselves as well as whether or not you would like to be anonymised, thereby protecting your identity.

Interview guideline

In this study, you will be asked to answer a few questions. The researcher will record the conversation using an audio recorder.

In order to semi-structure each interview, I usually devise a 'guide' so that I am fully prepared to take good advantage of the opportunity given to me. In it I document the theme, the unit of analysis, research ethos, and specific questions. For example:

(i) Theme: The pursuit of meaning in gamification design – a sensemaking approach

(ii) Unit of analysis: gamification development team

(iii) Research approach and ethos: interpretive field study focused on interviewee meanings; the research process is a means of vocalising and elucidating the interviewees' mental models (Rubin and Rubin 1995).

(iv)Specific questions that I would ideally like to ask:

Could you describe your role in the development of Somability, and what were your typical activities?

What was the original aim of Somability?

How did you want to achieve this aim?

How did you encourage users to find meanings in gamification?

Recount your version of events in the development of Somability – in story form.

Is there any particular event in the story which stands out for you, and why?

Were there any particular challenges you faced of any kind and how were they resolved (i.e. sources of enablement)?

Was the final version of Somability different from what you first expected? Why?

Observation guideline

I would like to observe you working in field with service users. I understand that most of the users have learning disabilities and I would like to be trained first in order to respect their rights.

I would like to record their performance in both virtual and physical worlds. Specifically, I am interested in how gamification helps them with real life knowledge and skills. I would like to record this data and compare it to the pervious one so as to reveal the effectiveness of gamification.

Time commitment

The interview usually takes 40 minutes.

The observation time scope will be adjusted according to different services.

Participants' rights

You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn/ destroyed.

You have the right to omit or refuse to answer or respond to any question that is asked of you.

You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study's outcome).

Confidentiality / anonymity

The data I propose to collect will not contain any personal information about you and will be stored in the Lancaster University Management School. The interview recorder will be encrypted and password protected. The record of the interview is guaranteed to be confidential in compliance with our ethics committee rules and that if any of the data is used in a paper, I will only use pseudonyms. I could email you the transcript afterwards if you like and if there is anything you are not comfortable with, I can delete it. Also, if you have any concerns you can contact my Head of Department Professor Richard Eglese, or my supervisor Dr. Patrick Stacey.

Regarding the confidentiality of Somability, I would like to publish the organization name in my thesis. On the other hand, I will respect the organizations' will and discuss with you before using any data. Your organization may have access to my final thesis if you wish.

For further information

Dr. Patrick Stacey will be glad to answer your questions about this study at any time. You may contact him at p.stacey@lancaster.ac.uk.

If you want to identify about the final results of this study, you should send the researcher a request by email please.

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Participant Identification Number:

CONSENT FORM

The pursuit of meaning in gamification design – a sensemaking approach

Name of Researcher

Liu Liu, Lancaster University Management School,

liul8@exchange.lancs.ac.uk

Research subject

This research is aiming at examining meanings in gamification design. The research is a part of the researcher's PhD degree.

Second point of contact

Dr.Patrick Stacey, Lancaster Management School,

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Please initial box

1. I confirm that I understand the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason. ☐

3. I understand that any information given by me may be used in future reports, articles or presentations by the research team. ☐

4. I understand that my name will not appear in any reports, articles or presentations. ☐

5. I agree to take part in the above study.

______________________	_______________	_______________
Name of Participant	Date	Signature
______________________	_______________	_______________
Researcher	Date	Signature

When completed, please return to the researcher. The original copy will be kept in the file of the research team at: Lancaster University Management School

Appendix 2: An example of data categorisation and identified themes

The analysis of the Study One: Case Study starts from coding the interview and observation data. With the assistance of the software NVivo, the transcripts are coded into 54 categories. For example, under the 'intrinsic rewards' category, three transcripts are linked:

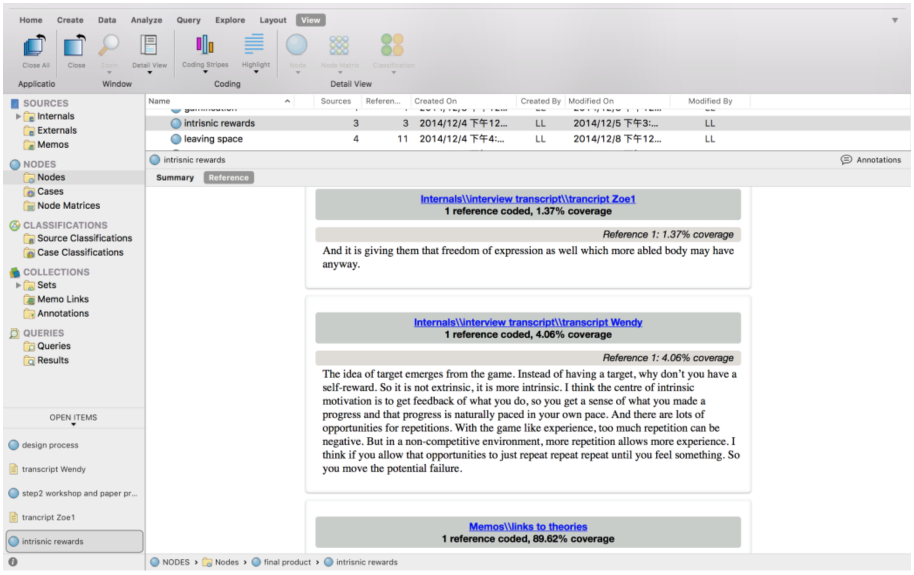

Figure 4. Data category 'intrinsic rewards' in NVivo

The next step of data analysis is to manage the codes into themes. There are seven themes in this research and each theme contains sub-themes for more detailed data organization. An example of the sub-themes is shown in the screenshot below.

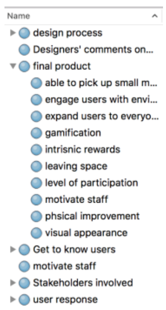

Figure 5. Data themes in NVivo

Appendix 3: Questionnaire survey content

The two survey groups were included in this research: healthcare professionals and game designers. The main content of the questionnaire offered to them is the same, but the questions associated with personal information are different to match their professions. The questionnaire is displayed on the next page.

Survey: Motivating disabled people through games

Dear participants:

There are approximately 1.5 million people in the UK with a learning disability and only few of them are getting proper physical support. This survey aims to identify useful game features that can be used to motivate users to be more physically active, so as to accelerate game designers to make more digital games that are beneficial to users with special needs.

What is a fitness game? A fitness game refers to any video game that is used as a form of exercise. It often relies on additional equipment to track body movements. Examples of gaming consoles with fitness gaming attributes are the Xbox Kinetic and Nintendo Wii.

As a healthcare professional, your participation in this survey is important because it will help us understand how fitness games can be designed to help people with learning disabilities. All of your feedback will be stored anonymously and will only be used for this research.

Thanks!

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Prof. Monideepa Tarafdar, Lancaster University, email: m.tarafdar@lancaster.ac.uk

Part 1: Personal Information

-----------------------The questionnaires distributed to healthcare professionals---------------

Question 1: Would you please choose your role from the following?

General Practitioner ☐ Nurse ☐ Psychologist ☐ Physical therapist ☐

Occupational therapist ☐ Support worker ☐ Primary caregiver ☐ Social worker ☐

Parent ☐ Guardian ☐ Teacher ☐ Teaching assistant ☐ SENCO ☐

Researcher ☐ Charitable help ☐ Manager of health care services ☐

Other____

Question 2: How long have you been working in this area?

2 years and less ☐ 3-5 years ☐ 6-9 years ☐ 10 years or more ☐

Question 3: Which type of learning disabilities do you mostly deal with?

(Please choose one category and answer all questions accordingly)

Mild ☐ Moderate ☐ Sever ☐ Profound ☐

---------------------------The questionnaires distributed to game designers-----------------------

Question 1: Would you please choose your role from the following?

Programmer ☐ Graphic designer ☐ Manager ☐ Producer ☐

Other____

Question 2: How long have you been working in this area?

2 years and less ☐ 3-5 years ☐ 6-9 years ☐ 10 years or more ☐

Question 3: Which type of game company do you work for?

Gaming system constructor ☐ Game developers (studios) ☐ Publishers ☐ Test labs ☐

Other____

Part 2: Survey

Question 1: Considering a fitness game for users with learning disabilities, please indicate the extent to which you agree with the following purposes.

Such games should:

	Strongly disagree				Strongly agree
help users to make movements freely	1	2	3	4	5
allow users to express feelings and emotions in movements (e.g. anger, joy)	1	2	3	4	5
improve users' muscle function	1	2	3	4	5
motivate users to carry out physical exercise	1	2	3	4	5
decrease users' anxiety and depression	1	2	3	4	5
help users improve self-esteem	1	2	3	4	5
help users build social connections	1	2	3	4	5

Please enter any further purposes or comments in the space provided: ____

Question 2: Apart from fitness games, users with learning disabilities may require other types of games. Please indicate the extent to which the following games would benefit users.

Games that:

	Least beneficial				Most beneficial
support learning abilities for academic studies such as math or literature	1	2	3	4	5
teach life-skills for independent living	1	2	3	4	5
enhance other cognitive abilities such as memory and numeracy	1	2	3	4	5
help rehabilitation from injuries	1	2	3	4	5
require group-play	1	2	3	4	5

Please enter any further games or comments in the space provided: ____

Question 3: Please indicate the usefulness of the following methods to understand the requirements of users with learning disabilities who are going to play the fitness games.

3 A) game designers should take inputs from the following people:

	Least useful				Most useful
potential game users with learning disabilities	1	2	3	4	5
family members	1	2	3	4	5
health and social care professionals	1	2	3	4	5
education professionals	1	2	3	4	5

3 B) game designers should learn from the following resources:

	Least useful				Most useful
theory on human movements such as walking and running	1	2	3	4	5
general game design theories	1	2	3	4	5
inclusive design theories for disabled users	1	2	3	4	5
their own game development experience	1	2	3	4	5
observations of potential game users in daily life	1	2	3	4	5
testing game prototypes	1	2	3	4	5

Please enter any further comments in the space provided: ____

Question 4: Considering the ability level of the user, a fitness game has to be both fun and simple. Please indicate the extent to which you agree with the following methods to simplify a fitness game.

Designers should make:

	Strongly disagree 1	2	3	4	Strongly agree 5
the rules of a game easy	1	2	3	4	5
games only convey necessary information to users	1	2	3	4	5
games that allow mistakes	1	2	3	4	5
games that allow repetitive play	1	2	3	4	5
games that accommodate user preferences	1	2	3	4	5
game interfaces clear	1	2	3	4	5

Please enter any further guidelines or comments in the space provided:

____

Question 5: Considering a fitness game for users with learning disabilities, please indicate the extent to which you agree with the following items with regards to assistive technology.

	Least important 1	2	3	4	Most important 5
Technology providing pictorial support for clear feedback	1	2	3	4	5
Technology providing verbal features such as music and sound (clapping)	1	2	3	4	5
Technology providing tactile features such as a touch screen	1	2	3	4	5
Technology providing non-tactile features such as eye movement recognition	1	2	3	4	5
Technology that incorporates real-world interaction into the game world	1	2	3	4	5
Technology providing specific training for caregivers, teachers and family members	1	2	3	4	5
Technology that has low cost	1	2	3	4	5

Please enter any further guidelines or comments in the space provided:

____

Question 6: Considering a fitness game for users with learning disabilities, please indicate the extent to which you agree with each statement that describes events that happen during the course of a game.

During gameplay, users should:

	Strongly disagree				Strongl agree
compete with each other	1	2	3	4	5
start to play with other game users, caregivers, staff and parents	1	2	3	4	5
meet new people with similar conditions	1	2	3	4	5
feel empowered because they are in control	1	2	3	4	5
become more independent from people who give assistance	1	2	3	4	5
build confidence as the game progresses	1	2	3	4	5
feel happier	1	2	3	4	5

Please enter any further comments in the space provided: ____

Appendix 4: Interface of the web survey

For the data collection purpose, the survey was distributed online via Qualtrics. To distinguish the two survey groups, separate questionnaires were used. Similar to the printed questionnaires, the different between the two sets of questionnaires only exists in the 'personal information' section. This section presents screenshots of the web survey for healthcare professionals.

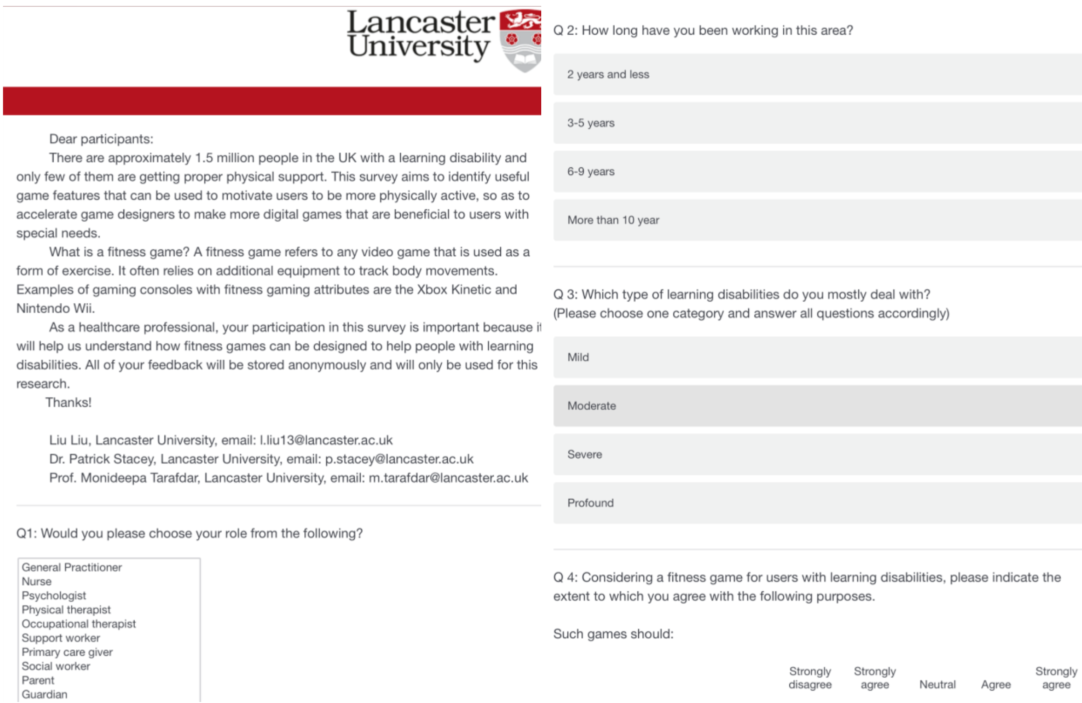

Figure 6. Screenshots of the web survey – page 1 and 2

a) help users to make movements freely					
b) allow users to express feelings and emotions in movements (e.g. anger, joy)					
c) improve users' muscle function					
d) motivate users to carry out physical exercise					
e) decrease users' anxiety and depression					
f) help users develop self-esteem					
g) help users build up social connections					

Please enter any further purposes or comments in the space provided:

Q 5: Apart from fitness games, users with learning disabilities may require other types of games. Please indicate the extent to which the following games would benefit users.

Games that:

	Harmful	Slightly beneficial	Moderately beneficial	Highly beneficial	Essential
a) support learning abilities for academic studies such as math or literature					
b) teach life skills for independent living					
c) enhance other cognitive abilities such as memory and numeracy					
d) help rehabilitation from injuries					
e) require group play					

Please indicate the usefulness of the following methods to understand the requirements of users with learning disabilities who are going to play the fitness games.

Q 6a: game designers should take inputs from the following people:

	Least useful	Not useful	Neutral	Useful	Most useful
a) potential game users with learning disabilities					
b) family members					
c) health and social care professionals					
d) education professionals					

Q 6b) game designers should learn from the following resources:

	Least useful	Not useful	Neutral	Useful	Most useful
a) theory on human movements such as walking and running					
b) computer game design theories					
c) inclusive design theories for disabled users					
d) their own game developing experience					
e) observations of potential game users in daily life					
f) testing game prototypes					

Please enter any further methods or comments in the space provided:

Figure 7. Screenshots of the web survey – page 3 and 4

Q 7: Considering the ability level of the user, a fitness game has to be both fun and simple. Please indicate the extent to which you agree with the following methods to simplify a fitness game.

Designers should make:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a) the rules of a game easy					
b) games only convey necessary information to users					
c) games that allow mistakes					
d) games that allow repetitive play					
e) games that accommodate user preferences					
f) game interfaces clear					

Please enter any further guidelines or comments in the space provided:

Q 8: Considering a fitness game for users with learning disabilities, please indicate the extent to which you agree with the following items with regards to assistive technology.

	Least important	Not important	Neutral	Important	Most important
a) Technology providing pictorial support for clear feedback					
b) Technology providing verbal support such as music and sound (clapping)					
c) Technology providing tactile support such as a touch screen					
d) Technology providing non-tactile support such as eye movement recognition					
e) Technology that incorporates real world interactions into the game world					
f) Technology providing specific training for care givers, teachers and family members					
g) Technology that has low cost					

Please enter any further guidelines or comments in the space provided:

Q 9: Considering a fitness game for users with learning disabilities, please indicate the extent to which you agree with each statement that describes events that happen during the course of a game.

During game play, users should:

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a) compete with each other					
b) start to play with other game users, caregivers, staff and parents					
c) meet new people with similar conditions					
d) feel empowered because they are in control					
e) become more independent from people who give assistance					
f) build up confidence as the game progresses					
g) feel happier					

Figure 8. Screenshots of the web survey – page 5 and 6

Appendix 5: Research-in-progress paper published in UKAIS 2015

Half way through my PhD, I wrote a research-in-progress paper and submitted to UKAIS (UK Academy for Information Systems) conference. It was accepted and presented in April, 2015.

DEVELOPMENT PROCESS OF INTRINSIC GAMIFICATION IN A LEARNING DIFFICULTY CONTEXT

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Abstract

The paper explores the development process of intrinsic gamification in a learning difficulty context through an in-depth case study. We found out that simplicity is the most vital mechanic and the freedom in the software benefits users physically, mentally and socially. As a result, the software meets user's competence, autonomy and connection needs and thus intrinsically motivates them to use it more.

Keywords: gamification; intrinsic motivations; development process; simplicity; learning difficulty context.

1.0 Introduction

Gamification has introduced game elements in various industries and has been proven successful. Traditionally, gamification adopts extrinsic mechanics such as badges and levels. On the other hand, there are raising concerns about the overuse of extrinsic motivation and scholars have proposed to increase the usage of intrinsic mechanics. However, barely any studies tried to learn the development process of intrinsic gamification. In this research, we conducted an in-depth case study of intrinsic gamification software to explore its mechanics and internal motivations. It could potentially make theoretical contributions to literature and practical contributions to the industry.

2.0 Prior Research

Gamification refers to the utilization of game elements in non-game circumstances (Deterding et al, 2011), and it has gained widespread use in industry (Huotari and Hamari, 2012). In this paper, we studied interactive software named Somability which uses game elements to encourage movements among people with profound and multiple learning difficulties (PMLD). This user group often suffers from more than one disability and one of these is profound intellectual damage (Lacey and Oyvry, 2013). The disability usually includes sensory or physical impairment and might involve autism and other mental illness (Lacey and Oyvry, 2013).

Traditionally, gamification adopts extrinsic mechanics such as badges, levels, achievements, points to motivate people (Nicholson, 2012). These mechanics set up different tasks with clear goals, which help users stay on track and keep them focused (Schell, 2008). Although gamification has been proven successful and been warmly welcomed by many companies, there are several criticisms regarding the extrinsic mechanics. First of all, researchers are concerned that they might lose their effects once removed (Zichermann and Cunningham, 2011). Furthermore, extrinsic gamification mechanics are not appropriate methods for changing customer behaviour in the long-term because people tend to lose interest in them (Nicholson, 2012). Moreover, the application of extrinsic rewards could be risky since they are very different from real life and there are rare cases where people use them to disconnect with reality (Nicholson, 2012). Besides, intrinsic motivations can be damaged by extrinsic rewards, especially when users find tasks interesting and advantageous (Deci and Ryan, 2002). These criticisms point out that gamification could be improved and consequently motivate users in a more efficient way.

In response, scholars started to introduce intrinsic mechanics to gamification. This attempt is based on Self-Determination Theory (SDT) which believes that when an event meets any of the three needs 'autonomy, competence and relatedness', people find it interesting and enjoyable, and thus carry out activities unconditionally (Deci and Ryan, 2002). This inspired people adding mechanics to gamification to trigger intrinsic motivations. However, there are few studies about real life gamification examples. In this paper, we attempted to learn how Somability was developed and what mechanics motivated users internally.

3.0 Method

In order to study the development process of intrinsic gamification, we chose an interpretive approach (Walsham, 1993) and mainly used interviews to collect data. For the first round of data collection, we met seven people that were involved in the development and interviewed them separately for appropriately 45 minutes. Additionally, we attended three events where the software was displayed and its service users were invited to demonstrate. And this gave us a chance to observe service users' performance. We then transcribed all interviews and kept detailed notes of the observation we made during the events.

To analyse data, we stayed closely to the transcripts and carried out microanalysis of words, phrases and lines (Corbin and Strauss, 1994). Later, with the help of NVivo, we conducted low-level coding of the text and produced 54 'free nodes'. Eventually, we borrowed the concept of agile design (Martin, 2003) and categorized the nodes. After analysing activities in different categories, we established links across all categories and found evidence for applying intrinsic mechanics in gamification design. As patterns and themes emerge, we began abstracting terms (cf. Miles and Huberman, 1994) and conceptualizing the process of intrinsic gamification development.

4.0 Case description

4.1 Somability and Cariad Interactive

Somability is an application that was produced by Cardiff Metropolitan University in partnership with Cariad Interactive. It gives service users access to recreational activities through affordable technologies, with musicality and rhythmic, hence promotes dynamic movements. It contains three applications reach, balance and flow, as well as three modes mirror, skeleton tracking and colourful shadows.

Cariad Interactive has four main partners, Wendy, Joel, Pete and Marek, each of whom played different roles in the development of Somability (table 1). During the development of Somability, Cariad Interactive partnered with Rhondda Cynon Taf Skills for Independence and Artis Community and did beta tests with Gladys Resource Centre in Aberdare. In order to collect data for this paper, we managed to interview people from each organization to talk about their contribution to the development of Somability. Table 1 illustrates the interviewees' positions and organizations they belong to.

Name	Position	Organizations
Wendy	Managing director and project manager	Cariad Interactive
Joel	Lead programmer	Cariad Interactive
Pete	Art Director	Cariad Interactive
Leah	Research assistant of Wendy	Cardiff Metropolitan University
Zoe	Dancing instructor	Artis Community
Kath	Facilitator	Rhondda Cynon Taf Skills for Independence
Florence	Carer	Gladys Resource Centre

Table 1 Information of interviewees

4.2 Development process of Somability

As explained in Figure 2, the development of Somability contained four stages: user analysis, design, implementation and release.

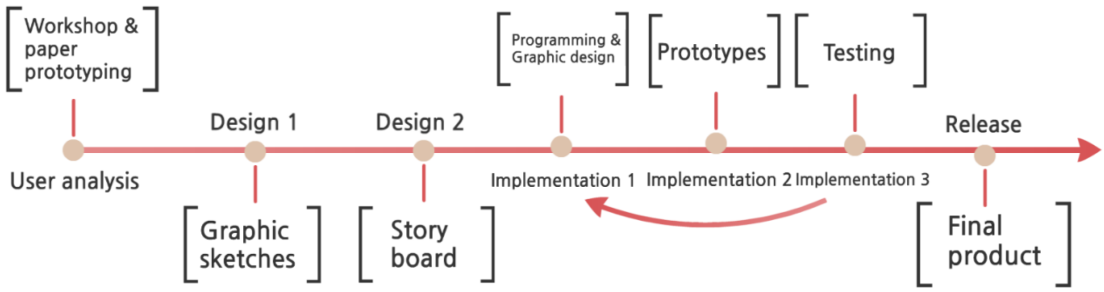

Figure 2 Process model

In the user analysis stage, the development team gathered around for workshops and did paper prototyping to learn users' needs. This involved people from Cardiff Metropolitan University, Cariad Interactive, Artis Community and Gladys Resource Centre. And they were engaged through role-playing, rehearsal and performance. This allowed the team to discover the idiosyncrasies of individual service user's needs, and thus to find basic daily movements that could engage anyone even with limited movability. In order to avoid over complicated design and to make the software accessible for everyone, the simplicity mechanic was raised and was kept towards the end.

In the design phase, the team translated basic movements into graphic sketches. Later, they built story boards to demonstrate how certain type of interaction may achieve the goals that they would like to achieve. Dividing by the scenarios that they wanted to implement at, the stories boards contained the movement sequences and special properties in the environment. These story boards were used in the next stage and they became a series of prototypes.

The implementation stage is an iteration of programming, graphic design, prototypes and testing. Pete and Marek were in charge of programming while Wendy and Joel did graphic design. They then brought out prototypes and tested them in Gladys Resource Centre. By observing users' performance and talking to carers, the development team found out that users would prefer an even simpler design. Therefore they removed some old gamification mechanics and iterated to the first sub-stage to improve the software. By consistently testing prototypes and making adjustments, the team came to a final product.

Nowadays Somability is finished and free to download from the project website and Windows Store. It is not only used in one day care centre but has been spread to more locations including disabled centres and schools.

5.0 Analysis

Because this research is still in its early stage, we only managed to carry out a limited analysis based on seven interviews.

As an application originally designed for people with profound and multiple learning difficulties, Somability partly followed a common software development process agile design (Martin, 2003) but also made adjustments according to its special service users. After comprehensive user analysis and prototype iterations, Cariad Interactive stuck to the simplicity mechanic, which results in improvements in user's physical, mental and social conditions, and in return intrinsically engages them (Figure 3).

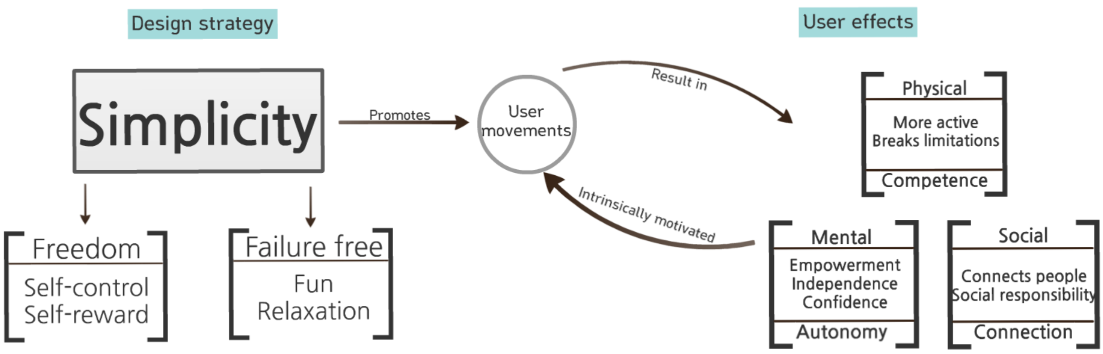

Figure 3 Grounded conceptual model

The simplicity provides a control-free and failure-free environment and therefore users could relax and control their own pace. More importantly, users can have a sense of achievement when they have made any progress. This leads them to perform expressive movements internally which results in physical, mental and social advancements. Physically, it is proved that service users are much more active than they used to be and they have made some movements that broke their physical records. Carers have also pointed out that because everyone wants to have a go in front of the machine, there is often competition. Mentally, the software helps people gain empowerment, independence and confidence and all of these meet their autonomy need. Socially, Somability connects people together and it made people more socially responsible and some of the active users became leaders of their dance group. This meets people's connection needs. Altogether, service users not only benefit from physical exercise, their competence, autonomy and connection needs could also be met via the software, and therefore be intrinsically motivated.

6.0 Discussion and implications

Gamification differs by contexts and its mechanics vary. Scholars have tried to discuss general intrinsic mechanics that gamification could adopt, however they might not be suitable for all software. Nicholson (2012) suggests that intrinsic mechanics could include a large range of choices, elements in the real physical world and tools to design by users. But these are not entirely applicable in a learning difficulty context due to users. To conclude, gamification development should always consider users and context of use.

This paper has contributions in both theoretical and practical worlds. Theoretically, it provides a process model for developing intrinsic gamification in learning difficulty context and it points out that the most important stage is user analysis. Practically, depending on the context, this simplicity mechanic could solve some of the challenges that gamification faces. The absence of extrinsic mechanics makes sure that users' interests in physical movements are long-lasting and not overtaken by the joy of collecting points.

7.0 Conclusion

Overall, we suggest that simplicity is one of the most important mechanics that drive gamification to success, especially in the learning difficulty context. This mechanic is discovered from careful user analysis, and proved to be intrinsically engaging. Thanks to the space and freedom in the software, users are motivated to try out anything without stress or control brought by extrinsic mechanics. The software not only benefits users physically, but also mentally and socially. As a consequence, the software meets users' competence, autonomy and connection needs and thus intrinsically motivates them to use it more. However, due to the limited data collected, this conclusion is still tentative and the researchers are continuously working on it.

8.0 Future work

This research is the starting point for our intrinsic gamification study. We are planning to expand it to more software and more design companies.

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Appendix 6: Full paper published in HICSS 2017

The full paper was written based on partial findings of this research and accepted by HICSS (Hawaii International Conference on Systems Sciences) 2017.

Simplifying Fitness Games for Users with Learning Disabilities

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Abstract

Motivating people with learning disabilities (LD) to carry out physical exercise is a difficult task. Simplified fitness games can address this problem. Yet we do not know much about the design characteristics of the fitness games for this particular user group. Based on Rouse's process model, this paper explores the design characteristics in three development phases: 'conceptual outline', 'implementation' and 'outcome'. A mixed-method approach has been adopted. First, interviews and observations were conducted. Based on the qualitative findings and a literature review, a questionnaire was generated addressing the important design characteristics in each phases. The questionnaire surveyed 235 people from both game and healthcare industries to assess their agreement to the design characteristics. By identifying critical design characteristics in each phase, our paper provides guidance for an inclusive and nuanced approach to designing games for the users with LD. It identifies concepts in fitness games that intrinsically motivate physical activities.

1. Introduction

People with learning disabilities (LD) often lack physical exercise due to their impairments [1]. To change this situation, simplified fitness games can be helpful. Literature has shown that fitness games are effective in a healthcare context generally [2]. However, to the best of our knowledge, there is no research that studies fitness games within the more specific healthcare context of LD, let alone any putative design characteristics [3, 4]. Given the fact that people with LD in the UK often suffer from problems associated with obesity and physical activity [5], it is imperative to generate alternative tools, such as games, that can support and improve the quality of life for the LD users.

To study the design characteristics of fitness games in the LD domain, our study borrows Rouse's process model [6] and focuses on three game design phases 'conceptual outline', 'implementation' and 'outcome'. Especially, considering the user's condition and ability, this research explores the characteristics in the design phases that help developing simplified fitness games.

2. Literature review

In order to assess the design characteristics of fitness games in the LD domain, we first review the literature concerning the LD user group and how fitness games are applied in this context. This provides the conceptual foundation for our research.

2.1. Challenges faced by people with learning disabilities

A learning disability is defined as 'a significantly reduced ability to understand new or complex information or to learn new skills, a reduced ability to cope independently, and an impairment that started before adulthood, with a lasting effect on development' [7]. Although the UK is the only country that uses the term 'learning disabilities', other English speaking countries such as the USA and Australia use the term 'intellectual disabilities' [8]. In this paper, for consistency, we use the term 'learning disabilities'. There are four levels of LD: mild, moderate, severe and profound [8].

Mild LD refers to slight sensory or motor deficits [9]. Most of the people in this group are never diagnosed and are able to live independently [9]. They might need help with employment and housing or when under unusual stress [9]. People in the **moderate LD** group can talk and care for themselves under supervision [9]. Adults can undertake simple work [9]. People with **severe LD** have a slow pace of learning [9]. They may be able to communicate in a simple way [9]. They can perform easy tasks and engage in limited social interaction [9]. However, they often need help with daily activities and need to live under close supervision [8]. A person with **profound LD** usually has a number of disabilities which could include impairments to hearing, movement and vision. This can also include conditions such as epilepsy and autism [8]. People with severe LD would often need help with daily activities [8]. Their behaviors could be challenging for others [10]. They find it very difficult to communicate with others [10]. As a consequence, this group of people have been neglected and excluded from society and there is need to increase meaningful social interaction [11].

In general, people with LD exhibit poor fitness performance in terms of strength, endurance, and motor coordination [12]. Research has shown that this low performance is associated with limited motor development, sedentary lifestyle, mental impairments and short attention span [12]. Lack of motivation is also a cause for low levels of fitness [13]. Their physical performance is influenced by level of LD, for example, athletes with lower LD level perform better in motor coordination tests [14].

In terms of their mental conditions, people with LD struggle from mental health difficulties more than the general populations [15]. They often withdraw themselves from the environment, engage in obsessive or compulsive behaviors that would stop them from participating in everyday activities, and have low self-esteem [15].

Overall, people with LD struggle with physical movements, mental illness and low ability to learn. In this research, the opinions of all levels of LD for fitness games were surveyed. Considering that many people with LD have limited ability to read and write [9], the survey was carried out among the healthcare professionals who have sufficient knowledge of the needs of this particular group [16]. To distinguish different levels of LD, the healthcare professionals who participated in the survey were asked to choose the level they mostly deal with. All their answers to survey questions were given according to the chosen LD level.

2.2. Fitness games for users with learning disabilities

A fitness game is a video game that is used as a form to promote physical activities [17]. Examples of some successful commercial fitness games include: Wii Fit, Just Dance, Zumba Fitness, My Fitness Coach and Kinect Sports [2]. Research has shown that an increase of moderate intensity physical activity has a positive result in improving health [5]. Particularly for disabled populations, performing specifically adapted exercise can change their current physical inactive situation [18].

Doing physical exercise not only helps people be stronger, but also contributes to decreasing anxiety and depression [19]. Additionally, regular physical activity promotes social inclusion and a sense of belonging [19]. Through body movements, people with LD can communicate their feelings to others [20] which they would struggle with verbally.

However, conventional fitness training programs are not always useful or appropriate for meeting the needs of people with LD [3]. In addition to their physical and psychological impairments, people with LD face a range of specific challenges including low motivation and little access to health care [3]. To promote physical exercise, fitness programs with motivational factors are recommended [21].

Fitness games have been tested to be effective in promoting physical exercise for adults with LD [3]. For school children with LD, fitness games have also been tested to be a success in physical education [4]. Combining exercise with computer games creates immersive and motivating training sessions [22]. When fitness games are designed for LD, they encourage end users to repeat daily movements and help them improve in an enjoyable and virtual simulated environment [23]. Meanwhile, playing fitness games can help users build self-esteem, confidence [24]. Play fitness games in groups also helps users connect [25] and change the isolated situation that the people with LD are facing.

Because of the special physical and mental conditions of this particular user group, fitness games have to be simplified. To discuss the design characteristics of simplified fitness games, this research focuses on the three typical phases based on Rouse's game design process model [6]: conceptual outline, implementation and outcome. There are many studies that process-map game design including the Boomerang [26], prototyping [27], as well as a variety of design techniques, like scenarios, body storming, paper prototyping, rapid prototyping, theatrical techniques of improvisation [28, 29], simulation [30], cuisinart [6], and play environments such as mixed reality [30]. Among all the process models, Rouse summarised a typical path that is easy to implement [6]. By adopting it in fitness game design, our research provides practical guidance for the industry. Additionally, Rouse's process model is user-orientated [6] which is critical when designing for LD users, given the sensitivity of their condition.

In the conceptual outline phase, game designers should focus on learning about user requirements and understand the associated game features. Designers have to decide the challenges in a game and the virtual environment to match these challenges. Besides, the pace of a game needs to be decided whether it is going to be slow or tense. Moreover, the rewards for end users have to be considered. [6]

In the implementation phase, designers firstly need to build a game architecture to satisfy the aims and features proposed in the first phase. The next step is to design game mechanics and refine them until they are perceived as being fun. Designers also need to choose the right forms to display the game and use suitable technology to interact end users with the virtual environment. With regards to human-computer interaction (HCI), the emphasis is on game interface design and visual adaptability [31]. When a game is finished, playtesting is required to collect feedback for further improvements. [6]

In the outcome phase, a game is expected to engage end users by providing them with enjoyment, challenges, social interaction, emotional experiences and aesthetics [6]. This research focuses on the intrinsic outcomes that a fitness game brings because such outcomes are long-lasting when it comes to engaging end users.

In summary, fitness games are able to help people with LD by motivating them to perform physical exercise and improving their mental status. Considering the special conditions of this user group, fitness games are required to be simplified to enable enjoyable gameplay and exercise. To design such fitness games, this research adopts a mixed-method to understand what their characteristics and features should be. The next section explains the research methods in this study.

3. Methods

This section discusses the mixed-method research design adopted for this study.

Combining qualitative and quantitative methods in this study is appropriate because of the complexity involved [32]. By combining both methods, researchers can: (i) confirm and corroborate each other's work via interplay, (ii) discover greater detail that develops the theories, (iii) generate new ways of thinking, and (iv) expand the depth and scope of the study [32]. There are many ways to combine these two methods and one of the combinations is demonstrated below [32]:

QUALITATIVE → QUANTITATIVE

(exploration) (confirm and deepen findings)

When applied to this study, we started with a qualitative case study based on interviews and observations for developing a fitness game named Somability. It provided insights into the perspectives of both game designers and users. After analyzing experiences of those that developed Somability, we learned that the three design phases suggested in the literature needed to be further clarified, explained and detailed, for the specific context of designing simplified fitness games for users with LD. To complement and extend the qualitative findings and confirm the results with a broader audience, the second phase of the study used a quantitative questionnaire-based method to understand the details of each design phase. The questionnaire was designed according to qualitative findings and literature. Survey respondents provided their perceptions of appropriate design characteristics in each phase for fitness game. Overall, a combination of methods enabled us to access richer data and provided a basis for a detailed and comprehensive analysis.

The next two sections go into more details about each study.

4. Qualitative study

The first phase of the research is a qualitative case study. The process involved working closely alongside a game company developing fitness games for users with LD. Ten interviews and three natural observations were conducted which helped discover three fundamental phases of designing simplified fitness games.

4.1. Case description

Somability is a fitness game that was produced by Cardiff Metropolitan University in partnership with Cariad Interactive. It contains three games: reach, balance and flow. Reach is a game that encourages users to reach high with their reflections to touch the shapes on the screen. The balance game requires users to open their arms and to balance as many digital balls as possible. Flow is a task-free game that allows users to perform any movements they like. There are three modes in Somability: mirror, skeleton and shadow. The mirror mode shows users' original reflection on the screen. Under the skeleton mode, users see their digital images as colourful skeletons. The shadow mode turns the digital images into colourful shadows and attaches beautiful lines to user's digital image. Users can choose any mode within the three games.

4.2. Qualitative data collection

In order to collect data for this paper, ten people involved with the development of this game were interviewed about their contribution to the development of Somability. The occupations of the interviewees were programmer, graphic designer, manager, researcher, dancing instructor, facilitator and caregiver. Each of them contributed to developing Somability in a different way. Interviewing them helped understand the design of the fitness game as a whole.

Additionally, three natural observations were taken in order to learn about the development team working. The first time involved travelling to the game studio and observing the game designers develop the game. The remaining observations focused on beta testing which was accomplished by designers with collaboration of users from a day care center. The last two observations involved not only game designers but also users. The users' responses to the game helped analyzing the design process. In all we observed 26 people.

4.3. Qualitative findings

The analysis of the interview transcripts and the observation reports was conducted with the help of the qualitative data analysis software NVivo. Initial coding of the text was applied and 54 nodes were produced. These nodes were then linked and categorized according to the different phases of Somability's development process.

4.3.1. Design phase 1: conceptual outline. Interviews with the Somability team stated that during the conceptual outline phase, game designers conducted comprehensive user analysis to find out the essential functions of a fitness game. In order to do this, game designers as well as experts from LD communities were involved working together through role-playing, rehearsal and performance. This allowed the team to discover the idiosyncrasies of individual service user's needs, and thus find basic daily movements that could engage anyone even with limited movability. In order to avoid over complicated design and to make the software accessible for everyone, the simplicity principle was raised and was kept towards the end. The simplicity principle required designers to only use the basic game elements to minimize confusion and stress for users.

Somability also intended to improve user's mental states. During the conceptual outline design phase, experts from day care centers expressed the needs for users to socialize. Through observing potential users, game designers agreed that movements in fitness games should be designed to enable users to play together. Another user requirement raised by healthcare professionals was that games should enable users to decrease anxiety through exercise.

In summary, in order to simplify the fitness game, Somability focused on two functions of the game. On the physical side, the game's primary goal was to motivate exercise by repeating basic daily movements. On the psychology perspective, Somability aimed to bring users together by a group-play game, and they also allowed users to decrease anxiety in free movements. From the case study, the first phase 'conceptual outline' is defined as the design period to decide fitness games' functions specific for an LD context.

4.3.2. Design phase 2: implementation. In the second design phase, implementation, Somability satisfied user requirements and designed a simplified fitness game. The three settings in Somability reach, balance and flow all have easy rules and clear instructions. All the responses in the games are positive and even when users fail in a game task, they would not receive negative feedback. Besides, Somability has no time limit which encourages users to repeat their movements to the extent that they are satisfied. By allowing mistakes and repetitive play, Somability promoted physical exercise.

Another design aspect that helped simplify the game was to make the interface clear. Somability offered users a clear interface by removing clutter and only providing the bare essential elements on the screen.

Overall, Somability tried to simplify the mechanics and interface in the implementation phase. Feedback from users and their caregivers have shown that easy rules, repetitive play and a clear interface are effective in fitness games. The second phase 'implementation' is the design period to simplify fitness games through game mechanics.

4.3.3. Design phase 3: outcome. In the third design phase, outcome, Somability tried to intrinsically motivate users to perform physical exercise. In addition to being driven by the game concepts in Somability, users were also motivated to stay playing because of other achievements such as improvements of independent and social interaction. Users of Somability felt in control because the game offered instant feedback that tracked their progress. They became more interactive with others because Somability brought users together to play in groups. In addition to this, the game provided a competition aspect when encouraging users to build more flowers on the screen. Besides, caregivers have also pointed out that because everyone wants to have a go in front of the machine, there is often healthy competition.

By matching the results of playing fitness games with users' intrinsic needs, this study explores means to design fitness games in order to intrinsically promote physical exercise. The third phase 'outcome' is defined as the design period that fitness games motivate users intrinsically.

In summary, conceptual outline, implementation and outcome were discovered to be the three design phases to make simplified fitness games for users with LD. To explore these concepts in the contextual details, the research uses questionnaires to gather further insights from a broader audience.

5. Quantitative study

Based on findings from both the qualitative data and literature research, a survey was created to target additional game designers and healthcare professionals. The purpose of the quantitative study was to extend the qualitative study and to learn about the detailed design characteristics in each development phase.

5.1. Hypotheses

In the conceptual outline phase, it is important to find out user requirements and thus design simplified game functions accordingly. For fitness games, the primary goal is to motivate exercise which is reflected in the case study analysis. Besides, interviewees expected fitness games to help users decrease depression. Fitness games can contribute to that because they are helpful in making users happier, healthier, and more open to others [3]. Additionally, fitness games involve users in various tasks and allow them to perform successfully, thus help users gradually build self-esteem and confidence [33]. The first hypothesis is built around the design characteristics in the conceptual outline phase. To examine this hypothesis, four sub-hypotheses H1a - H1d were generated (Table 1).

Hypothesis 1: in the conceptual outline phase, the functions of fitness games should be designed specific to an LD context.

To implement game functions, the fitness games should be based around simple concepts with clear instructions. Somability is designed with a high tolerance of mistakes and repetitive play; prior research shows that games designed for users with LD should allow them to process on their own rate and to repeat actions whenever they want [34]. Case study analysis also shows that the interface of fitness games should be specifically designed to provide a clear and forgiving virtual environment. When designed appropriately, the game's interface can provide visual cues which offer clear and immediate feedback [35]. Technology in fitness games simplifies the games and supports users. It uses visual, auditory, and tactile cues to improve user experience [36]. By adding tactile and non-tactile features, fitness games can simplify the means to control games. For the purpose of this study, the game mechanics including game rules, instructions and interfaces are discussed. The second hypothesis is about the game mechanics in the implementation phase. There are five sub-hypotheses H2a - H2e built to examine this hypothesis (Table 1).

Hypothesis 2: in the implementation phase, game mechanics should be used to simplify fitness games for people with LD.

An ideal fitness games drives users to exercise intrinsically out of interests and enjoyment. Providing intrinsic motivation is important because it changes user's behaviour in the long-term. This research borrows ideas from Self-Determination Theory (SDT) which suggests that the more control someone has over their decisions, the more likely they will be internally motivated to perform those actions. The three core facilitators in SDT are autonomy, relatedness and competence. Autonomy can be applied to fitness games by offering flexible game variation and utilizing positive feedback with the aid of clear instructions. Relatedness can be strengthened by making the connection between users more secure, frequent and robust. [37]

This research looks at how autonomy and relatedness aspects of fitness games can enrich the game itself. Additionally, interviews reflect that Somability created competition which motivated users to play more actively. In theory, all games are competitive because end users compete with each other or against a game system [38]. While winners of a game receive a sense of achievement, losers can also enjoy the gameplay provided that they are given positive feedback [39]. Moreover, prior research has shown that for people with disabilities, games have other psychological benefits such as improving confidence, self-esteem and enjoyment [40]. With regards to the outcome phase, we developed hypothesis 3, to address the role of intrinsic motivations in fitness games which is examined through the four sub-hypotheses H3a – H3d (Table 1).

Table 1. Phases, sub-hypotheses and sources

Phases	Sub-hypotheses	Sources
Conceptual outline	Fitness games should: H1a: promote physical exercise H1b: encourage social connections	Qualitative findings
	H1c: develop users' self-esteem H1d: decrease users' anxiety	[3] [33]
Implementation	Fitness games could be simplified through: H2a: allowing mistakes	Qualitative findings
	H2b: allowing repetitive play H2c: a clear interface H2d: tactile features H2e: non-tactile features	[34] [35] [36]
Outcome	During gameplay, users should: H3a: start to play with others H3b: become more independent	Qualitative findings
	H3c: compete with each other H3d: feel happier	[39] [40]

Hypothesis 3: in the outcome phase, fitness games for people with LD should be designed to intrinsically motivate users.

As shown in Table 1, all the sub-hypotheses were generated from qualitative findings and literature research results. Survey participants expressed their opinion about the importance of each sub-hypothesis with a five-point Likert scale: 1-strongly disagree, 2-disagree, 3-neutral, 4-agree, 5-strongly agree. Some blank space was left on the questionnaire for participants to make additional comments.

5.2. Quantitative data collection

The market for fitness games targeted at learning disabilities is very new and therefore there are not many existing products. Thus only a handful of people have experience designing these types of games. To access a larger audience, the survey was carried out among both game designers and healthcare professionals.

Game designers were the obvious initial choice because of their familiarity with designing games and the experiences they could share when adapting to fitness games. Questionnaires were distributed during two game events where game designers from various game studios gathered. Participants included game writers, graphic designers, game producers and games studio managers.

Healthcare professionals provided emphasis on the topic of LD and their inputs were extremely useful for their knowledge of user requirements. Because many people with LD have trouble with writing and communication [16], they are not directly surveyed. Instead we surveyed healthcare professional who work with people with LD and thus intimately know their conditions and needs. Most participants were caregivers who worked in care homes that specialized in LD. 30 care homes were visited to collect questionnaire responses. Occupations in this sector included nurses, caregivers, social workers and care homes managers. In addition to this, healthcare professionals such as teachers, council workers, charity organization employees and researchers in this discipline were also involved.

The two groups of experts used the same questionnaire but their responses were separate so as to compare and contrast findings across groups. Altogether, there were 245 responses with a response rate of 41.8% (245/586). 114 feedback were collected from game designers and 131 responses from healthcare professionals, generating response rates of 44.7% (114/255) and 39.6% (131/331) respectively. After screening, 10 surveys were removed due to missing data, leaving 235 samples.

5.3. Quantitative findings

To find out survey respondents' opinions about the three design phases, the response of each sub-hypothesis was compared with 3 (neutral). Considering that there were two participant groups, the similarity between the two groups was tested first with Mann-Whitney tests. This test was used because the answers of all questions were left-skewed instead of normally distributed. For the sub-hypotheses that received similar answers from the two groups (p-value greater than .05), both groups' answers were combined. The median of the combined answer was compared with 3 using one-sample Wilcoxon Signed Rank Tests. If the p-value was smaller than .05 then there was enough evidence to support that the sub-hypothesis was significantly more positive than 3. Regarding the sub-hypotheses that received different answers from the two groups (p-value smaller than .05), the median of each group was tested separately against 3 with one-sample Wilcoxon Signed Rank Tests.

Table 2. Sub-hypotheses that have similar values across two survey groups

Sub-hypotheses	Means of healthcare professionals	Means of game designers	Means of combined groups
H1a	4.26	4.06	4.17
H1c	4.26	4.05	4.16
H1d	4.11	4.15	4.13
H2b	4.03	3.90	3.97
H2e	3.75	3.60	3.68
H3a	3.90	3.96	3.93
H3b	4.28	4.27	4.28

Table 3. Sub-hypotheses that have different values across two survey groups

Sub-hypotheses	Means of healthcare professionals	Means of game designers	Means of combined groups
H1b	4.38	3.50	3.97
H2a	3.89	4.35	4.11
H2c	4.20	4.65	4.41
H2d	4.13	3.76	3.96
H3c	3.30*	2.71*	3.02*
H3d	4.48	4.73	4.59

*Means for the 'competition' sub-hypotheses

Table 2 and Table 3 summarise the responses of all sub-hypotheses. The two survey groups gave similar marks for the seven sub-hypotheses in Table 2. All the marks were significantly higher than 3 which demonstrate that survey participants thought these design characteristics were of great importance when simplifying fitness games for LD users. For the other six sub-hypotheses in Table 3, the two groups of experts responded differently. But other than the 'competition' sub-hypothesis (H3c), all other sub-hypotheses provided feedback higher than a value of 3 which supported all of them. In summary, the key design characteristics that were significant according to the data collected and analyzed are following:

In the conceptual outline phase, in addition to the primary purpose, motivating physical exercise, fitness games should also be designed to promote social connections and decrease anxiety. During gameplay, users of fitness games should be able to increase their self-esteem.

With these design concepts in mind, designers will adopt simplified mechanics and assistive technology in the implementation phase. The mechanics in fitness games for LD users should allow mistakes and repetitive play. The technology in games should be able to assist users' special condition. In order to do that, tactile and non-tactile features in a clear interface will be helpful.

Simplified fitness games not only make users healthier but also improve their mental and social conditions; as a result, users are intrinsically motivated to continue playing. Experts have supported that happiness, independence and social skills will grow during gameplay. However, a common game element, competition, has to be handled carefully and to be kept in a safe level.

Considering that there are four levels of LD and those in each level group might have different opinion about fitness games, the survey data collected from healthcare professionals was split into four groups and further analyzed. This is feasible because participants from healthcare industry were asked to indicate the group of LD that they mostly deal with and then answer the questionnaire accordingly. After comparing data from four groups, there is no significant difference or trend. Therefore the conclusion made before is valid for all LD groups.

In conclusion, the design characteristics in the conceptual outline and implementation phases have been validated by testing the nine sub-hypotheses (H1a – H1d, H2a – H2e). As for the design elements in the outcome phase, three sub-hypotheses (H3a, H3b, H3d) were tested to be correct. Autonomy and relatedness motivations were supported by both respondent groups, but game designers thought users should not be encouraged to compete (H3c).

6. Discussion and contributions

This section explores the differences and similarities across the two datasets in the quantitative study, as well as the links between qualitative and quantitative studies. Contributions of this research to theory and practice are also included.

6.1. Comparison across the two respondent groups in the quantitative study

With regards to the conceptual outline phase, survey response groups agreed on three sub-hypotheses (H1a, H1c, H1d) out of four. The only sub-hypothesis (H1b) that had split opinions was about whether fitness games should encourage social interaction. According to their comments on the questionnaire, game designers were concerned about the vulnerability of users with LD. Therefore they marked this sub-hypothesis (H1b) averagely 3.5, which is only slightly more than 3. But healthcare professionals wanted fitness games to be a conduit for connecting users with others, especially given that they often withdraw themselves from others. Prior research has shown the effectiveness of games when it comes to increasing social interaction [3, 19, 25]. Fitness games with group-play element are able to help change the isolated situation that this user group is suffering. However, users should interact with people they trust and always do it under supervision [9].

For the sub-hypotheses concerning the implementation phase, two (H2b, H2e) had similar feedback and the other three (H2a, H2c, H2d) did not. For the three sub-hypotheses that had different feedback from two response groups, two sub-hypotheses 'allowing mistakes' (H2a) and 'a clear interface' (H2c) had significantly higher marks from game designers in comparison to healthcare professionals. This indicates that when simplifying fitness games, healthcare professionals were most considerate about the limited abilities of the users; therefore they put great emphasis on forgiving game concepts [34] and a clear interface [35]. Given the equally high importance placed on this by the two respondent groups, both aspects were seen as compulsory. The other sub-hypothesis 'tactile features' (H2d) had a higher average score from healthcare professionals than game designers. Game designers thought it was not necessary and would add more cost. But given that all the answers in separate groups were significantly more than 3, results actually suggested an overall agreement on the sub-hypotheses (H2a, H2c, H2d).

Regarding the four sub-hypotheses concerning about the outcome phase, two survey response groups agreed on two sub-hypotheses (H3a, H3b) and disagreed on the other two (H3c, H3d). The sub-hypothesis 'feel happier' (H3d) had highest marks from both groups, even though there is a significant difference. Simplified fitness games should be able to receive this outcome because simple game concepts, forgiving game rules and clear interfaces will make users feel relaxed and enjoy the gameplay. On the contrary, the sub-hypothesis 'compete with each other' (H3c) had lowest marks from both response groups. Game designers had a mark (2.7) that was significantly lower than 3, indicating that they thought competition should be totally avoided. Healthcare professionals thought competition was not a bad thing (3.3, significantly higher than 3) but needed to be handled with care; providing a positive outcome even for losers of the game. As a result, applying a competitive nature to fitness games appeared to be a delicate topic pointing to the idea that it could be applied but with great caution.

6.2. Comparison between qualitative and quantitative findings

After comparing the findings from qualitative and quantitative analysis, it became clear that most of the quantitative data supported the qualitative findings.

Perhaps the greatest difference between the qualitative and quantitative findings was the topic of competition. Somability encouraged users to compete with each other in a game to produce flowers on the screen by clapping hands; the user with the louder clapping would have more flowers. Somability demonstrated a successful attempt at applying competition to motivate users to partake in physical activity. However, survey respondents, in particular game designers, thought that competition among users with LD should be limited. One survey respondent commented on the questionnaire saying 'I like everyone to be a winner. So no one gets disappointed and resents using the game'. This worry is reasonable because research has shown that competition in games drives the end users to a more goal-oriented behavior, which has been tested to have a negative effect on social and body engagement [41]. Besides, a player who is behind in an unbalanced competition might quit because a lead is overwhelming [23].

Although winners are always motivated to carry on playing, this does not necessarily mean that losers are discouraged completely. The losers of games can be intrinsically motivated if they were offered positive feedback [39]. With that said, fitness games could apply the idea of providing positive responses such as the sounds of applause when users make progress. Besides, users should be encouraged to compete against themselves but not against others. In addition, designers can motivate users to play by other methods instead of competition, for example, the enjoyable experience of exploring the virtual game environment [22].

Overall, the research suggests that it is best for fitness games to avoid unhealthy competition. However, adding positive feedback in fitness games can help motivate both winners and losers. Users with LD should be guided to compete with themselves.

6.3. Contributions to theory and practice

This research contributes to literature by making a theoretical connection between fitness game design and inclusive design. It identifies and describes three key design phases for simplified fitness games, critical for users with LD. There is evidence to suggest that the design characteristics associated with these phases have been verified. The paper also emphasizes the intrinsic motivations in fitness games. It does so by combining Self-Determination Theory with game design theories to generate ways in which intrinsic motivations can be assessed during gameplay. Among the intrinsic motivations, we highlight the important and sensitive topic of the use of competition in fitness games and points out that it should be handled with caution. Further, this study emphasizes the involvement of expert practitioners such as game designers and healthcare professionals in evaluating the usefulness of design guidelines in this delicate context. In contrast to prioritizing engagement of end users in evaluating HCI design [42], in this particular context of designing for LD, practitioners such as healthcare professionals are equally important and provide critical perspectives on the design element.

In a practical sense, this research outlines the key design concepts of a successful fitness game and it potentially contributes to the quality of life of people with LD. Research on fitness games brings to this user group, physical, mental and social benefits as well as entertainment opportunities [42]. For game designers, the design characteristics proposed can help them avoid previously identified pitfalls. Such guidelines provide designers with a structured approach to make fitness games for LD users. Moreover, this research breaks down the boundary between researchers, commercial game designers and healthcare professionals. Researchers are encouraged to collaborate with expert practitioners when developing design guidelines so as to make conceptual theories more applicable to targeted field. In return, practitioners are recommended to involve in the development of design guidelines to help advancing knowledge.

7. Conclusion

This paper used a mixed method approach to investigate the three design phases of ‘conceptual outline’, ‘implementation’ and ‘outcome’ with a focus on simplified fitness games for LD users. Findings from both the qualitative study and the quantitative study support the idea that such games should consider user's physical, mental, social and motivational needs. Our paper therefore proposes and provides guidance for an inclusive and nuanced approach to designing games for people with LD that is sensitized to their specific conditions and requirements.

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