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Persuasive Technologies for Active Ageing

A Virtual Gym to Motivate Independent-Living Older Adults to Socialize and Exercise Regularly

(Ph.D Thesis)

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Abstract

Most of the world countries are challenged with a large ageing population who spend most of their time at home and are mostly sedentary (8.5 hours per day as of today). Sedentary behavior and physical inactivity affect the social, physical and mental states of people leading to social isolation and physical declines and hence an ideal candidate for chronic and degenerative diseases.

To maintain an active aging process (healthy state of physical, mental and social wellbeing), regular and daily exercising is necessary. However, many older adults do not maintain regular exercising due to poor health, lack of company, lack of motivation, lack of transportation and suitable outdoor facilities.

In this context, home based physical exercises can help people maintain their physical activity and ICT can act as a key player and facilitator by providing interactive training applications (through desktops and mobile devices), self-monitoring (using activity trackers and wearables) and automated coaching (using rule-based systems or remote assistance).

Yet, for many people and, in particular, the sedentary older population at home; even with the existence of the technology, there is not enough motivation to maintain a regular exercising routine. Thus, this thesis aims to investigate the IT-mediated persuasive strategies that help independent-living older adults at home to maintain a regular exercising lifestyle. In particular, this research examines the effect of social inclusion and group exercising on the motivation of trainees at home to adhere to the training program which has proven to be effective.

Keywords

[persuasion technology, older adults, physical exercises, social interaction]

Contents

Chapter 1

Introduction

1.1 Ageing and physical inactivity

The world ageing population is growing rapidly and life expectancy is increasing. Consequently, by 2020, a large portion of the society will be over 75 years old [1]. Most older adults are challenged with cognitive declines [2] (e.g., hearing, vision, memory, attention). Beside this, physical abilities deteriorate later in life (e.g., strength, balance, mobility).[3].

Physical inactivity and sedentary behavior in older adults especially those who are retired and spend most of their time at home is one of the main factors in their health decline. Harvey et al. [4] reviewed 23 studies that investigate late life sedentary behavior in 7 countries (by measuring everyday activity using an accelerometer) and reports that 67% of older adults (60 years and above) are sedentary for more than 8.5 h during their waking day. In particular, those older than 75 years were found to be less active than those in the 65-74 age group, indicating the importance of more physical activity for the 75+ age group.

According to the World Health Organization [5], physical inactivity is also a significant economic burden for the society and the European health-care systems, bringing about significant direct and indirect costs due to mortality, morbidity, poor quality of life, and increased health expenses.

For example, it is estimated that in England, indirect costs of physical inactivity amount to 8.2 billion per year [6], while, in Switzerland, direct costs of treatment are estimated at 1.1 - 1.5 billion [7].

On the contrary, physical activity, especially in the form of structured exercises, has been linked to positive outcomes in physical, social and mental wellbeing of older adults [8]. Engaging in physical activities reduces risk of falls [9], slows progression of degenerative diseases [10], and improves cognitive performance and mood in older adults [11]. Research even suggests that most active older adults are twice as likely to have no disabilities related to daily activities prior to death, as compared to sedentary ones [12].

1.2 Barriers and challenges to exercise

There are, however, a variety of barriers that make it difficult for older adults to maintain or increase their physical activity level: lack of easy access to facilities and infrastructures, reduced functional abilities, and lack of motivation [13]. Among the factors affecting motivation, self-efficacy (i.e., perceived capability and confidence), which is a strong predictor of adherence to physical exercises, is less exhibited in older adults compared to other age populations [14]. In addition, older adults and in general people challenged with physical and cognitive decline are less able to leave their homes and participate in physical and social activities on a regular basis.

Along with the physical activity decline, a reduced participation in social activities and changes in social roles put older adults at risk of social isolation. Extensive research has found links between social isolation and adverse physical and mental health, e.g., increased mortality rates for older adults, elevated blood pressure, dementia, depression, and cognitive decline

[15, 16, 17]. On the other hand, engaging in social interactions is beneficial to the health and wellbeing of older adults [15]. Accomplishing practical activities together is an indirect means to stimulate and strengthen social ties, which is particularly beneficial for older adults with limited opportunities to interact [18].

The ICT innovations of the last decade, from smart TVs to portable devices connected to the internet; revolutionized the ways in which we can establish a community among people and deliver interactive content. There are many computer-mediated applications and tools, which enable and persuade the older adults to do home based training exercises. Serious games [19], exergames [20] and persuasive mobile applications [21] are some of these examples. However, the existing applications are not customizable and it is not possible to personalize them according to the older adult's needs and interests. The older adults tend to have more health disparities as they age [22] and prescribed training plans vary from therapist to therapist and from clinic to clinic [23]. In addition motivating older adults at home to exercise is challenging due to their heterogeneous population and different tastes and interests [24]. This requires a dedicated training plan for the trainees that resonates with their specific impairments and also dynamic tailoring of the exercise for each individual to ensure the effectiveness and persuasiveness the training.

1.3 Research objectives

Given the aforementioned barriers and challenges described above, the goal of this thesis is to design and study persuasive training applications that leverage social interaction and motivate older adults to be physically active.

We aim to address the independent-living older adults that, due to the obstacles listed previously, can not participate in everyday outdoor activities (e.g., going to a gym). Thus, the design of such applications should be inclusive, taking into account older adults' disparate physical abilities and their lower computer literacy.

We introduce ICT tools and models that enable these heterogeneous groups of older adults to participate in scheduled and supervised training programs from their homes. In particular, we aim to:

- enable older adults at home to participate in physical exercises remotely,
- motivate older adults to adhere to long term physical activities from home,
- and facilitate virtual social communities where older adults with diverse physical abilities and health disparities can exercise together (in groups).

In addition, we study and report on interventions designed to understand the effect of *social facilitation*, and in particular of *social presence*, on the desire of trainees to exercise together, and it's impact on the adherence to a training program. To reach this goal, we try to answer the following research questions:

Q.1. Can (and to what extent) IT-mediated social interaction motivates older adults at home to be physically active?

Q.2. How technology can enable older adults with disparate physical abilities to exercise in a social context (in groups)?

The answer to these two fundamental questions can be very beneficial in understanding the co-relation between social interaction and physical activity in older adults. We also seek to understand how technology can pair people with different physical abilities to exercise together. We designed a social training application (a virtual gym) that allows people with different physical abilities to get together in a social context and exercise together. To enable people with different physical abilities, tailoring exercise intensity for each individual is crucial. Tailoring and monitoring the trainees is managed by the community of coaches that use our tools (the coach platform) to design and personalize the training program for each individual trainee in the group. To validate the design, we conducted pilot studies and a two months Prospective Cohort Trial with 40 independent-living older adults in Trento. The results of the trial, along with secondary intervention studies using our system, reveals the strong relation between social interaction and physical activity. Within these studies, we also validate the design of applications that can peer disparate older adults to exercise in groups.

1.4 Key findings

Reviewing the literature and a technical review of current applications and trends for fitness training, we identified the main aspects of training applications for older adults. From the review we learned the provision of multi-modal interaction with the user. We also learned that social persuasive strategies are more effective to motivate the older adults to exercise. The presence of a human coach (trainer) is important for sensitive training programs and in particular for the older adults. In addition, automatic sensing is preferred opposed to manual data collection, yet automatic sensing technology is not accurate for sensitive data collection.

From the Prospective Cohort Trial, we learned that social facilitation (virtual co-presence) and social persuasive strategies leverage physical activity. Older adults who exercise in a social group perform better and exercise more frequently. Healthy older adults can use virtual training applications from home and follow a physical training program. We also learned that older adults consider features related to training more useful than communication features. In addition, using virtual gym application for physical training can improve the physical wellbeing of the older adults.

The overall studies and learning of this thesis validate the usability of social, yet tailored, training applications for the independent-living older adults at home. The conceptual model and design guidelines along with our learning from the user studies (what worked and what did not work) provides information on various aspects of virtual social training applications.

1.5 Structure of the thesis

This PhD dissertation emphasizes our development, research and findings over the course of my doctoral research. The findings are organized in chapters explaining various phases of the research work, study protocol and validations. Parts of the text and findings described in this research work were published in scientific journals and conference proceedings, where each reused material is cited accordingly. In the following, I summarize the main topics discussed in each chapter.

Chapter 2 summarizes the state of the art in IT for prevention [25], ICT solutions for home based physical training, persuasive strategies for home based intervention, usability of home based training applications and systems for the older adults at home. We also describe the gaps of the literature that we aim to address in this thesis.

Chapter 3 presents our work on reviewing the current market fitness applications for home based training. We identify the key aspects of fitness applications (i.e., interaction design, sensing and monitoring, coaching and tailoring, persuasive technology) and then evaluate the top applications of the major mobile and game console markets with respect to these aspects. The findings of our evaluation is in press for publication [26]

Chapter 4 presents the evolution of "gymcentral" a unified platform that enables coaches to plan training programs and monitor trainees performance and a virtual social gym (gymcentral trainee's application) that enable older adults at home to follow exercises in a social context. This chapter explains the conceptual model and implementation of gymcentral and its features [27, 28].

Chapter 5 presents a Prospective Cohort Trial conducted to test and validate the virtual Social Gym. We also present our findings on the effect of normative influence and social facilitation on physical activity. In addition, we present the physical and social outcome of using gym central for physical training. The results discussed in this chapter were published in [29, 30, 31].

Chapter 6 summarizes the secondary pilot studies, focus groups, trials and follow ups of the gymcentral service. In particular, it presents the pilot studies prior to implementation of gymcentral, and deployment of gymcentral in external trials.

Finally, **Chapter 7**, summarizes the thesis, discusses the conclusion of this research work, states limitations and the future work.

Chapter 2

State of The Art

2.1 Introduction

In this chapter, we review the state of the art in designing persuasive training applications for older adults. Persuasion technology (using computers to change what we think and do) is an emerging field first introduced by Fogg [32] in his book. Since then, many researchers examined the effect of persuasive technology in various domains (e.g., healthcare, military, education). In this review, we aim to cover the recent research on using persuasive strategies to motivate older adults to be physically more active using IT-mediated applications.

We also review studies that experiment with home-based interventions for physical training and we discuss the findings in the literature about their effectiveness and shortcomings.

We then review various aspects of the interaction design of home-based training applications and discuss different design techniques such as exergames, the use of virtual environments and interactive video exercises.

Finally we review the literature on persuasive strategies for home-based physical training in two categories of *individual persuasion* and *social persuasion* and we discuss their provisions and shortcomings.

2.2 Home-based interventions for physical training

Several studies and meta-reviews [33, 34, 35] assessed the effectiveness of home based exercising on the physical abilities of the older adults. Various physical training programs and in particular *Otago* exercise program were proven to be effective in improving the physical function of the older adults in home-based interventions.

The design of the physical training interventions for trainees at home were explored from the conventional *paper-based prescription* with home-visit and telephone call monitoring strategies [36] to *software* and *hardware* solutions which provides real-time monitoring and live feedback (e.g. *BASE*[37]) to them.

Interactive video exercising which, the exercise instruction are recorded by an expert and delivered to the home user in a schedule is been practiced frequently. For instance, Ofli et al. [38] experience with a video exercising system featured with a *MS-Kinect* that provides video exercises to the trainees and measure the performance using the Kinect body motion sensor. The real-time sensing technology allows the system to provide automated and live feedback to the trainee while exercising. However, exercises are not tailored to the skills of the trainees and there is no human coach in the loop. Silveira et al. [39] also introduce *Active LifeStyle*, a video exercise training application for physical exercising (strength and balance) that runs on iPad tablets. The application provides scheduled *strength* and *balance* exercises to the users. In this study, user performance was obtained by user's manual entry (feedback) after each training session. The study evaluates 3 user groups, comparing the conventional paper based prescription to technology based exercising individually and in a social context and confirms physical improvement while following the training plan from the application. However, exercise tailoring were not practiced in this interventions.

In addition to the interactive video exercising, physical training were experimented in virtual context and with a virtual coach and reported usable and preferred by the older adult users. However the effectiveness of the training applications were not measured (e.g., Albaina et al. [40]). Physical therapy and stroke rehabilitation using Nintendo Wii exergames proven to be effective and persuasive in a study [41], yet the authors emphasis on the need of social engagement and exercise-tailoring to achieve better effectiveness.

A meta review on exergames[1] [42] for physical activity reports on lack of conclusive results on the physical improvements benefits of exergames interventions. Molina et al. [42] reports that using market games and training programs such as *Nintendo Wii* and *MS-Kinect* games makes it difficult to precisely measure the physical improvements after the intervention since the exercises are mostly in the forms of playful games.

On the contrary, a meta review of *non face to face* physical intervention [43] reports that IT-mediated and paper based interventions are found effective in increasing and maintaining the physical activity of the older adults. Yet, few interventions incorporate the exercise tailoring for the individuals in the trial. In addition to the need for exercise tailoring, a cross sectional study [44] determines that most of the older adults find poor health as the main barrier to exercise (57%). Following by poor health, lack of company (43%) and lack of interest (36) are the major barriers to exercise.

Discussion. The review of literature in training application for physical activity reveals that although physical training applications can be usable and have positive outcomes for the trainees, few studies experiment with the exercise tailoring and a human coach is not presented. Later, we try

[1] Games that require physical activity to advance

to address these limitations by experimenting a training application that provides supervision of a human expert (coach). Chapter 4 depicts our approach in designing an application that tailor the exercise to the specific needs of the trainee. We then validate the effectiveness of the application in Chapter 5.

2.3 Interaction design for home-based training applications

IT-mediated home-based training applications were designed in various forms (e.g., training applications on mobiles, Desktop computers and serious games and exergames on game consoles). In this section we review the current research on designing user interfaces for the older adults who have lower computer literacy and also challenged in using everyday technology. We then review the use of virtual environments (VR) for promoting physical training and finally we review exergames designed to engage older adults in physical activities.

2.3.1 Interface design and usability

We discussed in the introduction section that many older adults are challenged with *hearing, vision* and *memory.* Thus, if they fail to interact with a system due to their limitations, they will be disappointed, or unable to use the technology. In addition, Fogg [32] in his book discusses that, the *use context* of a persuasive system should be similar to the users' real life and the user should generally like the *interface.*

In the literature, several studies propose context familiarity as a feature to persuade the older adults. A study has shown that older adults are more likely to perform activities similar to their daily life. [45]. Another study [46] developed two computer games aiming at improving the older adults cognitive ability. In this context, they prepared two different input devices for the game. The input devices were *drum-like* game pad and *Wii remote controller*. The study has shown that drum-like input device were better adapted by older adults, since it was easier to use it and had more familiarity to the them. Despite the similarity to real life activities, the *use context* should be easy to understand and interact. Tsai and Lee [47] experimented the usability of icons in small touch screens. The study reveals that using and placing icons and pictures instead of text can help the older adults to have a better interaction with mobile interfaces. Another study [48] discusses the importance of *suitable HCI* for promoting well-being for the elderly. Using most of the technologies requires learning which is demotivating. Hence, the study presented "Accenture's Intelligent Home Service" as an infrastructure with a very simple user interface. The study shows that simple interfaces without *pre-learning* are more successful to motivate older adults.

We discussed that *similarity* and *simplicity* are two key design elements while designing for the older adults with physical limitations. However, the *medium* also plays a significant role in delivering simple and similar use context. For many years, interaction with computers required the user to use a mouse and keyboard, which is more difficult that direct interaction. Loureiro and Rodrigues [49] discuss that some older adults who are not used to technology, regard technology as something not belonging to their own and show resistance in using it. Using computer technologies by older adults goes back to their perception that they are too old to learn and to use technology. The other problem is anxiety about making errors. However, during the last decade technology moved to a new trend and today there are *smart phones*, *tablets*, and *tabletops* that provide natural user interfaces. In the recent years, research about the impact of natural user interfaces in motivating the elderly to use information and communication technologies got considerable attention. *Natural user interfaces* (e.g., touch devices, tablets) enable the older adults to have a *direct interaction* with the content and therefore it simplifies the interaction. On the other hand, the use of fingers and direct connection with the objects on the screen, gives users a feel of similarity with real objects. Loureiro and Rodrigues [49] also reviewed a number of projects which use *multi-touch* as an interface for older adults. The survey concludes that using touch devices are easy and fun and therefore improves the user's self-efficacy while using the system. Moreover, lower level of computer literacy is needed to interact with these touch devices. Studying and using natural user interfaces is an emerging field. A study in 2012 [50] presents a tablet based game for the older adults aiming at motivating them to exercise. The outcome of the study has shown that the main reason for why many older adults show resistance to technology is because the technology itself did not adapt the older adults' needs and behavior. Thus, the author claims that the interaction of the older adults and computers has a great impact on the way they feel about their experience with computer devices. In addition, tablets are privileged devices for seniors, because they simplify the interaction. They have a larger dimension than smart phones, they are smaller than computers and they have almost all the functionalists of a computer. Mobility of tablets allows the users to take them everywhere and use them from their comfort zone.

Discussion: The review of the literature identifies the main challenges of designing a senior friendly user interface as, *simplicity*, *context familiarity* and *direct interaction*. However, unlike young generation, the level of computer literacy is lower in the older population. In addition, many older adults are challenged with physical declines which makes it harder for them to interact with everyday technology. For this group, the design of specific applications that takes into account the wide range of older adults with different abilities and computer literacy is important. In our approach, we apply the learning from the literature to design a training application that is inclusive, and take into account the challenges that older adults with low computer literacy have.

2.3.2 Exergames for physical training

Gaming technology has also been used to help older adults in training. Devices such as the MS-Kinect [51, 52] and Nintendo-Wii allow users to use their body movement to control in-game characters. Both customized [53, 41] and off-the-shelf solutions [54, 55, 56] have been tried to train older adults. Nonetheless, few have been tested by older adults at home [55] or have used virtual coaches [53], as these gaming consoles were initially designed for the younger population.

Most exergames are designed to prevent physical decline by helping and motivating older adults to engage in physical activities, maintaining and even improving physical abilities such as muscle strength and balance. Gaming consoles that allow players to control games with their movement favor the development of these systems. For example, many of the games available for the Nintendo Wii console have been tested with seniors in several studies. [57, 58], almost always with positive results in terms of acceptance of the technology and increase of physical activity. There are also efforts to improve the design of these games to make them even more suitable [59].

In this regard, SilverPromenade [60] is an exergame specifically designed to motivate institutionalized frail older adults (e.g., living in assisted living facilities), into taking virtual walks by easily stepping on and off the Nintendo Wii's balance board (i.e., a board similar to a weight scale that serves as a game controller for the Wii).

To a lesser extent, also Microsoft's XBox 360 Kinect console which does not need a remote sensor but instead uses a 2D camera, has been tested successfully to stimulate visual performance of institutionalized older adults with wheelchairs [61].

According to [54], exergames in groups can also enable an Active Ageing by improving *psychological factors* like self-esteem and affect.

Other than game consoles, physical training often demands for custom-built devices and sensors. For example, [62] have used a custom-built device with a camera and body sensor to record movement of a person in order to monitor and guide him or her into exercising through *Tai Chi*. By learning Tai Chi, the beneficiary will also improve their physical abilities. Similarly, a custom-built walk-board is used by [63] to encourage older adults to walk more by detecting when they are walking over it and giving incentives to do it again. The incentive is implemented by using the metaphor of a *virtual sheep* that they have to take care of within an animated farm, displayed in a PC. The more they walk, the better the situation of the sheep. Also for walking, [64] developed a custom-built robot that plays with people in a ball game where the ball is exchanged between both of them while the robot is moving. Seniors playing the game have to hand the ball back to the robot, which push him or her to walk.

Mobile devices have also been leveraged for exergames. This is the case of "Walk 2 Win" [65], a mobile game that older adults can play in group or individually and in which to progress, they need to walk in a closed environment and discover hidden artifacts. The application uses a smartphone and local Wi-Fi to detect the user's geographical location and a central server to synchronize and moderate the game.

Discussion. The review of the literature shows that exergames and games that combine the elements of fun and competition can be used as a persuasion to motivate the older adults at home to be physically more active. However, exergames are designed to be fun, making it difficult to deliver precise and intensive training applications. Use of exergames can be beneficial when designing training programs that aim to address the general wellbeing.

2.3.3 Virtual environments for physical training

Training at home does not feel the same as training outdoors or at the gym. Therefore many home-training settings rely on virtual environments to evoke similar conditions. IJsselsteijn et al. [66] analyzed *intrinsic motivation* and *sense of presence* when exercising indoors, using a stationary bike and a projector to show a virtual racetrack. The study involved 24 Philips employees, with an average age of 41.3 years old. Intrinsic motivation scores, presence, and cycling speed were higher for high immersion settings (a 3D real-time first person view of the track, in comparison to a 2D aerial view with a dot representing the user position), and the sense of presence increased when having a virtual coach.

Other studies concur, showing that virtual worlds increase the sense of presence, or psychological immersion [67, 68]. Users feel as if they are an integral part of the virtual world and get more engaged in the activities, thus making virtual worlds suitable to facilitate social engagement for the health support and physical functioning of the older adults [42, 69].

In addition, positive results have been obtained when comparing virtual training environment with traditional settings. Siriaraya et al. [69] compared adaptable *Virtual Reality* (VR) technology for physical rehabilitation versus conventional rehabilitation program, reporting that VR can provide a more controlled and natural exercises and improve the rehabilitation process. Besides, the technology allows health care experts to create complex, controllable, and interactive rehabilitation training which, can be tailored for each individual patient either in clinics or at home.

Discussion: Most of the aforementioned studies were carried out in care homes or laboratories, under the supervision of therapists or caregivers. Furthermore, physical presence was required to participate together and there were no control groups to test lone participation conditions nor co-presence for remote, independent training settings. In this thesis, we measure the effectiveness of the virtual presence (co-presence) on engaging the older adults in exercising sessions and report on its benefits.

2.3.4 Training applications

Some of the training applications applications benefit from incorporating persuasion techniques but without making the training into a game like serious and exergames do. An example of this type of applications is *Active Lifestyle* [70], an iPad based training application that provides video-based training exercises to improve strength and balance. The application also incorporates persuasive strategies (i.e. positive and negative reinforcement, social interaction with public bulletin board and private mailing system, collaborative training, self-monitoring and reminders) in order to motivate the user into adhering to the training plan. Similarly, *Flowie* [40] is a training application for motivating older adults to walk. Flowie keeps track of the daily step count of the person with a pedometer and displays progress using growing flower in a situated display placed in the home. A third example of the same type is *Seniorcize*[2], a tablet application that presents workout sessions and tips about physical exercises.

Steffen et al. [71] designed an application to suggest physical exercises and monitor the user activity through a wearable sensor, thereby coaching the user throughout the exercises. Other works have used robots as trainers, which is the case of “robot exercise instructor” [72], a mobile robot that coaches the user to perform seated exercises to improve physical strength. During the training, the robot performs the exercise activity

[2] `http://www.walkinglibrary.com/seniorsize.html`

and the trainee imitates the robot.

Consolvo et al. [73] provides a fitness device that allows older adults to monitor their own physical activities and sends the data to their phone to support user self-awareness about his physical conditions.

Discussion. We reviewed some examples of training applications for physical activity. Some of the training applications presented incorporate persuasive strategies. Unlike exergames, training applications are more focused on training that fun and gratification and hence more applicable for intensive training. Chapter 3 discuss our in depth review on training applications and we discuss the main aspects of training applications and their provisions and shortcomings.

2.4 Persuasive technology for home-based physical interventions

As discussed, despite the availability of usable technology, motivating older adults to exercise is a challenge. Among the factors affecting motivation, self-efficacy (i.e., perceived capability and confidence) is reduced in older adults compared to other age populations [14, 13]. Other aspects such as the *perceived drawbacks* (e.g., illness, pain, discipline) and the tendency towards *sedentarism* (e.g., due to habits or psychological issues) also play against the motivation to engage in physical activity [14].

In order to mitigate these effects, researchers have explored various types of persuasion technologies in the design of training solutions. We classify the persuasion strategies in the literature in two major categories of *individual motivation strategies*, where the persuasion mechanism does not require the presence of a social community and *social motivation strategies*, where the presence of a social group (e.g, co-participants, family and supporters) has a positive effect on the participants exercising behavior

[70].

2.4.1 Individual motivation strategies

Individual motivation strategies range from appealing and usable interaction design, to self-monitoring, alerts and recommendations, positive and negative reinforcements, and gamification [32, 74]. Several studies experimented with the effectiveness of such strategies with older adults.

Serious games

Toward the end of the 1980, researchers start to pay attention to computer technologies that are persuasive for the elderly population. In 1990, Whitcomb [75] identifies games as the most appealing computer software to older adults. Whitcomb [75] argues that games have the elements of fun and they provide immediate feedback to the user. However, he concludes that only few games are interesting for the older adults and we need to find a path for more interesting games.

The fact that not all computer games are appealing by the older population was of interest of researchers for many years. In 2002, Aison et al. [76] reviewed the appeal and interest of game playing among a group of older adults ranging from 66 to 79 year old. The participants were asked to play a set of video games and they took note about the player behavior during game playing. The result of the experiment shows that the participant showed a high degree of interest in playing games in general, but games with *familiar content*, *distant from violent content*, and preference for *educational* or *historical* information are more persuasive for the older adults. Another study 8 years later [77], provided several games for a group of 224 elderly and 127 of them completed a survey. A questionnaire was prepared to ask the older adults to rate their interest in different genre of the games. Most of the participants selected puzzle game or traditional games playing. The study identifies that many older adults would like to play game for challenge and competition. However, game playing is not socially accepted among the older population. As a result, the authors conclude that there is a need to further evaluate the appeal of game playing among the older adults, because their mindset is different from adolescents or the young people. Beside these, Ijsselsteijn et al. [24] discuss that the majority of the older adults appeal to play games where there is an organizational stimulation or study programs and many of the games failed to engage the older adults because of their challenging interface. The authors mention that older adults are more likely to play games that provide social contact or face-to-face interaction.Ijsselsteijn et al. [24] conclude that seniors have variety of interests, tastes and abilities, which makes them a heterogeneous group. Games should be designed according to their needs.

Although most games are only for fun and gratification, there are games known as *serious games* with the primary purpose is not entertainment and fun. Serious games are used to encourage and motivate the player to perform a serious task. Rego et al. [78] reviewed serious games for rehabilitation and conclude that computer games can be very useful to train users and slow down their physical and cognitive deterioration. In this context, several research works studied serious games as a persuader to motivate the elderly to exercise. In 2010, Perry et al. [23] proposed a platform for the *neurorehabilitation* of the elderly using serious games. The study reveals that computer games represent powerful tools to increase motivation and active participation during the training exercises. Hence, it is very promising to apply game elements for a rehabilitation task. The article list the effective criteria of rehabilitation therapy using serious games as: *Adaptability to motor skill level, Meaningful tasks, appropriate feedback, therapy appropriate range of motion, focus diverted from exercise, intentional movement* and *quantitative measures.* However, the author concludes that the neoro-rehabilitation process varies from therapist to therapist and from hospital to hospital and therefore, it is not possible to identify the best solution yet.

As discussed, serious games are the persuasive games that have a well-being potential in their essence. However, games in general have the elements of fun and challenge and therefore it is possible to apply these elements in a non-game context. Applying game mechanic in a non-game context is an emerging field so called "Gamification". Although gamification uses game elements, applications applying games elements are not considered as serious games. During the recent years, researchers experimented the use of game elements in several domains from education to military and health care. In this context, a study [79] presents a game based system aiming at motivating the elderly to perform rehabilitation exercises. The study has shown that using game design elements (e.g., *incorporating of high scores, achievement medals, adaptive difficulty, different game modes* and *offering effective feedback*) can motivate the elderly to participate and engage in the rehabilitation exercises.

Discussion: The review of the literature stresses several aspects and further challenges. The essence of game playing is appealing by the elderly. In addition, serious games and gamification have a great potential for persuading the elderly to participate in rehabilitation processes. However, older adults demand games that resonate with their interests. Beside this, the effects of game playing in long terms require further investigations. Rehabilitation processes are various and each needs a different set of games. In our approach, we will touch these issues by applying game elements in a training application as part of our persuasive features.

Exercise tailoring

A study in 2009 [46] investigated multi-modal interface as an approach to cover usability for variety of elderly with different physical abilities. In addition, a method were used in a game to collect feedback from the older adults while game playing and tune the difficulty of the game for run time. Another study In the same year [40] presented Flowie as virtual couch that motivates the elderly to walk more. The author mentions that exercise tailoring can introduce new ways to encourage healthy walking among the older adults by monitoring the actual activity patterns and notify the person about the performance using different metaphors. In this study, a virtual couch was proposed that motivates the older adults to walk more. The virtual couch uses a pedometer and analysis the users' activity pattern and based on these data, guide the user to walk more.

Discussion: Considering a long term training plan. The platform should evolve with user improvement and tune the level of the exercise according to the user improvement. Although there are very few studies on the effect of dynamic exercising, the existing examples reveal that exercise adaptability remains the individual users persuaded in exercising for long terms. Therefore, in the design of "Gymcentral" we experiment the dynamic exercise tailoring.

Alerting and reminders

To maintain the older adults motivated during a long term training plan, *Continues praise messages* and *exercise reminders* are important. In 1981, Garnett et al. [80] compared the effectiveness of telephone follow up in improving patients compliance to adhere to their medical prescription. The study reveals that phone calls had little effect on adhering the patients to their medical therapy plan. Later in 2007, Kripalani et al. [81] reviewed different interventions that try to improve patients adherence. The author claims that in general the overall quality of the literature is poor because of the wide variability in study design and patients populations. In 2010, de Oliveira et al. [82] proposed *Movipill* as a mobile game to persuade the older adults to adhere to their medication prescription. The study approach was to use a social game for the older adults to persuade them to adhere to their medical prescription. The study revealed that using social pressure and enabling users to remind each other can be very effective.

Discussion: The review of the literature shows that using reminders and praise can improve the adherence of long lasting training programs. We address the implementation of reminders in chapter 4

2.4.2 Social motivation strategies

Fogg [32] in his book identifies the most important social elements of a persuasive system as: *social learning, social comparison,* and *normative influence*. Oinas-Kukkonen and Harjumaa [74] define a system with social learning features as systems that provides "means to observe other users who are performing their target behavior and to see the outcome of their behavior" and defines a system with social comparison features as a system that provides "means for comparing performance with the performance of other users".

In the literature, several studies used social support and influence to persuade the older adults to have a healthy behavior. Several researchers combined these social aspects with serious games and some neglected game mechanic and used only social influence and support as a persuasive strategy. In 2006, Gasser et al. [83] investigated the acceptance of mobile lifestyle coaching in traditional web applications. The approach was to use social features to motivate the users to follow a training plan. In the design of the application self-monitoring, goal setting, collaborative exercising and alerting prompts were used. The study concluded that the players playing in group achieved slightly better results that those playing individually. Another study in 2010 [84] presents a mental well-being training application integrated into Facebook as a wide social network. The study reveals the effects of social network in retention of the user in a health promoting application. The study reveals that there is a desire for social interaction among the participants. Participants were very pleased by the huge amount of feedback they receive from their friends and other people in the system and most of them stated that it was motivating them to post more healthy messages.

Although the target users of the aforementioned studies were not specifically from the elderly population it is possible to apply the same strategies for elders. In 2010, Romero et al. [45] studied the design and development of a playful persuasion to motivate older adults to maintain social interactions. The approach of the research was to involve older adults, family and care givers in an ecosystem. The research conducted a study based on user studies, surveys and direct interviews. The outcome of the study reveals that the older adults spend quite a lot of time engaging in group-activities. The older population are willing to participate in an activity if they see other people at their age range doing that particular activity. During the last 5 years, a few other studies applied and experimented social influence and support to motivate older adults to participate in exercising sessions. Mubin et al. [65] present a socially interactive game for the older adults. The aim of the study was to motivate the participants to walk more while playing in a collaborative game. The participants in the study mentioned that playing in a group motivated them to participate equally. The author argue that based on the finding on this research, it is very important that the game provides social interaction. One year later, Gamberini et al. [85] presented “Eldergame” as a table-top gaming console for the elderly aiming at preventing cognitive decline of the ageing society. 4 older adults could play social game while sitting around a round table and share one tabletop interface. Although the article claims a high acceptance rate from the participant elderly, however we were not able to find any result from the impact of collaborative game playing. Age invader [86] is one of the successful examples of a system that connects the older adults with their grandchildren. Age invader provides a virtual reality environment for the older adults and their grandchildren so that they can play interactive games remotely. The experiment has shown that not only computers can remove distance barriers, but also they will be able to compensate the elders' disadvantages while playing with young people, so it is possible to sustain older adults' interest in continuation of the game. The authors identified that the most important key to the enjoyment of the game was social interaction.

Beside social comparison and normative influence, very few studies discuss the effect of social learning in motivating the elderly to practice a healthy life. Baumer et al. [87] analysis the qualitative data from two other studies and concludes that *openendedness* allows user flexibility and freedom in defining what is health. Openendedness means awareness of the activities and decisions of other users as well as the relationship of ones own activities to the group. The authors claim that this approach let the end users themselves to decide what is a healthy state.

Moreover, Anderson-Hanley et al. [88] studied the effects of social presence, and in particular of the moderating effects of competition, in the exercise behavior of older adults in a virtual biking environment. In their study, the introduction of competitive avatars enhanced the effort of the competitive participants, without negative effects on the non-competitive ones. However, the effect of the social presence in the long term adherence and social user behavior was not explored in this work.

Discussion: In summary, research suggests that **social motivation strategies** are more effective than individual strategies, in particular for the older adults [70, 89]. Social support given by family, friends and caregivers can improve the self-efficacy of older adults and thus increase motivation to engage in physical activity [90, 45].

The review of the literature on the use of social influence to persuade the older adults reveals that, the older adults in general have a great interest in having social interaction. However, when it is about competition and collaboration, they should be able to collaborate or compete with equal peers. As we mentioned earlier, ageing impairments are diverse and therefore the abilities of each elderly could be very different from her peers even if they are in the same age range. This remains a challenge for us that since collaborative and competitive game playing or exercising require equal peers, it is not always possible to peer the distinguished elders to compete or collaborate in a group. A collaborative or competitive training application for a group of elderly with different degree of interaction abilities cause discourage to those who are less skilled. Beside this, the effects of virtual social presence on both exercising behavior and long term adherence has not been explored yet in home-based training settings with older adults. In this thesis, we focus on gaining more insights into this type of social facilitation and their effects and report them on chapters 4 and 5.

2.5 Conclusion

In this chapter, we reviewed the literature on various aspects of designing persuasive IT-mediated solutions for the independent-living older adults.

We reviewed the current literature on designing physical interventions using IT. The main findings from the literature reveals that although the older adult population is heterogeneous, training applications does not tailor the program for trainees. In addition, most of the interventions do not include a human coach who can monitor and interact with the trainees while exercising. Thus, participants with different physical abilities can either find the training program too easy or too challenging. In this thesis, we aim to tackle this shortcoming by designing and validating a training application that delivers tailored training to the individual trainees. In chapter 4 we explain our approach on designing a training service that provides monitoring tools to human coaches, and respectively enable coaches to adjust the exercise intensity for the trainees. This approach helps trainers to deliver the most suitable and effective training program to each individual trainees using the application. We then validate our proposed application in terms of physical outcomes and benefits of tailored training for the older adults in chapter 5.

Reviewing the literature in designing training applications for the older adults provides guidelines on the interaction design of such applications. As many older adults are challenged with physical and mental declines and the level of computer literacy is lower in this population, the design of IT-mediated applications should be inclusive taking into account their limitations. We learned that older adults prefer applications that are more similar to their daily life activities. In addition applications with simple functionality and with less pre-learning requirements are preferred by the older adults. We have also learned that virtual environments for exercising is suitable and motivating for the older adults. Given this lessons learned, we introduce a virtual gym application (Chapter 4) that mimics the environments of a real gym (e.g., reception, receptionist, locker room, classroom). The findings in the literature led us to design the virtual gym application on a tablet, since tablets are portable devices that provide direct interaction and easier to use than computers with a mouse and keyboard.

We reviewed the literature on persuasion technology and use of persuasive strategies to motivate the older adults to perform physical activities. We reviewed persuasive technologies in two categories of *individual*, referring to motivation strategies that do not require the presence of a social group and, *social*, referring to motivation strategies that use social interaction with family and friends to encourage older adults to exercise. The learning from the literature highlights that social persuasion strategies are more appealing for the older adult population. In this thesis, we aim to study the effect of social motivation strategies in more depth. In particular we study the effect of normative influence and social facilitation in a virtual gym on physical activity. In chapter 4 we describe how we include social interaction features to the virtual gym (i.e., bulletin board, private message, virtual co-presence, invitation tool) to enable trainees to exercise and interact with each other. We then test the social persuasion strategies in Chapter 5 and present our findings on the effect of social interaction on physical activities.

In this chapter, we briefly reviewed different kinds of IT-mediated tools for physical training (e.g., exergames, training applications). In Chapter 3 we present our technical review on the top training applications of the major online app markets. We identify the main aspects of the training applications and identify the gap in the current fitness applications and the literature. The lessons learned from this Chapter and Chapter 3 drives our path in designing the virtual gym service.

Chapter 3

Fitness applications for home-based training

3.1 Introduction

We have reviewed the scientific research in Chapter 2. In this chapter, we present our published work (Khaghani-Far et al. [26]), a review on trends and applications for fitness training at home. Because older adults represent such a specific and important class of people for which home training may be the most convenient (and sometimes only) option, we specifically analyze research and applications based on their suitability for older adults. Besides discussing current technologies and research, we also underline limitations and research gaps in IT-based home training solutions in general and for older adults in particular.

3.2 Home-based fitness applications

With the purpose of analyzing home fitness apps in practice and revealing any emerging classes of applications, we set to analyze the type of support that is currently implemented in commercial fitness applications. In what follows, we describe the selection criteria, the design dimensions and literature considered in the analysis, and the emerging application archetypes.

3.3 Selection strategy

We screened 524 of the most popular health and fitness applications in the app stores for the following platforms: Android and iOS (mobile, 167 apps; category: health & fitness), Windows and Mac (desktop, 167 apps; category: health & fitness), and Nintendo and Xbox (gaming console, 190 apps; category: music & fitness / kinect). The selection was done based on the implementation of the notion of *most popular* that each app store supports for ranking apps, typically based on number of downloads and of active users (Android: emphTop Apps; iOS: *Popular apps*; Windows: *Top Apps*; Mac: *Popular apps*; Xbox and Wii: all games screened) in Italy as of June 2015, and includes both free and paid applications. We focused on this set of applications as it represents the solutions that users are more exposed to, and which have more visibility.

From this initial set, we excluded i) the applications which were not related to fitness, and ii) older and free-tier versions of apps already evaluated as part of the same list (to avoid duplicates). As a result, we included 200 fitness applications (100 mobile apps, 60 desktop apps and 40 console apps) in our analysis, coded by two experts with an inter-coder agreement of 94%.

3.3.1 Design dimensions

The effectiveness of home-based training programs for older adults has been the subject of recent reviews [91, 92, 93]. [92] evaluated physical activity interventions for older adults and demonstrated that interventions do not need to be face-to-face to be effective. [91], in a review of interventions with and without technology, determined that internet-based interventions can be also effective and economically viable. The lessons learned from the literature and our exploration of current fitness applications highlight a set of common design aspects:

Interaction design refers to the technology (software and hardware) used to deliver the training program and to interact with the fitness application.

Coaching and tailoring refers instead to the type of instructions, feedback and assessment that are given throughout the training, and how it is customized to fit the trainees needs and abilities.

Monitoring and sensing denotes the mechanisms employed to measure performance indicators relevant to the training program.

Persuasion and motivation discusses instead, how the various applications and devices encourage trainees to start and continue exercising.

We take the findings from these previous meta-reviews, along with the relevant literature from the HCI community for each of the dimensions under consideration, to derive design recommendations and analyse their adoption in current fitness applications.

3.3.2 Application archetypes

Three general classes of applications emerged when looking at the type of support implemented for each of the design dimensions, each focusing on a specific aspect: Training apps: The distinctive feature of this class of applications is exercise prescription. Not all training apps support monitoring or feedback, but they all provide explicit training programs. Tracking apps: Applications that dont offer training programs, but rather focus on tracking various aspects of user activity (e.g., steps, distance, elevation; 88%) and physiological indicators (e.g., heart rate, respiration; 44%) are included in this category. Fitness games: These apps involve physical activities in a game context, without necessarily following a training program (only 35% have a training program). A distinctive aspect is the use of competition, comparison and cooperation persuasion strategies (91%), which generally is the highest among the three classes of apps.

These archetypes are illustrated in Figure 3.1, and discussed in detail in the following sections. For each archetype, we particularly analyse its specific focus area.

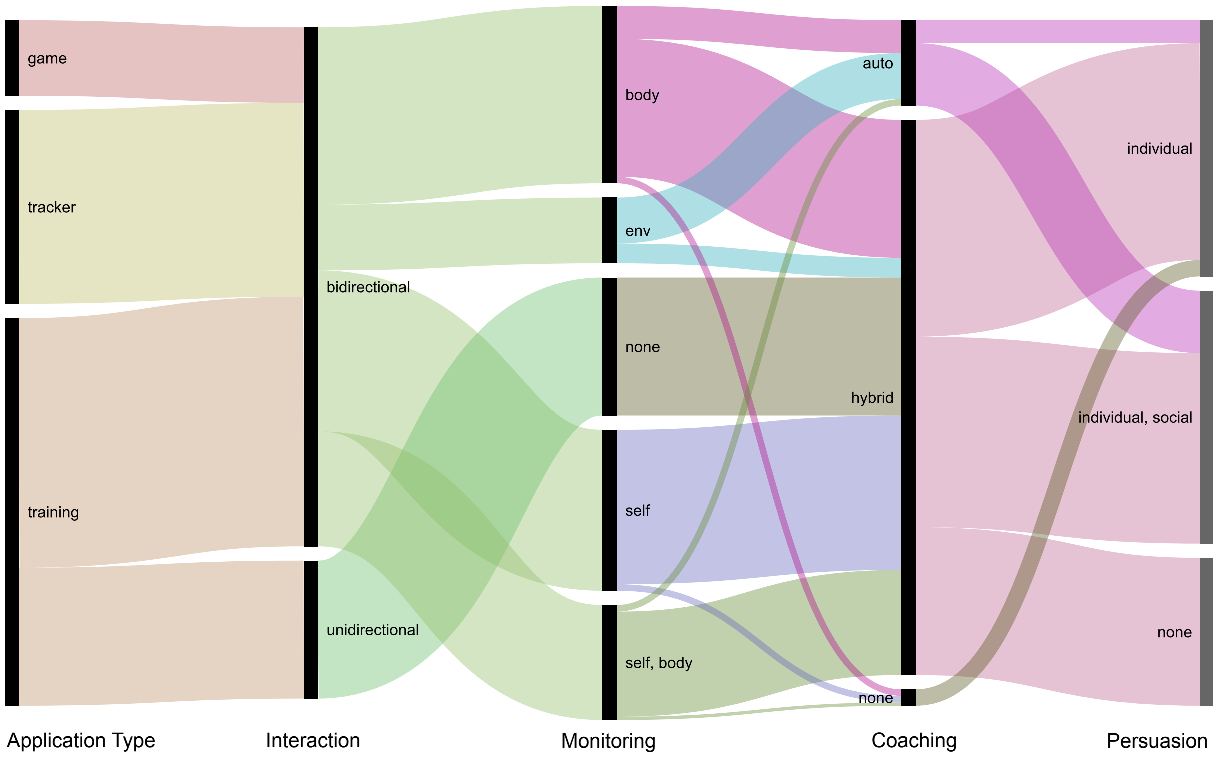


Figure 3.1: Alluvial chart illustrating common patterns in fitness application (archetypes)

3.4 Dimensions

3.4.1 Interaction design

The special abilities of older adults, along with level of education and access to technology, are of particular importance in the design of technology-based physical activity interventions. As discussed by [91], the effectiveness of such interventions is ultimately related to the ability of the older adult to follow the training program using the technological instrument, thus calling for a better understanding of the underlying components of the interactive fitness applications.

With the notion of design guidelines discussed in the literature, and the top rated apps in the online stores, we identified three different aspects to the design of interactive training applications:

Direction of the interaction unidirectional denotes training programs in which information related to training flows only from the application to the user (the application does not measure user activity in any way) and bidirectional denotes applications in which information related to training flows in both directions (e.g., the system prescribes the exercises and the users report - manually or via sensors - about their training activity to the the application).

Input type describes how the user interacts with the medium: this is indirect when the user action needs to be translated to provide the input (e.g., using a mouse pointing device); direct, when the action does not need translation (e.g., using a touch-enabled device); natural, when the input components are invisible and the interaction happens by using natural gestures (e.g., posture recognition in MS Kinect); and

Training output refers to how the training is represented (text, illustrations, audio, video and virtual and immersive environments).

Exercise programs delivered via workout DVDs, represent a large percentage of desktop apps (67%) and provide unidirectional access to training programs. In this setting, trainees have access to static exercise instructions with no feedback (from the medium) on their performance. Despite this limitation, in a study with 237 community-dwelling older adults, this class of solutions demonstrated to produce meaningful gains in physical function [94]. On the other hand, training applications in mobile and console platforms rely more prominently on bidirectional access, providing not only training instructions but also the possibility of logging activities and reflecting on training performance (mobile 84%, console 100%).

Research on human computer interaction points to *direct input*, like the one provided by touch-enabled mobile devices as being more accessible for older adults [95, 96], compared to indirect input found in most desktop applications which rely on mouse and keyboard. Indeed, touch-enabled applications designed especially for older adults have been shown to work in remote training settings [70]. Applications in game consoles, instead, rely on sensors such as the MS Kinect[1] and the Wii Remote[2] that offer natural input capabilities. A study by [97] has shown that older adults interacting with the mixed controllers (gestures and buttons) found in Nintendo Wii, require less learning time and perform better, compared to the ones based on gesture-recognition-only found in Xbox Kinect. Nonetheless, the same study reports a preference of older adults towards gesture-recognition controllers due to perceived benefit in performing more physical movements.

In terms of output, there are no formal studies on which representation is more effective. [93] discusses this aspect further and concludes that it is not clear what mechanism of delivery can be considered more effective.

[1] `https://www.microsoft.com/en-us/kinectforwindows/`
[2] `http://www.nintendo.com/wiiu/`

However we understand from research in multimodal interfaces that combination of formats is preferable (e.g., combinations of visual and audio, or visual and haptic), especially when they compensate declines in perception skills [98, 96]. In fact, mobile fitness applications designed with the specific goal of facilitating remote training do in fact use a combination, with text (73%) and videos (53%) as dominant formats. Instead, applications in game platforms, due to the tracking capability of the sensors, deliver training instructions via virtual and immersive environments.

A summary of design considerations and current practices is shown in Figure 3.2.

3.4.2 Sensing and monitoring

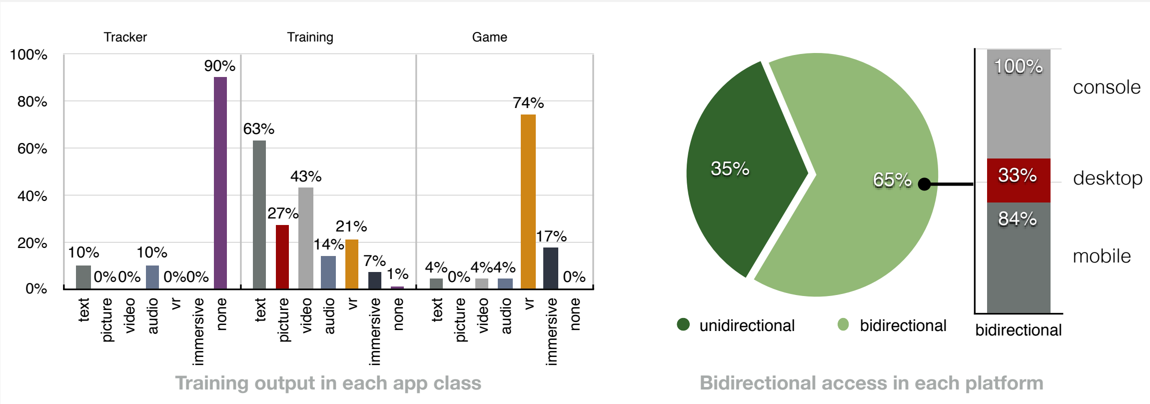
Different types of instruments can be used to capture relevant training data, and at a high-level we can describe them in terms of:

The sensing method referring to how the data is collected, from self-reported data to specialized sensors (wearable or environmental), and

The aspect observed referring to what is being collected, e.g., general activity, physiological indicators or detailed motion patterns.

The choice for the instrument typically depends on the type of activity to be performed (e.g., indoor, outdoor), the aspects to be measured and the level of accuracy needed [99].

Self-reported questionnaires can be used to inquire trainees about their performance and adherence to the training and also their overall physical activity and wellbeing. Many applications (47% of trackers and training apps) rely on this instrument given its ability to capture training-related data without the need of specialized sensors. Self report is also used in research trials due to its ability to easily collect data from a large number of people without affecting participants behavior during the experiment



Design considerations

- Unidirectional training programs can be effective, however there might be differences in adherence (see persuasion and motivation).
- Direct input devices are more accessible to older adults [95, 96].
- Combination of training output formats can help to compensate declines in perception skills [98, 96].

Current trends of gaps

- Training applications offer the most diverse output with text (63%) and video (43%) at the top. Games prominently use virtual (74%) and immersive (17%) environments. Most trackers do not offer training programs (90%).
- Training apps, primarily desktop (67%), are notoriously unidirectional in that the program does not require the user to provide feedback to function.Mobile and console games are often bidirectional, partly due to the use of the sensing capabilities of these platforms.

Figure 3.2: Interaction design in fitness applications

[100]. However, self reporting is time consuming and can be a complex cognitive task, especially for target groups with memory limitations such as older adults [100], which could lead to misreporting [91]. In addition, from the trainees perspective, entering health data manually can lead to a

decline in the usage of the application [101].

Sensing technologies have advanced to the point that we can wear and use devices with sophisticated capabilities. Wearable sensors, and other types of body-fixed sensors, can now measure indicators such as general activity level (e.g., Fitibit[3], Nike Fuelband[4] nikeplus-fuel, Misfit[5], Striiv[6]), quality of sleep (e.g., Fitbit, jawbone[7]), heart-rate (e.g., Polar FT4[8]), and even breathing quality (Spire[9]), enabling advanced monitoring capabilities. Such objective measures are desirable to get a more precise picture about the progress in non face-to-face interventions [91]. These sensors usually come with a companion application as well as programmatic interfaces (API) that enable their integration with third party systems. Moreover, built-in sensors (activity tracker and heart-beat) embedded into smart watches (e.g., Android Wear[10] and Apple Watch[11]) and on top of wearable operating systems enable developers to add sensing to their apps. Yet, only 20% of the training apps and 90% of trackers which we have analyzed support integration with wearable or built-in sensors and the remaining rely on self-report data. In terms of perception of these sensing technologies, a two-week study with 8 older adults reported no usability issues but a negative change in the attitude (in 5 participants) due to accuracy limitations in measuring some daily activities (e.g., walking in a treadmill), being uncomfortable to wear, and being considered a waste of time [102]. Indeed, the level of accuracy of these devices might not render them appropriate for all scenarios (e.g., clinical trials), as demonstrated in

[3]http://www.fitbit.com/
[4]http://www.nike.com/us/en_us/c/
[5]http://misfit.com/
[6]http://www.striiv.com/
[7]https://jawbone.com
[8]http://www.polar.com/en/products/get_active/fitness_crosstraining/FT4
[9]http://spire.io
[10]https://www.android.com/wear/
[11]https://www.apple.com/watch/

a study [103] with pedometers.

Environmental sensors and advanced motion sensing devices such as MS Kinect and Nintendo Wii Remote enable more advanced performance tracking capabilities and also better suits for trainees at home. A central aspect of these capabilities is the body motion tracking, which its reliability and accuracy has been demonstrated in a research experiment [104]. Environmental sensors can also measure physiological data. For example, the new MS Kinect provides touch-free heart-rate measurement (by scanning the skin surface of the trainee), with an accuracy within a few beats per minute[12] under good conditions.

A summary of design considerations and current practices is shown in Figure 3.3.

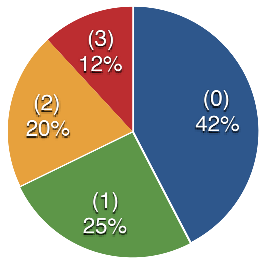
3.4.3 Coaching and tailoring

The coaching process is commonly described by a series of phases before, during and after the training [17]:

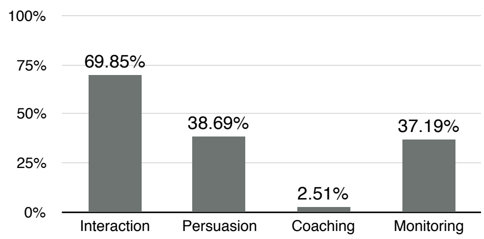
1. identifying the needs, abilities, desires and goals of trainees
2. prescribing a tailored training plan
3. providing support by monitoring the progress of trainees
4. modifying the training plan accordingly

Technology can provide different levels of support in this process, from entirely human to fully automatic (virtual) coaching. For the trainees at home, studies have shown that coaching, either by a human or virtual coach, not only makes the training more effective and safe, but also more engaging [105, 38].

[12] `http://support.xbox.com/en-US/xbox-one/games/xbox-fitness-faq`



Coverage of ideal settings in the 4 design aspects according to the literature
(N) = compliance with N design recommendations (max 4)



Compliance of apps per design aspect

Design considerations

- Self-reports can be used to collect data from users without sophisticated sensing technology. However it is time-consuming and can be a complex cognitive task, especially for target groups with memory limitations such as older adults [100].
- Long term usage of sensing devices can be discouraged by limitations in measuring daily activities of older adults (e.g., walking on a treadmill) and being uncomfortable to wear [102].
- Environmental sensors are effective and can render the interaction more natural [104].

Current trends and gaps

- Body-fixed sensors (wearable) are widely used in trackers (90%), while self-reporting is more popular in training apps (47%). In games, we see body-fixed (57%) as well as environmental (43%) sensors.
- Trackers support mostly training activity (activity, 88%) and physiological data (bio, 45%). In training apps, tracking is more diverse but attendance logging is the most popular (attendance, 40%). Console games extensively use motion sensors to track actual movements (motion, 96%).

Figure 3.3: Sensing and monitoring in fitness applications

Support for coaching begins with solutions where coaching is provided by a human, and technology essentially acts as a communication tool. An example of such setting was experimented [106] with low-income postnatal women, where SMS messages were used to deliver tailored instructions and to get feedback, resulting in prolonging the duration of physical activity of the target trainees. Indeed, in a review of physical interventions by [91], such low-tech solutions are considered as valid alternatives to increase physical activity in low income older adults. The human coach does not only provide information and feedback, but also exercise knowledge, encouragement and emotional support while the trainee goes through exercising sessions [107].

Technology can also assist the human coach in monitoring and tailoring the training program. Fitness applications nowadays (e.g., Fitbit, Nike+) come with sensors or feedback mechanisms that facilitate the monitoring by a coach or the trainee itself. Tailoring training programs are also supported by dashboards that assist human coaches in tuning the plans based on trainees performance (e.g., Gymcentral[13]). This aspect has shown to be particularly important in a review of 12 internet-based interventions [93], where interventions with tailored information have resulted in lower attrition rate per month (2.7%) compared to those with generic information (6.6%). Furthermore, we should note that the role of the Coach can be played by the trainee itself or an expert. In our analysis, the human factor in the coaching mechanism was the trainee itself in most of the cases. Only 3% of the training applications provided an expert support (a human expert except the trainee itself).

We discovered that a few applications (2%) rely on "virtual coaches" instead of human coaches. Virtual coaches are pre-programmed or smart machines and applications that monitor, prescribe and tailor the training program for the trainees [108]. An example of such solution was experimented by [71], who developed a personalized exercise trainer for the elderly using a wearable sensor that detects the movement of the user while

[13] `http://gymcentral.net`

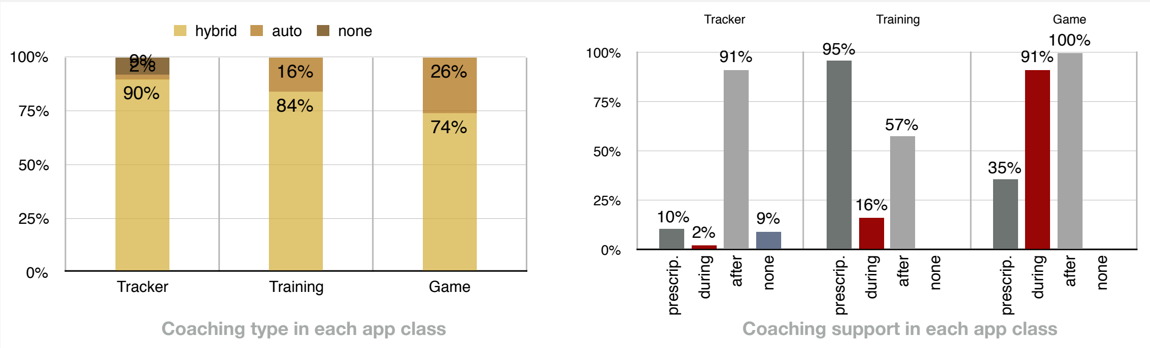
exercising, automatically tuning the exercise level, and providing audio feedbacks during the exercise. The authors of this study however did not formally evaluated the system but report on positive feedback from the older adults. More formal studies, such as [109] compared the effect of a fitness application with virtual coaching, with respect to applications without coaching, and concluded that the trainees with a virtual coach adhered longer to the training program. However, coaching in this form does not provide the social support that a human coach can provide. Indeed, studies express the need for a real coach [107], especially when dealing with sensitive trainees such as older adults [110].

To cope with the aforementioned shortcomings and barriers [108], experimented with "Reactive Virtual Trainer" which, unlike the conventional virtual trainer, is creative and provides emotional and psychological support to the trainees similar to a human coach and tailors the fitness program according to the physical and emotional states of the trainees. However, Ruttkay and Zwiers [108] proposes that although the RVT is preprogrammed by a human expert, yet it can not substitute a human coach in critical cases since the precision of such technologies is not accurate enough and longitudinal user studies is required to measure the long term effect of RVT in a training program.

A summary of design considerations and current practices is shown in Figure 3.4.

3.4.4 Persuasive technologies

Programs aiming at promoting physical activity and lifestyle changes incorporate components aiming at increasing adherence and reducing attrition [91, 93]. In technology-based interventions such components can be described in terms of persuasion strategies. Persuasive strategies for home-based training can be grouped in two major categories [70]:



Design considerations

- Coaching, either by a human or virtual coach, is preferable over a solution without coaching [105, 38]
- For sensitive training applications and for the older adults population, the presence of a human expert in the loop is recommended [110].
- Reactive Virtual trainer can provide emotional and psychological support along with the exercise instructions but are not recommended for exercises that require high precision [108]

Current trends and gaps

- Most apps use hybrid coaching (90%), especially covering the prescription and after training phases. Apps in game consoles tend to provide support in real time during the training (91%).
- Training apps in game consoles provide more complete support than mobile apps.

Figure 3.4: Coaching in fitness applications

Indivudual referring to strategies that leverage the individual wills and natural drive and,

Social referring to strategies that demand the presence of a community of people with the roles of family, supporters and peer trainees.

We use this classification to describe a subset of strategies from the work of [32] that are applicable to home-based training applications:

- **Individual persuasion strategies**

  Reminders and suggestions The application reminds trainees of their exercises sessions and suggest better exercising habits.

  Positive & negative reinforcement The application prompts positive or negative comments about the exercising behavior of the trainee to raise awareness.

  Self-monitoring The application provides to trainees, performance monitoring and awareness about their current progress.

  Rewards The application praises the trainee by providing virtual badges, medals, awards and recognition upon completion or success on exercising sessions.

- **Social persuasion strategies**

  Social learning (comparison), cooperation and competition The fitness application provides social features that allow trainees to compare their performance with others, collaborate toward common goals, or compete.

  Social support The application provides social features such as messaging and forums enabling trainees to interact with each other and create a community of people supporting each other.

  Recognition The trainees individually or in a group get public recognition on their awards, progress and contributions.

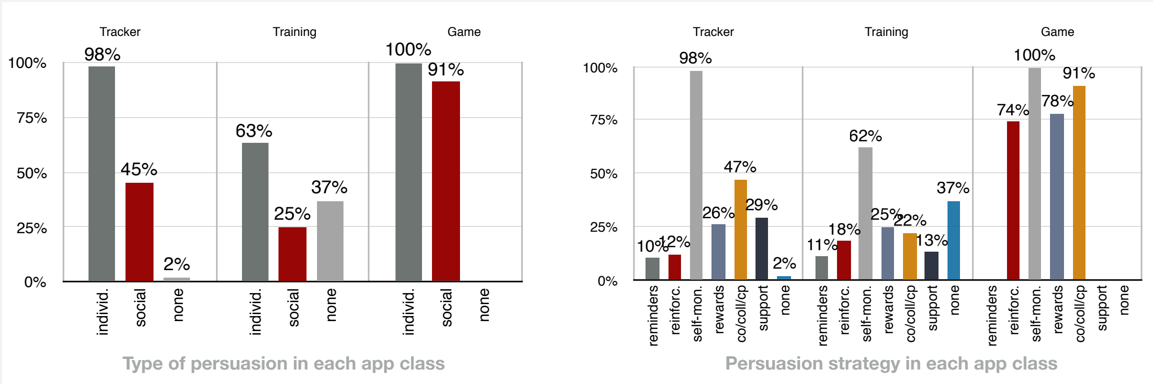
Individual persuasion strategies have been evaluated in several studies (e.g., [70, 111]). For instance, [111] designed a mobile app for the elderly that persuade them to walk. The system incorporates reminders, notifications, self-monitoring and a “coin metaphor” as rewards for the users. The system rewards the trainees walking activity with "virtual coins" and their social interaction with "virtual diamonds". Findings after an intervention with older adults reveals that all of them found self-monitoring and the reward metaphor motivating to exercise regularly. However, some participants argued that they would have preferred other types of metaphors than "virtual coin" for instance. In fact, researchers (e.g. [24]) emphasis that the heterogeneity in the older population require persuasive strategies, and in particular individual persuasion strategies, to be tailored according to older adults abilities, interests and taste.

However, beyond personalization and usability issues, several studies report on higher level of interest in social persuasion strategies and report that in particular older adults prefer apps that leverage their social activities [24, 20]. Silveira et al. [70] experimented the effectiveness of individual and social persuasion strategies in two groups of individual trainees and social trainees. The result of the study reveals that the long-term adherence was higher in the social group. Moreover, the follow up of the research and further experimentations with individual and social trainees discovered a raise in exercising duration for the social training group.

Despite the evidence in the literature, individual persuasion strategies are more extensively adopted than social strategies, especially with trackers (98% individual, 46% social) and training apps (63% individual, 25% social). A summary of design considerations and current practices is shown in Figure 3.5.

3.5 Findings and opportunities

This investigation has shown that home fitness landscape is sprouting with ideas and applications which offers a variety of interaction modes, coaching methods and, measuring techniques. Current solutions provide very good



Design considerations

- Individual persuasion strategies, such as self monitoring, are effective in persuading the trainees to adhere to the training plan [70, 111].
- The use of social persuasion strategies can increase adherence of older adults to home-based training programs [70].
- Designing persuasive strategies for older adults requires tailoring and personalization of the strategy, as older adults are heterogeneous and have different taste and abilities [24].

Current trends and gaps

- Except for games (90%), social strategies are just a fraction (25% training apps, 45% tracker apps) of individual persuasion strategies.
- Self-monitoring is the most popular individual persuasion strategy (86%), followed by rewards (43%) and reinforcement (31%).
- Comparison, cooperation and competition (53%) are the social strategies more popular, followed by social support (14%).

Figure 3.5: Persuasive strategy in fitness applications

support for the general population, especially for those that do not require expert coaching. However, there are very few applications that explicitly target older adults and are designed for the average interaction skills and physical abilities of the average adult in their late life. This is the case despite the ample evidence of the positive effect of sustained training on mental and physical health and in turn, the benefit that better health has in terms of reduced expenditure by government and families [112].

Thus, sensible groups such as older adults find more limited support in current solutions. This is evidenced in Figure 6 and the description below, where we summarized the result of inspecting current applications against the various design considerations motivated in this paper.

The principal lessons learned are specific ingredients that stimulate higher level of engagement and of adherence to training programs:

– The provision for social persuasion mechanisms in addition to individual persuasions.

– The presence of a human coach (as opposed to virtual or no coaches).

– The adoption of sensors that enable automated detection of activity (as opposed to manual data entry), but only as long as the sensors are accurate and do not generate lack of trust in the user as to the reliability of the measures.

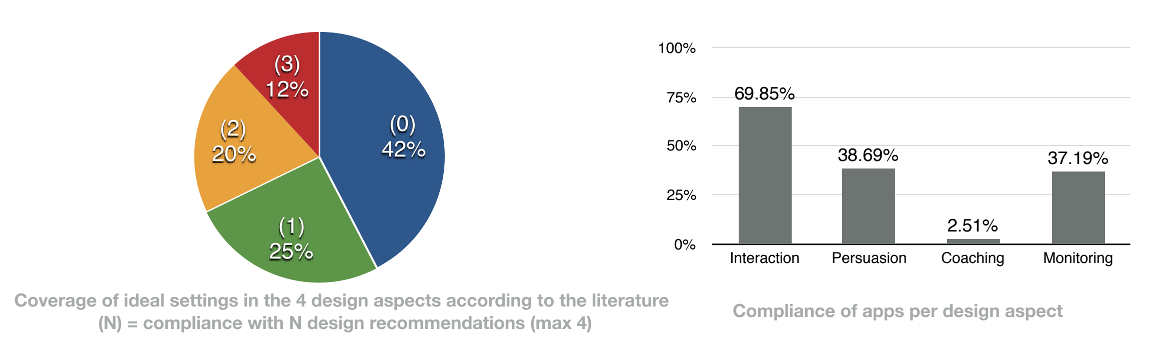
– The provision of a multi-modal interaction with the user.

From existing research it is however still unclear which UI representation and metaphors works better in terms of stimulating adherence, making this a topic of further research.

Figure 3.6 depicts the summary of gaps.

3.6 Conclusion

In this chapter, our review on current market trends and application for fitness training apps were presented. We analyzed top application of the major market players (i.e., Android playstore, Apple Appstore, MS-Kinect, Nintendo Wii and Mac and Windows applications) against the findings in the literature and reviewed their strength and shortcomings for the trainee's at home and in particular for the older adults. The findings of this chapter along with the review of the state of the art (refer to chapter 2) identified the key features of a suitable technology-based training service for the older adults at home. The key aspects identified (i.e., interaction design, sensing and monitoring, coaching and tailoring and, persuasive technologies) led us to the design of Gymcentral platform. Chapter 4 describes the design and implementation of gymcentral service driven by the findings of this chapter and chapter 2.



Observations

- There are no apps that comply with the design considerations from the literature in the 4 design aspects we review in this paper.
- The most limiting aspects are the very few solutions that provide expert feedback during training.

Summary of gaps

Interaction The suitability of fitness application is in part influenced by the platform. Mobile and game consoles provide the input and output mechanisms that can facilitate interaction. Indeed, we have seen a higher adoption of bidirectional and multimodal interfaces in those platforms. However, how the applications use these ingredients to implement usable interfaces is still a topic for further research.

Sensing Automatic detection of activities are preferable for older adults, especially when it comes to objective measures. Still, self-reporting is widely used as a method for data collection, despite potential effects in adoption and precision of readings. On the other hand, integration of sensors in fitness applications is still limited, with the exception of applications in game consoles that offer motion tracking capabilities during training.

Coaching Training programs supervised by an expert human coach are preferable for older adults. However, most of the applications on the outlined markets rely on hybrid solutions (technology + self coaching), focusing mainly on exercise prescription, while only 3% of the analysed training applications provide expert human coach support.

Persuasion The few studies on persuasion strategies to boost adherence, especially in older adults, show strong evidence on the benefits of using persuasion strategies, and especially social strategies. However, very few of the training application exploit these features, other than allowing users to reflect on their activities. In general, we see this as a clear opportunity for applications that exploit these aspects.

Figure 3.6: Summary of compliance of fitness apps with design considerations

Chapter 4

Gymcentral: design and implementation

4.1 Introduction

The lessons learned from the review on the literature (Chapter 2) and our review on current trends and applications of fitness apps (Chapter 3) drives the motivation of designing a unified training platform that provides IT-mediated tools to coaches and trainees (namely *Gymcentral*). In this Chapter, we present the design rationale (with respect to the learning from chapter 2 and 3). Then, we present the conceptual model of gymcentral platform and its design evolution (beta testing and prototyping) through the course of my doctoral research work. The final structure of gymcentral evolved in two modules of the coach app (a web interface for coaches to plan and monitor training programs) and the trainee app (a tablet application that delivers scheduled training application to trainees and enable social interaction among them).

We describe the coach application, the platform's infrastructure and the APIs in brief and focus on the design and implementation of the trainee-application and its features.

Later, in chapters 5 and 6, we present the validation and user studies conducted using gymcentral. In particular, we used gymcentral as a test-bed to evaluate the correlation between social interaction and physical activity and we validate the physical and social outcomes of physical training using Gymcentral application, for older adults.

4.2 Design rationale

The review of the state of the art, drives the need of a comprehensive and customizable platform that enables a wide body of older adults to follow exercise programs from home. We also aim to enable the coaches (e.g., sport trainers, physiotherapists, rehab therapist) to be able to build training programs that server the specific requirements of a training program.

Despite the numerous physical training programs for home-based training, our target trainees are heterogeneous meaning that the training program should be tailored to serve their individual needs. Given these settings, we also aim to boost the trainees' social interaction and enable them to exercise in groups. Finally, we aim to provide monitoring instruments to both the coach and the trainees. Given these three aspects, in the following we present design rationale and the conceptual model of the training platform (Gymcentral).

4.2.1 Interaction design

We have learned from the state of the art that many older adults and in particular those with poor computer literacy often show resistance in using technology. Context familiarity and simplicity can motivate these population to adapt to IT-mediated technologies. In our design approach, we use virtual environments that represent the features of a real gym.

4.2.2 Coaching and tailoring

As discussed before, we aim to enable coaches and trainers to plan training programs, deliver it to the trainees and monitor their performance. We discussed in Chapter 3 about the importance of human coach in the loop, in particular for the older adults. A human expert presence before, during, and after the training can ensure that trainees are following the most suitable, effective training. We aim to enable coaches to monitor trainees performance during the training and respectively tailor the exercise intensity.

4.2.3 Persuasive technology

In addition to exercise tailoring and interaction design, we aim to motivate trainees to adhere to the training programs prescribed by the coaches. To reach this goal, we are incorporating several individual and social persuasive features in the trainees app. The following explains these strategies in detail.

Individual persuasion strategies

Self-monitoring Strategies under this category are means that provide behavior monitoring to the individual[32]. We aim to provides trainees with performance monitoring and awareness about their current progress. The progress is visualized using a garden metaphor [73], in the gym.

Positive & negative reinforcements This strategy relies on presenting positive and negative stimulus to improve individuals behavior [32]. The application prompts positive or negative comments about the exercising behavior of the trainee to raise awareness [70]. The reinforcement message is displayed after a training session according to the number of exercises completed, with three different states: positive (completeness $\geq$ 75%), neutral (75% $>$ completeness $\geq$ 25%) and negative (25% $>$ completeness $\geq$ 0). The message is given by a gnome with a mood that matches the tone of the message.

Social persuasion strategies

Social learning Also known as comparison, it refers to providing means to observe other people who perform the same behavior [32]. In the application, social features allow trainees to compare their performance with others. It offers a bulletin board where the performance of the trainees is automatically shared after a training session [74, 70].

Social support This category groups strategies by providing social interaction features that leverage social influence [32]. The application provides social features such as messaging and a bulletin board, enabling trainees to interact with each other and create a community of people supporting each other [74, 70].

Social facilitation It groups strategies leveraging on the fact that people are more likely perform better when they discern others are performing the same behavior [32]. The application implements this strategy by providing social spaces like a locker room and classroom that allow for social awareness. Trainees can see a virtual representation (avatars) of other trainees virtually present in each space [74, 32].

Normative influence Also known as peer-pressure, it refers to strategies aiming at increasing the likelihood that a person will adopt to a target behavior by peer pressure [32]. The application leverages this strategy by allowing users to send and receive invitations to exercise together, thus acting as a peer pressure mechanism [74, 32].

Social interactions are also a central part of the offerings of the application. Thus, the application provides the following social features:

4.3 Conceptual model

Given the design rationale and our design approach of the virtual gym, this section present the conceptual model of gymcentral. We describe the stakeholders of the application, features related to training, monitoring and social features.

4.3.1 Stakeholders

The two main stakeholders of the platform (gymcentral) are the community of trainers (coach) who manages the trainees, create training program for them and supervise the training of each individual using gymcentral monitoring instruments. The second stakeholder is the trainee who use gymcentral training tools to perform exercises and interact with the coaches and the other trainees (Fig. 4.1[black rectangles]). In the following, the role of each stakeholder in the presented layer is described.

4.3.2 Training layer

The training layer is composed of activities (the exercise activity) and sessions defining the start and end time of the activities and grouping activities into training session. Both activities and sessions and assigning activities to sessions can be managed by the trainers. A group of sessions then can form a training program, and trainers then can subscribe trainees to the designated training programs. Finally, a group of training programs form a club which act as a online social community and contains a group of trainees and coaches that can interact with each other. The training

Layer conceptual model is depicted in Fig. 4.1 (White, solid border).

4.3.3 Monitoring and tailoring layer

Alongside the training features, gymcentral provides a set of monitoring tools that enables trainees to record their performance in the exercising sessions and also to share it with the coaches and themselves. The monitoring layer of the model enable coaches to attach feedback questionnaires to the training exercises (to both exercise activities and sessions). On the other end, trainee's will be able to provide feedback to these questionnaires. The feedback provided by the trainees along with the metrics that are automatically obtained from the training session (e.g., duration of exercising, heart-rate, motion sensors) can be used to measure the trainees progress and performance. The monitoring tool enable coaches to tailor the intensity of the exercise for individual trainees and also enable trainees themselves to self-monitor their progress. Fig. 4.1 displays the monitoring model in white rectangles with dashed borders.

4.3.4 Social layer

Social features of Gymcentral platform aim to enable coaches and trainees to share their training activities with each other. In addition, trainees and coaches can send and receive public messages to a bulletin board which is visible to the entire members of the club. Private messaging is another form of communication in the club, allowing trainees and coaches to chat privately with one another. For instance, trainees can chat with the coach(es) of the training program and discuss their training process. Beside these, gymcentral enable trainees to send and receive predefined messages to each other in real-time. The social features are depicted in Fig. 4.1 in gray rectangles.

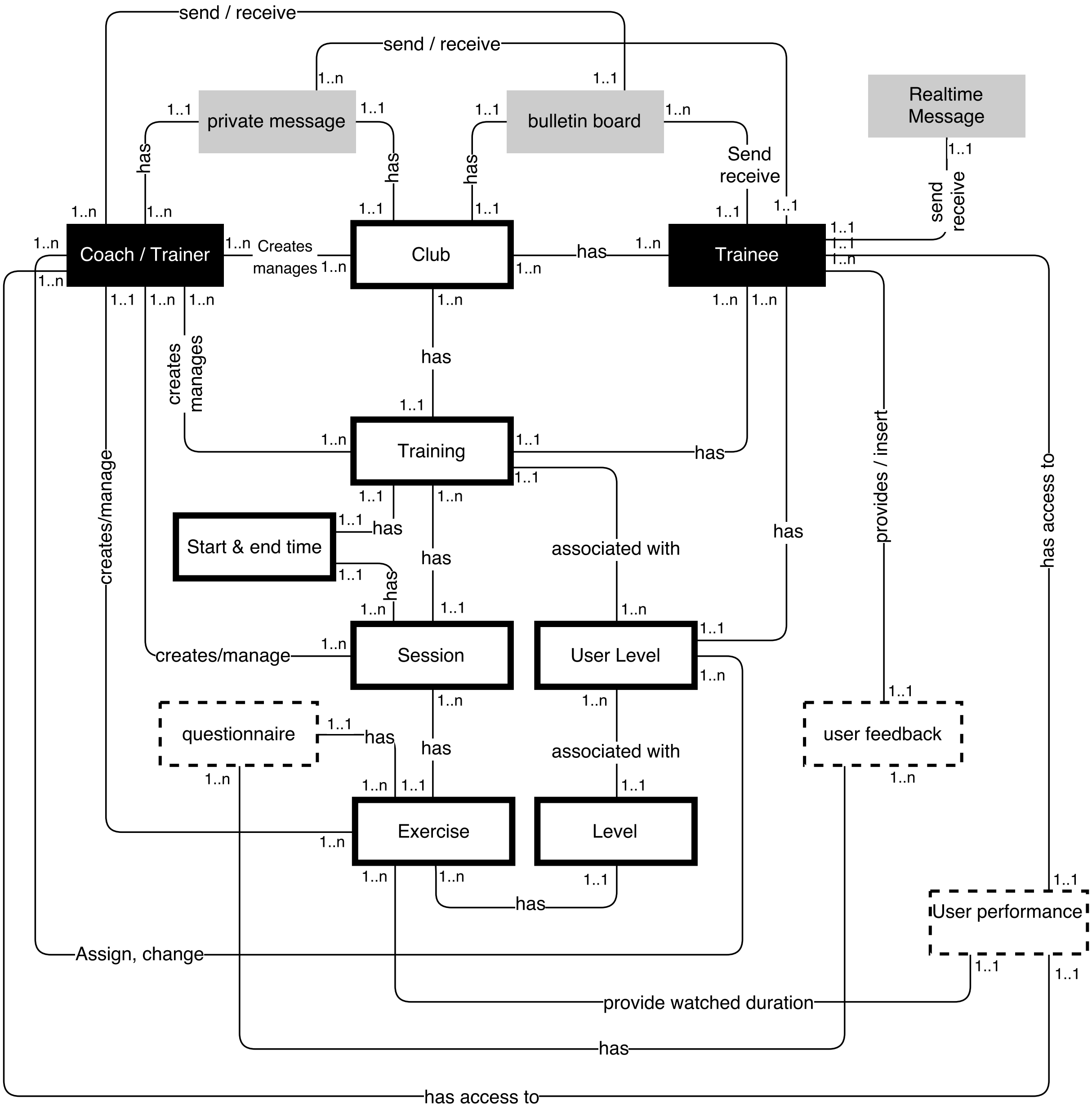


Figure 4.1: Gymcentral Conceptual Model

4.4 Design evolution

With respect to the design rationale of gymcentral explained in the previous section, this section present the prototyping and design path of the Gymcentral platform. In particular we focus on the design and beta testing of the tools and application designed for the trainees.

4.4.1 Background

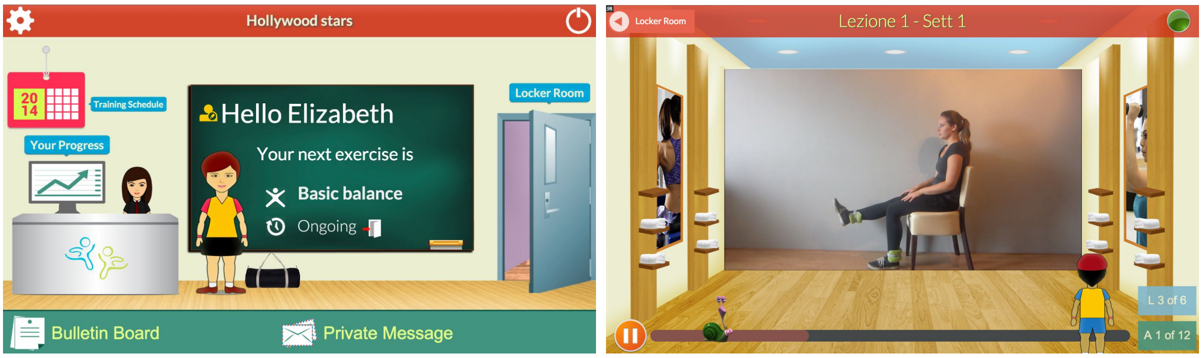
Gymcentral platform and in particular the trainee's application has evolved from the design and research work done by Silveira et al. [39] on Active Lifestyle. The learning from the user studies [70] conducted with Active Lifestyle convinced us that there are indication of success in using social interaction to promote physical activity. Thus, we elaborated on the current model of the application and enhanced it's feature. Beside this, the learning from the state of the art on *context familiarity* and *simplicity* directed us to design a virtual gym application that mimics the features and spaces of a real gym in a virtual environment. We designed gymcentral trainee's application for Tablet devices since they provide natural interaction and easier to use by the older population. In the new edition (Gymcentral) we also developed a web based platform for the coaches to enable them to manage training programs, tailor exercises and monitor trainees. In the following we explain the design path of our approach.

4.4.2 Iterations and evaluations

The first iteration of the design consisted of the fundamental features driven from the design rationale and our aim in mincing a virtual gym for home users. Figures 4.2a and 4.2b depict screen-shots of the first designs.

Beta testing

Early on 2014 the application proved to be not mature enough to go support a real life data collection for validation purposes. The app was in need of more testing and user interface design refinement, as well as bug fixing. In order to identify problems, a set of internal beta testing of Gymcentral application was carried out by us, prior to the users testing. Sociologists from the team performed beta testing in order to identify pain points with



(a) First Iteration (Reception) (b) First Iteration (Classroom)

Figure 4.2: Gymcentral Trainee's App: Early Designs

regards to both usability and broader user experience; remarks were listed, and suggestions for improvements were provided as the crisp output of such actions. The early beta testing allowed us to point out design shortcomings on a very high level. Using heuristic evaluation [113], usability and UX-related matters were highlighted. In total, three iteration cycles were executed: two in April, and one in September, before the launch of the study (refer to chapter 5). The usability report are presented in table 4.1.

Usability testing with the think aloud protocol

After the above mentioned beta testing, the first version of the interface design was evaluated in June 2014 with a usability test using a *think aloud* protocol with a 63 years-old user classified as *transitionally frail* by the Groningen Frailty Index [114] and *under-active* according to the Rapid Assessment of Physical Activity questionnaire by [115].

During the test the user was asked to explore the application and interact with it to carry out different kinds of tasks. The think aloud protocol and a final semi-structured interview allowed to uncover different usability problems that were later used as a guide to refine the development of the interface. Moreover, it raised other issues that were not strictly related to usability, but could however be considered for further developments of the

Table 4.1: Beta-testing of Gymcentral trainee's application

Context	**Remarks**	**Suggestions for improvement**
Reception	How should I know that the reception is a reception if there is not any indication?	A sign Reception above the image of the receptionist?
Bulletin Board	How should I know that I have a new message?	A notice near the bulletin board symbol (as a mail or a Facebook alert)?
	Ive tried to insert messages, but some have been deleted	Why?
Home page	Maybe it is not so clear that through the symbol in the upper left I can access to the Club List. And why after you choose a Club can you change the avatar too? It might confuse the users.	
Blackboard	The possibility of changing avatar (near the Hello xxx message) tends in my view to confuse the user.	Maybe it would be better if a user had only one avatar.
Classroom	After I read the instructions of the exercise, I click I understood, and Id expect to see the video. But I have to click on the pause button, then on skip button, then on I understood, and finally the video starts.	Why?
Classroom	What means the yellow button on the top right?	?
Classroom	How should I know how many times I have practiced my exercise and how many times are left?	Maybe It would be useful to have a sort of counter?
Classroom	I dont see my avatar	Why?

application.

In general, observations and comments were mainly related to the clarity of the labels, to the social and communication features and to the interaction mechanisms. A summary of the main findings is reported below:

- The device was not very comfortable to interact with in a horizontal position, placed on the table, so one of the first issue raised was the need for a physical support for the tablet, such as a case with stand function;
- Some labels were sometimes not clear or confusing, and the test provided useful suggestions about the improvement of labels, instructions, signs, icons, and notifications;
- It was not always clear to understand who was a particular avatar in the gym or in the locker room, and the test allowed to specify clear suggestions about how to improve the feedback and the identification of other participants;
- With regard to communication features, the user proposed to add the option to enable those features and to choose her contacts. Moreover, she suggested to add more communication tools in the locker room, such as a plain text field to chat;
- With regard to interaction mechanisms, the fact that different functions could be achieved from different rooms was a potential complexity factor for the user. In summary, the user was satisfied with the application and at the end of the session asked if she could download it with the exercises and the training program on her personal tablet. She also raised a number of usability problems and suggested more improvements. The conceptual map in Fig 4.3 reports a macro-categorization of the major issues raised during the demo. The most

important usability issues were taken into consideration in the refinement of the application that was used in the study described in the following sections. Further comments were registered and will be available for further developments of the application.

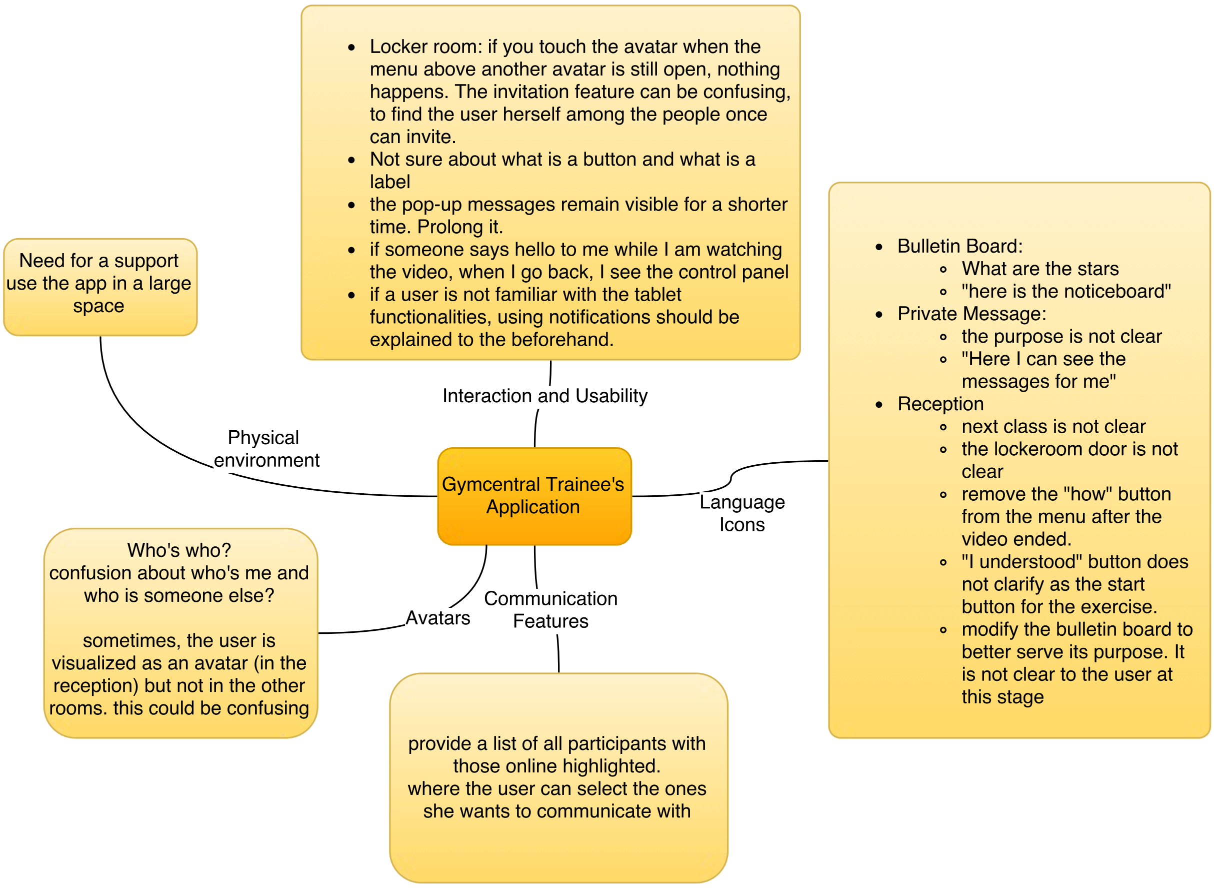


Figure 4.3: Conceptual map showing a macro-categorization of the major issues raised during the demo of personal Fitness Club in June 2014.

4.5 Applications and features

The beta testing and the think aloud study helped us to iterate towards the final design for the study. The following explains the final features of the trainee's application (running on a tablet) and the coach application (web based) and their features.

4.5.1 Trainee application

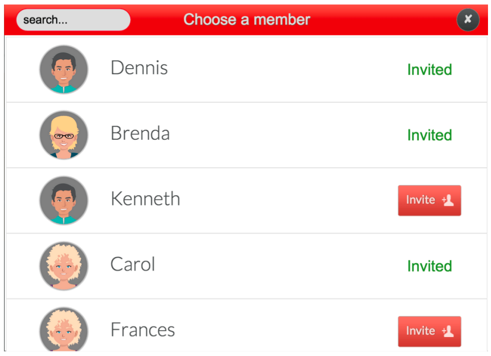
The final design of the application for trainees is based on a virtual environment that mimics the spaces and services found in a real gym. The main features of the tool are the following:

Figure 4.4: Reception

Reception The entry point to all the services of the gym. A virtual receptionist helps the user in getting oriented and suggests courses of action (Fig. 4.4).

Locker room A virtual representation of a gym locker room, where trainees prepare for the training session and often chat. The locker room enables trainees to (i) see who is online and ready for the training session, (ii) invite trainees that are absent to come online and join, and (iii) interact by sending to each other predefined messages in real-time (Fig. 4.5a).

(a) Locker Room



(b) Invitation Feature

Figure 4.5: Virtual locker room

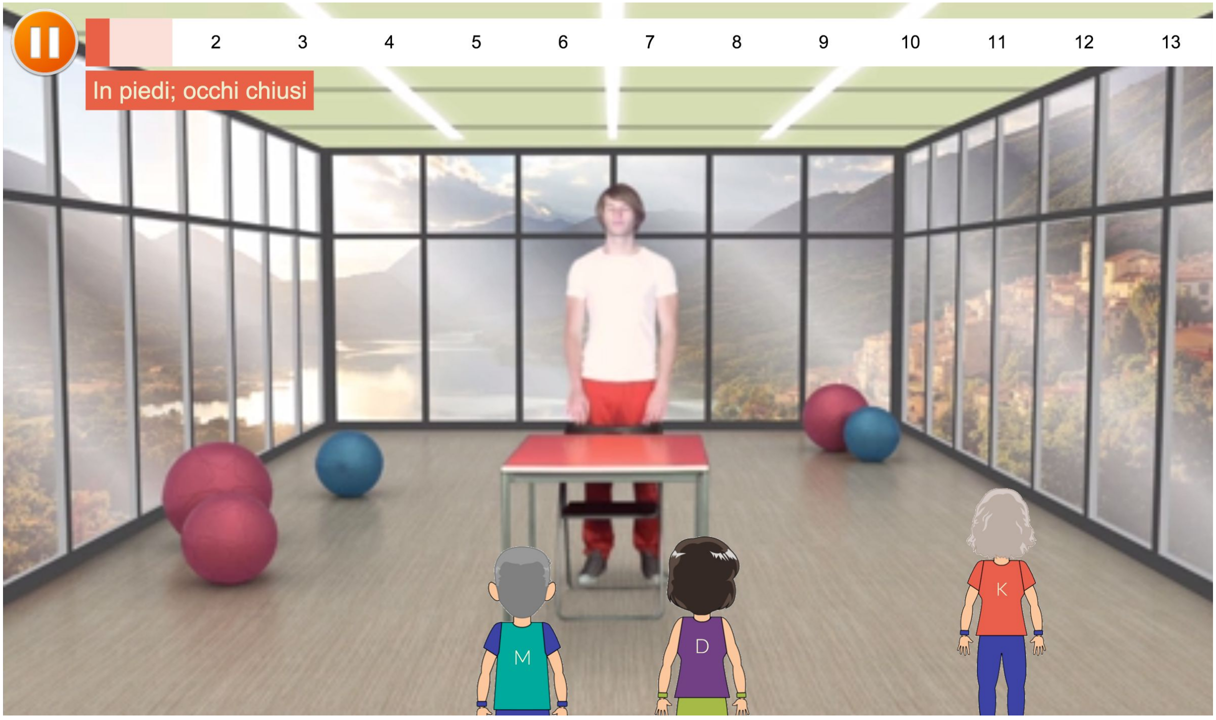
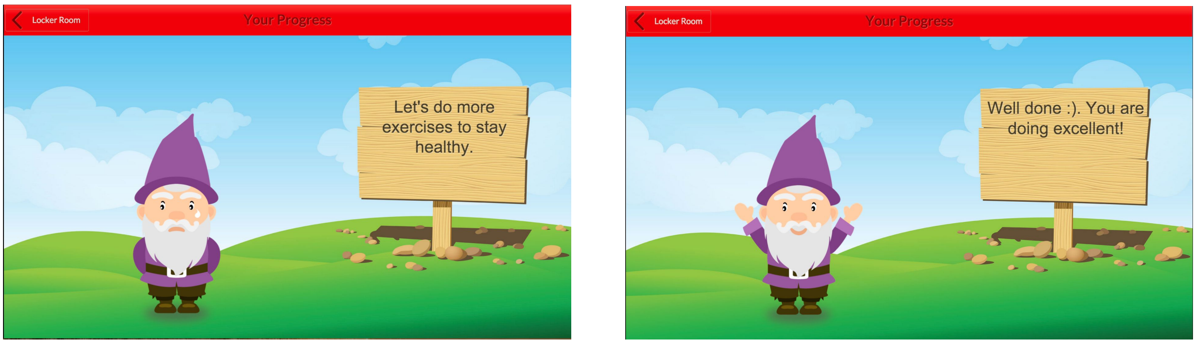


Figure 4.6: Classroom

Invitation feature A feature, available when a user is in the locker room, that enables trainees to send invitation messages to other trainees, inviting them to exercise together (Fig. 4.5b).

Classroom The virtual representation of a training room, where users



(a) Positive and negative reinforcements

(b) Overall Performance

Figure 4.7: Progress Report

have access to the exercise instructions given by a coach. Trainees are not only able to see the coach but also other trainees exercising at that moment as static avatars (Fig. 4.6).

Progress report It allows trainees to check their progress within the training program. The visualization is through a growing garden metaphor. The mission of the trainee is to follow the program and, by

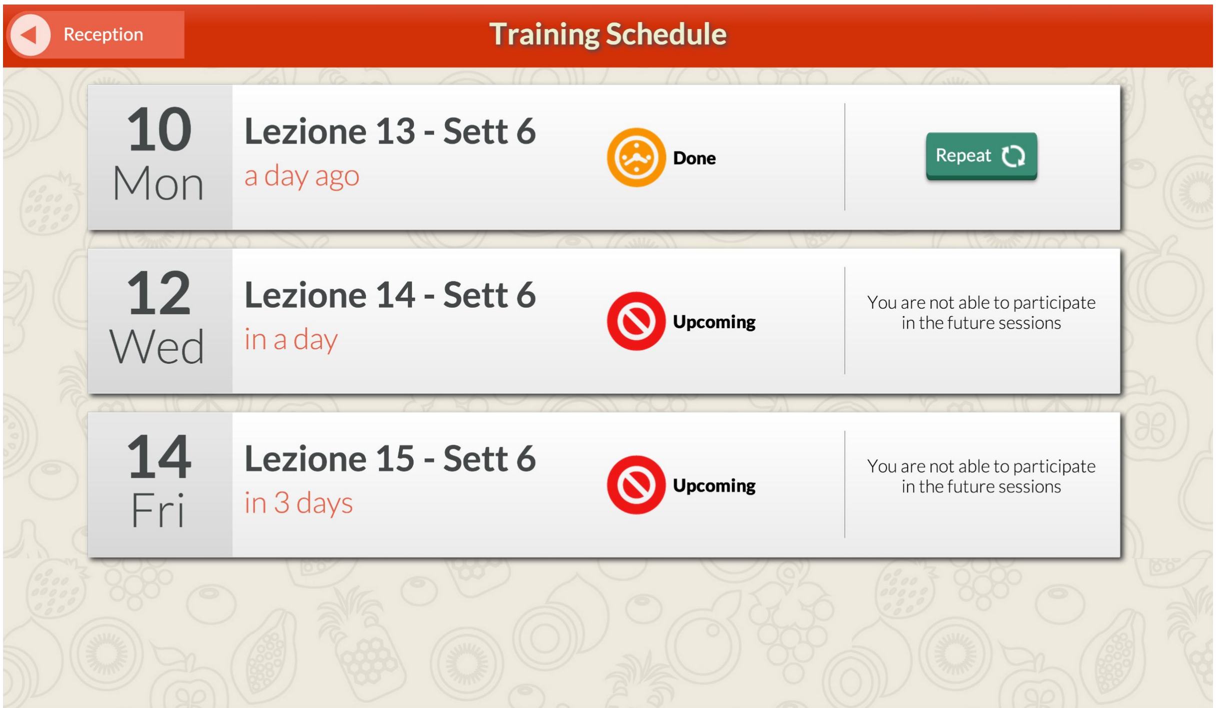
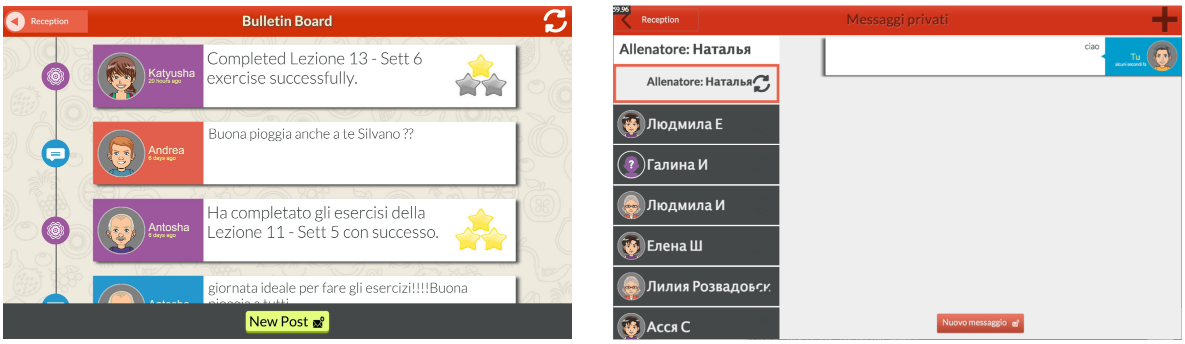


Figure 4.8: Agenda: Weekly training schedule

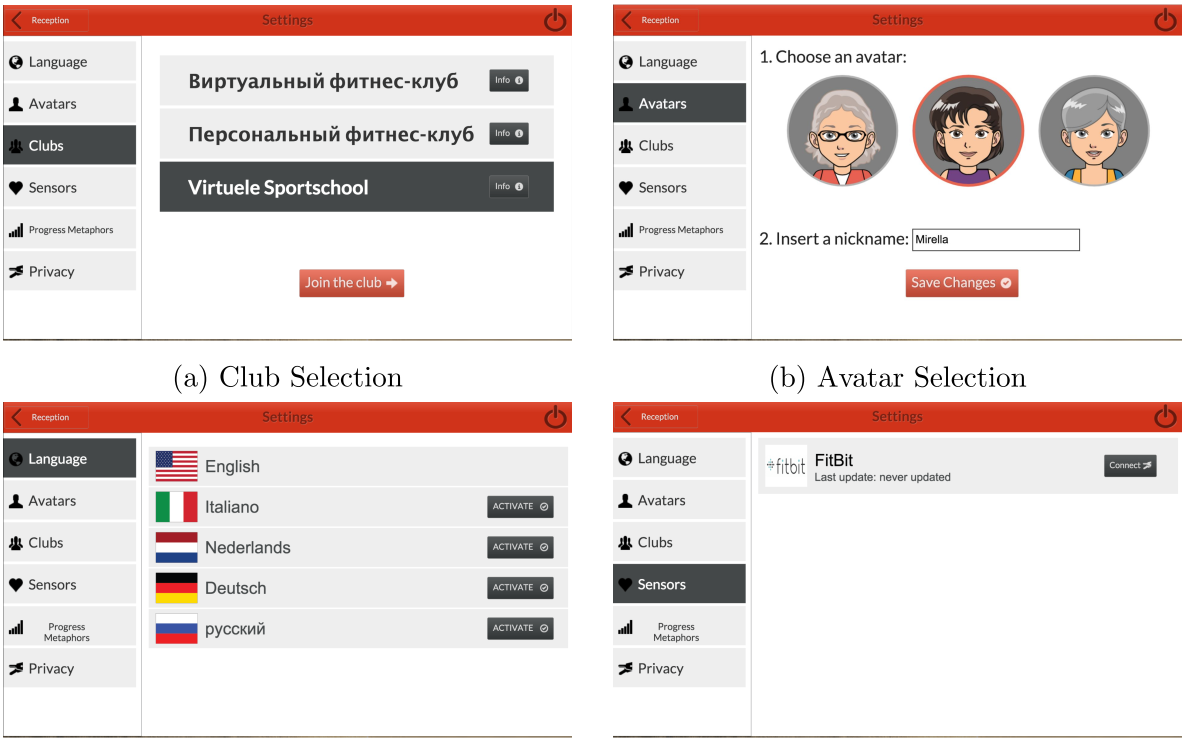


(a) Bulletin Board (b) Private Messaging

Figure 4.9: Messaging

doing so, help growing the garden. While users visit their garden (or their progress) they will see a gardener (a gnome) working there, informing them about the current status of the garden and encouraging them to keep on exercising (Fig. 4.7).

Training schedule It displays the training schedule of the user, remind-



(a) Club Selection (b) Avatar Selection

(c) Language Selection (d) Sensor Connection

Figure 4.10: Application Settings

ing them of the upcoming sessions (Fig. 4.8).

Messaging A bulletin board is a social interactive tool that, allows trainees to exchange public messages and see each others training activities. In addition, a private internal email allows trainees to have private conversations (Fig. 4.9).

Settings [1] Enable trainees to choose a nickname, select their avatar, choose the application language and authorize access to their personal activity trackers (Fig. 4.10).

[1]Access to the settings were disabled in the intervention to simplify the application

4.5.2 Coach application

The Coach application is designed to enable the human coach to start, manage and monitor the execution of home-based fitness programs. In a nutshell, it allows the coach to:

- Define the exercise program, including video exercises, performance indicators and intensity levels.
- Assign intensity levels (associated to the exercise program) to trainees, according to the initial physical assessment. This makes it possible for older adults of different abilities to follow the training program together.
- Tailor the exercise program continuously to match the progress of the individual trainees, or to prevent adverse events (e.g., stop an exercise if a trainee experiences pain when performing it).
- Provide support and feedback, communicating suggestions or answering questions via the messaging features.
- Monitor the performance of the trainees, by looking at the performance indicators defined for the training program. The indicators can be collected via self-reports, computed automatically by the trainee app (e.g., completeness, participation) or collected from sensors.

With the above features the system incorporates a human expert in the entire coaching process.

4.5.3 Architecture and application programming interfaces

Gymcentral trainee's application designed to serve a wide body of training programs and social activities. To serve this purpose, and to enable system developers to add on features to the application, the architecture designed to be modular. Figure 4.11 depicts the high level architecture of the application. The front-end application programmed in JavaScript, and can run on various platforms (i.e., modern internet browsers, native mobile apps and, smart TVs). Front end application communicates with two back-ends (APIs) in charge for providing the training program and enabling users to interact in real-time.

The core of the application provides features such as languages, avatars, sensors (provides connection hooks to third party sensors). The rest of the features can be added or removed to serve the training program needs. In particular, the core API of the front end provides tools to developers to build interactive social spaces. For this study, we implemented a locker room and a classroom using this API.

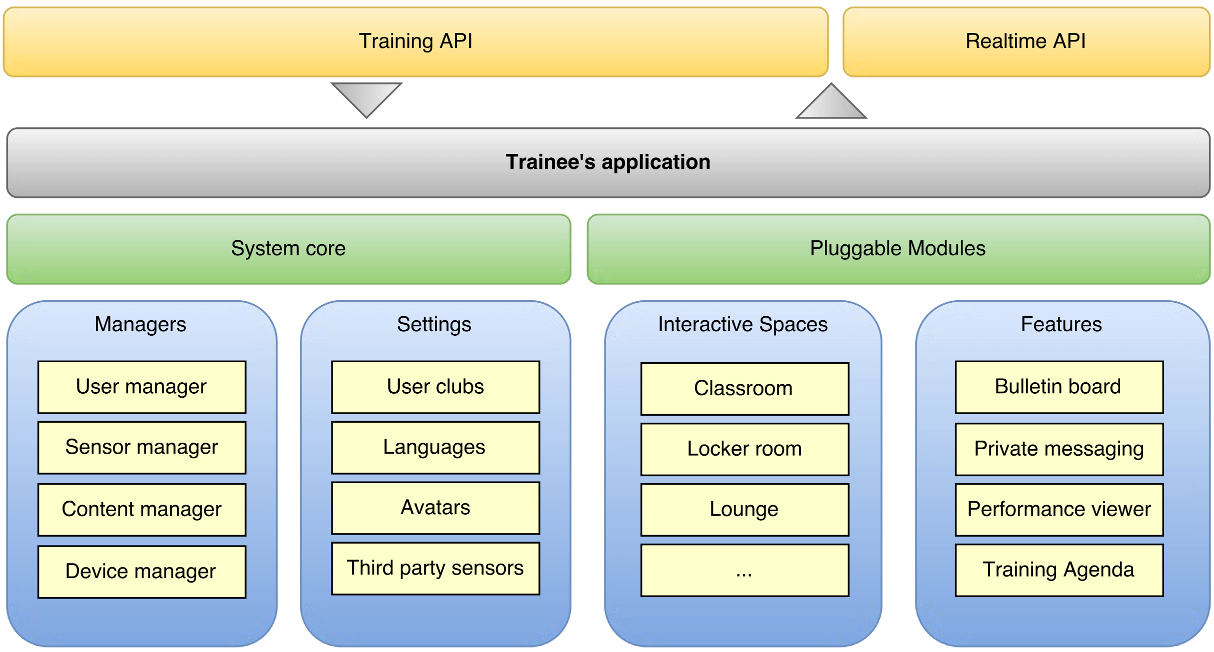


Figure 4.11: Gymcentral High Level Architecture

4.6 Conclusion

In this chapter, we explained the design rationale and evolution of gymcentral platform. We also described the core components and features of the platform. Gymcentral platform built on top of Active Lifestyle and modeled to suit for physical training application at home by providing an ecosystem for trainers to create and manage training programs and trainees to follow these programs in a social context and from home.

We used gymcentral platform to test the effect of social persuasion on physical activity. Given the flexibility of the application, we modified a version suitable for Otago exercise program. Chapter 5 explains a prospective cohort trial, using gymcentral application. In chapter 5 we used two version of gymcentral (full version, vs a simplified version without the social and persuasive features) to experiment with the effect of social persuasion of physical activity. Besides, we validate the usability, physical and social outcomes of gymcentral training application for users at home. Moreover, chapter 6 describes the use and validation of gymcentral in secondary physical interventions with different settings.

Chapter 5

Prospective cohort trial

5.1 Introduction

This chapter describes a prospective cohort trial pilot (Study protocol and results) using Gymcentral platform (chapter 4). Part of the material presented in this chapter and the results section are re-used from our published articles (published: [29], under review: [31, 30]). In this study we aim to evaluate the usability of gymcentral trainee-application and the effect of social interaction on physical activity for trainees at home. In this regard, we recruited 40 older adults participants for the intervention. Older adults participants were divided randomly in two groups of experimental (social) and control and used two versions of gymcentral trainee's application (full version with social and persuasive features and simplified version without social interaction and persuasive features) for a period of 8 weeks. Gymcentral coach platform was used by an expert trainer, and customized to provide Otago physical exercise program. We analyzed the outcome measures (attrition & adherence, social persuasion effects, usability of the application and, physical and social wellbeing outcomes of gymcentral) and discuss on the results using the control group to infer the effects of the measures.

5.2 Hypothesis and objectives

The objective of this study were twofold. In the first place, the study aimed at evaluating the usability (feasibility) of Gymcentral application. As described in Chapter 4, Gymcentral is an application for tablet that allows older adults to follow autonomously a home-based exercise program. The application includes different motivational and social features that allow participants to communicate with each other and with the personal trainer, and to follow their progress through a garden metaphor, by visualizing a garden that blooms as they perform the exercise sessions. The application allows users to follow a personalized exercise program by visualizing exercise instructions and videos, and also integrates monitoring by means of the application logs and manual user feedback. In addition, the study aims at investigating the effects of Gymcentral social persuasion strategies and in particular social interaction on physical activity. We also investigate the physical and social outcomes of using gymcentral for training.

The main hypothesis we aim to address in this study are:

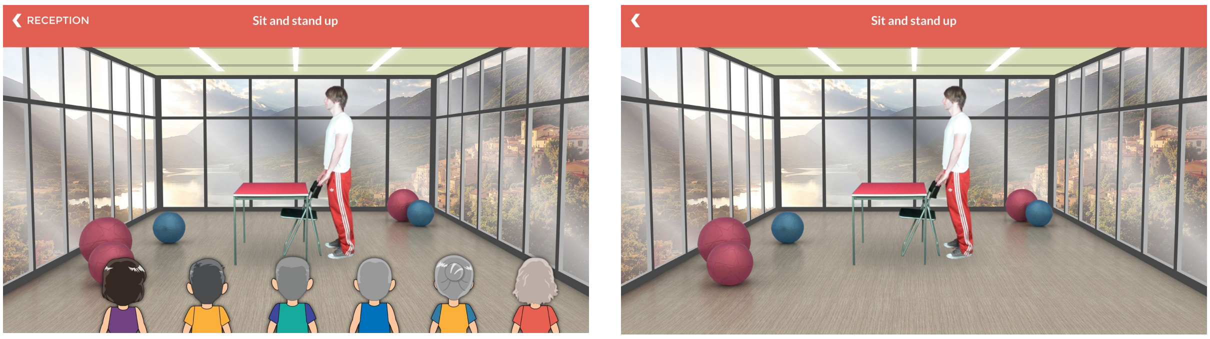
- Is it feasible to perform a home-based exercise program including exercise instructions by means of a tablet?
- Can (and to what extent) IT-mediated social interaction motivates older adults at home to be physically active and adhere to physical training programs?
- What are the physical and social outcomes of exercising with gymcentral application?

5.3 Intervention design

In this study we followed a framework for the design and evaluation of complex interventions in health settings described by Campbell et al. [116].

Participants were assigned to the experimental (or social) condition and to the control condition using a matched random assignment procedure [117, 118]. This technique is particularly useful to help ensure that different groups are equivalent on one or more characteristics prior to treatment. The variables used in the random assignment were age and participants frailty level. Pretest analysis of age, frailty, and self-reported physical activity measured with the Rapid Assessment of Physical Activity questionnaire [115] did not reveal significant differences between the experimental (social) and the control group.

Participants in the social condition were given a version of the *Trainee App* that included the virtual social environment, the progress metaphor and the home-based exercise program (refer to 4.5). In the control condition, participants received a version of the application that focused only on the home-based program, without social or individual persuasion features. In Figure 5.1 we illustrate the difference in the participation to training sessions.



a) Social participation to training sessions b) Individual participation to training sessions

Figure 5.1: Participation to training sessions in the (a) social condition, and (b) control condition.

Prior to the intervention, three training modules (~1.5 h each) were offered to the participants. The first two modules regarded the use of the tablet and its main applications, while the third focused on the usage of the Gymcentral app. In this case, control group and social group received appropriate training, based on the features of their application. All participants took part in the lessons. Individual lessons were also organized for those who had questions, and community managers were available in selected days at the associations for participants who had further questions or doubts.

In order to understand the perceived usability of both apps, we used the *System Usability Scale* [119] between participants in the social condition and in the control group after a first contact with the application. Not surprisingly, the version of the app used in the control condition was perceived as more usable compared to the more complex interface in the social group (on a 0 - 5 range; social: 3.3, SD = 0.5; control: 4.25 SD = 0.6). However, we did not observe any issues impeding the normal use of the applications.

All participants received a 10.1 inch Sony Xperia tablet with Wi-Fi and 3G support, the user guide including the names and telephone numbers of the support team, and instructions about the use of the tablet and the application, one pair of ankle weights to perform the exercises and a folder to allow the vertical positioning of the tablet.

Before starting the exercise program, all participants underwent physical assessment with a personal trainer, in order to allow for personal tailoring of exercise type and intensity, and to personalize the starting level of each participant. In addition, participants enjoyment of physical activity was measured using the *Physical Activity Enjoyment Scale* [120, 121] to test for differences that might favor the participation in one of the groups. However, an analysis of variance showed no significant main effect for the groups ($p = .477$).

The study was carried out in October - December 2014, in Trento, Italy. The first week was devoted to technical deployment and application testing, followed by 8 weeks of training and 1 week of post-training measurements. The timeline of the study is illustrated in figure 5.2.

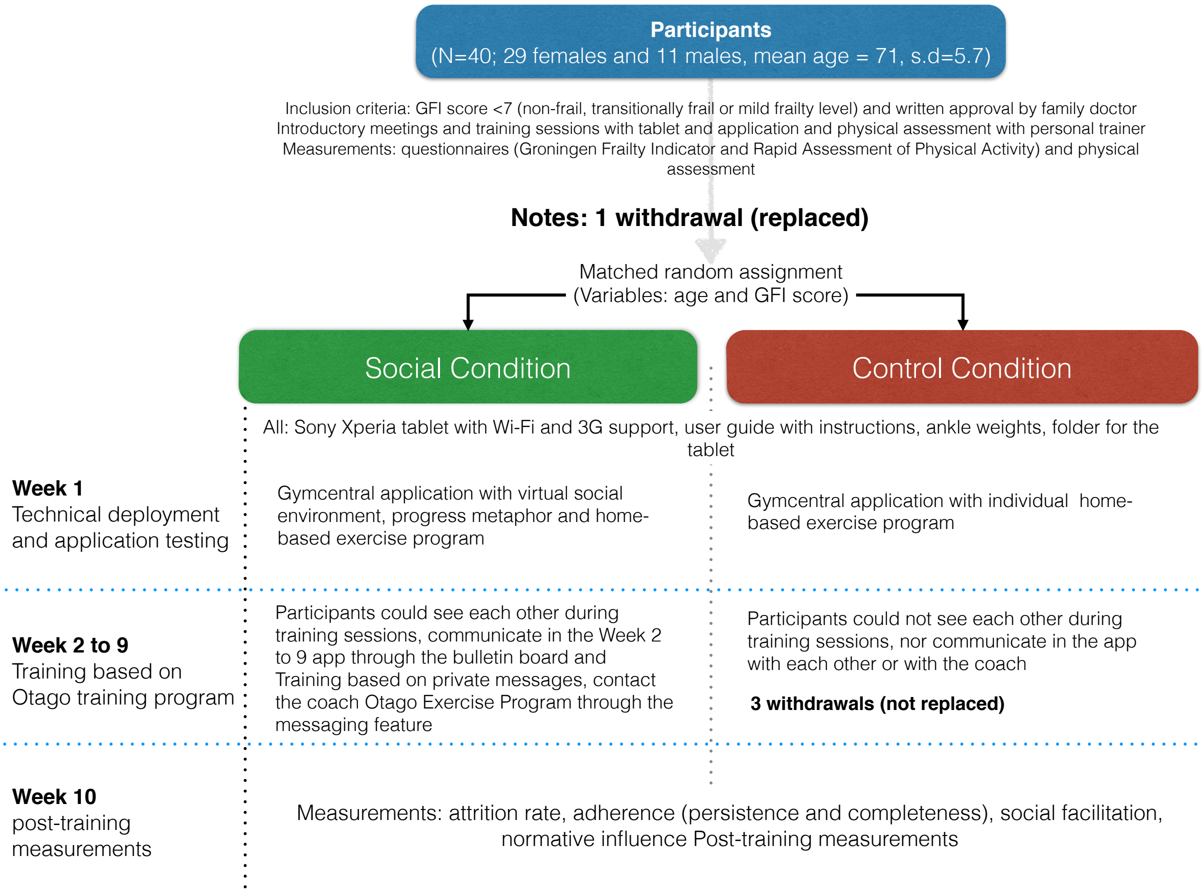


Figure 5.2: Flowchart depicting the study setting and timeline.

The exercise program was based on the *Otago* Exercise Program [122], specifically tailored for older citizens, and consisted of 10 levels of increasing difficulty. The program includes simple exercises based on functional everyday movements that could be safely executed at home (e.g., side hip strengthening exercise, backwards walking for balance). The duration of the exercise sessions ranged from 30 to 40 min, with longer sessions in the higher levels. Participants from both groups were assigned an initial level by the Coach based on the pre-test analysis. During the exercise program, participants were asked to perform at least two exercise sessions per week. They could gradually progress in intensity during the program. In both social and control groups, progression was gradually suggested every week. If participants agreed to level-up, the following level was unlocked, requiring a confirmation from the personal trainer in the case of the social group.

The interventions by the coach during the training were expected to be: (i) every week, to advance trainees in the exercise program (level-up) and give them feedback, and (ii) upon direct contact from the trainees. The Coach App supported the interventions of the coach with monitoring, personalisation and feedback features. However, while in the social group the feedback and support was done within the app via messaging features, in the control group, it was done via telephonic contact due to the absence of social features in that condition.

Technical support during the study was required at one point due to intermittent connectivity problems in the 3G signal in some areas of the city. This affected both group in the same way, the only difference being that the study group could report them through the app while the control group was reporting by phone. No differences in support related to the app were registered.

5.4 Outcome measures

This section presents the metrics which, we aim to measures in this intervention. The primary goal was to experiment the effect of social persuasion strategies on physical activity, adherence and, attrition. We also validated the usability of the full version of the trainee's application vs a simplified version and the physical and social benefits of exercising with the application. In the following we describe the outcome measures in detail.

5.4.1 Attrition & adherence

The attrition rate was measured with the proportion of participants lost at the end of the study. Taking into account relevant related studies on IT-based systems for healthy ageing [70], a 7.5% attrition rate was considered acceptable.

The adherence to the exercise program was computed using data about usage patterns collected from the application logs, for both of the control and social group. In order to better explore adherence patterns, for each participant, two measures were considered. The first is related to persistence throughout the eight weeks of the exercise program, and was computed considering the ratio between the number of participations to exercise sessions by a participant and the number of the exercise sessions planned in the program. Participation was measured by logging the attendance to the scheduled training sessions in the virtual classroom, from the first to the last exercise (even if the exercises were skipped). The second measure is related to the level of completeness of the exercise sessions. It was calculated considering, for each session, the percentage of exercises videos that the user actually followed (watched) - excluding the time of preparation and skipped exercises - with respect to the total duration of the exercises planned for the session.

For example, participant A and participant B could both have high scores in the level of completeness, meaning that when they take part in a workout session, they tend to perform most of the exercises, completing a high percentage of the session. But, for example, participant A could score lower that participant B in the persistence measure, in case he/she took part in only few of the total number of exercise sessions planned in the program, while participant B attended a higher number of sessions during the eight weeks of the study.

In general, using as a baseline previous studies on tablet-based interventions [70], a rate of 70% was considered an acceptable criterion for success for both measures. More specifically, we expected a higher adherence for the social group, as a consequence of a higher motivation and engagement in the participation of the program, due to the presence of communication functionalities, and the garden metaphor for monitoring ones progress.

5.4.2 Effects of social persuasion on physical activity

Users could participate in a training session at any time, and they could join other users or exercise alone. The participation of all the users were logged in the system.

We consider a user participation to be "joint" if there was at least one or more users exercising at the same time for a minimum of one minute. On the contrary, if a user participated alone during the entire training session, the participation is considered as individual. We measure co-presence by computing the ratio of joint participations with respect to the total number of participations. Measuring co-presence we analyze the tendency of trainees in exercising in groups vs exercising alone. We also measure if co-presence had an effect on the duration of exercising. Measuring co-presence can thus reveal the role of social facilitation and normative influence [32] on physical activity.

5.4.3 Usability & technology acceptance of gymcentral

After several iteration on gymcentral application (refer to 4.4.2) we aim to test the usability of gymcentral in a real world scenario and for the older adults at home. Thus, usability of the application was measured using the *System Usability Scale* [119] at two time points: the first time at the beginning of the study, after the tutorial on the application (when users could try out the app themselves for the first time), and the second time at the end of the study. Usability of the application was expected to be lower for the Social group at the beginning of the study, reflecting participants initial difficulties to deal with a more complex user interface. However, the familiarity with the system that should have been acquired by the end of the eight weeks training program was hypothesized to reflect an increase perceived system usability at the end of the study.

As for the technology acceptance, a number of dimensions were investigated with a questionnaire developed on the basis of previous literature (for example, Phang et al. [123], Davis [124]). Participants expressed their preferences on a 5-points *Likert scale* (1 = completely disagree, 5 = completely agree). The dimensions considered include anxiety toward the application, attractiveness and acceptance of the application, satisfaction of the service provided, perceived usefulness of the application and intentions to use the application in the future. Participants attitudes towards gymcentral application were collected with a questionnaire at the beginning and at the end of the study. In particular, we expected all dimensions related to technology acceptance to improve after the eight weeks period of the training program.

As part of the usability metrics, we also analyze the nature of interaction established between the participants in the trainee's application. The analysis infer the messages communicated between the trainee's and the coach in both Bulletin board and the private messaging features of the application. The analysis indicates the kind of community formed among participants using Gymcentral trainee's application.

5.4.4 Effects of Gymcentral on physical wellbeing

In addition to social persuasion and usability, we also measure the physical and social benefits of the intervention using gymcentral. As described earlier in this chapter, we used Otago physical training program in this intervention. The Otago Exercise Program is used worldwide and is one of the most tested fall prevention programs by the Centers for Disease Control and Prevention, with four randomized controlled trials and one controlled multi-center trial. The program includes muscle strengthening and balance-retraining exercises of increasing intensity. Previous studies showed that the Otago Exercise Program is effective for reducing *falls* and *fall-related injuries* among high risk individuals, and that it can increase the percentage of older adults who are able to live independently in their community [125, 126]. Specific assessment exercises, developed and validated within the Otago Exercise Program [125, 126], were used to measure participants leg muscle strength and walking ability at the beginning and at the end of the study. In particular, the assessment exercises were:

- *30 second Chair Stand test* [127]: the purpose of this test is to evaluate leg strength and endurance. From seated position, the participant rises to a full standing position and then sit back down again for 30 seconds. The outcome measure is the number of times the participant comes to a full standing position in 30 seconds.

- *Timed Up & Go test* [128, 129]: the purpose of this test is to assess older adult mobility. From the seated position, the participant stands up from the chair, walks for 3 meters at his/her normal pace, then turns, walks back to the chair and sits back down again. The outcome measure is the number of seconds to complete the test.

With regard to performance, we expected for both groups a significant increase from pre- to post- test in the 30 second Chair Stand Test and the Timed Up & Go test, with a more marked increase for the Social group, possibly reflecting a more consistent participation the exercise program.

5.4.5 Effects of Gymcentral on social wellbeing

We measure the effect of social persuasion and co-presence on physical activity. On the contrary we also measure if the effectiveness of the Gymcentral service in improving social wellbeing. The effect was assessed on the basis of participants feedback, collected at the beginning and at the end of the study with two questionnaires measuring social closeness and loneliness. *Social closeness*, measured with the MPQ Tellegen and Waller [130], is related to the interpersonal domain, tends to correlate with positive mood states such as joy and enthusiasm and describes the tendency to be involved in interpersonal relationships (p. 275). People who score higher in this scale tend to describe themselves as sociable, warm, affectionate, seeking support and valuing close relationships [130] (p. 274).

Another aspect related to social wellbeing is *loneliness*. Shifts in the social environment, and in particular loneliness, are believed to be an important aspect in the life of aging people [131]. Loneliness involves individual perception of social isolation, feelings of not belonging and being disconnected, and is a central aspect of a group of socio-emotional states including, among others, self-esteem, optimism, anxiety, anger and social support. To measure loneliness, we used a shorter version of the R-UCLA Loneliness Scale (Peplau and Cutrona [132]) developed by Hughes et al. [131]. With regard to social wellbeing, we expected an improvement in participants social closeness and a decrease of participants perceived loneliness at the end of the study, with more pronounced effects in the Social group. v

5.5 Participants

Participants aged 65 or older, independent-living, self-sufficient and with a non-frail, transitionally frail or a mild frailty level were considered eligible for the study. These inclusion criteria were measured by self-reports. Participants frailty level was measured using the Groningen Frailty Indicator (GFI; [114]), a validated questionnaire that screens for self-reported limitations in older adults [133, 134]. The GFI score ranges from zero *not frail* to fifteen *very frail*. Older adults were considered eligible for the study with a score lower than 7 (non-frail, transitionally frail or with a mild frailty level). Since wearable sensors and wireless connections were part of the study, participants wearing pacemakers were considered not eligible.

Older citizens were mainly contacted through two volunteering organizations[1] based in Trento, Italy, which offer different services to independently living older adults. Participants who showed interest in the study were contacted by the researchers to make sure that they conformed to the inclusion criteria. Forty (40) participants between 65 and 87 years old being selected for the study (29 females and 11 males, mean age = 71, *s.d.* = 5.7). All participants obtained a formal written approval by their family doctor to allow them to participate in the study. After the recruitment process, both doctors and participants received a written outline and explanation of the study before participating.

The gender imbalance in the initial set of participants is due to the difficulties posed by recruiting older adults and the availability in the volunteering organisations. However, studies [135, 136] suggest that both male and female react to sport activities equally, despite differences in initial motives for participation. Thus, these previous studies support the generalisation of the analysis proposed in this paper.

Out of the initial 40 participants, 4 withdrew at different times during the course of the study due to unpredictable health or family problems. One participant could be replaced because the withdrawal occurred just

[1]Users participation in the study, including the partnership with the mentioned volunteering organization, was managed by dedicated staff at Smart Crowds Territorial Lab, Trento RISE (www.smartcrowds.net).

before the start of the study, while the others could not be replaced since they withdrew during the second half of the study. For this reason, the results are based on data from 37 participants (28 females and 9 males, mean age = 71, s.d. = 5.8, between 65 and 87 years old).

Volunteered participants had variable physical conditions and low familiarity with technology. Some of them were already used to offline physical activity (e.g., swimming pool, low-impact exercise, gardening), yet most of them were sedentary. In what regards technological skills, less than 20% of the participants had ever used a tablet before, and less than 10% used it regularly. Thus, participants were provided introductory courses on how to use the tablet along with a written presentation of the study and written instructions for the use of the tablet and the application.

The study received ethical approval from the CREATE-NET Ethics Committee on ICT Research Involving Human Beings (Application N.2014–001).

5.6 Results

Given the outcome measures described in the previous section, This section reports on the results of the analysis accordingly.

5.6.1 Attrition and adherence rates

Out of the initial 40 participants, 4 withdrew at different moments during the course of the study due to unpredictable health or family problems. One participant was substituted because the withdrawal occurred before the start of the study. This resulted in a 7.5% attrition rate, measured in terms of the proportion of participants lost at the end of the study. It should be observed, however, the reasons behind the withdrawal of these participants were solely related to unexpected health and family problems or in one case, because of technical issues regarding Internet connection problems which, could not be solved.

Adherence to the exercise program was computed using data about usage patterns collected from the application logs, both for control and social group. In order to better explore adherence patterns, for each participant, two measures were considered:

- persistence throughout the eight weeks of the exercise program
- level of completeness of the exercise sessions.

With regard to persistence, a total number of 24 sessions were planned during the eight weeks of the study (3 sessions per week). In order for the exercise program to succeed, participants were asked to carry out at least two of the three sessions that were planned each week. To calculate persistence, the total number of exercise sessions in which each participant took part was divided by 24, the total number of possible training sessions across the 8-weeks period of the study.

The general persistence rate in the two groups was 76% (SD = 22.6%). More specifically, in the social group the persistence rate was 85%, while in the control group it was 64% (Fig. 5.3).

A *t-test* for independent samples was used to analyse the difference in persistence during the training program between the social and the control group. The test showed that the social group had a significantly higher persistence rate *(M = 85.4%, SD = 16.1%)* compared to the persistence rate of the control group *(M = 64.2%, SD = 24.1%, t(35) = 3.18, p = .003)*.

Indeed, grouping the participation by week, distributing the users by number of participations (1, 2 and 3), we notice that participants of the study group did not only comply with the coach instructions (at least two sessions per week, as requested from them), but they did more (Fig. 5.4).

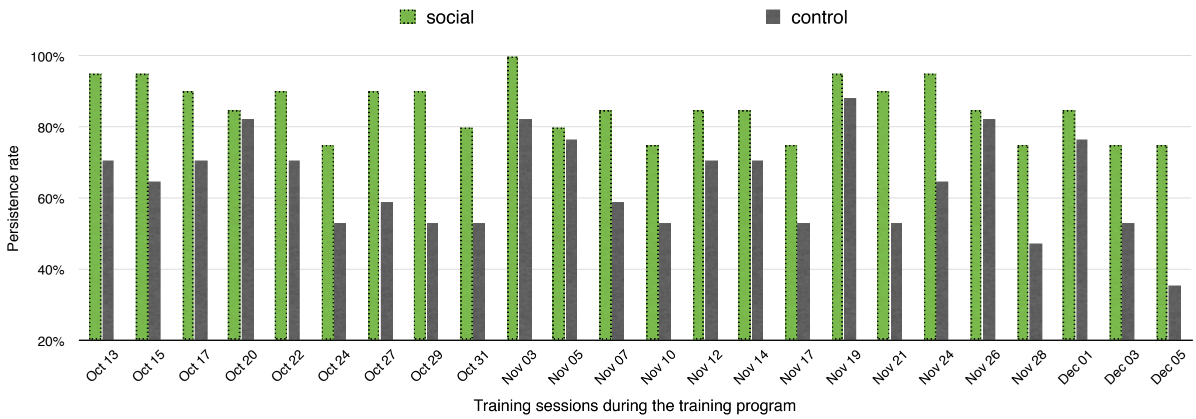


Figure 5.3: Persistence rate in the control and social groups during the eight-week period of the study.

This indicates that the various features of Gymcentral were more engaging than the simple app.

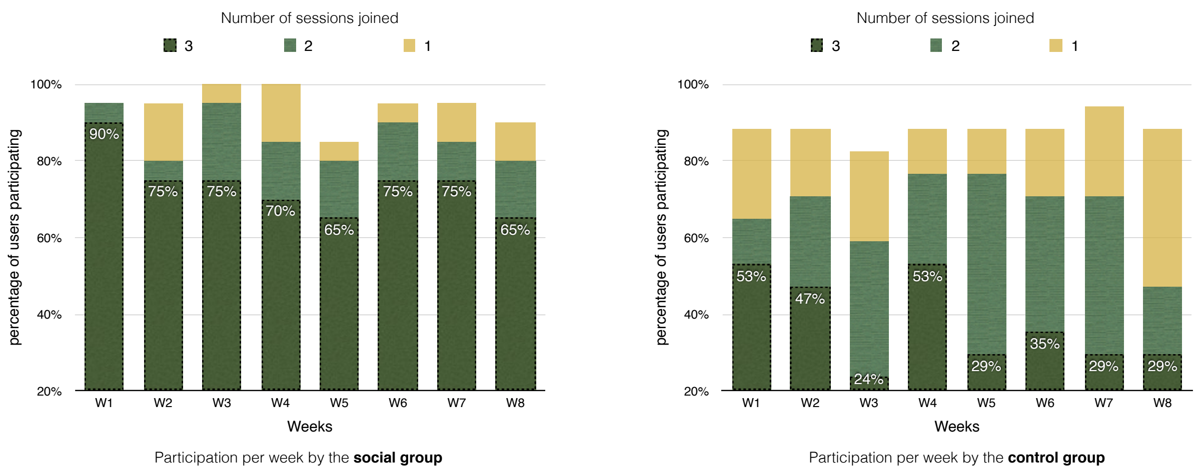


Figure 5.4: Attendance rates of the social and control groups per week.

The second measure related to adherence is the completeness rate, which refers to the extent to which, participants tend to complete all the exercises included in a working session once they have begun to work out (completeness was calculated by measuring the ratio of the duration of videos that the participant had watched to the total duration of videos of the session).

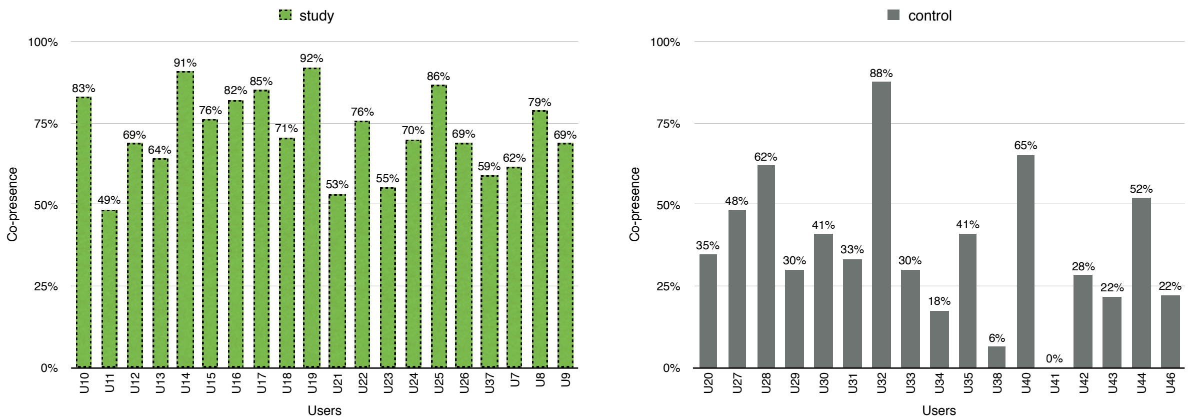
The overall completeness rate in the two groups was very high, specifically 90.32% (SD = 17.4%), meaning that overall participants tended to complete the working sessions once they started. The completeness rate in the social group was slightly higher compared to that of the control group, although it was not statistically significant (respectively, M = 91.75%, SD = 12.46% for the social group, and M = 88.63%, SD = 22.24% for the control group).

In general, the data shows positive results with regard to attrition and adherence rates, providing evidence for the effectiveness of tablet-based home exercise programs. More specifically, the social group, who used the system, including communication features and the garden metaphor to monitor ones progress, showed a significantly higher persistence rate throughout the study, indicating an increased engagement in the program.

5.6.2 Effects of social persuasion on physical activity

A total of 669 participation to the training sessions were registered in the social group, for the 20 participants, and 451 for the 17 participants in the control group. The co-presence in the social group was of 71.86% (SD = 12.53%). In the control group instead, the co-presence was of 36.52% (SD = 21.92%). In the latter case, co-presence represents the meet-ups by chance as users were not aware of each other. Figure 5.5 depicts the percentage of joint sessions for both social and control groups. The percentage demonstrates the ratio of times in which the trainee was exercising in a joint session.

A t-test for independent samples reveals a significant difference between the social and the control group ($t(35) = 6.14, p < .001$). However, to compensate the effect of a higher number of participants in the social group and to get a conservative estimate, we excluded the three most active participants from the social group (U7, U13, U26) along with all their



Co-presence in the **social group** Co-presence in the **control group**

Figure 5.5: Percentage of co-presence in the social and control groups.

data, and analyzed co-presence in this new condition. The difference is still significant, with a co-presence of 62.68% for the remaining 17 participants of the social group, compared to the 36.52% of the control group ($t(32) = 3.90, p < .001$). This result suggests that participants in the social group were motivated to join the sessions at the same time.

Further analysis beyond our outcome measures were done for informative purposes:

Co-presence and the motivation to stay online

We further investigated if co-presence caused longer duration of stay in the classroom, by comparing the difference in the time spent by each user in the *joint* and *individual* sessions. The results shows an average raise of 10.81 min (SD = 16.52) in the time spent in joint sessions for the social group, and of 6.62 min (SD = 10.14) for the joint session of the control group (control group participants were not able to see each others presence. Therefore the 6.62 min increase is due to the effect of longer sessions and not user motivation). Still, the social group exercised 4.19 min more than the control group. However, the difference is not significant according to the t-test analysis ($t(35) = 0.91, p = 0.37$).

Co-presence and the motivation to finish the exercises in one session

In the study settings, training sessions were composed of 12 to 13 activity bouts. However, participants could optionally perform all of the designated activity at once (once in a row) or complete the session activities partially (e.g., activity 1 - 5) and return later to the same training session to perform the remaining activities (e.g., 6 - 13). Thus, we analyzed the ratio of completed sessions at once in three situations of (i) completed at once when exercising individually and in joint sessions, (ii) completed at once individually and, (iii) completed at once in joint sessions.

From the 669 recorded sessions for the 20 participants of the social group, the ratios are as: (i) completed individual + joint = 40.75%, (ii) completed individual = 34%, (iii) completed joint = 42.42%. For the 451 recorded sessions for the 17 participants of the control group the ratios are (i) completed individual + joint = 39.46%, (ii) completed individual = 34.92%, (iii) completed joint = 50.51%. Although the completion ratio for joint sessions is higher in both social and control groups, this is mostly caused by the fact that longer sessions increase the chance of meeting with the other trainees, and in any case the difference is not significant.

Success rate of invitations to join a training session

Participants in the social group were given the possibility to send invitations to the other trainees, by asking them to join to the classroom with them. Out of 20 participants of the Social group, 11 participants had sent at least 1 invitation. We account for 129 invitations received, and the percentage of invitations that caused trainees to join within 2 min of notice is 50.59%, indicating that a considerable number of received invitations caused the participants to start training immediately.

5.6.3 Usability

A mixed between-within subjects analysis of variance (t-test) was conducted to compare pre- and post- scores of the *System Usability Scale* between participants in the social group and in the control group (Figure 5.6). There was a significant interaction between group and time ($F(1, 34) = 8.286, p = .007$, partial eta squared = .196). There was a significant main effect for time ($F(1, 34) = 37.113, p < .001$, partial eta squared = .522), with both groups showing an increase in the System Usability Scale scores at the end of the study. The main effect comparing the two groups was also significant ($F(1, 34) = 14.614, p = .001$, partial eta squared = .301), suggesting that, all other variables ignored, the social application (full version) is less usable than the control application given its richer features.

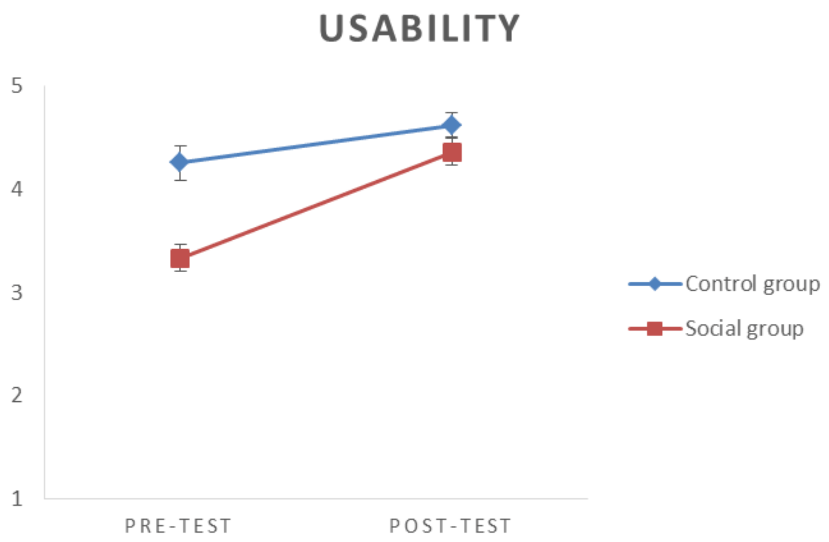


Figure 5.6: Mean usability scores of the application before and after the eight week exercise program (System Usability Scale)

The significant interaction between time and condition shows that the effect of time on the usability scores of the application varied between groups. In particular, while at the beginning of the study the simplified version of the application assigned to the Control group performed better with regard to perceived usability, the SUS score improved more over time in the Social group than in the Control group. This result suggests that although the social application including communication features and the garden metaphor was perceived as more complicated and difficult to learn at the beginning, perceived usability increased at the end of the study. Looking at the graph (Figure 5.6), it can be observed that although usability increases in both groups, this increase in the usability is much more in the Social group. Multiple comparison tests (t-test) showed that usability improved significantly both for the Control ($p = .038$) and for the Social group ($p < .001$).

With regard to technology acceptance, we considered anxiety toward using gymcentral trainee's application, attractiveness and acceptance of the application, satisfaction of the service, perceived usefulness and intention to use the application in the future.

Anxiety The analysis showed no significant interaction between group and time (p = .069) and no significant main effect for time (p = .372), but showed a significant main effect for group (F(1, 34)= 5.543, p = .024). Although the data showed a tendency towards a decrease of anxiety at the end of the study for the social group, this tendency is not significant. However, multiple comparison tests with Bonferroni correction showed that anxiety significantly decreased for the social group (p = .044), but not for the control group (p = .518). A closer analysis of the studentized residuals [137] allowed us to detect two outliers in the data. After removing those observations, the analysis showed a significant interaction between group and time (F(1,32) = 4.713, p = .037), suggesting that anxiety towards the application significantly decreased over time for the social but not for the control group. However, this result is not conclusive. One possible explanation for this controversial outcome is a low statistical power due to a small sample size, combined with the presence of the two outliers.

Attractiveness The analysis did not reveal a significant interaction between time and group ($p = .661$), nor a significant main effect for group ($p = .576$), but it showed a significant main effect for time ($F(1,34) = 7.448$, $p = .01$). Multiple comparison tests with Bonferroni correction showed that attractiveness of the application significantly increased for the social group ($p = .023$) but not for the control group ($p = .134$). While the results of the analysis of variance suggests that, taken together, both groups reported to like the Gymcentral trainee application significantly more at the end of the study, post-hoc comparisons suggest that this difference was significant for the social group but not for the control group. It is likely that during the eight weeks period of the study participants gained confidence with the application, and after an initial learning period, the use of the application became part of their exercise routine. This result also suggests that the Gymcentral trainee application was widely accepted and positively perceived even after eight weeks of workout program, without any apparent effect of boredom due to the exercise routine.

Satisfaction The analysis did not reveal a significant interaction between time and group ($p = .308$), nor a significant main effect for group ($p = .49$) or for time ($p = .051$). However, multiple comparison tests with Bonferroni correction showed that satisfaction significantly increased from pre- to post- for the social ($p = .028$) but not for the control group ($p = .513$). Furthermore, an exploration of the studentized residuals revealed the presence of one outlier. The analysis of variance repeated after excluding the outlier showed a significant main effect for time ($F(1,33) = 6.561$, $p = .015$). Although not conclusive and requiring further investigation with larger sample size and higher statistical power, this result suggests that satisfaction of the service provided by Trainee app may have increased during the eight weeks period of the study, and that this increase may have been more marked for the social group, consistently with the results reported in the previous paragraphs.

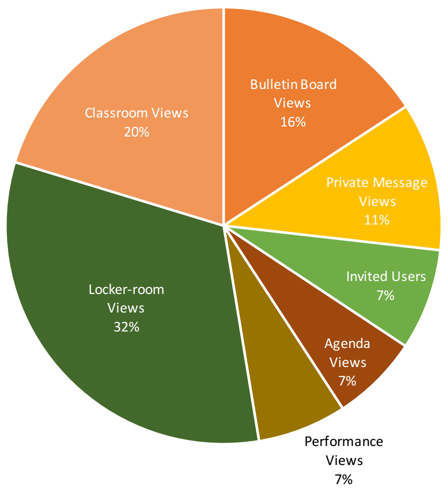
Usefulness The analysis did not reveal a significant interaction between time and group ($p = .09$), nor a significant effect of the main effect for group ($p = .192$), but it showed a significant main effect for time ($F(1,34) = 4.291$, $p = .046$). Multiple comparison tests with Bonferroni correction suggest that there was a significant increase in the perceived usefulness of the application for the social ($p = .007$) but not for the control group ($p = .827$). Consistently with the previous analyses, this suggests that, overall, participants perceived Gymcentral as more useful after the training program, and that perceived usefulness in the social group may have improved more with respect to the control group.

5.6.4 Usefulness of Gymcentral features

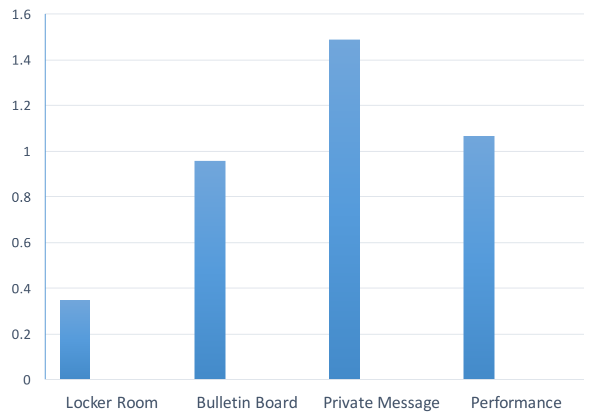
In addition to measuring the usefulness of the application between the social and the control group, participants in both groups were asked to rate the main features of the full version of the application on a 1-5 Likert scale. The average score that participants of the social group gave to the main features of the app were analyzed (table 5.1). Beside this, the frequency of using each of the features of the full app by the social group participants were measured (figure 5.7a). Finally, average duration of time spent using different features (i.e., classroom, locker room, bulletin board, private message and, performance monitoring) were measured (figure 5.7b).

Given these data, participants chose progress monitoring (self-monitoring) features as the most useful features of the app. However, looking at the usage statistics performance view was only 7% of the usage and participants spent 1 minutes on average for their visit. The results indicates that performance monitoring, despite the low usage is a very important feature for the trainees. Program agenda (Schedule) was ranked similar to the progress monitoring and despite its low usage, it was perceived as one of the most useful features of the training app.

Features related to exercising and, exercising in a group and inviting others were ranked bellow the agenda and performance monitoring in the table (table 5.1). By looking at the usage statistics, we can see that 20% of the usage goes to classroom and only 7% of the usage belongs to inviting others. However, participants spend on average 42 minutes in the classroom which is motivated by the fact that they needed to watch video exercises that lasts between 20 minutes to 1 hour. On average, participants found classroom and social exercising features useful (average score 4.63 out of 5).



(a) Average usage of Gymcentral features



(b) Average duration (in Minutes) spent in Locker room, Bulletin Board, Private Messaging and the Performance monitoring.

Figure 5.7: Gymcentral: features' usage statistics by participants of the social group

Features	Number of Replies	Average Scale
Following progress	19	4.79
Progress in the garden	19	4.74
Private message with the coach	17	4.71
Checking the schedule	18	4.67
Exercising in the classroom	19	4.63
Inviting others to join	15	4.40
seeing others in the classroom	19	4.32
Bulletin board	14	4.14
Seeing others in the locker room	9	4.00
Private message with trainees	13	3.38
Locker room real-time interaction	5	2.80

Table 5.1: Perception of participants on trainee's app features after the intervention (Likert Scale; 1: completely agree, 5 completely disagree)

The locker room feature appears to be the most controversial feature among all. While according to the usage statistics (figure 5.7a locker room is the most used feature, participants spent the least time in the locker room (around 0.38 of a minutes on average, figure 5.7b). In addition, participants ranked features related to the locker room with low scores (e.g., real-time interaction in the locker room: 2.8 out of 5; table 5.1). One possible reason for the locker room being highly used is that it was the entry point to the exercising room, but since participants did not have any interactive content to engage with in the locker room, they did not spend time in it, as the result the real-time interaction with other participants in the locker room became less useful.

In summary, participants found the features related to the exercise and self-monitoring more useful that the social features. Yet, the usage statistics reveals fair usage of the social features alongside the exercising features of the application.

5.6.5 Online Social Behavior

During the training program intervention, participants posted 113 messages on the bulletin board and exchanged 411 private messages. To understand what was posted on the bulletin board and what kind of private messages were exchanged, we randomly sampled 20% of the messages and manually coded them. We first categorized the messages without using pre-existing categories. Then, after a comparison with the relevant literature about online behavior and communities [138], we developed a coding scheme of 5 top- and 12 sub-categories as following:

Community building

Togetherness The author interacted with the community saying hello to everybody or to someone in particular, inviting them to participate; posted something that stressed the value of the community, welcoming and stimulating others to participate.

Thank you The author thanked someone in particular or the entire community for help, support, or understanding.

Sorry The author said s/he was sorry for something.

Entertainment The author shared jokes, quotes or aphorisms, humor containing jokes.

Gymcentral

Happy about Gymcentral The author referred a positive experience with the application in the context of the study, posting positive comments about the app and how fun it is.

Problem The author described a problem with the application, such as slow connection or malfunction, or other technical issues.

Information The author provided technical advice, recommendations, suggestions on technical problems, general information or announcements about the application.

Question The author posted a question about the application and about technical issues with it.

Physical Activity

Support The author offered support, advise or sympathy toward a specific other or the entire community, encouraging others to do physical activity and to participate in the exercise program.

Congratulations The author congratulated with someone in particular or with the entire community for participating in the training program and for doing the exercises.

Me The author shared his/her own experience with the training, telling others that s/he is committed to exercise, s/he participated in a training session, s/he is ready to exercise or to level-up, s/he had problems with physical activity or that s/he could not exercise for a particular reason.

Question The author posed a question to a particular person or to the entire community about the training, such as how to do the exercises, or asks the coach if s/he can level-up.

Self-disclosure

The author posted something personal about him/herself, not related to physical activity, including what s/he is doing or has done in life or during the day, or shared a personal story.

Other

Messages that cannot be categorized into the previous categories.

Nature of interaction

Using this coding scheme, two independent coders classified the sampled messages. *Cohens kappa coefficients* for the bulletin board were .85 on top-categories and .84 for sub-categories, and for the private messages they were .87 for top-categories and .85 for sub-categories, indicating a general high agreement. After the independent coding, one coder classified all the messages combining the coding results.

In general, participants preferred private messages (411 messages) to the bulletin board (113 messages). The bulletin board (figure 5.8a) was used mainly to promote community building, and in particular a sense of togetherness. Here, participants played a central role posting the majority of messages in this sub-category ("hello everybody, how are you, everything fine?", "Good morning everybody! How's it going with the training? Have a nice day, bye"), and using a humorous tone in the conversations ("Hi P., youre a little lazy. Bye"). They also publicly thanked the coach ("Thanks [coach] for the support, the ankle weights are an efficient tool to strengthen our arms and legs") and other participants for a number of reasons, for example for an invitation to join a session ("Hi E.! Thank you for the invitation. Have a nice day!!"). The coach, although to a lesser extent, participated in building a sense of community not directly referring to physical activity, welcoming and greeting participants ("Have a nice start to your week everybody!"), and thus contributing to stress the value of the community.

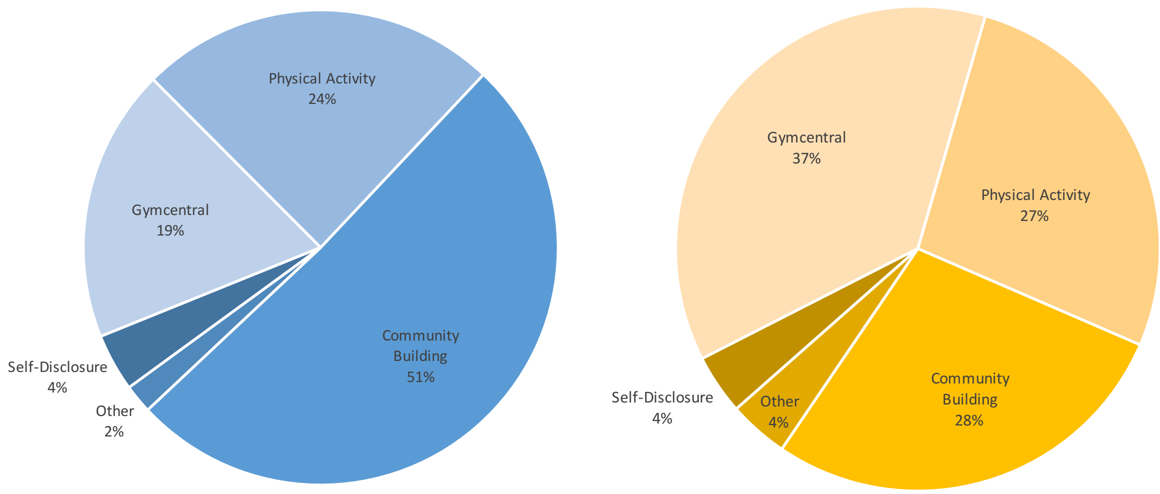
When talking about physical activity, the bulletin board was mainly used by the coach and participants to congratulate and support each other in the physical training. In particular, the coach was very active in publicly congratulating participants ("Well done everybody for this week too. Many of you wrote me that you'd like to level-up. VERY WELL, I remember you that you can contact me for any problem! Have a nice week-end everybody", "My congratulations to everybody for the last week!"). He also supported them to take part in the exercise sessions ("Keep on going!!", "Come on with the training again tomorrow, then during the weekend you can rest!").

Participants talked about Gymcentral mainly to report technical issues they were experiencing. In particular, during the study we encountered slow connection problems that compromised the correct functioning of the application, in particular the video streaming. This was reported by participants on the bulletin board ("This evening I had a few problems with the tablet, it stopped, but I did the exercises anyway. Bye [coach] and everybody. Bye, M."). Participants also publicly expressed positive comments about Gymcentral ("Hurrah for the virtual gym!", "Oh! A bright butterfly appeared in the garden, wonderful, thank you!"). Finally, the technician participated to the activities on the bulletin board mainly to provide information and advice about the technical issues with the application.

With regard to private messages (figure 5.8b), the figure shows that they were used in a different way. First, participants used private messages four times more than the bulletin board, exchanging 411 messages. Second, they talked more about Gymcentral, while community building activities were present to a lesser extent.

Considering the messages of community building, we can observe that, similarly to the bulletin board, participants promoted a sense of togetherness ("Hi N., how are you?", "How's the training going? Girl, we missed you, bye P."), using a humorous tone in their conversations ("What a lazybones, never see you in the gym. Bye", "Tarzan in the forest doesnt shout so well. Maybe he's following us, a sign of the cosmic value of our exercises. Byee").

Messages about physical activity were mostly sent by the coach to individually support participants ("Exercising together helps to have more true grit!"), and to a lesser extent to congratulate them ("Bravo L.!"). Interestingly, when participants talked about physical activity, they did not do so to congratulate and support each other as they did in the bulletin board, but instead talked about their personal experience with the exercises, and particularly turned to the coach to inform him or ask for advice. Indeed, 25 of the 29 messages sent by participants in this sub-category were directed to the coach ("Hi [coach], I'm A., I've done all the exercises, have a nice day", "Hi [coach], I struggle to finish the last two exercises!!!").



(a) Bulletin Board (b) Private Messaging

Figure 5.8: Nature of communication during the 8 week intervention (only the social group)

Analysis of the interaction

The majority of messages about Gymcentral were sent by participants to report technical issues with the trainee app, especially related to connection problems ("Hi [coach], there are connection problems, the exercises keep stopping, I'll try later. Bye S."). Out of these 61 messages sent out by participants, 28 were directed to the technician, and 22 to the coach. On the other hand, information about the application was mainly provided by the technician ("Maybe the Internet connection is very slow. Please try to go next to the window for a better Internet coverage"), the coach ("I think it's the bad weather's fault") and the community manager ("Hi P... Unfortunately, for the connection problems we can do very little because they depend on [Internet provider]...").

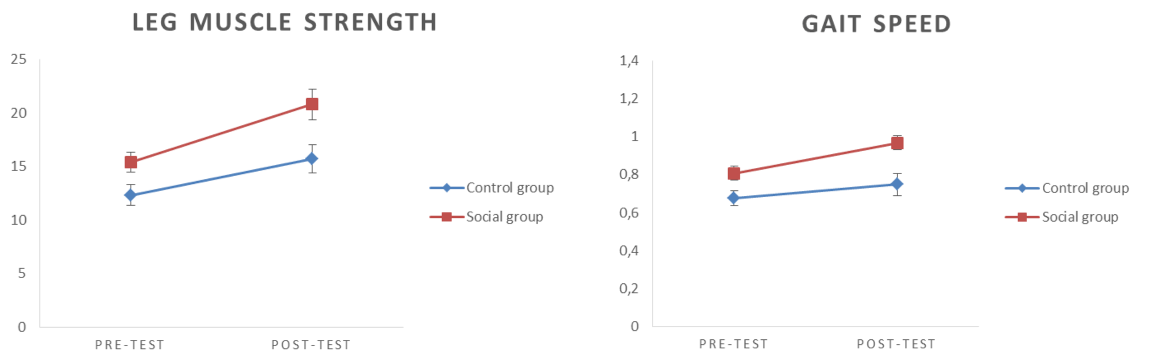
Participants tended to use the private messages more for self-disclosure, to talk about their life outside of the virtual gym ("Tonight we're going to the cinema to watch [a movie on] Leopardis life. It lasts more than two hours. Let's hope not to sleep!"). When prompted, the coach and the community manager replied revealing something about their lives too ("I frequently go to Tuscany, in Greve in Chianti in the zone of the Chianti Classico!").

In general, the most active user was the coach, both on the bulletin board, with 24 posts, and in private messages, with 120 messages sent and 117 received. Interestingly, he used differently the bulletin board and private messages features to motivate and involve participants. In particular, he preferred to congratulate publicly with participants on the bulletin board, while he used private messages to push them to keep on training.

5.6.6 Physical improvement

Two types of assessment exercises, developed and validated within the Otago Exercise Program [125, 126], were used to measure participants *leg muscle* strength and *walking* ability at the beginning and at the end of the study. With regard to leg muscle strength, a mixed between-within subjects analysis of variance was conducted to compare pre- and post-scores in the 30 second *Chair Stand* test between participants in the experimental and in the control group (Figure 5.9a). The analysis did not show a significant interaction between group and time (p = .326), suggesting that time did not have a substantially different effect on the performance in the two groups. There was however a significant main effect for time ($F(1, 33) = 19.275, p < .001$, partial eta squared = .369), with both groups showing a significant improvement in the test assessing leg muscle strength. The main effect comparing the two groups was also significant ($F(1, 33) = 7.955, p = .008$, partial eta squared = .194), suggesting that, despite randomization and the non-significant difference between the self-reported physical activity in the two groups (measured with the *Rapid Assessment of Physical Activity Questionnaire* by Topolski et al. [115]), participants in the Social group performed better than participants in the Control group. This could be due to random variability, possibly related to the small sample size, but still does not affect negatively the results confirming that leg muscle strength significantly improved in both groups after the eight weeks period of training. Moreover, multiple comparison tests with Bonferroni correction showed that both groups significantly improved after eight weeks of training ($p < .001$ for the Social group and $p = .032$ for the Control group).

With regard to gait speed, a mixed between-within subjects analysis of variance was conducted to compare pre- and post- gait speed in the Timed



(a) Participants' scores in the 30 second Chair Stand, measuring leg muscle strength, before and after eight weeks of training.

(b) Participants' gait speed in the Timed Up & Go test, measuring walking ability, before and after eight weeks of training.

Figure 5.9: Physical Improvement

Up & Go test between participants in the experimental and in the control group (Figure 5.9b). The analysis did not reveal a significant interaction between time and group ($p = .19$), but it showed a significant main effect for time ($F(1, 33) = 8.887, p = .005$, partial eta squared = .212), and for group ($F(1, 33) = 7.859, p = .008$, partial eta squared = .192). Although the interaction was not significant, multiple comparison tests with Bonferroni correction showed that gait speed significantly improved for the Social group ($p = .002$) but not for the Control group ($p = .285$).

5.6.7 Social wellbeing

Two questionnaires were used to measures participants social wellbeing before and after the training program. Social closeness was assessed by means of the *MPQ* questionnaire [130], while loneliness was measured using the shorter version of the R-UCLA Loneliness Scale developed by Hughes et al. [131].

Social closeness

No significant interaction between time and group (p = .357), nor a significant main effect for group (p = .614) or for time (p = .44) were found, suggesting that social closeness did not significantly change from pre- to post- measurement for both groups.

Loneliness

With regard to loneliness (Figure 5.10), a mixed between-within subjects analysis of variance did not reveal a significant interaction between time and group (p = .18), nor a significant main effect for group (p = .915), but it showed a significant main effect for time (F(1,33) = 8.131, p = .007, partial eta squared = .198). However, multiple comparison tests with Bonferroni correction showed that the perception of loneliness significantly decreased only for participants in the Control group (p = .007), but not for participants in the Social group (p = .281). Although the graph shows a tendency toward a decrease of loneliness in the Social group, this change was not statistically significant. Further studies with a larger sample size and a longer training period should further investigate if there is indeed a non-significant decrease in feelings of loneliness in participants using the full version of gymcentral trainee's application, or if this result is due to low statistical power. However, a possible explanation for the significant decrease in the perception of loneliness in the Control group is related to the periodic telephone contacts received by participants. Indeed, it is a common practice in clinical evaluation studies involving older adults to provide social visits to the control group in order to mirror the time and attention provided to the treatment group, as suggested by several authors (for example, Buchner et al. [139], Hogan et al. [140], Michael et al. [141], Tinetti et al. [142]). In our study, each participant in the

Control group received one telephone call every two weeks, and it is possible that the effect of these social contacts was strong enough to produce a significant decrease in participants perception of loneliness. Besides calling for further investigations on the effectiveness of the Gymcentral service in improving participants social wellbeing, this results open the possibility to include brief periodic telephone contacts to participants as an additional motivational service that could help in reducing the feelings of loneliness that are often experienced by older adults.

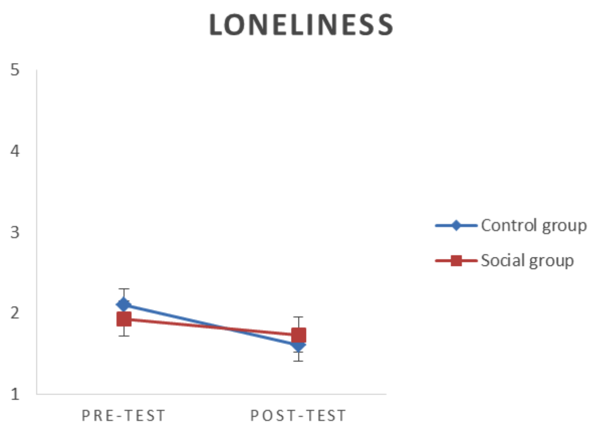


Figure 5.10: Participants' mean scores in the abbreviated form of the R-UCLA Loneliness Scale before and after the eight weeks period of the exercise program.

5.7 Discussion & conclusion

This chapter described the use of Gymcentral service i) as a test-bed to experiment the effect of social interaction with physical activity and ii) to validate the usability of a virtual gym for physical training programs for the older adults at home. In this regard, a prospective cohort trial conducted for the experiment. 40 older adult participants (65+) were recruited for the study. Participants were randomly divided in two groups and were asked to use two versions of gymcentral trainee's application at home. Gymcentral training service provided Otago exercise program with 10 intensity levels. Participants from both groups followed the exercise using the application for a period of 8 weeks from their homes. An expert personal trainer used the coach application of gymcentral service, monitored the training process of the participants and managed the intensity level of the exercise for each individual.

As part of the study protocol, we identified several outcome measures and hypothesis (i.e., attrition & adherence, social persuasion, usability and, physical and social benefits) of the intervention. Before, during and after the intervention, we collected data with respect to the outcome measures from standard questionnaires before and after the study and, application interaction logs during the study. Using the data obtained from these sources, we analyses the outcome measures in the result section. In summary, the key findings are:

Attrition & Adherence Four participants withdrew at different times during the intervention resulted in 7.5% attrition during the 8 weeks period. With regard to adherence, 85% persistence for the social group and 76% persistence of the control group shows higher adherence in the social group while both groups had a highly accepted adherence to the intervention.

Social persuasion High percentage of co-presence in the social group shows the tendency of participants to exercise in groups. In addition, higher attendance rate (more that prescribed) in the social group depicts the positive effect of co-presence (social facilitation).

Usability Although the usability (SUS) depicts lower usability for the full version of the app (due to a more complex system), usability increased by the end of study for the social group and closed to the usability of the control group.

Features' usefulness Perceived usefulness of using gymcentral application increased by the end of the intervention only for the social group. The social group participants ranked the features of the app related to self-monitoring as the most useful while features such as real-time interaction in the locker room were not selected as highly useful.

Online social behavior most communication (messages sent by participants of the social group) in the bulletin board feature of the app were around gymcentral technical issues and internet connection problems. The majority of messages send via the private messaging tool were between the coach and the technical expert. most messages communicated in the bulletin board were related to topics not directly related to training and coach messages encouraging the participants to exercise.

Physical & social benefits At the end of the intervention, physical wellbeing with respect to Otago exercise program improved for both groups. Leg muscle strength improved significantly for both groups and gait speed improved in the participants of social group. With regard to the social wellbeing, no significant change were detected before and after the intervention. yet the control groups loneliness reduced due to telephonic interaction during the study.

The findings of this chapter help us to better understand the co-relation between social interaction and physical activity. In addition we validate the usability and usefulness of gymcentral service. In the next chapter, we describe the deployment of gymcentral in secondary studies.

Chapter 6

Gymcentral secondary studies

6.1 Introduction

Gymcentral platform as a unified solutions for trainers and trainees was validated in a prospective cohort trial pilot (Chapter 5). In addition to the main trial, gymcentral service was incorporated in several other physical training interventions. This chapter acknowledge the finished and ongoing interventions using gymcentral. We brief the use of a simplified version of gymcentral in a prospective cohort trial with collaboration with university of Groningen and Philips electronics. In addition, we present the the on-going and upcoming studies using gymcentral service in collaboration with National Research Tomsk Polytechnic University. Finally, we report on the upcoming interventions using gymcentral service and interviews with residents of two Boston community housing on gymcentral and in collaboration with consortium on technology for proactive ageing (CTPA).

6.2 Groningen long-term intervention

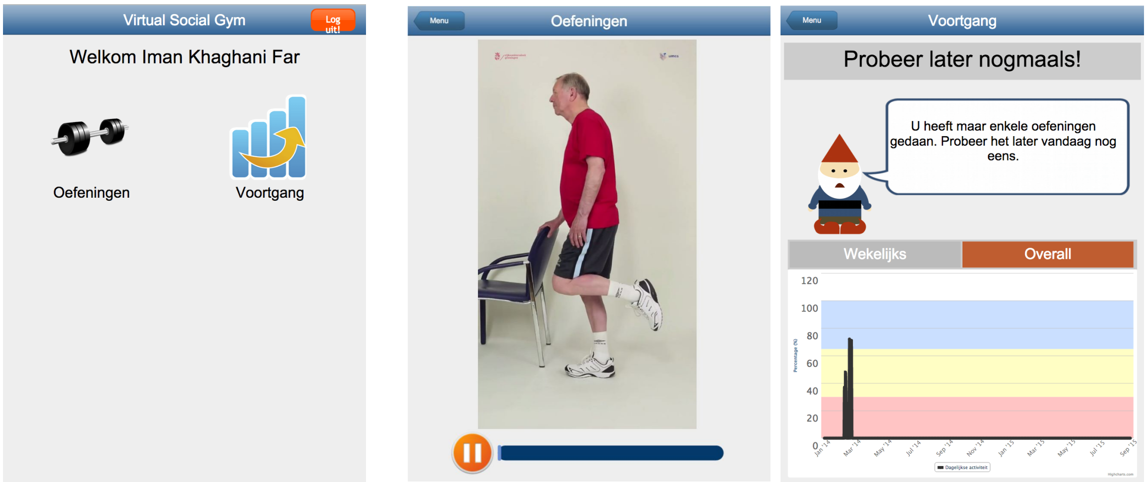
A simplified version of gymcentral application were developed to evaluate the effect of using mobile video exercises with and without remote coaching (telephonic communication) in a physical training program[143]. Forty transitionally frail older adults participated in the intervention in a period of 6 months. The simplified version of the application consisted of 3 main features (i.e., dashboard, exercise video player and, performance monitoring). The following describes each of the application features:

Dashboard dashboard (menu) as the entry view of the application. Dashboard allows users to access the training exercise videos and the self-monitoring (figure 6.1a).

Video exercise video exercise player allows participants to select a training level and watch the exercise instruction video. Participants will receive a positive, neutral, negative reinforcement after the exercise base on the amount of videos they have watched (figure 6.1b).

Performance monitoring enables participants of monitor their daily performance (obtained from a wearable activity tracker) and their weekly performance. Participants who exercises adequately receive a positive message from an animated gnome. Otherwise the gnome message will encourage them to exercise more (figure 6.1c.

The early results of the 6 months prospective cohort trial reveals that all participants were able to use the application. However, most participants were challenged with the internet connection. After technical investigation, we discovered that the mobile internet connection does not perform well for participants who live in rural areas. Poor internet connection was the main reason of drop out from the study. To fix this issue, we uploaded the videos on the tablet device and let the application play the videos locally. The fix reduces the number of drop outs.

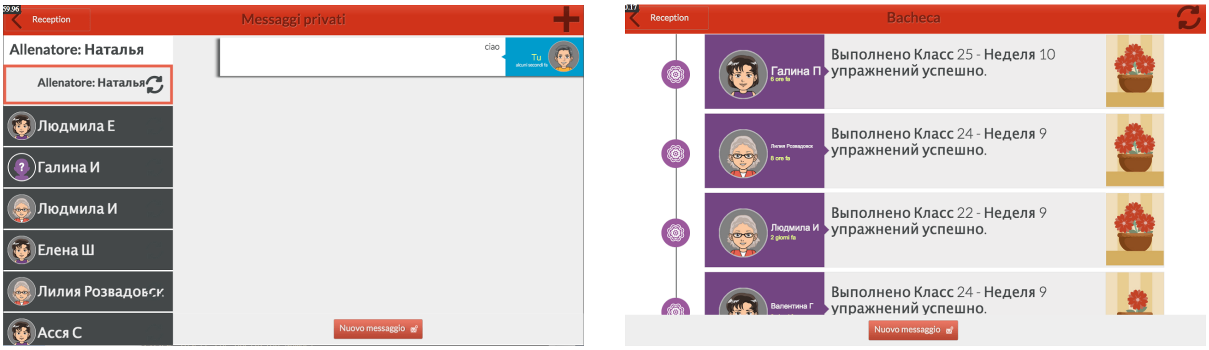


(a) Dashboard (b) Video exercise (c) Performance monitoring

Figure 6.1: Gymcentral: Screen-shots of gymcentral application for Groningen intervention

6.3 Gymcentral in Russia

In chapter 5 we test gymcentral with older adult participants in Trento. The learning from the trial helped us to evaluate the overall usability of gymcentral and fix the design shortcomings. We also investigate the effect of gymcentral persuasive features vs. a simplified version without any features. The findings of the previous study led the path to further experiment with the effects of social interaction on physical study. Hence, in a newly designed intervention in Tomsk, we plan to test gymcentral in two versions. The experimental version in this case study consist the full features of Gymcentral (refer to chapter 4). However, unlike the first PCT (chapter 5), the control group use a version of gymcentral that only eliminates the social features (i.e., bulletin board, locker room, presence in the classroom). However, participants of the control group have access to the same private message tools as the experiment group. Both groups can interact with the coach through the trainee's application. Within these new features, we aim to isolate the social interaction features and measure the same outcomes described in 5.4.



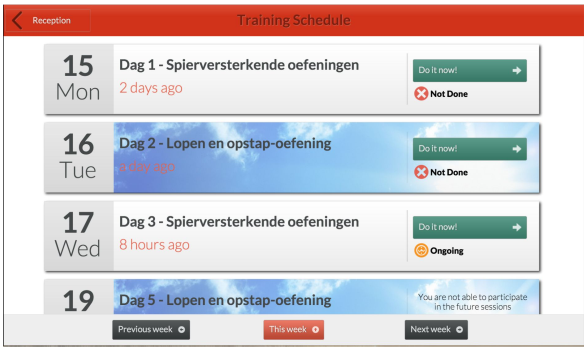
(a) Private Message (b) Bulletin board

Figure 6.2: Screenshots of Gymcentral application in Russian

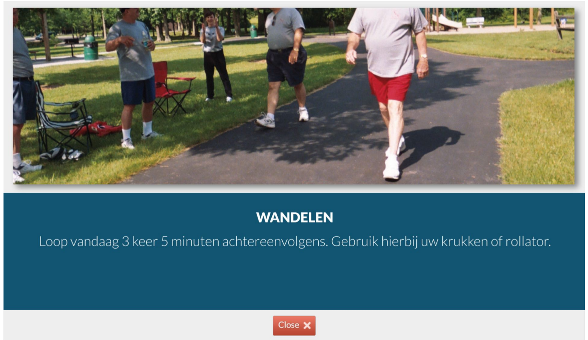
In addition to the focus on social interaction effects, we also aim to study the cross-cultural values of gymcentral by comparing the results obtained from the previous PCT in Trento.

6.4 Gymcentral in the Netherlands

A follow up of the Groningen prospective cohort trial is designing an intervention with gymcentral service. The upcoming trial is going to use gymcentral in a slightly different settings. Gymcentral services (chapter 4) such as the coach application and the trainee's application are going to be used in the trial. However, the trainee's application in this study will provide outdoor (figure 6.3) and indoor exercises to the trainees. In this setting, users (trainees) have access to video exercises which provides indoor exercise in a schedule. In the same schedule participants have access to image/text based exercises, providing the outdoor exercise instruction.



(a) Agenda: displaying indoor and outdoor activities



(b) Outdoor exercise instruction

Figure 6.3: Gymcentral: outdoor training activities

6.5 Boston community housing

In collaboration with CTPA, we have presented gymcentral trainee's application to the residents (mostly 60+ year old) of two community housing in Boston. During the presentation, participants provided their comments on some of the features of the application. The following list some of the main questions and answers during the interview.

Main barriers to exercise Some of the participants chose laziness as the main reason, while some indicated exercising is stressful. Lack of entertainment and no energy (poor health) to exercise where among the other reasons.

Social exercising Almost half of the participants indicated their willingness to exercise in groups. Some of the participants said they don't want to exercise in groups, because they are afraid of being judged by the other people who perform better. When we discussed the opportunity exercising in a virtual environment while they can hide their identity, they showed more interests in exercising in a group.

Use of avatars in the virtual gym Participants in general preferred avatars that looks like them. However, one participants argued that she would prefer a more fashionable younger-looking avatar. The avatar preferences were paradoxical as some participants preferred anonymous avatars when exercising in a group and identifiable avatars (identity) when sharing their participation with others.

The interview helped us to firstly establish a collaboration with the resident. In addition, we discovered some of the aspects related to gymcentral. Although the interview was very limited, the discussions and the opinions of the participants such as their preference in social exercising, sharing exercise activity with friends and family and their preferences on avatar selection is noticeable.

6.6 Active Brain

Gymcentral trainee's application is a modular software allowing researchers and developers to built training activities of any kind on top it. In this chapter we have discussed how variations of gymcentral is being used in different physical training interventions. Beside physical training, cognitive training exercise and brain teasers can also be developed on top of gymcentral. For instance, at the beginning of this research work, we have developed and experiment with a cognitive training game that can be used in gymcentral as an activity. The brain training activity named "Active-Brain" was designed as a simpler version of Dance Dance Revolution game, known to improve divided attention segment of the brain (figure 6.4)

We conducted a pilot testing [27] with 4 older adults. Participants were asked to play the active brain game and state their opinion on the usability and appealingness of playing games. The interview with the participants shows that they prefer to play competing games and also to share the performance with their friends. However, some of the players found the game

(a) Participants playing active-brain game

(b) Outdoor exercise instruction

Figure 6.4: Active-Brain: brain teaser activity for improving divided attention

to easy and therefore demotivating, while some other found it challenging. Hence, tailoring the game difficulty revealed to be important to keep the individual with different abilities interested.

6.7 Conclusion

In this short chapter, we presented some of the external ongoing and upcoming interventions using Gymcentral. We also discussed the small group discussions which we had with the older adults. Finally we presented an example of using gymcentral for cognitive training. The overall ongoing and upcoming studies validates the usability and applicability of gymcentral as a training service for the older population at home. Yet, further research is required to better understand the cross-cultural differences of social interaction on physical activity.

Chapter 7

Conclusion

The world we are living in today is ageing rapidly. Higher living standards and better healthcare among others reduced the mortality rate and allows people to live longer. Many people are getting older, retiring and spending more time sedentary at home. We have described that sedentary behavior reduces social interaction and deteriorates physical and mental abilities. To actively age and to reduce the risks of degenerative and chronic diseases in later life, regular physical activity can keep us healthy. However, active ageing is not only limited to physical activity but it is a wide range of social, physical and mental activities that keep people healthier.

In this context, many older adults, in particular, those who spend most of their time at home, find regular physical activity challenging due to various factors (e.g., poor health, lack of company, lack of facility and transportation). Thus, this PhD thesis aimed to introduce ICT tools and services that leverage the social skills of the older adults at home and enable them to maintain regular physical training.

This chapter summarizes the main findings of this dissertation, discusses the outcomes of the thesis and acknowledges the limitation and future work.

7.1 Findings

The aforementioned barriers to exercise motivates the objective of the thesis. We reviewed the literature (Chapter 2) seeking the current research challenges in designing IT-mediated solutions for wellbeing. We then reviewed the current applications on the major online markets to understand the shortcomings of the current solutions for fitness training. The learning from the literature and the findings of the application review drew the path way which we took to design IT-mediated solutions (Gymcentral service) that enables older adults with disparate physical abilities to exercise in a social context. The main Prospective Cohort Trial - although considered as a pilot study and with the imposed limitations - validates our main hypothesis. In addition, we validate that social interaction motivates people to stay physically more active. We validate the usability of IT-mediated training applications for older adults at home. Finally, we measure the physical and social outcomes of exercising in a virtual gym. Gymcentral service is been incorporated in several ongoing and upcoming studies which emphasizes on its applicability and feasibility. The following brief the main contribution and findings of this thesis and summarize the outcome.

7.1.1 Fitness applications

Chapter 3 presents our technical review on the top fitness applications in 6 major app markets (i.e., Google PlayStore, Apple AppStore,). Initially, over 500 applications in the category of heath and wellbeing were selected. We then filtered the most relevant applications (N=200) and compared them in 4 aspects related to supervised home training. Applications were ranked based on their interaction design (i.e., direction of interaction, input type and, training output), sensing and monitoring (i.e., the sensing method, the aspect observed), coaching and tailoring mechanism and the persuasive strategies used in the application. We compared these aspects with the literature and provided guidelines and gap for researchers and developers. The main findings of the review are:

- Applications delivered on interactive platforms and those application which use natural and direct interactions are more suitable and appealing for the older adult users. In addition, multi-modal interfaces can better serve the heterogeneous older adult users.
- To enable monitoring, applications which use automatic monitoring and incorporate less obstructive sensing technology are more suitable for the older adults. In addition, use of sensors in fitness applications is limited except game consoles that are featured with motion sensing.
- Presence of a human coach in a training program is preferred by the older adults. However, only 3% of the application in the market provide human coach support. Automatic coaching is economically more convenient and less consuming, yet they can not provide the same level of psychological support that a human does.
- While most of the applications for fitness training use only individual persuasion strategies (e.g., self-monitoring, gamification), there is a strong evidence in the literature that social persuasion strategies are more effective for the older adults.

The findings of this review provides guidelines to researchers and developers who design fitness application for the older adults at home. In addition, the findings helped us to model gymcentral to fulfill the main aspects of a training application that is suitable for a wide body of older adults at home.

7.1.2 Tailored training plan in a social context

As discussed earlier in Chapter 2, the older adults are a heterogeneous population meaning that some of them are physically and mentally healthy, while some of them are challenged with various physical and mental declines. Designing training program is often challenging as grouping these disparate population to follow a similar training plan is not effective. In addition, while a challenging training program can be demotivating for an individual with lower physical abilities, the same training program can be overly easy for another individual which is physically more active. In this research, we designed and validated a training platform that enable trainers (human coaches) to tailor training programs for each individual trainee. However, unlike the real world, trainees can exercise together (in groups) or at least have the feeling of co-presence (virtual presence) while each trainee is exercising in a level that best suits them. Both Gymcentral coach and trainee's applications enable tailored training while being social. The trainee's application group people to exercise together and the coach application enable trainers to monitor each individual and modify the intensity of the exercise. The outcome is a model for researchers and designers to build dynamic tailored training application on top of Gymcentral platform.

7.1.3 Effects of social facilitation on physical activity

With the prospective cohort trial (Chapter 5), we sought to understand the effect of persuasive strategies and in particular social persuasion on the physical activity level. Thus, we randomly divided 40 participants to 2 groups of social and control. We assigned a version of gymcentral trainee's application with all of it's persuasive features (refer to 4.5) to the social group trainees. To test our hypothesis, we assigned the participants of the control group to a simplified version of the gymcentral trainee's application that acts as a simple video exercise player. Given this setting, participants of both groups followed the training plan for 8 weeks. At the end of the intervention, we analyzed the interaction logs of both application. The result of the analysis reveals interesting facts about the correlation of social persuasion strategies on physical activity. The summary of findings are:

Attrition & Adherence The attrition rate was only 7.5% resulting in 4 withdrawal. However, all 4 participants withdrew for reasons other than issues related to the application or training. 3 participants withdrew due to health problems. The attrition rate is reasonably acceptable, however it indicates that dues to various health problems that many older adults are facing, the attrition rate can be higher for the older people. With regard to adherence, we measured participants persistence throughout the training intervention. Out of the 24 sessions planned during the 8 weeks of the intervention, participants of the social group had a persistence rate of 85% and the standard deviation was 16%, while for the participants of the control group, persistence rate was 64& and the standard deviation among participants 24%. Both results emphasis that participants of the social group exercised more persistently. In addition the lower standard deviation in the social group indicates that exercising together (the feel of copresence in a virtual environment) normalized participation among the participants of the group. Beside these, we analyzed the attendance rate and noted that participants of the social group often exercised more than they were asked. Participants were expected to follow 2 training sessions per week, while in many cases participants of the social group exercised 3 times per week. One possible explanation is that the participants exercised more because of the social interaction opportunities that they would have get by exercising.

Social facilitation & normative influence Participants of the social group had the opportunity to see other participants in the virtual classroom and while exercising. Participants could see their counterparts presence in the form of avatars indicating that their friends are present in the classroom and exercising. However, the control group participants could only see the coach video. Given this settings, we analyzed the virtual co-presence in both groups. We also analyzed the co-presence for the control group to remove the co-presence that occurs by chance or mutual exercising habits (for example participants dominantly exercise in the morning). The analysis of co-presence reveals that participants of the social group exercised with at least 1 more person 71% of the times. While co-presence rate was only 36% for the control group. Since the control group were not able to see the presence of each other, we assume the 36% co-presence is by chance. Yet, a t-test between groups reveals a statistically significant different. In addition, the standard deviation for the social group was only 12%, while for the control group S.D. was 22%. The results indicates the willingness of participants to exercise in a social context and seeing other participants exercising virtually can motivate participants to exercise with them.

However, since in this intervention there was an imbalance in the number of participants between groups (3 participants withdrew from the control group), we removed the data of the top three most active participants from the social group and re-run the analysis. Even by removing the top three active participants, the co-presence of the social group is 62% and significantly higher than the co-presence of the control group.

Finally, we measured the effect of co-presence on the duration of exercising. The analysis reveals no significant different between groups and thus co-presence does not have a major effect on the duration that participants exercise in a training session.

7.1.4 Usability of Virtual Social Gym (Gymcentral)

Along with investigating the effect of social facilitation on physical activity, we have conducted various usability test before, during and after the intervention (Chapter 5). We sought to test gymcentral (an IT-mediated training application) usability for the older adults and in particular those with limited computer literacy. In addition, we aimed to determine the usefulness of the features introduced in the trainee's application (i.e., bulletin board, messaging, progress monitor, locker room and, classroom). Several standard system usability scale questionnaires were provided to the participants of both groups before and after the intervention. The usability questionnaire determines that participants of the social group found the application more challenging before the start of the intervention. However, after the intervention, there was a significant change in the usability of the application for the social group. The results indicates that, the virtual gym, provided to participants with low computer literacy (less familiarity with technology) were found usable at the end of the 8 weeks intervention. Analyzing the messages communicated by the participants depicts that most of the problems occurred during the intervention relates to internet connection problems. Some participants experienced long pauses while following the video instruction because of poor internet connection. Other than that, participants did not have any major issue using gymcentral.

An analysis on the perceived usefulness of the features reveals that participants of the social group ranked features related to training the highest. Features such as the performance monitoring and communication tools with the coach of the training were identified as the most useful. The least useful features were related to real-time interaction in the locker room and private messaging with other trainees. The results indicate that although participants moderately used the social features, they found features related to training more useful.

The analysis on the nature of communication among trainees and the coach shows that most participants used the communication features (i.e., bulletin board and private message) to talk about issues related to using gymcentral application and talking social news not related to exercising. Indeed, few messages were related to training and the exercises.

The findings on usability of gymcentral, perceived usefulness, and the nature of communication in the gym in general provides insight for designing IT-mediated training applications and further investigation of social interaction in virtual training environments.

7.1.5 Physical and social outcomes

Participants of the Prospective Cohort Trial (refer to 5) participated in Otago physical exercise program. Leg Muscle Strength and Gait Speed were measures before and after the intervention to determine the physical change using the gymcentral application. participants of both group showed improvement in both measures after the intervention. However, participants of the social group had a slightly better physical performance after the intervention. Although an in-between group comparison shows no significant difference, one possible reason can be the that participants of the social group exercised more than the control group participants. In addition, social wellbeing (i.e., social closeness and loneliness) measured before and after the intervention revealings that the social wellbeing indexes did not significantly changed for the social group. However, the loneliness reduced for the participants of the control group. One possible reason could be the telephone calls that the coach had with the participants of the control group. The overall results indicates that although social interaction (social facilitation and normative influence) has a positive effect on physical activity, yet physical activity (at least during this limited intervention) did not have a significant effect on the overall social wellbeing of the participants.

7.2 Limitations and future work

Studying the effect of persuasive strategies on human subject and using IT-mediated solutions often impose limitations and challenges. One of the main limitation of this research work was to eliminate the effect of organizational stimulation. Trainees were recruited for the trial could be influenced by organizers involvement and socially enforced to complete the exercise. Although trainees' participation were on voluntarily basis, still the organizers could be potential stimulus for the participation and adherence to the intervention. In addition, participants of the study were friends with each other outside of the virtual gym and this connection can impose external social stimulation to adhere to the intervention. More intervention with more participants and in particular for longer periods is needed to re-validate the findings of our studies.

Longitudinal interventions with less involvement of organizers can better determine the effect of persuasion strategies examined in this research. In addition, studying the physical and social outcomes of exercising in virtual social application for longer periods is necessary to understand the long term effects and usability of such interventions.

In this thesis, we have identified positive impact of social interaction on physical activity using IT-mediated interventions. However, future work is needed to study the effect of social interaction in more depth and with participants with different cultural heritage and values. Cross-cultural studies can be beneficial to better understand the effect of social interaction on physical activity worldwide.

Gymcentral trainee's application were customized to run on computer tablets. However, there are other innovative and influential technologies which are dominantly used by older adults. For instance, many older adults have a TV at home. In addition television has a bigger screen and makes it easier to mimic the visualization of a virtual gym. Further studies required to study the usability and appealingness of the virtual gym on other mediums such as smart TVs.

While gymcentral creates a virtual social community for trainees at home, and it provides tailored training program to the trainees, the monitoring capability is not precise and robust. We have discussed in Chapter 3 that although user feedback and questionnaires are dominantly used in fitness applications as a way to obtain user performance, the process is often obtrusive and time consuming. Automatic sensing technologies such as wearables and motion sensing devices can monitor the activities of the trainees while exercising (in the virtual gym). In addition, activity trackers can monitor trainees activities 24/7 and provide more insightful information to the trainers (coaches) and the trainee itself.

In this thesis we validated some of the persuasive strategies such as social influence, co-presence and normative influence on physical training. Yet, there are other design and strategic aspects that can motivate older adults to use virtual gym for exercising. Further studies is needed to analyze the effect of audio/visual appearances of the virtual gym. Investigating user preferences for avatars (e.g., race, color, body shape, similarity) along with the virtual environments used for training can identify other potential persuasive instruments.

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Appendix A

Trento User Study

A.1 Interaction Logs

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 10	Tue Oct 28 2014 22:59:01 GMT+0100 (CET)	Tue Oct 28 2014 23:28:24 GMT+0100 (CET)	29	0	Individual Session	-	Yes	11	1	12	end	incomplete	5
user 10	Thu Oct 30 2014 09:12:17 GMT+0100 (CET)	Thu Oct 30 2014 09:12:43 GMT+0100 (CET)	1	0	Individual Session	-	No	0	1	1	end	incomplete	5
user 10	Fri Nov 07 2014 09:53:56 GMT+0100 (CET)	Fri Nov 07 2014 10:19:49 GMT+0100 (CET)	26	0	Individual Session	-	No	4	3	7	end	incomplete	6
user 10	Tue Oct 21 2014 15:37:05 GMT+0200 (CEST)	Tue Oct 21 2014 16:28:47 GMT+0200 (CEST)	52	0	Individual Session	invited users	No	13	0	13	end	complete	5
user 10	Mon Oct 20 2014 18:00:31 GMT+0200 (CEST)	Mon Oct 20 2014 18:41:38 GMT+0200 (CEST)	41	0	Individual Session	-	No	13	0	13	end	complete	5
user 11	Mon Oct 20 2014 20:58:32 GMT+0200 (CEST)	Mon Oct 20 2014 21:06:11 GMT+0200 (CEST)	8	0	Individual Session	-	No	2	0	2	end	incomplete	5
user 11	Tue Nov 11 2014 19:17:09 GMT+0100 (CET)	Tue Nov 11 2014 19:34:14 GMT+0100 (CET)	17	0	Individual Session	-	No	2	0	2	end	incomplete	8

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 11	Thu Oct 16 2014 07:13:21 GMT+0200 (CEST)	Thu Oct 16 2014 07:30:26 GMT+0200 (CEST)	17	0	Individual Session	-	No	5	0	5	end	incomplete	4
user 11	Tue Oct 14 2014 18:37:06 GMT+0200 (CEST)	Tue Oct 14 2014 18:55:29 GMT+0200 (CEST)	18	0	Individual Session	-	No	6	0	6	end	incomplete	4
user 11	Fri Nov 14 2014 13:59:49 GMT+0100 (CET)	Fri Nov 14 2014 14:49:02 GMT+0100 (CET)	49	0	Individual Session	-	No	8	1	9	end	incomplete	8
user 11	Fri Nov 28 2014 19:35:31 GMT+0100 (CET)	Fri Nov 28 2014 20:36:32 GMT+0100 (CET)	61	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 11	Mon Nov 24 2014 16:35:16 GMT+0100 (CET)	Mon Nov 24 2014 17:36:58 GMT+0100 (CET)	62	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 11	Thu Nov 20 2014 12:18:11 GMT+0100 (CET)	Thu Nov 20 2014 13:25:56 GMT+0100 (CET)	68	0	Individual Session	invited users	No	12	0	12	end	incomplete	9
user 11	Mon Oct 13 2014 07:50:17 GMT+0200 (CEST)	Mon Oct 13 2014 08:16:16 GMT+0200 (CEST)	26	0	Individual Session	-	No	13	0	13	end	complete	4
user 11	Sat Oct 25 2014 16:15:57 GMT+0200 (CEST)	Sat Oct 25 2014 16:58:15 GMT+0200 (CEST)	42	0	Individual Session	-	No	13	0	13	end	complete	5
user 11	Sat Oct 18 2014 07:31:02 GMT+0200 (CEST)	Sat Oct 18 2014 07:59:42 GMT+0200 (CEST)	29	0	Individual Session	-	No	13	0	13	end	complete	4
user 11	Fri Oct 17 2014 15:29:43 GMT+0200 (CEST)	Fri Oct 17 2014 16:00:32 GMT+0200 (CEST)	31	0	Individual Session	-	No	13	0	13	end	complete	4
user 11	Fri Oct 24 2014 17:40:42 GMT+0200 (CEST)	Fri Oct 24 2014 18:14:17 GMT+0200 (CEST)	34	0	Individual Session	-	No	13	0	13	end	complete	5
user 11	Fri Oct 31 2014 07:32:29 GMT+0100 (CET)	Fri Oct 31 2014 08:10:48 GMT+0100 (CET)	38	0	Individual Session	-	No	13	0	13	end	complete	6

usernames	**Joined Classroom (timestamp)**	**Left Classroom (timestamp)**	**duration (minutes)**	**No of meetups**	**co-presence**	**invited users before joining**	**Invited?**	**No of completed activities**	**No of Skipped activities**	**Total completed Exercises**	**If completed the session**	**If did at once**	**User Level**
user 11	Thu Oct 23 2014 07:12:46 GMT+0200 (CEST)	Thu Oct 23 2014 07:41:48 GMT+0200 (CEST)	29	0	Individual Session	-	No	13	0	13	end	complete	5
user 11	Sat Nov 15 2014 16:55:37 GMT+0100 (CET)	Sat Nov 15 2014 16:56:38 GMT+0100 (CET)	1	0	Individual Session	-	No	0	0	0	not end	incomplete	8
user 11	Sat Nov 15 2014 07:16:22 GMT+0100 (CET)	Sat Nov 15 2014 07:19:10 GMT+0100 (CET)	3	0	Individual Session	-	No	1	0	1	not end	incomplete	8
user 11	Wed Nov 19 2014 19:45:41 GMT+0100 (CET)	Wed Nov 19 2014 19:56:29 GMT+0100 (CET)	11	0	Individual Session	-	No	3	0	3	not end	incomplete	9
user 12	Mon Nov 17 2014 20:49:01 GMT+0100 (CET)	Mon Nov 17 2014 20:49:41 GMT+0100 (CET)	1	0	Individual Session	-	No	0	0	0	end	incomplete	8
user 12	Fri Nov 21 2014 21:26:22 GMT+0100 (CET)	Fri Nov 21 2014 21:44:47 GMT+0100 (CET)	18	0	Individual Session	-	No	2	0	2	end	incomplete	8
user 12	Tue Nov 04 2014 20:18:15 GMT+0100 (CET)	Tue Nov 04 2014 20:29:42 GMT+0100 (CET)	11	0	Individual Session	-	No	2	0	2	end	incomplete	5
user 12	Sat Nov 08 2014 20:57:57 GMT+0100 (CET)	Sat Nov 08 2014 21:06:31 GMT+0100 (CET)	9	0	Individual Session	-	No	2	0	2	end	incomplete	6
user 12	Sat Nov 22 2014 19:59:00 GMT+0100 (CET)	Sat Nov 22 2014 20:38:12 GMT+0100 (CET)	39	0	Individual Session	-	No	6	0	6	end	incomplete	8
user 12	Mon Oct 27 2014 13:08:16 GMT+0100 (CET)	Mon Oct 27 2014 13:28:38 GMT+0100 (CET)	20	0	Individual Session	-	No	7	0	7	end	incomplete	5
user 12	Mon Nov 03 2014 12:42:32 GMT+0100 (CET)	Mon Nov 03 2014 13:11:10 GMT+0100 (CET)	29	0	Individual Session	-	No	13	0	13	end	complete	5
user 12	Wed Nov 05 2014 20:05:53 GMT+0100 (CET)	Wed Nov 05 2014 20:58:03 GMT+0100 (CET)	52	0	Individual Session	-	No	13	0	13	end	complete	6

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 12	Tue Nov 18 2014 19:15:37 GMT+0100 (CET)	Tue Nov 18 2014 20:23:55 GMT+0100 (CET)	68	0	Individual Session	invited users	No	13	0	13	end	complete	8
user 12	Sat Nov 01 2014 19:07:52 GMT+0100 (CET)	Sat Nov 01 2014 19:36:06 GMT+0100 (CET)	28	0	Individual Session	-	No	13	0	13	end	complete	5
user 12	Tue Nov 25 2014 18:26:02 GMT+0100 (CET)	Tue Nov 25 2014 18:45:10 GMT+0100 (CET)	19	0	Individual Session	-	No	2	0	2	not end	incomplete	9
user 13	Sat Nov 08 2014 19:59:57 GMT+0100 (CET)	Sat Nov 08 2014 20:07:59 GMT+0100 (CET)	8	0	Individual Session	-	No	2	0	2	end	incomplete	5
user 13	Mon Oct 27 2014 22:15:05 GMT+0100 (CET)	Mon Oct 27 2014 22:23:15 GMT+0100 (CET)	8	0	Individual Session	invited users	No	2	0	2	end	incomplete	4
user 13	Tue Oct 21 2014 21:48:37 GMT+0200 (CEST)	Tue Oct 21 2014 22:12:53 GMT+0200 (CEST)	24	0	Individual Session	-	No	6	0	6	end	incomplete	3
user 13	Sat Dec 06 2014 10:43:41 GMT+0100 (CET)	Sat Dec 06 2014 12:17:41 GMT+0100 (CET)	94	0	Individual Session	-	No	7	0	7	end	incomplete	0
user 13	Mon Nov 10 2014 13:52:13 GMT+0100 (CET)	Mon Nov 10 2014 14:48:50 GMT+0100 (CET)	57	0	Individual Session	-	No	8	0	8	end	incomplete	6
user 13	Sat Nov 01 2014 22:43:29 GMT+0100 (CET)	Sat Nov 01 2014 23:14:36 GMT+0100 (CET)	31	0	Individual Session	invited users	No	10	0	10	end	incomplete	4
user 13	Sat Oct 18 2014 21:26:31 GMT+0200 (CEST)	Sat Oct 18 2014 21:54:38 GMT+0200 (CEST)	28	0	Individual Session	-	No	10	0	10	end	incomplete	3
user 13	Wed Dec 03 2014 11:22:18 GMT+0100 (CET)	Wed Dec 03 2014 12:47:43 GMT+0100 (CET)	85	0	Individual Session	-	No	11	0	11	end	incomplete	9
user 13	Mon Nov 03 2014 11:12:05 GMT+0100 (CET)	Mon Nov 03 2014 11:42:45 GMT+0100 (CET)	31	0	Individual Session	-	No	11	0	11	end	incomplete	4

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 13	Thu Nov 06 2014 11:28:19 GMT+0100 (CET)	Thu Nov 06 2014 11:56:34 GMT+0100 (CET)	28	0	Individual Session	-	No	11	1	12	end	incomplete	5
user 13	Tue Nov 11 2014 11:44:18 GMT+0100 (CET)	Tue Nov 11 2014 12:27:38 GMT+0100 (CET)	43	0	Individual Session	-	No	12	0	12	end	incomplete	6
user 13	Sat Nov 29 2014 10:58:11 GMT+0100 (CET)	Sat Nov 29 2014 12:40:54 GMT+0100 (CET)	103	0	Individual Session	-	No	12	0	12	end	incomplete	8
user 13	Fri Oct 31 2014 17:17:10 GMT+0100 (CET)	Fri Oct 31 2014 17:46:10 GMT+0100 (CET)	29	0	Individual Session	-	No	12	0	12	end	incomplete	4
user 13	Fri Nov 21 2014 11:00:24 GMT+0100 (CET)	Fri Nov 21 2014 11:44:04 GMT+0100 (CET)	44	0	Individual Session	-	No	12	0	12	end	incomplete	7
user 13	Tue Nov 25 2014 12:07:05 GMT+0100 (CET)	Tue Nov 25 2014 13:39:34 GMT+0100 (CET)	92	0	Individual Session	-	No	12	0	12	end	incomplete	8
user 13	Thu Nov 06 2014 20:57:03 GMT+0100 (CET)	Thu Nov 06 2014 21:24:12 GMT+0100 (CET)	27	0	Individual Session	-	No	11	1	12	end	incomplete	5
user 13	Fri Oct 17 2014 21:26:32 GMT+0200 (CEST)	Fri Oct 17 2014 21:55:53 GMT+0200 (CEST)	29	0	Individual Session	-	No	13	0	13	end	complete	3
user 13	Mon Oct 13 2014 22:04:46 GMT+0200 (CEST)	Mon Oct 13 2014 22:13:49 GMT+0200 (CEST)	9	0	Individual Session	-	No	7	0	7	not end	incomplete	2
user 14	Thu Dec 04 2014 08:01:20 GMT+0100 (CET)	Thu Dec 04 2014 08:37:59 GMT+0100 (CET)	37	0	Individual Session	-	No	4	6	10	end	incomplete	10
user 14	Thu Dec 04 2014 08:38:30 GMT+0100 (CET)	Thu Dec 04 2014 08:42:46 GMT+0100 (CET)	4	0	Individual Session	-	No	0	11	11	end	incomplete	10
user 14	Thu Nov 13 2014 08:14:44 GMT+0100 (CET)	Thu Nov 13 2014 08:58:33 GMT+0100 (CET)	44	0	Individual Session	-	No	10	3	13	end	complete	8
user 15	Thu Oct 30 2014 19:40:40 GMT+0100 (CET)	Thu Oct 30 2014 19:53:28 GMT+0100 (CET)	13	0	Individual Session	-	No	4	0	4	end	incomplete	5

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 15	Wed Nov 26 2014 20:49:14 GMT+0100 (CET)	Wed Nov 26 2014 21:37:03 GMT+0100 (CET)	48	0	Individual Session	-	No	10	0	10	end	incomplete	8
user 15	Wed Oct 29 2014 20:41:19 GMT+0100 (CET)	Wed Oct 29 2014 20:53:56 GMT+0100 (CET)	13	0	Individual Session	-	No	6	5	11	end	incomplete	5
user 15	Thu Oct 16 2014 20:45:54 GMT+0200 (CEST)	Thu Oct 16 2014 21:14:09 GMT+0200 (CEST)	28	0	Individual Session	-	No	11	0	11	end	incomplete	3
user 15	Tue Oct 21 2014 18:09:58 GMT+0200 (CEST)	Tue Oct 21 2014 18:35:06 GMT+0200 (CEST)	25	0	Individual Session	-	No	13	0	13	end	complete	4
user 15	Wed Oct 29 2014 20:37:43 GMT+0100 (CET)	Wed Oct 29 2014 20:40:51 GMT+0100 (CET)	3	0	Individual Session	-	No	2	0	2	not end	incomplete	5
user 16	Wed Nov 12 2014 18:08:19 GMT+0100 (CET)	Wed Nov 12 2014 19:01:02 GMT+0100 (CET)	53	0	Individual Session	-	No	11	1	12	end	incomplete	8
user 16	Fri Nov 07 2014 17:06:34 GMT+0100 (CET)	Fri Nov 07 2014 17:47:17 GMT+0100 (CET)	41	0	Individual Session	-	No	11	2	13	end	complete	7
user 16	Mon Oct 27 2014 17:31:10 GMT+0100 (CET)	Mon Oct 27 2014 18:11:00 GMT+0100 (CET)	40	0	Individual Session	-	No	10	3	13	end	complete	6
user 16	Tue Oct 14 2014 10:17:46 GMT+0200 (CEST)	Tue Oct 14 2014 10:47:15 GMT+0200 (CEST)	29	0	Individual Session	-	No	0	0	0	not end	incomplete	4
user 16	Fri Oct 17 2014 10:23:11 GMT+0200 (CEST)	Fri Oct 17 2014 10:53:58 GMT+0200 (CEST)	31	0	Individual Session	-	No	0	0	0	not end	incomplete	4
user 17	Wed Oct 15 2014 17:25:24 GMT+0200 (CEST)	Wed Oct 15 2014 17:28:38 GMT+0200 (CEST)	3	0	Individual Session	-	No	1	0	1	end	incomplete	2
user 17	Mon Dec 01 2014 10:54:11 GMT+0100 (CET)	Mon Dec 01 2014 12:09:52 GMT+0100 (CET)	76	0	Individual Session	-	No	11	0	11	end	incomplete	8

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 17	Fri Dec 05 2014 15:56:26 GMT+0100 (CET)	Fri Dec 05 2014 17:10:05 GMT+0100 (CET)	74	0	Individual Session	-	No	12	0	12	end	incomplete	9
user 17	Wed Nov 26 2014 12:42:24 GMT+0100 (CET)	Wed Nov 26 2014 13:42:56 GMT+0100 (CET)	61	0	Individual Session	-	No	13	0	13	end	complete	8
user 17	Tue Nov 11 2014 07:27:07 GMT+0100 (CET)	Tue Nov 11 2014 08:01:20 GMT+0100 (CET)	34	0	Individual Session	invited users	No	13	0	13	end	complete	4
user 17	Thu Nov 06 2014 07:58:34 GMT+0100 (CET)	Thu Nov 06 2014 08:33:52 GMT+0100 (CET)	35	0	Individual Session	-	No	13	0	13	end	complete	4
user 18	Mon Oct 20 2014 19:08:00 GMT+0200 (CEST)	Mon Oct 20 2014 19:52:21 GMT+0200 (CEST)	44	0	Individual Session	-	No	13	0	13	end	complete	5
user 18	Mon Oct 27 2014 20:19:07 GMT+0100 (CET)	Mon Oct 27 2014 21:00:50 GMT+0100 (CET)	42	0	Individual Session	-	No	13	0	13	end	complete	6
user 18	Thu Oct 30 2014 07:32:43 GMT+0100 (CET)	Thu Oct 30 2014 08:08:46 GMT+0100 (CET)	36	0	Individual Session	-	No	13	0	13	end	complete	6
user 18	Fri Oct 31 2014 20:26:41 GMT+0100 (CET)	Fri Oct 31 2014 21:09:22 GMT+0100 (CET)	43	0	Individual Session	-	No	13	0	13	end	complete	6
user 18	Mon Oct 13 2014 20:07:44 GMT+0200 (CEST)	Mon Oct 13 2014 20:15:12 GMT+0200 (CEST)	7	0	Individual Session	-	No	2	0	2	not end	incomplete	4
user 19	Mon Oct 27 2014 21:27:01 GMT+0100 (CET)	Mon Oct 27 2014 21:38:05 GMT+0100 (CET)	11	0	Individual Session	-	No	3	0	3	end	incomplete	5
user 19	Mon Oct 27 2014 21:38:18 GMT+0100 (CET)	Mon Oct 27 2014 21:38:41 GMT+0100 (CET)	1	0	Individual Session	-	No	0	0	0	not end	incomplete	5
user 21	Sat Nov 01 2014 14:08:31 GMT+0100 (CET)	Sat Nov 01 2014 14:12:02 GMT+0100 (CET)	4	0	Individual Session	-	No	1	0	1	end	incomplete	4

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 21	Fri Nov 07 2014 14:59:31 GMT+0100 (CET)	Fri Nov 07 2014 15:00:48 GMT+0100 (CET)	1	0	Individual Session	-	No	0	1	1	end	incomplete	4
user 21	Thu Oct 16 2014 14:16:55 GMT+0200 (CEST)	Thu Oct 16 2014 14:25:02 GMT+0200 (CEST)	8	0	Individual Session	-	No	2	0	2	end	incomplete	4
user 21	Thu Oct 16 2014 17:43:59 GMT+0200 (CEST)	Thu Oct 16 2014 17:49:36 GMT+0200 (CEST)	6	0	Individual Session	-	No	1	1	2	end	incomplete	4
user 21	Wed Dec 03 2014 15:32:45 GMT+0100 (CET)	Wed Dec 03 2014 15:54:43 GMT+0100 (CET)	22	0	Individual Session	-	No	3	0	3	end	incomplete	6
user 21	Wed Nov 05 2014 23:02:11 GMT+0100 (CET)	Wed Nov 05 2014 23:43:36 GMT+0100 (CET)	41	0	Individual Session	-	No	11	2	13	end	complete	4
user 21	Mon Nov 24 2014 23:54:54 GMT+0100 (CET)	Tue Nov 25 2014 00:33:05 GMT+0100 (CET)	38	0	Individual Session	-	No	11	2	13	end	complete	6
user 22	Mon Nov 17 2014 21:55:22 GMT+0100 (CET)	Mon Nov 17 2014 22:07:33 GMT+0100 (CET)	12	0	Individual Session	-	No	2	0	2	end	incomplete	7
user 22	Thu Nov 13 2014 21:35:33 GMT+0100 (CET)	Thu Nov 13 2014 21:52:44 GMT+0100 (CET)	17	0	Individual Session	-	No	4	0	4	end	incomplete	6
user 22	Thu Dec 04 2014 21:08:28 GMT+0100 (CET)	Thu Dec 04 2014 21:59:08 GMT+0100 (CET)	51	0	Individual Session	-	No	7	0	7	end	incomplete	9
user 22	Wed Dec 03 2014 14:19:15 GMT+0100 (CET)	Wed Dec 03 2014 15:10:27 GMT+0100 (CET)	51	0	Individual Session	-	No	7	0	7	end	incomplete	9
user 22	Wed Nov 12 2014 21:44:16 GMT+0100 (CET)	Wed Nov 12 2014 22:13:24 GMT+0100 (CET)	29	0	Individual Session	-	No	8	0	8	end	incomplete	6
user 22	Thu Oct 23 2014 07:45:35 GMT+0200 (CEST)	Thu Oct 23 2014 08:12:47 GMT+0200 (CEST)	27	0	Individual Session	-	No	12	0	12	end	incomplete	3

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 22	Mon Oct 13 2014 08:19:35 GMT+0200 (CEST)	Mon Oct 13 2014 08:40:58 GMT+0200 (CEST)	21	0	Individual Session	-	No	13	0	13	end	complete	2
user 22	Tue Nov 11 2014 19:44:59 GMT+0100 (CET)	Tue Nov 11 2014 20:24:07 GMT+0100 (CET)	39	0	Individual Session	-	No	12	1	13	end	complete	6
user 22	Sat Nov 01 2014 07:27:37 GMT+0100 (CET)	Sat Nov 01 2014 07:55:26 GMT+0100 (CET)	28	0	Individual Session	invited users	No	13	0	13	end	complete	4
user 22	Tue Nov 04 2014 07:42:36 GMT+0100 (CET)	Tue Nov 04 2014 08:08:43 GMT+0100 (CET)	26	0	Individual Session	-	No	11	0	11	not end	incomplete	4
user 23	Wed Nov 05 2014 09:41:19 GMT+0100 (CET)	Wed Nov 05 2014 09:44:24 GMT+0100 (CET)	3	0	Individual Session	invited users	No	1	0	1	end	incomplete	5
user 23	Mon Nov 24 2014 15:07:16 GMT+0100 (CET)	Mon Nov 24 2014 15:46:08 GMT+0100 (CET)	39	0	Individual Session	invited users	No	5	2	7	end	incomplete	8
user 23	Thu Nov 13 2014 16:23:20 GMT+0100 (CET)	Thu Nov 13 2014 16:55:48 GMT+0100 (CET)	32	0	Individual Session	-	No	8	2	10	end	incomplete	6
user 23	Fri Nov 07 2014 16:20:22 GMT+0100 (CET)	Fri Nov 07 2014 16:52:03 GMT+0100 (CET)	32	0	Individual Session	-	No	12	1	13	end	complete	5
user 23	Wed Oct 22 2014 16:17:38 GMT+0200 (CEST)	Wed Oct 22 2014 16:49:14 GMT+0200 (CEST)	32	0	Individual Session	-	No	13	0	13	end	complete	3
user 23	Wed Nov 19 2014 15:46:04 GMT+0100 (CET)	Wed Nov 19 2014 16:26:28 GMT+0100 (CET)	40	0	Individual Session	invited users	No	11	2	13	end	complete	7
user 23	Mon Nov 03 2014 15:31:28 GMT+0100 (CET)	Mon Nov 03 2014 16:02:30 GMT+0100 (CET)	31	0	Individual Session	-	No	13	0	13	end	complete	5
user 23	Mon Oct 27 2014 09:08:28 GMT+0100 (CET)	Mon Oct 27 2014 09:42:45 GMT+0100 (CET)	34	0	Individual Session	-	No	13	0	13	end	complete	4

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 23	Wed Oct 29 2014 15:26:27 GMT+0100 (CET)	Wed Oct 29 2014 15:54:05 GMT+0100 (CET)	28	0	Individual Session	invited users	No	13	0	13	end	complete	4
user 23	Thu Oct 30 2014 15:44:27 GMT+0100 (CET)	Thu Oct 30 2014 16:12:12 GMT+0100 (CET)	28	0	Individual Session	-	No	13	0	13	end	complete	4
user 23	Tue Oct 21 2014 16:39:04 GMT+0200 (CEST)	Tue Oct 21 2014 17:13:31 GMT+0200 (CEST)	34	0	Individual Session	-	No	13	0	13	end	complete	3
user 23	Sat Nov 15 2014 14:13:56 GMT+0100 (CET)	Sat Nov 15 2014 14:46:10 GMT+0100 (CET)	32	0	Individual Session	-	No	8	5	13	end	complete	6
user 23	Mon Nov 17 2014 15:37:10 GMT+0100 (CET)	Mon Nov 17 2014 16:19:00 GMT+0100 (CET)	42	0	Individual Session	-	No	11	2	13	end	complete	7
user 24	Fri Nov 28 2014 15:40:03 GMT+0100 (CET)	Fri Nov 28 2014 15:41:59 GMT+0100 (CET)	2	0	Individual Session	-	No	0	1	1	end	incomplete	8
user 24	Thu Nov 27 2014 00:26:35 GMT+0100 (CET)	Thu Nov 27 2014 00:29:37 GMT+0100 (CET)	3	0	Individual Session	-	No	0	2	2	end	incomplete	8
user 24	Wed Nov 26 2014 23:58:16 GMT+0100 (CET)	Thu Nov 27 2014 00:05:24 GMT+0100 (CET)	7	0	Individual Session	-	No	0	4	4	end	incomplete	8
user 24	Thu Nov 27 2014 13:46:54 GMT+0100 (CET)	Thu Nov 27 2014 13:49:26 GMT+0100 (CET)	3	0	Individual Session	-	No	0	4	4	end	incomplete	8
user 24	Fri Oct 31 2014 09:18:46 GMT+0100 (CET)	Fri Oct 31 2014 09:36:31 GMT+0100 (CET)	18	0	Individual Session	-	No	6	3	9	end	incomplete	5
user 24	Sat Nov 29 2014 08:33:27 GMT+0100 (CET)	Sat Nov 29 2014 09:15:47 GMT+0100 (CET)	42	0	Individual Session	-	No	3	8	11	end	incomplete	8
user 24	Tue Oct 14 2014 14:34:03 GMT+0200 (CEST)	Tue Oct 14 2014 15:12:17 GMT+0200 (CEST)	38	0	Individual Session	-	No	9	2	11	end	incomplete	3

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 24	Fri Oct 24 2014 09:20:34 GMT+0200 (CEST)	Fri Oct 24 2014 10:00:12 GMT+0200 (CEST)	40	0	Individual Session	-	No	13	0	13	end	complete	4
user 24	Sat Nov 15 2014 09:14:54 GMT+0100 (CET)	Sat Nov 15 2014 09:26:00 GMT+0100 (CET)	11	0	Individual Session	-	No	1	12	13	end	complete	7
user 24	Sat Nov 29 2014 08:30:34 GMT+0100 (CET)	Sat Nov 29 2014 08:32:24 GMT+0100 (CET)	2	0	Individual Session	-	No	0	0	0	not end	incomplete	8
user 24	Tue Nov 11 2014 08:12:04 GMT+0100 (CET)	Tue Nov 11 2014 08:15:53 GMT+0100 (CET)	4	0	Individual Session	-	No	1	0	1	not end	incomplete	6
user 24	Mon Nov 24 2014 07:59:19 GMT+0100 (CET)	Mon Nov 24 2014 08:08:42 GMT+0100 (CET)	9	0	Individual Session	-	No	1	2	3	not end	incomplete	8
user 25	Tue Nov 11 2014 21:05:38 GMT+0100 (CET)	Tue Nov 11 2014 22:09:22 GMT+0100 (CET)	64	0	Individual Session	-	No	10	0	10	end	incomplete	7
user 25	Thu Nov 27 2014 06:59:56 GMT+0100 (CET)	Thu Nov 27 2014 08:01:52 GMT+0100 (CET)	62	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 25	Wed Dec 03 2014 07:09:57 GMT+0100 (CET)	Wed Dec 03 2014 08:19:16 GMT+0100 (CET)	69	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 25	Mon Dec 01 2014 09:19:02 GMT+0100 (CET)	Mon Dec 01 2014 10:34:55 GMT+0100 (CET)	76	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 25	Thu Nov 06 2014 07:05:08 GMT+0100 (CET)	Thu Nov 06 2014 07:53:52 GMT+0100 (CET)	49	0	Individual Session	-	No	13	0	13	end	complete	7
user 26	Thu Nov 20 2014 14:27:40 GMT+0100 (CET)	Thu Nov 20 2014 15:13:51 GMT+0100 (CET)	46	0	Individual Session	-	No	7	0	7	end	incomplete	9
user 26	Wed Nov 05 2014 11:36:32 GMT+0100 (CET)	Wed Nov 05 2014 12:10:26 GMT+0100 (CET)	34	0	Individual Session	-	No	9	0	9	end	incomplete	7

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 26	Fri Oct 31 2014 18:34:44 GMT+0100 (CET)	Fri Oct 31 2014 18:58:10 GMT+0100 (CET)	23	0	Individual Session	-	No	10	0	10	end	incomplete	6
user 26	Fri Nov 28 2014 09:50:16 GMT+0100 (CET)	Fri Nov 28 2014 10:45:26 GMT+0100 (CET)	55	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 26	Sat Nov 29 2014 09:33:55 GMT+0100 (CET)	Sat Nov 29 2014 10:32:11 GMT+0100 (CET)	58	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 26	Thu Dec 04 2014 14:28:50 GMT+0100 (CET)	Thu Dec 04 2014 15:25:52 GMT+0100 (CET)	57	0	Individual Session	-	No	11	0	11	end	incomplete	10
user 26	Fri Nov 07 2014 13:55:37 GMT+0100 (CET)	Fri Nov 07 2014 14:32:36 GMT+0100 (CET)	37	0	Individual Session	-	No	10	1	11	end	incomplete	7
user 26	Sat Nov 22 2014 16:09:22 GMT+0100 (CET)	Sat Nov 22 2014 17:10:41 GMT+0100 (CET)	61	0	Individual Session	-	No	11	0	11	end	incomplete	9
user 26	Tue Nov 11 2014 14:10:25 GMT+0100 (CET)	Tue Nov 11 2014 15:08:14 GMT+0100 (CET)	58	0	Individual Session	-	No	12	0	12	end	incomplete	8
user 26	Fri Nov 14 2014 16:22:49 GMT+0100 (CET)	Fri Nov 14 2014 17:19:25 GMT+0100 (CET)	57	0	Individual Session	-	No	11	1	12	end	incomplete	8
user 26	Sat Oct 25 2014 19:59:42 GMT+0200 (CEST)	Sat Oct 25 2014 20:37:41 GMT+0200 (CEST)	38	0	Individual Session	-	No	13	0	13	end	complete	5
user 26	Sat Nov 01 2014 08:53:07 GMT+0100 (CET)	Sat Nov 01 2014 09:30:48 GMT+0100 (CET)	38	0	Individual Session	-	No	13	0	13	end	complete	6
user 26	Sat Nov 08 2014 13:12:29 GMT+0100 (CET)	Sat Nov 08 2014 13:54:43 GMT+0100 (CET)	42	0	Individual Session	-	No	13	0	13	end	complete	7
user 26	Thu Nov 13 2014 14:22:56 GMT+0100 (CET)	Thu Nov 13 2014 15:28:26 GMT+0100 (CET)	65	0	Individual Session	-	No	12	1	13	end	complete	8
user 37	Wed Oct 22 2014 12:42:29 GMT+0200 (CEST)	Wed Oct 22 2014 13:15:37 GMT+0200 (CEST)	33	0	Individual Session	-	Yes	13	0	13	end	complete	5

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 37	Thu Nov 06 2014 16:12:41 GMT+0100 (CET)	Thu Nov 06 2014 16:29:13 GMT+0100 (CET)	17	0	Individual Session	-	No	2	0	2	end	incomplete	6
user 37	Sat Nov 08 2014 17:27:53 GMT+0100 (CET)	Sat Nov 08 2014 17:41:17 GMT+0100 (CET)	13	0	Individual Session	-	No	2	0	2	end	incomplete	6
user 37	Fri Nov 21 2014 10:19:04 GMT+0100 (CET)	Fri Nov 21 2014 10:49:43 GMT+0100 (CET)	31	0	Individual Session	-	No	4	1	5	end	incomplete	8
user 37	Mon Oct 13 2014 11:09:08 GMT+0200 (CEST)	Mon Oct 13 2014 11:38:46 GMT+0200 (CEST)	30	0	Individual Session	-	No	13	0	13	end	complete	4
user 37	Fri Oct 24 2014 11:16:26 GMT+0200 (CEST)	Fri Oct 24 2014 11:47:27 GMT+0200 (CEST)	31	0	Individual Session	-	No	13	0	13	end	complete	5
user 37	Sat Nov 15 2014 09:58:45 GMT+0100 (CET)	Sat Nov 15 2014 10:03:49 GMT+0100 (CET)	5	0	Individual Session	-	No	1	0	1	not end	incomplete	7
user 7	Tue Nov 18 2014 12:30:44 GMT+0100 (CET)	Tue Nov 18 2014 12:47:57 GMT+0100 (CET)	17	0	Individual Session	invited users	No	2	0	2	end	incomplete	9
user 7	Tue Oct 28 2014 21:05:48 GMT+0100 (CET)	Tue Oct 28 2014 21:24:29 GMT+0100 (CET)	19	0	Individual Session	-	No	2	0	2	end	incomplete	6
user 7	Sat Nov 15 2014 20:46:51 GMT+0100 (CET)	Sat Nov 15 2014 20:54:23 GMT+0100 (CET)	8	0	Individual Session	invited users	No	1	1	2	end	incomplete	8
user 7	Thu Nov 20 2014 15:57:08 GMT+0100 (CET)	Thu Nov 20 2014 16:06:55 GMT+0100 (CET)	10	0	Individual Session	-	No	1	2	3	end	incomplete	9
user 7	Tue Nov 25 2014 10:30:16 GMT+0100 (CET)	Tue Nov 25 2014 11:25:54 GMT+0100 (CET)	56	0	Individual Session	invited users	No	11	0	11	end	incomplete	9
user 7	Thu Nov 27 2014 14:15:54 GMT+0100 (CET)	Thu Nov 27 2014 15:16:35 GMT+0100 (CET)	61	0	Individual Session	invited users	No	11	0	11	end	incomplete	10
user 7	Fri Nov 21 2014 23:12:45 GMT+0100 (CET)	Sat Nov 22 2014 00:17:57 GMT+0100 (CET)	65	0	Individual Session	invited users	No	11	1	12	end	incomplete	9

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 7	Mon Oct 13 2014 16:56:13 GMT+0200 (CEST)	Mon Oct 13 2014 17:24:17 GMT+0200 (CEST)	28	0	Individual Session	invited users	No	13	0	13	end	complete	4
user 7	Sat Oct 18 2014 18:24:08 GMT+0200 (CEST)	Sat Oct 18 2014 18:52:46 GMT+0200 (CEST)	29	0	Individual Session	-	No	13	0	13	end	complete	4
user 7	Thu Oct 23 2014 14:58:27 GMT+0200 (CEST)	Thu Oct 23 2014 15:28:34 GMT+0200 (CEST)	30	0	Individual Session	invited users	No	13	0	13	end	complete	5
user 7	Fri Oct 17 2014 16:04:54 GMT+0200 (CEST)	Fri Oct 17 2014 16:31:14 GMT+0200 (CEST)	26	0	Individual Session	invited users	No	13	0	13	end	complete	4
user 7	Mon Nov 03 2014 14:31:51 GMT+0100 (CET)	Mon Nov 03 2014 15:14:17 GMT+0100 (CET)	42	0	Individual Session	invited users	No	13	0	13	end	complete	7
user 7	Fri Oct 24 2014 10:15:44 GMT+0200 (CEST)	Fri Oct 24 2014 10:48:41 GMT+0200 (CEST)	33	0	Individual Session	invited users	No	13	0	13	end	complete	5
user 7	Thu Nov 06 2014 09:55:52 GMT+0100 (CET)	Thu Nov 06 2014 10:41:54 GMT+0100 (CET)	46	0	Individual Session	invited users	No	13	0	13	end	complete	7
user 7	Tue Oct 21 2014 12:57:38 GMT+0200 (CEST)	Tue Oct 21 2014 13:31:01 GMT+0200 (CEST)	33	0	Individual Session	invited users	No	13	0	13	end	complete	5
user 7	Wed Nov 12 2014 19:58:44 GMT+0100 (CET)	Wed Nov 12 2014 20:57:03 GMT+0100 (CET)	58	0	Individual Session	invited users	No	13	0	13	end	complete	8
user 7	Thu Oct 16 2014 15:33:56 GMT+0200 (CEST)	Thu Oct 16 2014 16:08:19 GMT+0200 (CEST)	34	0	Individual Session	invited users	No	13	0	13	end	complete	4
user 7	Fri Nov 07 2014 08:51:56 GMT+0100 (CET)	Fri Nov 07 2014 08:52:15 GMT+0100 (CET)	1	0	Individual Session	-	No	0	0	0	not end	incomplete	7
user 7	Tue Nov 18 2014 22:06:14 GMT+0100 (CET)	Tue Nov 18 2014 22:06:33 GMT+0100 (CET)	1	0	Individual Session	-	No	0	0	0	not end	incomplete	9

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 7	Mon Nov 24 2014 09:44:13 GMT+0100 (CET)	Mon Nov 24 2014 09:44:26 GMT+0100 (CET)	1	0	Individual Session	invited users	No	0	0	0	not end	incomplete	9
user 7	Tue Nov 25 2014 10:29:59 GMT+0100 (CET)	Tue Nov 25 2014 10:30:11 GMT+0100 (CET)	1	0	Individual Session	invited users	No	0	0	0	not end	incomplete	9
user 7	Sat Nov 22 2014 22:39:10 GMT+0100 (CET)	Sat Nov 22 2014 22:39:43 GMT+0100 (CET)	1	0	Individual Session	invited users	No	0	0	0	not end	incomplete	9
user 7	Thu Nov 13 2014 18:19:52 GMT+0100 (CET)	Thu Nov 13 2014 18:20:29 GMT+0100 (CET)	1	0	Individual Session	invited users	No	0	1	1	not end	incomplete	8
user 7	Mon Nov 10 2014 09:18:10 GMT+0100 (CET)	Mon Nov 10 2014 09:19:46 GMT+0100 (CET)	2	0	Individual Session	-	No	0	3	3	not end	incomplete	7
user 7	Thu Nov 20 2014 15:48:43 GMT+0100 (CET)	Thu Nov 20 2014 15:57:04 GMT+0100 (CET)	8	0	Individual Session	-	No	0	4	4	not end	incomplete	9
user 8	Tue Nov 18 2014 10:05:19 GMT+0100 (CET)	Tue Nov 18 2014 10:25:40 GMT+0100 (CET)	20	0	Individual Session	invited users	No	3	9	12	end	incomplete	7
user 8	Wed Oct 29 2014 09:09:59 GMT+0100 (CET)	Wed Oct 29 2014 10:01:32 GMT+0100 (CET)	52	0	Individual Session	-	No	11	2	13	end	complete	6
user 8	Tue Nov 04 2014 10:02:03 GMT+0100 (CET)	Tue Nov 04 2014 10:44:35 GMT+0100 (CET)	43	0	Individual Session	invited users	No	13	0	13	end	complete	6
user 8	Fri Nov 07 2014 11:43:07 GMT+0100 (CET)	Fri Nov 07 2014 11:47:24 GMT+0100 (CET)	4	0	Individual Session	-	No	0	13	13	end	complete	6
user 8	Tue Nov 18 2014 10:05:04 GMT+0100 (CET)	Tue Nov 18 2014 10:05:14 GMT+0100 (CET)	1	0	Individual Session	invited users	No	0	0	0	not end	incomplete	7
user 8	Tue Nov 18 2014 10:00:43 GMT+0100 (CET)	Tue Nov 18 2014 10:03:39 GMT+0100 (CET)	3	0	Individual Session	-	No	1	0	1	not end	incomplete	7

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 9	Thu Nov 27 2014 16:18:29 GMT+0100 (CET)	Thu Nov 27 2014 16:41:42 GMT+0100 (CET)	23	0	Individual Session	-	No	0	6	6	end	incomplete	9
user 9	Thu Dec 04 2014 22:37:11 GMT+0100 (CET)	Thu Dec 04 2014 23:09:34 GMT+0100 (CET)	32	0	Individual Session	-	No	2	5	7	end	incomplete	10
user 9	Fri Nov 28 2014 23:13:09 GMT+0100 (CET)	Fri Nov 28 2014 23:44:13 GMT+0100 (CET)	31	0	Individual Session	-	No	0	7	7	end	incomplete	9
user 9	Tue Oct 21 2014 20:39:40 GMT+0200 (CEST)	Tue Oct 21 2014 21:07:02 GMT+0200 (CEST)	27	0	Individual Session	-	No	1	7	8	end	incomplete	5
user 9	Thu Oct 30 2014 20:47:04 GMT+0100 (CET)	Thu Oct 30 2014 21:27:45 GMT+0100 (CET)	41	0	Individual Session	-	No	2	6	8	end	incomplete	6
user 9	Sat Nov 01 2014 09:31:45 GMT+0100 (CET)	Sat Nov 01 2014 10:27:04 GMT+0100 (CET)	55	0	Individual Session	-	No	2	7	9	end	incomplete	6
user 9	Tue Oct 14 2014 20:59:20 GMT+0200 (CEST)	Tue Oct 14 2014 21:19:48 GMT+0200 (CEST)	20	0	Individual Session	-	No	0	9	9	end	incomplete	3
user 9	Tue Dec 02 2014 22:04:41 GMT+0100 (CET)	Tue Dec 02 2014 23:28:38 GMT+0100 (CET)	84	0	Individual Session	-	No	2	9	11	end	incomplete	10
user 9	Wed Nov 26 2014 22:02:05 GMT+0100 (CET)	Wed Nov 26 2014 23:39:32 GMT+0100 (CET)	97	0	Individual Session	-	No	2	10	12	end	incomplete	9
user 9	Wed Oct 29 2014 21:44:18 GMT+0100 (CET)	Wed Oct 29 2014 22:21:36 GMT+0100 (CET)	37	0	Individual Session	-	No	9	3	12	end	incomplete	6
user 9	Tue Nov 18 2014 20:51:43 GMT+0100 (CET)	Tue Nov 18 2014 21:43:46 GMT+0100 (CET)	52	0	Individual Session	-	No	9	4	13	end	complete	8
user 10	Mon Nov 17 2014 16:51:30 GMT+0100 (CET)	Mon Nov 17 2014 16:58:57 GMT+0100 (CET)	7	1	Joint Session	invited users	No	1	0	1	end	incomplete	8

usernames	Joined Classroom (timestamp)	Left Classroom (timestamp)	duration (minutes)	No of meetups	co-presence	invited users before joining	Invited?	No of completed activities	No of Skipped activities	Total completed Exercises	If completed the session	If did at once	User Level
user 10	Mon Dec 01 2014 19:34:18 GMT+0100 (CET)	Mon Dec 01 2014 19:54:30 GMT+0100 (CET)	20	1	Joint Session	-	No	2	0	2	end	incomplete	10
user 10	Mon Nov 24 2014 19:59:22 GMT+0100 (CET)	Mon Nov 24 2014 20:42:28 GMT+0100 (CET)	43	1	Joint Session	-	No	6	0	6	end	incomplete	9
user 10	Tue Nov 18 2014 17:53:54 GMT+0100 (CET)	Tue Nov 18 2014 19:07:34 GMT+0100 (CET)	74	4	Joint Session	invited users	No	9	0	9	end	incomplete	8
user 10	Fri Dec 05 2014 13:21:04 GMT+0100 (CET)	Fri Dec 05 2014 14:17:38 GMT+0100 (CET)	57	1	Joint Session	-	No	9	0	9	end	incomplete	10
user 10	Wed Nov 19 2014 09:35:22 GMT+0100 (CET)	Wed Nov 19 2014 10:36:36 GMT+0100 (CET)	61	2	Joint Session	invited users	No	10	0	10	end	incomplete	8
user 10	Wed Nov 26 2014 10:24:26 GMT+0100 (CET)	Wed Nov 26 2014 11:44:46 GMT+0100 (CET)	80	1	Joint Session	-	No	11	0	11	end	incomplete	9
user 10	Wed Dec 03 2014 08:56:44 GMT+0100 (CET)	Wed Dec 03 2014 09:56:41 GMT+0100 (CET)	60	1	Joint Session	-	No	11	0	11	end	incomplete	10
user 10	Fri Oct 31 2014 19:34:02 GMT+0100 (CET)	Fri Oct 31 2014 20:17:46 GMT+0100 (CET)	44	3	Joint Session	invited users	No	11	0	11	end	incomplete	5
user 10	Mon Nov 10 2014 09:35:49 GMT+0100 (CET)	Mon Nov 10 2014 10:14:35 GMT+0100 (CET)	39	1	Joint Session	-	No	11	0	11	end	incomplete	7
user 10	Wed Nov 12 2014 08:16:47 GMT+0100 (CET)	Wed Nov 12 2014 09:09:06 GMT+0100 (CET)	52	5	Joint Session	invited users	No	12	0	12	end	incomplete	7