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Supporting Healthy Lifestyles through Pervasive Games

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Submission date: June 2016
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To my family.
Specially to my mother
For being the light during my darkest times.

Abstract

A sedentary lifestyle has increased the amount of people with obesity and diabetes. Obesity has become an urgent matter in recent years since the number of children with this condition has increased in alarming numbers.

This thesis addresses this issue throughout the use of pervasive games to support healthier lifestyles. A healthy lifestyle refers to the balance between physical activity and food intake. Nowadays popular health and tracking apps have not integrated this relationship as they are mainly focus on either exercise or nutrition. The latter focus only considering the amount of calories or the type of food the user consumes. But they don't contemplate the association between mood and food. The former focus is mostly used to track the energy expenditure of the user's physical activity.

Thus, this thesis supports healthy lifestyles using a prototype of a mobile application. To do so, requirements have been gathered from young people through a workshop and a questionnaire. Then, the requirements were compared against the literature to define all the relevant features. Finally, a prototype has been designed. Such support is provided in three main areas: Exercise, Nutrition and Mood. Feedback is given about the user's exercise and by interacting with nutrition and mood through a virtual character that can feed and exercise. All the food contained in the application shows its nutritional value, number of calories and it is related to a mood score. The higher the mood score is, the happier the virtual character will be. And the other way around: if the score is low, the character will become sad.

The outcome of this project has been evaluated by students from the Trondheim International School and was presented to people from the IT industry. The diversity of both groups gave a different perspective of the us and areas of application of the final prototype.

The evaluation results have shown that the use of a virtual character can help the user to understand and realize the impact of food and its relationship with the mood. The virtual character creates a cognitive conflict among children because they are encourage to change their idea about the relationship between junk food and happiness. The cognitive conflict can help to destabilize misconceptions and create new and solid knowledge.

Acknowledgment

I would like to thank my supervisor Prof. Sobah Abbas Petersen for her support and valuable feedback during the development of this thesis.

I am much obligated to Misa Djordjevic and the 8th grade students from the Trondheim International School for their help and participation in the design and evaluation workshop. Thank you for willingly sharing your time and opinions for the materialization of this project.

My gratitude to my family and friends for their support throughout the entire process, both by their valuable input and helping me putting the pieces together. I will be forever grateful for your love and support even when the coffee did not have any effect on me.

Finally, I would like to express my gratitude to the National Council of Science and Technology in Mexico (CONACYT) for the financial support they gave me to study throughout my Master of Science program.

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Abbreviations

NEAT	=	Non-Exercise Activity Thermogenesis
AHPC	=	American HorsePower Challenge
DDR	=	Dance Dance Revolution
WHO	=	World Health Organization

Chapter 1

Introduction

1.1 Background

Modern life has been turning around a sedentary lifestyle and has increased the number of people with obesity and diabetes. This new lifestyle has changed our daily habits in a way that now people eat poorly and unhealthy, lack physical activity and social interaction. This change has rapidly become a critical and urgent issue. In the United States more than one third of children and adolescents were overweight or obese in 2012, one in six children was overweight or obese in Norway in 2014 and worldwide 42 million children under the age of five were overweight or obese in 2013 (Hyattsville, 2012; of Public Health, 2014; Organization, 2015).

Statistics from the American Medical Association show that in the United States, "obesity has more than doubled in children and quadrupled in adolescents in the past 30 years" (Ogden et al., 2014; Hyattsville, 2012). Obesity has short and long-term affectations on health and well-being. Examples of the latter are risk of cardiovascular diseases, pre-diabetes and joint problems, while as long-term affectations exist the likelihood to become obese adults and increased risk for many types of cancer (Guo and Chumlea, 1999; Freedman et al., 2005).

However, modern technology is now being used to promote a healthy lifestyle through pervasive games among children and adolescents. A pervasive game is a game that brings the digital world into the physical one and blends into the users' everyday activities. These games can be used to support healthy lifestyles by capturing the users' attention and motivate

them by interacting with their health information in a meaningful way. This kind of approach can help them to make the right choices in a virtual environment that can after be applied to their daily life.

The current research in pervasive games shows that they can encourage people to follow a healthy lifestyle, either through games that motivate the users to exercise (exergames) or games that provide health and wellness management (known as ”Games for Health”) by monitoring their daily activities and giving feedback about how healthy they live.

1.2 Motivation

The aim of this project is to provide a prototype of a pervasive game that can help improve the lifestyle of young people.

The primary focus of this project is the relation between mood and food in order to raise awareness and help users to make informed choices about food intake in their daily lives. It also supports physical activity by monitoring and simulating.

The main target group are children due to the interest of modify and prevent behaviors leading to obesity in an early stage.

1.3 Objectives

The objectives of this project are:

1. Support the users to obtain knowledge about a healthy lifestyle
2. Motivate the users to exercise and have a healthy diet
3. Provide the users with feedback about their behavior

1.4 Project Scope

Pervasive games have a wide range of applications and areas of interest such as Workplaces, Education and Learning, Health and Well-being, Culture among others. This project designs a prototype of a pervasive game for the health and well-being sector due to the interest of focusing on lifestyle and its related illnesses.

The prototype provides support for physical activity and intake of healthy foods areas as they are part of the current research of pervasive games. It addresses young people such as children and teenagers. This project attempts to bring together exercise, nutrition and mood affectations in one design. The final outcome of this project is a prototype covering the must have requirements for the game.

1.5 Research Questions

- RQ1: Do children feel motivated to change their nutrition habits when mood changes are represented?
- RQ2: Can the ”Tamagotchi approach” help the user to feel more aware about nutrition, mood and exercise?
- RQ3: Can mood, nutrition and exercise combined together help children to improve their current lifestyle?

1.6 Approach

In order to evaluate the objectives a preliminary design is made based on the literature. Later a workshop with school children takes place to gather requirements without them knowing that there has already a design been made. Next, requirements from both designs are combined and prioritized, in order to select the most important requirements. Then several screens and game flow are designed in an interactive platform and finally the design is evaluated by the school children.

1.7 Structure of the Report

This project is meant to give an overview over the main concepts such as pervasive games and describes the design and evaluation of the prototype of the pervasive game.

Chapter 2 Theoretical Background gives an overview of pervasive games, their elements, units, challenges and examples.

Chapter 3 Literature Review looks at the current research of lifestyle oriented pervasive games and its application in illnesses such as obesity. It also explores the types of players and task. And gives an overview of the relation between food, exercise and mood.

Chapter 4 Persuasive Design gives an insight of persuasive factors and technology applied to pervasive games.

Chapter 5 Methodology explains the methods used through the different phases of this project.

Chapter 6 Requirements describes the process of selecting the most important features based on the children's ideas and the literature.

Chapter 7 Design presents the functional specification of the prototype.

Chapter 8 Evaluation describes the evaluation session conducted with the target group and a presentation given to IT people.

Chapter 9 Discussion discusses the results and answers to the research questions.

Chapter 10 Conclusions summarizes and concludes this work, it gives as well recommendations for further work.

Chapter 2

Theoretical Background

Pervasive computing (also referred as ubiquitous computing) is ”roughly the opposite of virtual reality, since it forces the computer to live out here in the world with people” (Weiser, 1991), this means that technology is blended into the users' lives that they can barely notice it. Whereas ”virtual reality is an alternate world made of computer-generated images that respond to human movements”. (Steuer, 1992)

The term of ”Pervasive Computing” was introduced by IBM in 1998 as a new concept that integrates computers within the real world (Hinske et al., 2007).

However, pervasive computing is often related to games, creating the pervasive genre of gaming that blends the virtual environment with the real world where any action can be part of the game, for example Dance Dance Revolution (DDR) and WiiSports.

2.1 Pervasive Games

There is no clear definition of pervasive games because they can be approached from different perspectives such as the technology that enables the game to be played, the game itself or a mix of both causing an ambiguity problem.

Therefore, pervasive games can be defined as:

1. ”A ludic form of mixed reality entertainment with goals, rules, competition and attacks, based on the utilization of mobile computing

and/or pervasive computing technologies" (Hinske et al., 2007).

2. "A game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally" (Montola, 2005).

3. "A extension of the gaming experience out of the real world while the player becomes unchained from the console and experiences a game that is interwoven with the real world and it is potentially available at any place and any time" (Benford et al., 2005).

4. "The construction and enacting of augmented and/or embedded game worlds, that reside between tangible and immaterial space" (Kampmann, 2005).

Thus, the term pervasive games involves different genres of computer games sharing elements which expand their own game domain or "magic circle" either in a spatial, temporal or social way (Kampmann, 2005; Montola, 2005).

According to Montola, "spatial expansion indicates that the socially constructed location of the game is unclear or unlimited", this means that games can take place in a virtual of physical environment allowing them to be played anywhere and everywhere. Temporal expansion refers to the time when the game is played and whether the user is aware that he is playing or not. And social expansion refers to where the game is played and the people who interacts with it in a direct or indirect way (Montola, 2005).

2.2 Axes

As mentioned before, a pervasive element is the one which expands the "magic circle" of the game in a spatial, temporal or social way.

There are four different dimensions for such expansions that will contribute to the player's experience:

First is the physical dimension which relates the user with the objects and persons in the real (physical) world. Second is the mental/intellectual dimension which refers to challenges and experiences regarding brain and mind. Third is the social dimension reflecting the interaction and communication with other players. And forth is the immersive dimension or im-

mersion of the player into the game and relates to the entertainment given by the game (Hinske et al., 2007).

To mark the possible domains of pervasive games, Kampmann suggest four axes (Kampmann, 2005):

1. Distribution: Refers to the combination of information technologies into a networked digital environment that is ”always on, always available, and unobtrusive”
2. Mobility: Mobility in the context of computing, network and user mobility, context aware, and cross-platform services.
3. Persistence: Having total availability all the time.
4. Transmediality: ”Challenges the relation between sender, text and receiver. Allows the users to co-create content and recycle/reuse different media content”. (Jegers, 2007)

These four axes, illustrated in Figure 2.1, focus on the foundational prerequisites for pervasive games to exist.

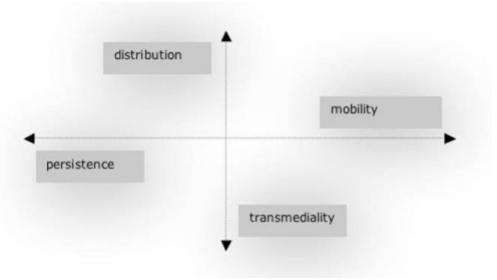

Figure 2.1: Pervasive Game Axes by Kampmann

2.3 Game flow

The game flow or pervasive player enjoyment model describes how pervasive and mobile computing technologies handle important aspects of game play implied by the character of pervasive games.

Jegers suggests eight elements in the game flow model (Jegers, 2007):

1. Concentration: Support the player on switching concentration between in-game tasks and surrounding factors of importance.

2. Challenge:

   * Stimulate and support the players in their own creation of game scenarios and pacing.

   * Help players in keeping a balance in the creation of paths and developments in the game world.

   * Provide an appropriate level of challenge set by physical world preconditions.

3. Player skills: Should be very flexible and enable the players' skills to be developed in a pace set by the players.

4. Control:

   * Enable the players to pick up game play easily and provide quickly the current status of the game.

   * Provide a flexible interaction style that enables gaming in many possible physical settings.

   * Make it hard for the player to cheat and uphold the feeling of fairness and equal opportunities for competition.

   * Be implemented on technological platforms that are easy to use and manage for the players.

5. Clear goals: Should support the players in forming and communicating their own immediate goals.

6. Feedback:

   * Make the progress clear towards the users' goals.

   * Players should always know their status or score.

7. Immersion:

   * Support seamless transition between different everyday contexts.

   * Enable the player to shift focus between the virtual and the physical parts of the game world.

8. Social Interaction:

    * Should support and enable possibilities for game-oriented, meaningful and purposeful social interaction within the gaming system.

    * Incorporate triggers and structures that motivate the player to communicate and interact socially.

2.4 Game Elements

Hinske groups the elements of a game which partially overlap with the game flow elements. The elements defined by Hinske are (Hinske et al., 2007):

1. Rules: Pervasive games should continuously monitor the game, observe the rules, and always be aware of the current game state. Violations to the rules should be reported in an adequate way.

2. Competition: Pervasive games should provide means to the players for a smooth engagement in a fair competition.

3. Goals: Pervasive games should support the players in forming and communicating their own intermediate goals.

4. Outcome: Pervasive games should always keep score of the game.

5. Decisions: Pervasive games must allow the player to make decision at any time.

6. Emotional Attachment: Pervasive games should provide a compelling experience for the player, using multimodal devices in order to realize physical, intellectual or social experiences and challenges as well as provide a good immersion into the game.

Additionally, to these elements are actors and resources, however suggestions on how to improve these elements strongly depend on the game.

2.5 Key Units

Games can be divided into three interlaced key units (Kampmann, 2005), that include elements listed above. These units are:

1. Game Rules: Juul describes six parameters as (Juul, 2010):
    * Rules.
    * Variable, quantifiable outcomes.
    * Values assigned to possible outcomes.
    * Player effort.
    * Players attached to outcome.
    * Negotiable consequences.

2. Game Entities: These are defined by Kampmann as ”an abstract class of an object that can be moved and drawn over a game map”. These entities can be inventory objects, non-playing characters, a text message, etc. (Kampmann, 2005)

3. Game Mechanics: Lundgren & Bjrk define them as ”any part of the rule system of a game that covers one, and only one, possible kind of interaction that takes place during the game, be it general or specific” (Lundgren and Bjork, 2003).

2.6 Game Mechanics

The game mechanics of this project will use the game feedback loop, proposed by Fabricatore, as part of the user's decision making process, and it will be the main source of fun (Fabricatore, 2007). This loop is represented in Figure 2.2 and occurs when the user has to make a decision. The loop starts by presenting information to the user, the user should process that information to make a decision, once the decision is made, the app will show the results of the decision to the user.

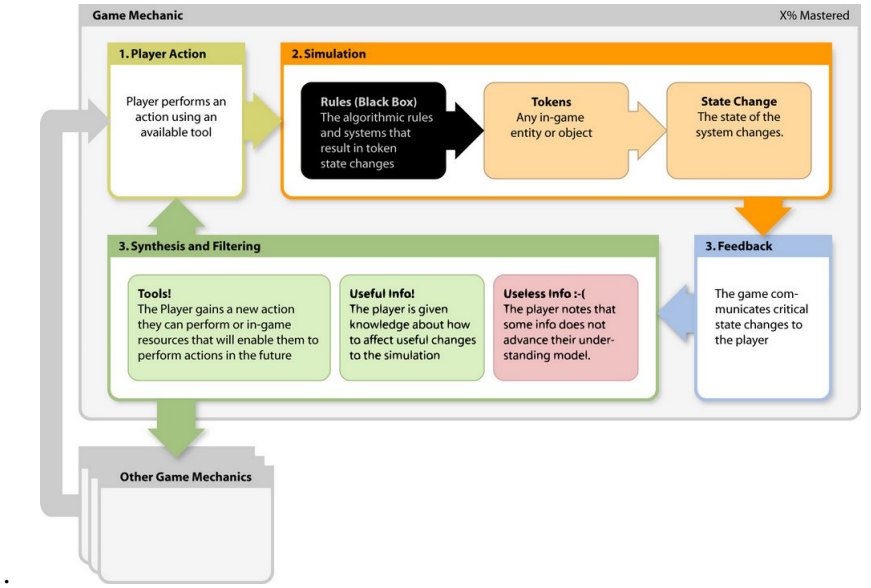

Figure 2.2: Feedback Loop by Carlo Fabricatore

2.7 Genres

According to the Integrated Project on Pervasive Gaming, the genres of pervasive games are (IperG, 2008):

2.7.1 Treasure Hunts

Treasure Hunts are games where the players are trying to find certain objects in unlimited game space. The target of the hunt may be a planted prize and often the prize or target is not valuable but the discovery is a reward itself.

2.7.2 Alternate reality games

These games take the substance of everyday life and weave it into narratives that layer additional meaning, depth and interaction upon the real world.

2.7.3 Pervasive LARPs

In live action role-playing games (LARPs), the participants physically act out as a character in an environment that has at least partially been propped to look like the story setting.

2.7.4 Urban adventure games

These games combine stories and puzzles with urban spaces. They take the player to areas with some historical or cultural significance to solve puzzles, this typically provides further instructions on how to find other locations.

2.7.5 Smart streets sports

Smart street sports are usually played in outside in urban areas or on university campuses where competing requires both physical exercise and cold tactical thinking.

2.7.6 Massively Multiplayer Mobile Games

These games are characterized by a large number of players playing the game for long periods of time through their mobile phones.

2.7.7 Boxed Pervasive Games

Boxed games are games with tools to stage and modify the game itself, or to create new games.

Pervasive Games are wide and diverse, allowing different types of genre classification depending on the perspective or the aspects of the gaming experience.

Magerkurth identifies the following genres (Magerkurth et al., 2005):

2.7.8 Smart Toys

Refers to traditional toys equipped with simple sensing technology linked to computer logic. A corresponding computer application might be also for digital storytelling or to encourage children. As toys don't have any rules

or limitations in their use, pervasive computing might emerge new gaming experiences.

2.7.9 Affective gaming

In affective gaming the emotional state of the individuals is measured with sensors that can be embedded into the environment, so that the users can interact very naturally with their entertainment technologies.

Once a player's affective state has been sensed, it can be used to inject personality into a gaming environment, resulting in an environment that meaningfully responds to a player's context rather than to preconceived gaming challenges (Mandryk, 2004).

2.7.10 Augmented Tabletop Games

This type of games integrates the states of players as central to the gaming experience and enrich physical game boards by adding the richness of the social situation to the virtual domain. By combining traditional board games with various kinds of pervasive technologies, this genre makes an attempt both to enhance the experience of playing traditional board games and to create new game designs.

2.7.11 Location-Aware Games

These games identify and track the positions of passive physical playing pieces, an entire building, a block or even a city can become part of the game board and the human players themselves become the proactive and highly unpredictable playing pieces.

2.7.12 Augmented Reality Games

They are a variation of virtual reality that draws virtual objects into a real-world environment. Users see their view augmented with 3D objects registered such that they appear to exist in real space. This genre provides complete freedom to the players to move around in the physical game world enhanced by virtual objects.

Jegers identifies other two categories (Jegers, 2007):

2.7.13 Alternate Reality Games

These games use a range of media technology to provide the players with hidden clues in their ordinary, everyday world, making use of objects and events which the players can visit giving the impression of being real.

2.7.14 Cross Media Games

Use a combination of current media and technology to produce the game play. Different technologies allow different ways to participate in the game, and multiple media channels provide means to receive information and perform actions in the games.

2.8 Challenges

Pervasive games are successful when they are developed in mobile devices, this is because these devices are already commonly used by people. However this aspect could constraint some game characteristics like allowing the users to use their whole body to interact with the game.

Capra et al., identify the following challenges that are distinctive for pervasive games (Capra et al., 2005):

2.8.1 Mobility

Mobility refers to problems related to multimedia interface design for small devices, disconnection, limited coverage and accuracy of GPS technology to determine position.

These are important because the technology selection will be based on whether the game is played indoors or outdoors, use handheld or bigger devices and if it will require Wi-Fi connection.

2.8.2 Interacting in public

All the people and surrounding that does not belong to the game directly but are indirect elements (non-players) can be troublesome. It also refers to the safety of the players when the game takes place on the streets.

2.8.3 Location specific

Location specific challenges emerge when the user experience needs to be redesigned or reconfigure every time the deploy location changes. It is highly related to the mobility challenge, since the performance of technologies such as GPS and Wi-Fi needs to be considered across the game zone.

2.8.4 Integrating the physical and the digital

Relates to the integration of the virtual environment within the physical world. Since pervasive games take elements from both the real and the virtual worlds, their design requires careful consideration of which elements to represent virtually, physically, or as a blend of both (Magerkurth et al., 2005).

2.9 Examples

TThe games presented in the following are the most known ones and are mostly location based since this kind of games are the first ones to be related when talking about pervasive games.

2.9.1 Can you see me now?

It is a mixed reality chase game played online and in the streets. Situated in a real city, online players are chased by physical players (called runners) that try to catch them by running on real streets.

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Figure 2.3: Can you see me know? screen

2.9.2 Treasure

The game is played in a big outdoor area where players are supposed to collect virtual coins that are hidden in the game area. When they approach the physical location of the coins, they can pick it up and later upload it to a server.

Figure 2.4: Treasure screen

2.9.3 Catch the flag

In the mixed-reality version of this game, each team has one knight and one guide among others. Guides use a desktop application to help knights with magic potions which allows the knights to become warriors. Knights receive instruction through mobile phones and catch the opponents flag by acquiring the Bluetooth object representing the flag in the real world. And as in the standard version of the game, any team that brings the opponents flag to its base wins.

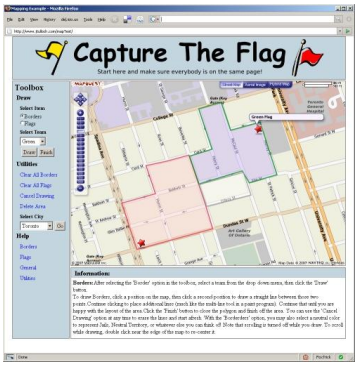

Figure 2.5: Catch the flag screen

Chapter 3

Literature Review

Now that the concept of pervasive games has been established, this chapter will explore related research in the area of obesity and lifestyle oriented illnesses.

Research made by the Journal of adolescence has shown that the use of video games has a link to obesity in children. The results indicate that ”children with higher weight played moderate amounts of electronic games, while children with lower weight played either very little or a lot of electronic games”. These results indicate a curvilinear relationship between children and games. The results also indicate that ”children with higher weight spent more time in sedentary activities than those with lower weight” (Vandewater et al., 2004). However, research in pervasive games has shown that it can revert this link by helping to prevent and amending lifestyle illness conditions. In 2009, Sawyer and Smith suggested a ”Serious Games Taxonomy”, including a ”Game for Health Taxonomy” (Sawyer and Smith, 2008) to provide an overview about health games and the different target groups.

The Serious Games taxonomy shown in Figure 3.1, is a matrix combining types of games with industries. The types of games are: Games for Health, Advergames, Games for training, Games for Education, Games for Science and Research, Production and Games as Work. The industries are: Government and NGO, Defense, Healthcare, Marketing and Communication, Education, Corporate and Industry. The elements that overlap a type with an industry are the areas of application.

	Games of Health	Advergames	Games for Training	Games for Education	Games for Science and Research	Production	Games as Work
Government & NGO	Public Health Education & Mass Casualty Response	Political Games	Employee Training	Inform Public	Data Collection / Planning	Strategic & Policy Planning	Public Diplomacy. Opinion Research
Defense	Rehabilitation & Wellness	Recruitment & Propaganda	Soldier / Support Training	School House Education	Wargames/Planning	War Planning & Weapons Research	Command & Control
Healthcare	Cybertherapy / Exergaming	Public Health Policy & Social Awareness Campaigns	Training Games for Health Professionals	Games for Patient Education & Disease Management	Visualization & Epidemiology	Biotech Manufacturing & Design	Public Health Response Planning & Logistics
Marketing & Communications	Advertising Treatment	Advertising, Marketing with Games, Product Placement	Product Use	Product Information	Opinion Research	Machinima	Opinion Research
Education	Inform about Diseases / Risk	Social Issue Games	Training Teachers / Training Workforce Skills	Learning	Computer Science & Recruitment	P2P Learning Constructivism Documentary?	Teaching Distance Learning
Corporate	Employee Health Information & Wellness	Customer Education & Awarness	Employee Training	Continuing Education & Certification	Advertising / Visualization	Strategic Planning	Command & Control
Industry	Occupation Safety	Sales & Recruitment	Employee Training	Workforce Education	Process Optimization Simulation	Nano / Bio-tech Design	Command & Control

Figure 3.1: Taxonomy of Serious games by Sawyer and Smith

Taxonomy for Health Games shown in Figure 3.2 defines in a deeper level this type of games. It is then divided between the target individuals and the game approach. The latter can be Preventive, Therapeutic, Assessment, Educational and Informatics. The former refers to Personal, Professional Practice, Research/Academia and Public Health.

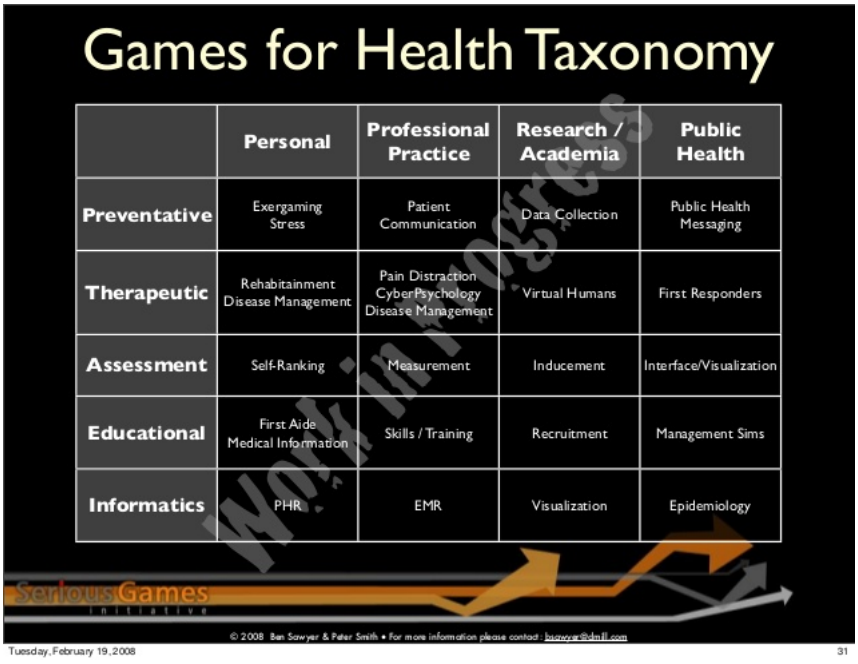

Figure 3.2: Taxonomy of Health games proposed by Sawyer and Smith

The further literature review will cover the Preventive/Personal and Therapeutic/Personal categories of the Health Games taxonomy since these are the areas in which pervasive games have been used to deal with childhood obesity and lifestyle oriented illnesses.

3.1 Preventive Pervasive Games

To end child obesity, the Commission of Ending Childhood Obesity of the World Health Organization (WHO) has developed a set of recommendations to address childhood obesity in different contexts. The recommendations cover six main areas: ”Intake of Healthy Foods, Promote Physical Activity, Preconception and Pregnancy Care, Early Childhood Diet and Physical Activity, Health, Nutrition and Physical Activity for School Age Children, and Weight Management”. (WHO et al., 2016)

These areas have been covered in a way or another of pervasive games, due to the scope and interest of this project, only Promote of Intake of Healthy Foods and Promote Physical Activity areas will be review.

Intake of Healthy foods and Promote Physical Activity aims to tackle the obesogenic environment (such as the availability of healthy foods and opportunities of physical activity in the neighborhood) and norms (such as cultural norms regarding the feeding of children).

3.1.1 Physical activity

Pervasive games can be developed to promote physical activity since they can merge video games with exercise equipment. These kind of games are called ”Exergames”, they have earned attention since health recommendations dictate that exercise is better than limit the food amount to prevent child obesity (Ross et al., 2004). However they are just a tool to motivate physical activity but they are not suited to be a replacement for ”real sports”.

There are different types of exergames due to the equipment and input devices used to perform the physical activity. The first type is the commonly known exercise bike, which can allow the user to pedal in a fix bike across a virtual landscape. Over the years exercise bikes have been found as gym bikes, training aid for cyclists or as an aim for small children to exercise and educate them. The second type is the foot operated pads used

as input controllers, the main representative of this type is the game Dance, Dance Revolution (DDR) which consists of ”a set of buttons pressed by the player stepping on them. The screen displays a set of dance steps matched to music, which the user is required to copy” (Sinclair et al., 2009). The third type is the motion sensor input, here games use the camera as a source of input to track the action performed by the game player. Its main representative is the Nintendo Wii console, which consist of a game console in which the controllers contain built in motion sensors. The Wii comes with a package of games called WiiSports. This is a ”collection of five sporting titles designed to showcase the motion sensor abilities of the controller” (Nansen, 2009).

There are games like Work of Workout designed to track and verify a user's daily physical activity and seeks to ”inspire gamers to participate in a different kind of role playing game than they may be used to, while making them more aware of their physical activity level”. (Doran et al., 2010). Another example is Exertainer, ”a sensor-enabled, interactive running entertainment system to support advanced exercise applications”, this game detects position and pace of the runners, allowing them to run naturally (Ahn et al., 2009). Another approach is to make the whole family to exercise since parents have influence over the lifestyle of the children. The location based game PiNiZoRo explores this aspect by encouraging families to exercise and explore the outdoors together by simulating a fight between pirates, zombies, ninjas and robots (Stanley et al., 2010). The last approach is the non-exercise activity thermogenesis (NEAT) which refers to the activities that a person can perform without noticing but that can help in the weight loss and expend a significant amount of energy. The main consideration for NEAT is that it is omnipresent in contrast with normal physical activities that need a specific place or time (Fujiki et al., 2008). Examples of these games are NEAT-oSudoku, where players can spend activity points (earned in NEAT-o-Race, another NEAT game) in hints to help them solve the puzzle, by spending the points, they are left behind in the NEAT-o-Race. The way to earn points again is to increase their physical activity from any activity under the NEAT category (Fujiki et al., 2008).

Examples of personalized exergames according to Gbel are: ErgoActive being a set of mini games that use an ergometer and integrate vital parameters of a player into gameplay, like using the physical activity of the user to control a film. SunSportsGo uses accelerometers to recognize movement categories and intensity, YMove uses ”video recognition to rec-

ognize movements which are directly injected into the game to control the direction of a car" (Göbel et al., 2010).

3.1.2 Food intake

On the side of Intake of Healthy foods, McMahon established that pervasive games have been used to "enhance children's capacity to make informed choices with regard to their own eating habits" and "the pervasive nature of the game allow the users to explore the effects of their decisions in a virtual pet"(McMahon, 2013).

"Nute's Adventures in Nomland" aims to help parents and children to "understand the different nutritional values of the food they eat by scanning the nutrition labels as part of the shopping activity" (Baek, 2013).

Another example is the game "Time to Eat!" which also uses a virtual pet, allowing the user to communicate with it, the game asks the user to take a picture of his or her food and submit it to the game where it is scored based in two factors: Whether the food was eaten and how healthy it was. The score also determines the emotional state of the pet. (Pollak et al., 2010).

3.2 Therapeutic Pervasive Games

One aspect to consider in the therapeutic games is that lifestyle diseases can have environmental causes since town planning and urban design can reduce the motivation for physical activity and influence food intake. To enforce daily behavior such as physical activity or nutrition habits the involvement of the urban environment is one of the most important factors, urban landscape and environment (location) needs to be considered when designed these games to "improve impact and play experience for users" (Knöll and Moar, 2011).

This is important since the Disease Management Games (also known as Therapeutic games) have a minimal interaction with the social environment because they are meant to teach health related knowledge to be used in a domestic environment or in a "safe" learning environment and mostly involve the simulation of self-care, knowledge gain and/or "feeding" of a virtual character to demonstrate the consequences of food habits.

However, management games are difficult for children and young people mostly due to teamwork conflicts between them and their parents. Another conflict is the lack of knowledge about the different type of measures that need to be taken related to food intake such as carbohydrate counting (Anderson et al., 1999).

Therapeutic games can make use of the ”Game as Life - Life as Game” scenarios to affect life in the game and in real life. The motivation behind the combination of virtual life with real life is ”to create a motivational link between real life behaviors” and ”the more immediate rewards provided in virtual environments” according to Burleson. As a result, the user gets a better understanding of the illness and the ownership of a long-term health. Children improve ”their motivation and health related behaviors” even if they don’t recognize the immediate effect (Burleson et al., 2009).

Examples are ”Nanoswarm” by Baranowski which ”increased daily fruit consumption by 0.67 servings” (Baranowski et al., 2011); ”The Fun, Food and Fitness!” by Baranowsk project increased ”water, fruit, juice, and vegetables consumption and reduced the number of sweetened drinks consumed” (Baranowski et al., 2003); ”Boy Scout 5-a-Day Badge” by Thompson increased fruit juice consumption and fruit juice availability at home, and vegetable consumption (Thompson et al., 2009) and ”Making chocolate-covered broccoli” by Glasemann motivates young people to learn how to calculate carbohydrates (Glasemann et al., 2010).

3.3 Food, Exercise and Mood

Human moods are closely related to how much sleep people have, how healthy they are, when and what they ate last and what kind of exercise they had lately. Mood is often conceptualized in terms of positive and negative effect. A negative mood is often described as being aversive and something to be avoided while a positive mood is something to be maintained. Under this idea people may engage in some behaviors to regulate their mood state, one example is the self-rewarding mechanism of food consumption as a way of indulgence.

Depending on the mood state is the tendency of consume specific types of food. A study made by Lyman indicates that junk food consumption is increased during negative mood states such as depression and frustration whereas healthy food is preferred during positive moods such as happi-

ness and self-confidence (Lyman, 1982). The hypothesis made by Singh is that ”individuals regulate their mood by changing both food choices and quantities” (Singh, 2014). A study made by Morris points out that mood regulation ”can affect the self-rewarding mechanism of food consumption” (Morris and Reilly, 1987), as shown in Figure 3.3.

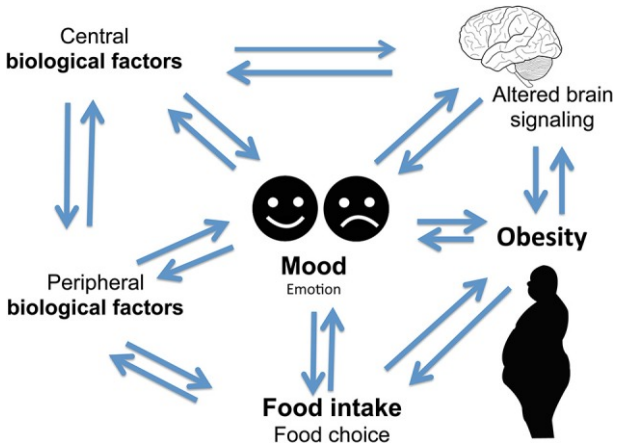

Figure 3.3: Food intake, mood, and obesity relationship (Singh, 2014).

Studies made by Jauch-Chara et al., and Welters indicate that the influence of foods on the activity of brain reward center ”can result in enhancement of appetite leading to obesity” (Jauch-Chara and Oltmanns, 2014; Weltens et al., 2014).

Volkow et al., indicate that some foods ”activate the brain regions of reward and pleasure in the same way drugs do”, this suggest ”a neuronal mechanism of food addiction leading to overeating” and thus, obesity (Volkow et al., 2011).

Kloiber suggests that ”mood disorders are often found in association with abnormal feeding behaviors. Obesity has as co-morbidities depression and anxiety” (Kloiber et al., 2007).

In patients with obesity, research made by Hopkinson and Bland indicate that 78% of obese people with depression episodes, ”crave for carbohydrates as snacks in addition to regular caloric intake”. The inability to control carbohydrate consumption might be one factor behind the weight loss of these patients (Hopkinson and Bland, 1982). The hypothesis made by Lieberman is that ”the carbohydrate craving is due to the postprandial changes in mood or by the depression episodes they experience” (Lieber-

man et al., 1986); the results of his study found that ”carbohydrate craves experienced an improvement in mood or a decline in depression, suggesting that this may represent an attempt at self-medication or self-regulation of their mood”.

3.4 Player types

Pervasive games take advantage of group-based competitions under the assumption that social components positively motivate users and encourages behavior change. The multiplayer approach permits the emerging of diverse individual participation styles from playing health games.

The following types were found in the American HorsePower Challenge (AHPC) (Xu et al., 2012):

3.4.1 Achievers

Achievers are players who, according to Bartle, ”give themselves game-related goals, and vigorously set out to achieve them” (Bartle, 1996). These players try to constantly improve their current scores. Their main motivation is personal reward by making individual progress and increase personal performance. This type of players can influence, inspire and encourage other type of players.

3.4.2 Active buddies

AHPC defines active buddies as ”players who enjoy the company of a small group of close friends who create and enjoy fun physical activities together”. They give a sense of trust during the game and they make competitions fun instead of stressful.

3.4.3 Social Experience Seekers

Bartle defines them as ”players who use the game’s communicative facilities, and apply the role-playing that these engender, as a context in which to converse (and otherwise interact) with their fellow players (Bartle, 1996). They enjoy the social aspect rather than the physical activity, resulting in a low fitness motivation.

3.4.4 Team Players

According to AHPC, team players are players who are more motivated about group achievements and rankings, they encourage others to improve the team performance. They are more enthusiast about contributing to a large cause and try to reinforce the group identity.

3.4.5 Freeloaders

They are those who, according to AHPC, ”do not contribute to the group achievement but still stay enrolled, often at the cost of the group’s performance”. They lose interest really quickly but they stay around to see what benefits they can get.

They don’t really care about the game activities or physical activities, which creates frustration among the other players because their low performance impacts the performance of the whole group.

3.5 Task Types

During the development of pervasive games to motivate children, we can find two types of tasks that influence the final outcome about whether the activity will be included in the daily life or it will be locked only in the game universe.

These tasks are ”Ego Involved Goal” and ”Task Involved Goal”. According to Macvean the first one refers to goals that when completed boost the ego of the player, either from the reward that comes from a well performed task or from the self-concept of performing better than others.

For the latter, Macvean defines them as ”goals in which the individual strives to succeed as they are interested in the actual task for its own qualities, to satisfy curiosity or just to improve without considering their peers”. (Nicholls, 1984; Macvean, 2011)

Macvean identifies a problem with the Ego Involved goals: ”players with low end performance spectrum will become demotivated, as their poorer performance is assessed in comparison to their peers”(Macvean, 2011). Whereas Butler identifies that in a Task-Involved goal context, ”players at both ends of the spectrum are motivated to improve on previous performances” (Butler, 1999).

3.6 Relevance

The importance of this literature review is to point out relevant details for the design stage. For example, consider where the users feel more comfortable playing the game (either in a domestic environment or outdoors), understand the differences between a therapeutic game and a preventive one and how they can be implemented accordingly. As well as the potential type of players and the game elements they want and expect to have, like e.g. scores, goals and personalization of the game, just to mention some. It is important to consider the type of task inside the game, to make sure the game will be played not just for novelty but for the correct reasons and have an impact in the user to maintain a healthy lifestyle.

Chapter 4

Persuasive Design

One of the objectives of this project is to motivate user to exercise and have a healthy diet. This objective relies on the idea that technology can persuade individuals to change their behavior. This is the core idea behind the use of persuasion in exergames since they aim to influence players to adopt strategies and actions by copying them from an intended target behavior.

4.1 Persuasion

Persuasion can be defined in several ways depending on the approach, some of these definitions are:

- Bettinghaus defined it as ”a conscious attempt by one individual to change attitudes, believes or behavior of another individual or group of individuals through the transmission of some message” (Bettinghaus and Cody, 1973).

- To Smith is ”a symbolic activity whose purpose is to effect the internalization or voluntary acceptance of new cognitive states or patterns of overt behavior through the exchange of messages” (Smith, 1982).

- O’Keefe suggests it to be ”a successful intentional effort at influencing another’s mental state through communication in a circumstance in which the persuadee has some measure of freedom” (O’keefe, 2015).

In general, we can say that persuasion aims an audience to adopt new attitudes to their current behavior because they are convinced with the persuasive argument.

4.2 Persuasion Factors

Technology can influence people and their behavior by understanding the following factors:

4.2.1 Contingency and Behavior

When designing persuasive techniques, behavior must be understood first, so the target behavior will be adopted by the players.

Exergames benefits can be divided in two types: Physiological and physical. The first is about player enjoyment and engagement, while the second is about exertion and physical activity. The design must be done thinking in both outcomes, having the user's behavior as reference.

The behavior of the user relates to contingencies and principles that can affect player's emotional states and the likelihood of game adoption.

Games influence the user's behavior by allowing certain dimensions of behavior to affect it, Adams suggests them to be (Adams et al., 2009):

- Topography: Refers to the form of the behavior or "what the behavior looks like"
- Frequency: It is the number of times a behavior occurs.
- Rate: Refers to the frequency within a specified period.
- Intensity: It is the strength or force with which a behavior is emitted.
- Latency: Refers to the time between a signal or prompt for a response and the incidence of the behavior.
- Duration: Refers to the time from the beginning to the end of a response without interruption.

These dimensions can be applied to some other types of games besides exergames, like Health games where the adoption rate wants to be increased.

4.3 Models and Technology

According to Fogg, ”persuasive elements in computer systems have originated from the belief that people often respond to computers as though they are living beings”(Fogg, 2002), like in the case of ”Tamagotchi” where the users were the owners of a virtual pet that could grow and develop based on the users' care. This game play leads the users to believe that they are interacting with ”real” pets.

4.3.1 Social Actors

Fogg suggests ”when computers are perceived as social actors then, they can have social influence to motivate and persuade” (Fogg, 2002). If we mix peoples' response to computers, social influences and dynamics, persuasion gets a bigger influence in its use in technology.

Social influence can be a great motivator in games if social pressure and social comparison are considered. Fogg presents ”five types of primary social cues applicable to computer systems”. These are:

- Physical: Face, eyes, body, movement
- Physiological: Preferences, humor, personality, feelings, empathy
- Language: Interactive language use, spoken language, language recognition
- Social Dynamics: Turn taking, cooperation, praise for good work, answering questions, reciprocity
- Social Roles: Doctor, teammate, opponent, teacher, pet, guide

Games that aim to persuade through psychological cues should do it in a simple way such as text messages to show empathy or onscreen icons, a more complex approach will try to portray personality so games elements will give the impression that they had preferences and personalities.

Social cues should be treated carefully when designed, to avoid the risk of users getting annoyed or even angry due to the repetition or type of cue.

4.3.2 Technology Design

To develop persuasive technology, Fogg proposes an ”eight step design process” which should be followed during the early stages to prevent failure in this kind of projects (Fogg, 2009). The process is illustrated in Figure 4.1 and described as follows:

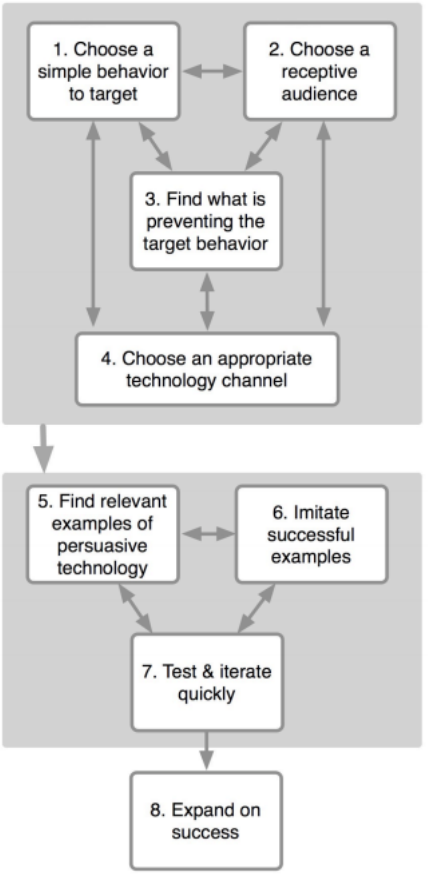

Figure 4.1: Eight steps in early-stage persuasive design (Fogg, 2009)

- Step 1: Select the smallest, simplest behavior that matters. Getting people to do small things naturally leads to their adopting more ambitious behaviors, even without a bigger intervention.
- Step 2: Choose the right audience, the one that is more likely to be receptive to the targeted behavior change.

- Step 3: Determining why people are not performing the behavior, the answer can be because a lack of motivation, ability, a well-timed trigger to perform the behavior or a mix of them. The answer to this question will determine the work required in later steps.
- Step 4: Choosing the technology channel will depend on three factors: the target behavior, the audience, and what is preventing the audience from adopting the behavior.
- Step 5: It is recommended to look at at least nine examples in total: three that achieve a similar behavior, three that reach a similar audience, and three that use the same technology channel.
- Step 6: Identifying and adapting successful technology examples to the design project at hand is the fastest, surest way to create effective persuasive technologies.
- Step 7: Consists in prototype the experience and see how people react. The response should be assessing ideally by measuring behavior.
- Step 8: Scale up, either design for a more difficult audience or assess new audiences. The method of expansion should be systematic, varying only one or two attributes from the success achieved.

4.4 Persuasion Approach

Persuasion techniques are used to drive the design of the prototype with the intention to make the players adopt a specific behavior (healthier lifestyle) and to increase the motivation through the achievement of better performances in the physical activity section, awareness about food intake and generate and convey empathy through the virtual character and its moods related to food.

Chapter 5

Methodology

5.1 Method

The research in game design has shown that user interfaces have to be designed in an iterative way (Buxton and Sniderman, 1980; Gould and Lewis, 1985; Nielsen, 1993) due to ”all the requirements for an interactive system cannot be specify in early stages” according to Dix (Dix, 2001).

Dix’s iteration model stated that ”the design has to be prototyped and tested with final users to reveal any problems or gaps in the design. Once found, they can be corrected in the next phase or iteration of the prototype which should be tested again” (Dix, 2001).

However, existing methodologies for desktop or console development, such as paper prototypes might not be adequate to pervasive games, Ballagas explained that in pervasive games ”complexity is added in every direction since there are multiple players with multiple backgrounds, dynamic context of use and diverse spatial qualities” (Ballagas, 2008).

A target group has been defined for this project, another approach to design is through Player-centered design, which by Sanders definition, ”looks for ways to ensure that the design meets the needs of the users” (Sanders, 2002).

One of the aims of this project is to modify user’s behavior towards food. In order to do that a persuasive approach will be applied. The design will iterate between the findings in the literature and the requirements from the target group.

This work will apply a mixed approach between iterative, persuasive

and player center design towards meaningful play.

5.2 Requirements

Preliminary Design

The initial part of the research about lifestyle pervasive games helped to define the target group and test users, as well as key concepts for the development of a pervasive game.

This gave the author an initial insight of what the users might want, the types of players to consider and the category of the game (preventive or therapeutic).

5.2.1 Approach

The approach to gather requirements and needs from the user target is through a workshop and a questionnaire with 8th graders. This approach may facilitate the design of the game and the identification of new game features. It also looks to investigate if the preliminary design was relevant for the target group without being completely exposed. This phase will apply an iterative design method to gather requirements in two different times from the literature and from the target group. As well a player center design method will be applied in order to gather requirements according to the target group's needs.

Workshop and Questionnaire

A workshop was arranged with the purpose of getting verification of the game features suggested by the literature and obtain an empirical view of how the target group defines the elements of the game including desired features and game mechanics. The design exercises will look to answer the following questions:

- After an introduction of health games, exergames and nutrition games, what elements do the participants would like to have in a mobile game?
- How do these elements relate to the current ones in the preliminary design?

- What elements are the most relevant?
- What elements will be included in the next phase of design?

5.3 Design

5.3.1 Approach

The design was based on the requirements gathered from the target group and it included elements suggested by the literature.

The prototype was developed in a tool that simulates a real mobile phone called Proto.io (Proto.io, 2011), in order to provide the most accurate look and feel for the users. It could be accessed through a web browser as well as the prototyping tool app.

The prototype relied on the literature to validate the design decisions, features and information provided to the user.

This phase applied the persuasive design method to include motivational and awareness elements into the game that were not part of the users' requirements.

5.4 Evaluation

5.4.1 Approach

The evaluation took the same approach as the section 5.2: A workshop and a questionnaire with the same target group. The purpose was to get an insight of what the users thought about the overall design and if it met their expectations.

Once again the player centered design was applied, so they could evaluate if their needs were part of the design and how it could have been improved. An iterative design approach was used to determine the further work of this project.

Workshop and Questionnaire

This workshop was arranged with the purpose of evaluate the design in terms of engagement, usability, motivation and awareness. The evaluation

workshop looked to answer the following questions:

- Are all the features that the users wanted included in the design?
- Are the features designed correctly?
- Are the users feeling motivated with the designed motivational elements?
- How the users perceived the achievement of rewards?
- How helpful is the virtual character to raise awareness?
- Is the app useful?

Chapter 6

Requirements

6.1 Preliminary Design

The design of this project was the result of the background research and scope delimitation of two areas inside healthy lifestyle: Nutrition and exercise. The main purpose was to combine these areas to raise awareness about an unhealthy lifestyle and to increase physical activity. The main target were children without any lifestyle related illness at the moment. Due to the age range, the expected profile of the players were achievers, social experience seekers and active buddies.

The game consists of an exercise module where a pedometer functionality will count the steps on a given day. This number will be then converted to coins that can be spend in the nutrition module. The latter module will consist of a virtual representation of the user inside the game in which physical changes will be reflected. These changes depend on the performed exercise during the day and the food eaten. To get food, the player can spend the coins in a virtual shop where he/she can buy all kind of food, both healthy and unhealthy. Once the character is fed and the physical change is performed, the game will also show the number of calories the food contains, weather the risk of obesity is increased or decreased and how healthy the character currently is. The possibility of adding challenges and rewards to motivate physical activity was also considered as a way to extend the exercise module.

6.2 Workshop

The requirements workshop started with a brief introduction to the concepts of health games, exergames and nutrition games. No game elements were described to the participants nor the current elements in the preliminary design. This workshop was focused on design in three categories: Exercise, Nutrition and Game Design using a coffee table brainstorming method. The ideas from other participants were always present for the rest of them and they were subject of discussion.

6.2.1 Workshop 1: Trondheim, Norway 09-03-2016

Participants: 8th grade students. Eleven girls and six boys.

Where: Trondheim International School.

Duration: 1 hour.

Details: After the introduction, the participants were asked to divide into three groups and sit at one of the prepared tables labeled as Exercise/Physical Activity, Nutrition/Healthy Eating and Game Design. Each table had a host to help and encourage the brainstorming. The participants were then asked to write down on post-it notes their ideas about the category, while no external input was given in order to stimulate the creativity of the participants. If their ideas were not clear or elaborate enough, they were discussed within the group on the table. The only help they got was when they had difficulties establishing concrete elements but had a clear idea in a scenario level, since some of them found out easier to draw their ideas and explain them further than writing concrete points. After 7 minutes the participants switched tables to brainstorm about another category.

6.3 Questionnaire

Once all the participants had finished the brainstorming in all the categories, a questionnaire was given out to them in order to obtain concrete data on an individual level covering the same three levels as in the coffee tables: Exercise/Physical Activity, Nutrition/Healthy Eating and Game Design. However the intention was to identify the current habits and knowledge of the participants as well as game preferences related to location, number of players, game challenges, among others.

6.4 Results

The resulting data from the design workshop in each of the categories as well as the questionnaire is described in the following. Further this section holds the comparison of results against the preliminary idea, the requirement identification and the choice of elements for design.

6.4.1 Workshop

After the three coffee table rounds, the ideas from the participants were classified in each category using the following criteria: Not related, Ambiguous and Related, defined as:

- Non-Related: Ideas that are out of scope or cannot be connected to the project
- Ambiguous: Ideas that need further explanation/details to be related to the project.
- Related: Concrete ideas that are understood as requirements

Game Design

Not Related	Ambiguous	Related
Subway Surf in real life	Healthy life challenge game	Matching icon
No Adds	Big Range of different things	Catchy name
Adds to get points	Ideas from different people	Attractive Layout
VR capable	Motivation quotes	Background music
Be able to be a pineapple	Photos	Colorful
Being able to eat tacos	First person	Different criteria on different levels
Achievement (cash)	Parkour	Own customizable avatar
Whole world	Skiing	Be usable offline

4K graphics	Realistic	Role Playing Game
Different characters to buy	Fun	Be able to compete with others
	Not to hard	Light weight to run
	High quality	Points for being healthy
	Easy to level up	Multiplatform
	Active goals	3D
	Start game guide	Point system
	Short tutorials	Suggest training routines
	Different game modes	Tell you how healthy some food is
	Power ups	Ranking system
	Fun	Levels
	Interesting	User profile

Table 6.1: Game Design ideas

Exercise/Physical Activity

Not Related	Ambiguous	Related
Being able to fly in an area like superman	Levels to smash things	Show blood pressure and calories
Vehicles	Fun activities alone	Step by step plan
Damm Daniel easter egg	Fun activities with friends	Calorie burn
Be able to become any animal	Exploring	Training routines
Sign a legal contract to run	Thumb exercise	Daily training plan
Bird fishing	Competition with rewards	Have a training partner
Sleep walking	Self defense	Dance-Tennis
Riding a unicorn in the sky	Fun sports	Find a sport to do
Megazone	Increase your metabolism	Dance

Paintball on skiis	Cheerleading	Training tutor
Surferboard while eating	Moving around music	
Summer snowball		

Table 6.2: Exercise/Physical activity ideas

Nutrition/Healthy eating

Not Related	Ambiguous	Related
Leaderboard about eaten pineapples	Make your own food	Get fat if you eat unhealthy
Potions	Cooking tool	Calorie counter
	Funny food	Get sick by eating McDonalds
	Detox water	Lose points when eating more than you burn
		Leaderboard
		Healthy burgers
		”Playlist” of food
		Healthy food recipes
		Know if the food is healthy
		Know how much sugar is consumed
		Know how much fat is eaten
		Meals suggestion
		Teach people to make healthy meals
		Show the amount of exercise to be done based on food eaten
		A character that eats what you eat
		Exercise to unlock recipes

Table 6.3: Nutrition/Healthy eating ideas

6.4.2 Workshop conclusions

The results show that Game Design seemed to be a difficult category for the participants due to the lack of interest and the ambiguity of their responses. Also most of the answers were repeated among the participants such as having a customizable avatar generating a creativity loop, as well as many of the technical requirements which are based on actual requirements for consoles and PCs. However, they pointed out relevant things such as having a catchy name and a matching icon for the game as a way to get interested on it.

In the physical activity category, most of the ideas refer to sports they would like to do, which do not necessarily have to be as part of the game such as swimming, horse riding, water slide, hula hoop and jiu jitsu. Considering this, most of the answers were not realistic or related to the purpose of this project, but creative indeed.

The last category nutrition/healthy eating had the most related elements and it was the most interesting for the participants since their ideas were more developed than in the other categories. Overall they show interest in learning how to cook healthy food through recipes and learn the nutritional value of the food.

In general, they seem to want a training counselor, training routines and learn about food through recipes and body changes.

6.4.3 Questionnaire

With a sample of eleven girls and six boys, the questionnaire showed that the participants have a defined concept about what healthy eating means to them; they identify that food has to be nutritious, balanced, must have vitamins, be diverse, make you feel good about your physical appearance and should not contain excessive amounts of sugar or fat. They are also aware that exercise is the best way to burn food calories.

In the nutrition module, the participants are more interested on learn how to balance a diet and see how food affects their health jointly, but not as much as separated entities, as shown in Figure 6.1 referring to Question

2, this goes accord with the results given by the workshop in the nutrition category, where they requested recipes and know nutritional food values.

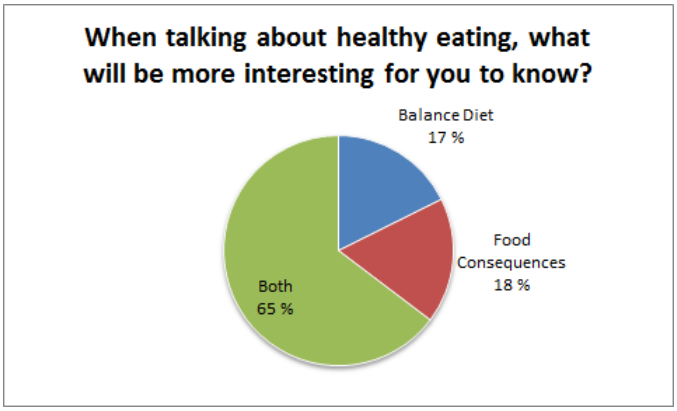

Figure 6.1: Question 2 percentages

Along with the results of the previous question about food consequences, the participants would like to visualize them both physically and emotionally inside the game according to Question 3, shown in Figure 6.2. However, the workshop showed that the children are slightly more interested in observing the physical consequences such as body changes, reflecting themselves into a character that mimics their behavior, or gets sick because of unhealthy food, as on the emotional side, they are just mainly interested of a character that becomes happy by eating healthy food and unhappy with unhealthy food.

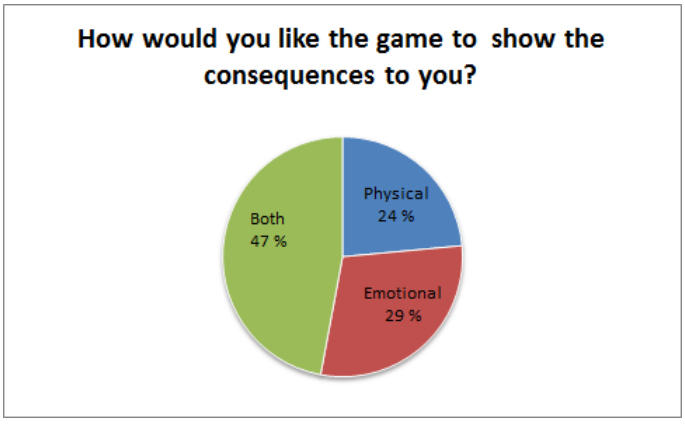

Figure 6.2: Question 3 percentages

In the exercise module, the participants are more interested on knowing the number of calories burnt while doing exercise than the number of steps made, as shown in Figure 6.3 related to Question 6. The results obtained in the workshop show that in the nutrition and exercise category, the participants are interested in calorie counting, both burn and ingested. While instead of counting steps and distance, they prefer exercise routines and daily training plan. One remark given by the participants is that the number of steps would be more relevant to them if they would have known beforehand the average number of steps and distance a person walks per day, so they can actually have a parameter to measure their performance.

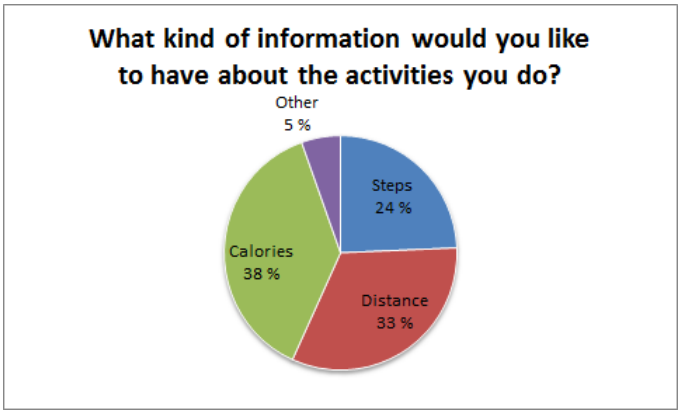

Figure 6.3: Question 6 percentages

The results of location preferences asked in Question 9, represented in Figure 6.4, show that the participants prefer a game that combines indoors and outdoors locations to encourage them to be healthy, this result can be due to a mix of interests, since some of the participants would rather exercise in a non-conventional way, such as dancing or try different routines involving cardio activities.

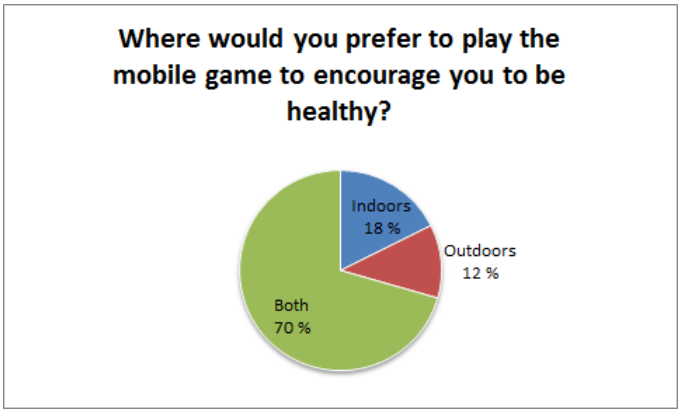

Figure 6.4: Question 9 percentages

Related to the players in the game, the participants have shown a high interest on competing against others than just see their own progress as shown in Figure 6.5 referring to Question 10. However, they would also like to have the option to switch from single player to multiplayer and the other way around, allowing them to challenge themselves and other players to improve their scores.

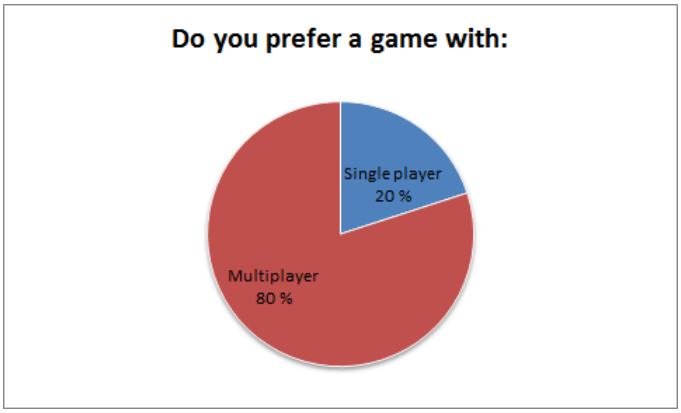

Figure 6.5: Question 10 percentages

This section has illustrated the most relevant aspects gathered through the questionnaire in the three categories and their relationship with the workshop results. The questionnaire can be found in Appendix A and the rest of the charts are in Appendix B.

6.4.4 Comparison with Preliminary Design

The purpose of the activities performed in the workshop was to verify the elements of the preliminary design and to gather new desired game features. The similarities section shows the aspects that match the first design whereas the differences part shows the new elements:

Similarities

- The game should have a representation of the user inside the game such a character.
- The character should reflect physical changes according to exercise and food.
- The number of calories should be presented in each food.
- A healthy level should be shown.
- The player should be able to feed their own character.
- Challenges and rewards in both modules.
- Nutrition data about food (such as amount of sugar and fat).
- Point system.
- User profile.

Differences

- Healthy recipes.
- Training routines.
- Healthy items and recipes should be present in the nutrition module.
- Show the amount of exercise required to burn meal calories.
- Physical activity to unlock items in the nutrition module.
- Suggestion of healthy food.

- Weekly challenges.
- Training plans per day.
- Multiplayer.

These results demonstrate that the preliminary idea was well oriented by trying to make the users identify themselves with a character in the game and being focused on show the potential physical changes on the character, as well as inform relevant data to the user about the food inside the game. However, the game should educate in both modules, it should tell the user which exercises to perform and how to prepare healthier food, instead of just measuring what the user do during the day and give a free choice of foods.

6.5 Requirements

Once that the desired features have been related to the preliminary design, the full set of relevant elements can be established as requirements, to define them only the Related column in tables 6.1, 6.2 and 6.3 will be use, some of the elements in those columns were grouped into one requirement, edited or change category for clarity purposes.

6.5.1 Game Design

- The game shall have a matching icon related to its topic.
- The game shall have an attractive name that reflects its topic and purpose.
- The game shall have all elements well distributed in the layout.
- The game shall have background music.
- The game shall be colorful.
- The game shall have different levels.
- The game shall have different criteria per each level.

- The user shall have different avatars to choose from.
- The user shall be able to customize his/her avatar.
- The game shall be usable offline.
- The game shall be a Role Playing Game.
- The game shall be multiplayer.
- The user shall be able to compete against other players.
- The game shall use a small amount of device resources.
- The game shall support different platforms.
- The game shall have 3D graphics.
- The game shall have a point system.
- The game shall have rewards
- The game shall have a ranking system
- The user shall be able to create his/her profile.

6.5.2 Exercise / Physical Activity module

- The module shall have step by step training plans.
- The module shall display the burned calories of each exercise.
- The module shall have training routines.
- The module shall have a daily training plan.
- The module shall have a training partner character.
- The module shall have different sports to choose from.
- The module shall have sport search functionality.
- The module shall have a dance section
- The module shall have a trainer character.

6.5.3 Nutrition / Healthy Eating module

- The user's avatar shall display physical changes for healthy eating.
- The user's avatar shall display physical changes for unhealthy eating.
- The user's avatar shall display emotions based on food choice.
- The module shall have a calorie counter
- The module shall contain different types of food.
- The module shall contain healthy recipes.
- The module shall display the amount of sugar consumed.
- The module shall display the amount of fat consumed.
- The module shall classify the food in healthy/unhealthy.
- The module shall suggest healthy meals.
- The module shall suggest healthy elements to combine with others to create meals.
- The module shall display the exercise equivalent based on food calories.
- The user's avatar shall have an "eating" functionality.
- The recipes shall be unlocked based on types of exercises performed.
- The game shall display the blood pressure related to calories intake

6.6 Elements for design

To specify the requirements that will be considered for the prototype design, the MoSCoW requirements prioritization technique will be used on each one of the modules.

MoSCoW stands for four hierarchical priority groups, where each group have the same requirement priority. Those groups are: (Ash, 2007)

- MUST have: Requirements are mandatory to be completed for the success of the project;
- SHOULD have: Requirements are important but not vital, they would be nice to have.
- COULD have: Requirements are wanted or desirable but not so important.
- WON'T have (also known as "wish list"): Requirements that won't be present in the deployed solution (as part of the time frame) but may be introduced later.

Therefore, the prioritization for this project is as follows:

Game Design

MUST have:

- The game shall have a matching icon related to its topic.
- The game shall have an attractive name that reflects its topic and purpose.
- The game shall have all elements well distributed in the layout.
- The game shall be colorful.
- The game shall be usable offline.
- The game shall use a small amount of device resources.
- The game shall have a point system.
- The game shall have rewards
- The user shall be able to create his/her profile.

SHOULD have:

- The user shall have different avatars to choose from.
- The game shall have different levels.
- The game shall have different criteria per each level.
- The game shall be a Role Playing Game.

COULD have:

- The game shall have background music.
- The game shall be multiplayer.
- The user shall be able to compete against other players.
- The game shall have a ranking system

WON'T have:

- The user shall be able to customize his/her avatar.
- The game shall support different platforms.
- The game shall have 3D graphics.

Exercise / Physical Activity module

MUST have:

- The module shall display the burned calories of each exercise.
- The module shall have a daily training plan.
- The module shall have training routines.

SHOULD have:

- The module shall have different sports to choose from.
- The module shall have sport search functionality.

COULD have:

- The module shall have step by step training plans.
- The module shall have a dance section

WON'T have:

- The module shall have a training partner character.
- The module shall have a trainer character.

Nutrition / Healthy Eating module

MUST have:

- The user's avatar shall display physical changes for healthy eating.
- The user's avatar shall display physical changes for unhealthy eating.
- The user's avatar shall display emotions based on food choice.
- The module shall have a calorie counter
- The module shall contain different types of food.
- The module shall classify the food in healthy/unhealthy.
- The user's avatar shall have an "eating" functionality.

SHOULD have:

- The module shall display the amount of sugar consumed.
- The module shall display the amount of fat consumed.
- The module shall contain healthy recipes.
- The recipes shall be unlocked based on types of exercises performed.

COULD have:

- The module shall display the exercise equivalent based on food calories.

WON'T have:

- The module shall suggest healthy meals.
- The module shall suggest healthy elements to combine with others to create meals.
- The game shall display the blood pressure related to calories intake

Chapter 7

Design

Once the requirements have been defined, the new application design will be described based on its main features. This chapter is meant to serve as a functional specification for the further implementation.

7.1 System Components

The system components should be, at minimum, a mobile application and a database:

7.1.1 Mobile application

The mobile application will be responsible of containing all the desired features, such as collecting exertion data produced by the user's physical activity, allow manually entering additional exercise data performed by the user, keeping a goal tracker, motivating the user to keep a healthy routine and making the user aware of the impact of his/her food and exercise choices.

7.1.2 Device Database

All relevant user information, tracking data, badges, goals, exercise routines, recipes, additional activities and character data generated must be stored for the mobile application to be managed and displayed. It should also contempt feature extensions such as social media (like e.g. as credential data and contacts), multiplayer, challenges among users and rankings.

7.2 Game Flow

The game flow integrates inner functionalities and user driven features. Once the profile is set, the user has the option to choose between three main modules: Home, Training and Recipes.

Home will be divided in three sections: the virtual character, the user's physical activity tracking and the badges section. The virtual character will have two main activities: Feed and Exercise. Whereas the physical activity tracking will have the option to visualize and add activities and goals, the badge section will show all the badges available in each of the modules.

The training module will contain a three-week routine plan. Each one of the weeks will be divided into its weekdays. Each day will contain a set of exercises that the user can complete.

The recipes module will display the different types of food categories. Once the user selects one category, a website will be launched with the selected category for the user to browse.

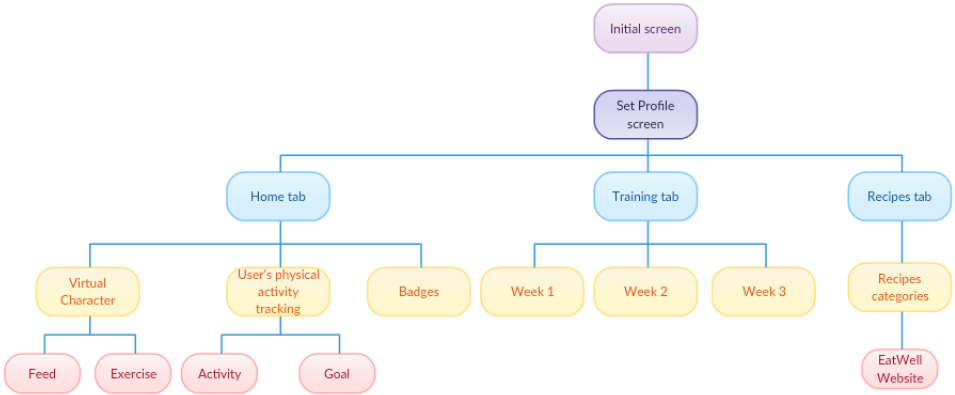

Figure 7.1: Game Flow

7.3 Mobile Application Overview

The game features consist of two categories:

- Inner functionalities - Regarding the data collection without the user intervention

- User driven features - Regarding the actions the users can perform that are provided by the application.

The latter category includes action that depends on the data collected as well as the raw data for the character simulation.

7.4 Inner Functionalities

7.4.1 Location and Tracking

Another key feature of the system is to detect and record the physical location of the user to determine the distance covered. Mobile Exertion Applications use data obtained from the built-in device (e.g. GPS) to get the real world location. However, this location acquisition process should be configured beforehand in order to first, save battery time and second to obtain the most reliable location.

The first configuration to be done is to allow the GPS to rest between location updates restraining in terms of distance, time or both, this configuration will reduce the accuracy of the location fixes but will save battery.

The second configuration will apply when a new location from the sensor is received, the sensor will return a few locations with a fix and they will be stored in a small buffer, once this buffer is full, the app must discard the remaining incoming locations and attend only the ones already stored in the buffer. Then it will select the best stored locations. Every location object given by the sensor has an accuracy value in meters (0.0 if an accuracy value is not associated), the app should get the ones whose accuracy fix value is the lowest and use those objects.

For the tracking feature, the app will gather the latitude, longitude and altitude directly through the GPS sensor, whereas effort, distance and time will be calculated.

Distance Metric

The GPS sensor will provide the location of the user in the form of latitude-longitude GeoPoint value. These GeoPoints can help to determine the distance between two of them.

Using the Spherical Law of Cosines (Veness, 2012), the distance between two GeoPoints will be calculated (in other words, the shortest distance over the earth's surface) using the following formula.

$$D = acos(\sin(\phi 1).\sin(\phi 2) + \cos(\phi 1).\cos(\phi 2).\cos(\Delta\lambda)).R$$

Where ϕ is latitude, λ is longitude, R is earths' radius ($\sim$ 6,371 km)

This formula will calculate the distance between two GeoPoints given by the sensor, and by adding different "segments", the total distance can be calculated. So, the more GPS location updates, the more accurate the total distance will be, however the total distance will always be an approximation due to this calculation uses straight lines between GeoPoints and does not consider curves that might exist in the physical world.

Time Metric

This metric will be calculated by saving a time stamp with every GeoPoint and then compare the time stamp of the GeoPoints used to calculate the distance.

Effort Metric

Effort will be measured by adding the number of calories burned (energy expenditure) while performing an exertion activity. There are different formulas to calculate this number which considers different variables such as gender, weight, time, heart rate, distance and inclination. However, obtaining the heart rate variable would have required additional devices. That is why the heart rate was replaced for distance. Furthermore, the distance is more meaningful to the user, as it represents actual user movement and provides suitable energy expenditure for the metric.

The next step was to determine how treadmills calculate the burned calories. They use speed, grade, weight and time spending exercising, however it is not so accurate due to the multiple metric conversions that need to be done and the assumption of being an 160lb male.

Due to these issues, the formula to be used will be the same as "my fitness pal" app (fitness pal, 2010):

$$CaloriesBurned = WEIGHT * 0.75 * DISTANCE$$

This formula was suggested on "My fitness pal" website as a simple way to accurately determine the calories burned while jogging. The weight has to be converted into pounds and the distance into miles using the following conversion:

$$1KG = 2,20462lb$$

$$1Km = 0,621371miles$$

One more thing to consider is the inclination the terrain can have or if the user is going through hills. To calculate the inclination, the altitude value should be compared to the previous established location to discern the inclines and use them to increase or decrease the effort value. Therefore, the formulas to use will be:

$$CaloriesBurnedDISTANCE((CBdist) = (WEIGHT{*}0.75){*}DISTANCE)$$

$$CaloriesBurnedINCLINE((CBinc) = (WEIGHT{*}0.75){*}INCLINE)$$

$$TotalCalories = CBdist + CBinc$$

Step Count

To calculate this value, the android built-in step sensors will be used.

The TYPE_STEP_DETECTOR sensor will be used to record the time stamp of each step incidence, however it should be used carefully since it has a high latency and the TYPE_STEP_COUNTER will be used to obtain the total accumulated number of steps since it was first registered in the app, this sensor has a low latency due to the processing to eliminate false positives making it more accurate.

7.5 User Driven Functionalities

7.5.1 Main Screen

The main screen (Fig 7.2) welcomes the user to the app and gives a small overview of the app functionality.

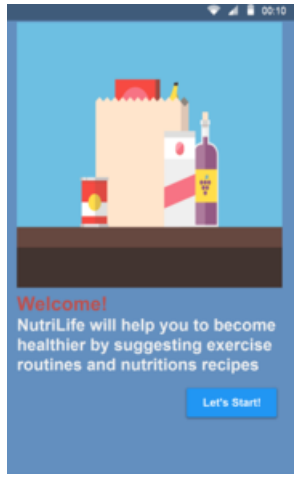

Figure 7.2: Main Screen

7.5.2 User Profile

The user profile (Fig 7.3) consists of five elements that are needed for the further calculations and that need to be input by the user. These elements are: Name, Age, Height, Weight and Sex. The name attribute can consist of the first and last name of the user and it will be used for the name of the virtual character in the game. The age will be used to determine the range of expected steps per day that the user must walk, Height will not be used for now so it is just an informative field representation, while weight will be used to calculate the user's effort (or calories burned) inside the app.

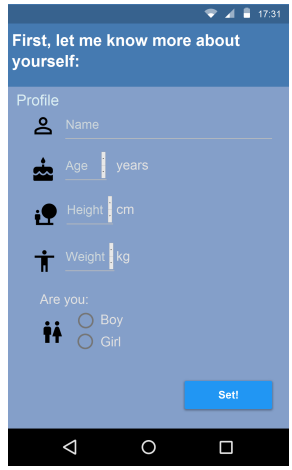

Figure 7.3: User Profile Screen

7.5.3 Home tab

Dashboard

The Home tab or the dashboard (Fig 7.4) is meant to show the user all the relevant information based on the collected data and the user's interaction with the app. It is divided in three main sections: The awareness section with a virtual character, the physical activity tracking section and the badges section.

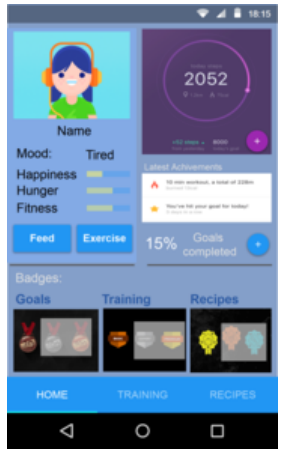

Figure 7.4: General dashboard

The sections descriptions are as follows:

Awareness Section

The awareness section (Fig 7.5) consists of a virtual character where the food and exercise choices inside the app will be reflected.

The character has the following attributes:

Picture: This picture represents the physical image of the character and it will match the genre of the user and will ”physically change” depending on the mood score, if the score is negative a ”fat” representation of the character will be displayed, if the score is positive, a ”healthy” version will be shown.

The picture will display different messages at random times of the day, explicitly saying what the character needs, either food or exercise.

Name: Same as the user's profile name.

Mood: The mood will be calculated based on the current food score, all the food that the character can eat will have a ”nutrition score” according to the Nutrition Scoreboard, if the score is negative (meaning that the character has ”eaten” only junk food) the mood will be negative as well, if the score is positive (meaning that most of the eaten food has been healthy) the mood will be positive too.

The corresponding mood will be if the score is:

- Greater than -15: Depressed
- Between -11 and -15: Bored
- Between 0 and -10: Tired
- Between 0 and 5: Calm
- Between 6 and 10: Pleased
- Greater than 10: Energized

Happiness: This attribute will display the nutrition score in which the mood is based, to emphasize the fact that food also can make us happy or avoid us from being happy depending in our choices.

Hunger: Here the times the character has been feed per day will be shown, and it will be divided in 5 sections as follows:

- Breakfast: 20%
- Snack 1: 20%
- Lunch: 20%
- Snack 2: 20%
- Dinner 20%

The progress bar will decrease by 20% when the difference between the current time and the last time the character was fed is greater than three hours and the "I am hungry" text will be randomly triggered if the condition is met. This decrement will represent and make the user aware that one meal is being skipped.

Fitness: This bar will represent the amount of steps the user is medically recommended to make during the day. This value will be taken from the research made by Tudor-Locke et al., for 6-12 year old girls is 12,000 steps/day and 15,000 steps/day for boys (Tudor-Locke et al., 2004). Each exercise the character can perform will have set a different amount of steps and will determine the progress in the bar. Once the recommend amount is reached the bar will be fully filled.

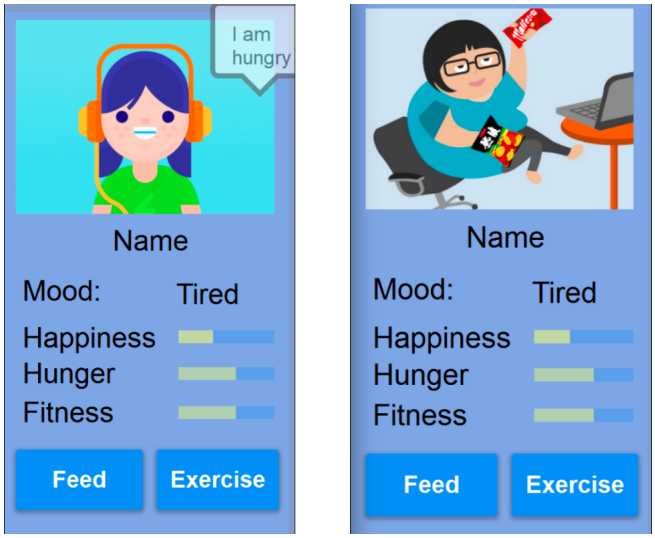

Figure 7.5: Virtual Character. Healthy and unhealthy version

Two actions can be performed to the character: Feed and Exercise.

Feed

The screen shown in figure 7.6 contains all the different options that the character can eat. The list contains junk food and healthy food, like breakfast, snacks, main dishes and desserts. It also offers healthy and unhealthy beverages. Every element is represented with a picture, a description and the number of calories contained in each one of them.

If the user clicks on any of the pictures, the corresponding standard nutrition facts will appear to provide more information to the user about what are they feeding to their character. The nutrition facts table will be taken from nutrition facts of FatSecret website (Secret, 2016).

To give each food a score, it will first be classified as ”Junk Food” or ”Healthy Food”, afterwards it will be ranked based on the number of calories in an ascendant order, where junk food will have negative numbers and healthy food positive numbers. The nutrition score will be updated accordingly once the user press the ”Eat!” button.

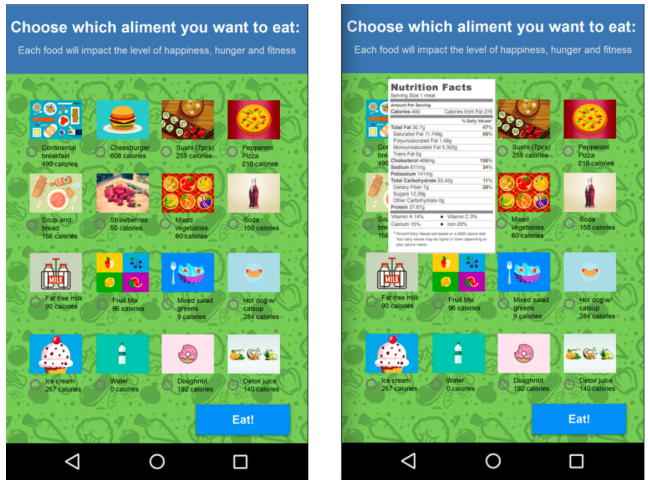

Figure 7.6: Feed screen

Exercise

The exercise screen (Fig 7.7) mainly contains different exercise activities that cannot be measured with a pedometer but that can still be converted into steps. Each activity has a number of steps to create the ”fitness score” of the character, the step value per minute will be taken from the ”Walk to the Moon” chart given by the Purdue University (University, 2006) and it

will be multiplied by 30, to be considered the as the amount of time the character will exercise each time. The chart can be found in Appendix C.

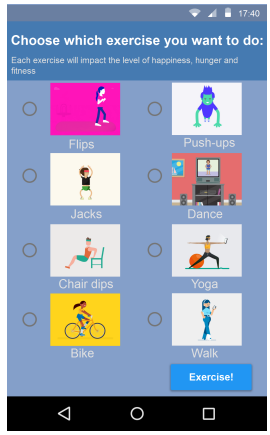

Figure 7.7: Exercise screen

Goals and Activity Performance Section

The screen (Fig 7.8) shows the current daily performance, the latest goal achievements and the percentage of completed goals. The data is mainly collected by the inner functionalities of the system. It is in this section where the user can see all the data related to the pedometer and GPS functionality per day.

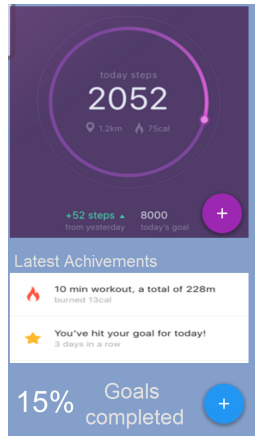

Figure 7.8: Goals and Activity performance screen

Current Daily Performance

In the current daily performance section (Fig 7.9) the user can see his/her performance as amount of steps, distance and the calories burned during the current day and add new activities, as a motivation element, the user can easily visualize how he/she has performed based on the previous day (either positive or negative).

If the user wants to see a more detailed performance, he/she just has to tap within this section and the ”Activities Overview” will be presented with the purpose of showing the user the history of all the activities performed, including the ones that the device cannot measure and which had to be input by the user manually. The data presented will be given in terms of time, steps and calories whenever it applies.

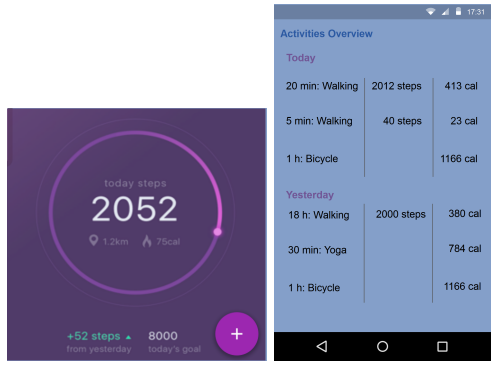

Figure 7.9: Current Daily Performance Sequence

Finally, the user is able to add activities (Fig 7.10) that either cannot be measured by a pedometer, that were not recorded due to the exercises' nature or any other factor. This screen will allow to describe the activity, assign it a type of exercise and the number of steps, calories or kilometers the activity was performed. In case this data is unknown for the user, he/she has the option to add the duration of the activity. All the activities showing in the type field will correspond to the ”Walk to the moon” chart found in Appendix C. When only the time is known the data will be given in steps.

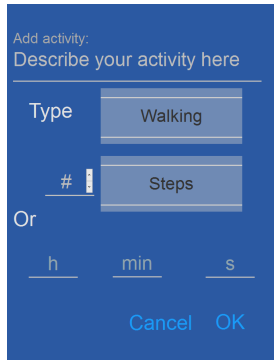

Figure 7.10: Add activity

Latest Achievements

The latest goal achievements section (Fig 7.11) is meant to motivate the user to keep reaching the goals that he/she predefined, it is a form of direct feedback.

If the user taps any of the achieved goals, and extra motivational message will be shown as a way to encourage the user to set a higher goal next time.

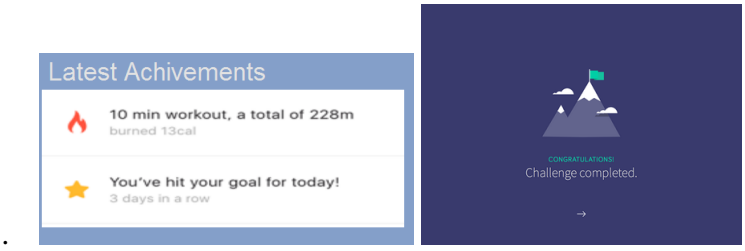

Figure 7.11: Latest Achievements

Percentage of goals completed

This section (Fig 7.12) will provide a numeric feedback, to give information about the overall status of goals completed. It also allows to create and add new goals to the pre-existing ones.

If the user taps on the percentage number of completed goals, the app will show the list of all goals based on calories, steps or type of activity.

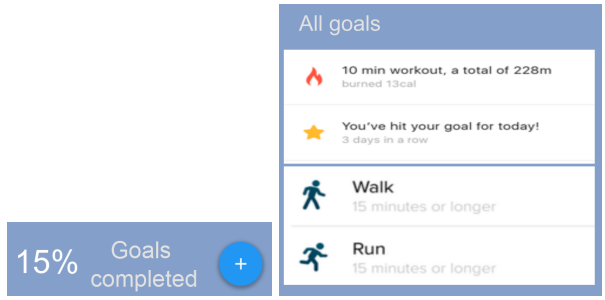

Figure 7.12: Percentage of goals completed

To create a new goal, the user must tap the add button (shown as a ”+” symbol) and screen will ask to describe the goal and give a target number of steps, calories or kilometers. (Fig 7.13)

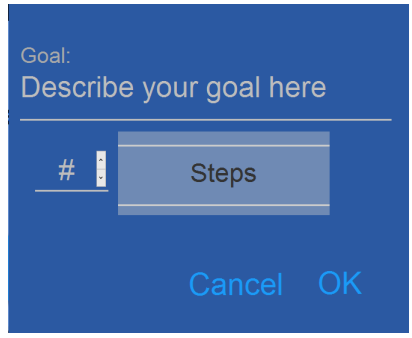

Figure 7.13: Add goal

Badges Section

As a reward, the app allows the user to collect badges depending on the activities that can be performed. It has three main categories: Goals, Training and Recipes. (Fig 7.14)

The goals and recipes section depends on the inner functionalities of the app and the usage consistency (such as step counting and goal setting), whereas training motivates the user to use the app and perform the suggested training routines.

Figure 7.14: Badges Section

Every time the user accomplishes the required amount of activities performed in any of the sections a new badge will be unlocked. The user can get more information about the badges by tapping on any badge, even if it is unlocked. (Fig 7.15)

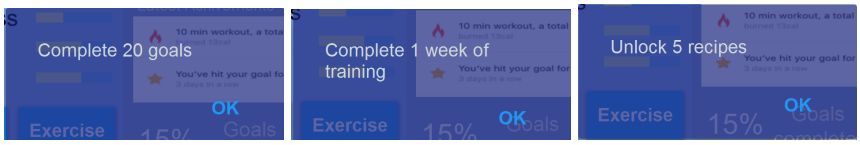

Figure 7.15: Badge Information

7.5.4 Training tab

The training tab (Fig 7.16) refers to the exercise module which main purpose it is to give the user exercise routines that they can follow. It contains three weeks of routines, having each day a full set of exercise routines. The user can select the day of the week he/she wants to complete and a list of exercises will show up. Each element in the list will specify its duration and the amount of calories to be burned.

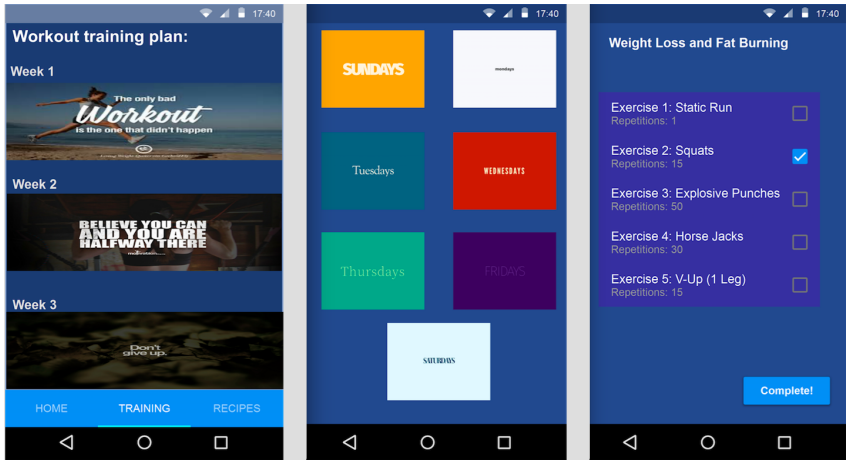

Figure 7.16: Training module screens

The exercises suggested per day are be taken from the American Council on Exercise: which is a nonprofit training provider and ”universal leader in group fitness, health coach and personal trainer certification” (American Council on Exercise, 2016) The calorie burned number will be given by online social network: FatSecret due to ”its comprehensive database of food nutrition facts” (Ma et al., 2010)

7.5.5 Recipes tab

The recipe section (Fig 7.17) will help the user to easily find healthy recipes online in various categories. In this section, the steps made during the day will act as a currency and the user can unlock more categories by ”spending” his/her steps. Once the user agrees to spend the steps, they will be deducted from the total amount of steps only in this section, the user will still be able to see the real amount of steps in the Home tab (Fig 7.4). When the user taps on any unlocked category, the EatingWell website will be launched in the browser, showing the recipes for the specific category.

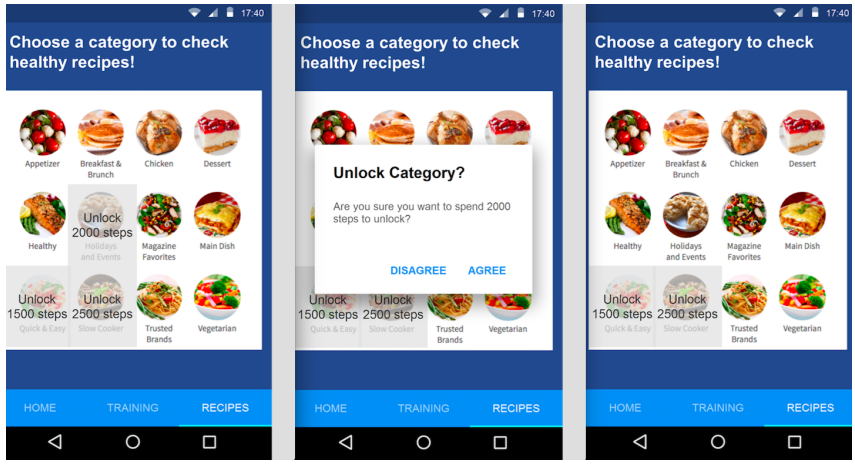

Figure 7.17: Recipe module screens

The food categories and the recipes are be taken from ”EatingWell, The Magazine of Food & Health” (Moran and Burson, 2014; EatingWell, 2016b) due to ”its inclusion of health consideration recipes for Diabetic and High Blood Pressure Diets” (EatingWell, 2016a).

7.6 Game Mechanics

The central concept of the game mechanics in this project is feedback loops that encourage learning. Such feedback will be found in the virtual character area.

If the user feeds the virtual character the states of hunger, happiness and mood will change, as well as the physical representation. If the character performs a physical exercise the states of hunger and fitness will be affected as well as its representation. The purpose of this kind of feedback is to make the user wonder about the effect caused by the given action.

Another application of this feedback is found inside the feed activity of the character. Once the user selects ”feed”, a list of available meals will be displayed, each with a corresponding picture and number of calories. The user can tap on any of the images and the system will show the nutrition facts of the selected meal.

The motivational elements can be found in the physical activity tracking area. This area will show the user’s latest achievements and the percentage of goals achieved. If the user taps in the former, a ”challenge completed”

image will be displayed, if the user taps in the latter, a list of achievements and goals will be shown.

The reward element will be available in the badges area. Once a predefined number of activities are completed, a badge will be unlocked and given to the user. Three levels of badges will be available to unlock to keep the user interested in performing activities inside the app.

Chapter 8

Evaluation

This chapter describes the execution and results of the design evaluation made with the target group and a presentation given to IT-related people.

8.1 Workshop

For the evaluation workshop, no introduction was given to the users. 4 android mobile phones (Samsung Galaxy SIII, Samsung Galaxy SII mini, HTC One and Moto G), 1 Iphone 6 and 2 laptops were set up previously. This workshop was focused on testing the main features of the application and to find new requirements.

8.1.1 Workshop 2: Trondheim, Norway 02-06-2016

Participants: 8th grade students. Eleven girls and six boys.

Where: Trondheim International School.

Duration: 45 minutes.

Details: The participants were divided in four groups of three persons, and three groups of two persons. Each of these groups were given either a laptop or a mobile phone with the prototype application running. For the first 15 minutes, the participants were asked to just try the app and write their opinions on a piece of paper. In the next 15 minutes the participants were asked to answer a questionnaire together with the app. The last 15

minutes were used to give a walk-through the app and to answer questions from the participants.

8.2 Questionnaire

After the participants tested the application they were given a questionnaire. This arrangement was made to measure the usability record the first impressions of the app without external stimuli. The questionnaire focuses on 4 main areas: Usability, Engagement, Motivation/Reward and Awareness. It also looked to identify new ways to motivate the participants. The questionnaire can be found in Appendix D

8.3 Presentation - Learning Technology forum

As a second evaluation for the prototype a presentation event was attended where current projects in the area of learning technology had been shown. The event was organized by the Computer Science department of NTNU and SINTEF and took place on 2nd June 2016 at DIGS in Trondheim, Norway. The participants of this event covered startups, companies, students and other academic people as well as general public. The task was to give a 1-minute elevator pitch per participant and 1 hour of project demonstration.

An introduction of the project was given as a form of elevator pitch to the audience. After that, a demo was set up for the audience to try. The demo consisted in a walk-trough of the main modules of the game and an explanation of the theoretical background for such modules. The participants were able to ask questions about design, motivation and theoretical background. They also were able to give input and impressions from their own technical background.

8.4 Results

This section describes the results from the evaluation workshop, the questionnaire and the presentation. It will also identify if all the features wanted were included and designed properly. It will describe the level of motivation and difficulty of get rewards, as well as the utility of the virtual character to raise awareness. All this according to the target group impressions.

8.4.1 Workshop

The 8th grades wrote their impressions while testing the app without previous introduction. Most of the comments were about the devices used, such as ”The app looks good but it scales weird and images are stretched”, ”It is very slow and the selection buttons are too small”. These issues were encountered due to the different types of devices and screen resolutions since the application was meant to be developed for Nexus 5 devices. Once the users were aware that those problems are not part of the app itself, they could focus on a more meaningful feedback.

The comments were:

- ”Go on other activities like meet friends or go to the cinema to become happy”.
- ”Easier to make it happy”
- ”Choose between different characters”
- ”Make the character look like the person you choose (Weight, height, etc).”
- ”More with the characters and easier words”
- ”See when the character is fat, like in layers”

The character was the focus of the participants' feedback. They wanted it to be more personalized, more options to choose from and they wanted it to be related more to the data in the profile screen. The participants found it a bit difficult to make the character happy, because the app was creating a cognitive conflict about the food given to the character. So, instead they suggested that the character should also involve social activities such as meeting friends to impact the mood. However social aspects were out of the scope of this project. As part of new requirements, the users would like to see the mood reflected in the character in addition to the physical changes.

8.4.2 Questionnaire

The sample for the evaluation questionnaire consisted of eleven girls and six boys. The user's needs were evaluated in 4 modules: Usability, Engagement, Motivation/Reward and Awareness. Additionally, a general question

section was evaluated. The participants were asked to test the application first and then answer the questions.

Usability

The usability was measured with a scale from 1 to 7, as 1 being really difficult and 7 very easy, as shown in Figure 8.1. The users were asked to perform a list of activities and give each activity an individual score. The results show that the navigation across the application was easy but in some parts troublesome for 47% of the participants. A few of the participants pointed out that the devices were slow and not working, however when they tried in a more stable environment the navigation was smoother. The activities overview screen was difficult for the users to find, due to the fact that there has not been an explicit signaling of where to find it. It aims to the user's intuition to tap in the current daily performance screen.

The virtual character received a high score, meaning that it was easy to feed and exercise. On the other hand, adding goals and activities received low and neutral scores from the participants who did not know they can perform those activities because they focused their attention on the virtual character.

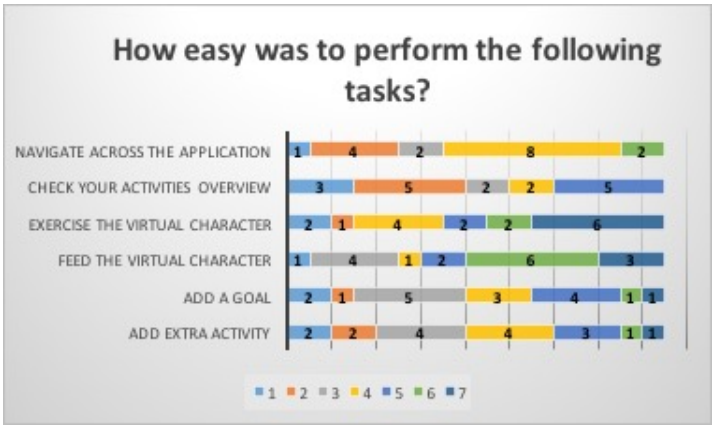

Figure 8.1: Usability section

Engagement

The engagement section consisted of two sets of questions, the first one, shown in Figure 8.2 looks to answer if all the features wanted where in-

cluded. The second set, shown in Figure 8.3 measures the level of user's agreement about the feature design.

The first set shows that the participants wanted all the features included in the application, even the ones that were not part of their requirements. Examples of these features are: badge collection, add activities and goals and visualization of improvements and achievements. However, the training section generated mixed opinions, this could be because during the design workshop the participants focused more in sports they do, instead of what would they like in an app.

As future requirements, the participants would like to have a tip section about the app, consider the sleeping activity of the character and consider a way to lose the game, such as the character dying.

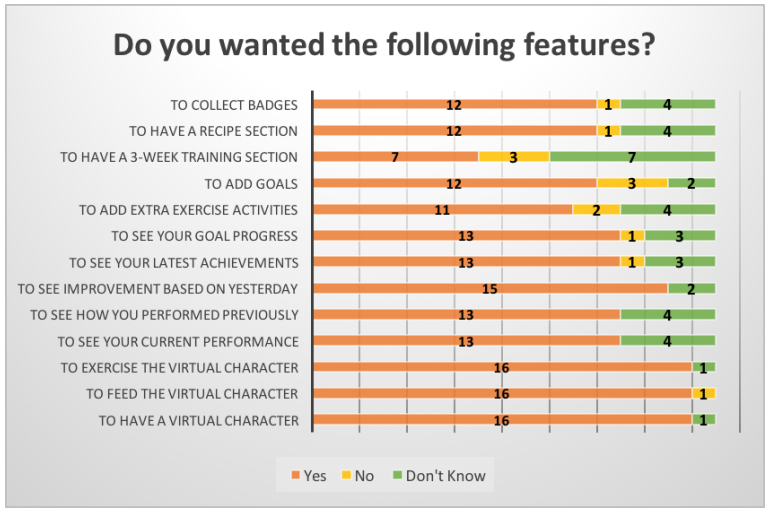

Figure 8.2: Engagement: Features wanted

The second set was evaluated with a scale from 1 to 5. Being 1 strongly disagree, 2 disagree, 3 neutral, 4 agree and 5 strongly disagree.

The results show that the participants are mainly neutral to the design, specially to the features that they did not request, as mentioned above. The level of agreement is higher in features they insisted to have, such as the recipe section and the virtual character

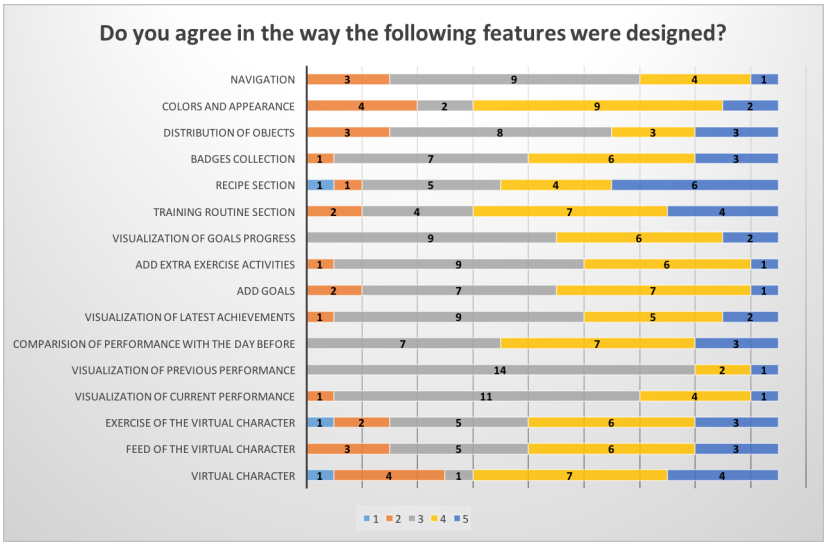

Figure 8.3: Engagement: Features design

The participants showed big interest in the app, the improvement comments were made mostly to the character and it's lack of personalization. They pointed out that the users should be able to choose between more avatars and have more options for the character.

Motivation and Reward

In the section of motivation, illustrated in Figure 8.4, the participants agreed on feeling somewhat motivated with motivation that does not come from the virtual character. In terms of it, the participants feel more motivated to take care of the virtual character but keeping the character happy generated mixed but consisted results. This consistency is due to the fact of the cognitive conflict. The participants feel highly motivated in looking for strategies to get a positive humor. However, when they realized that their own misconceptions make the character acquire a negative humor, some of them became frustrated and demotivated.

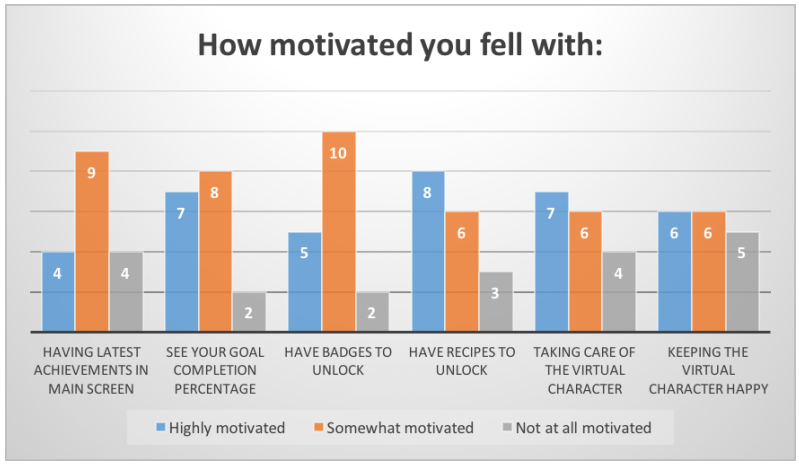

Figure 8.4: Motivation

The reward section was measured with a scale from 1 to 7, being 1 very difficult and 7 very easy. The results show that the participants are neutral about the difficulty.

The virtual character kept generating mixed options. The results indicate that the participants feel difficult to keep the character happy. This result is consistent with the cognitive conflict mentioned before.

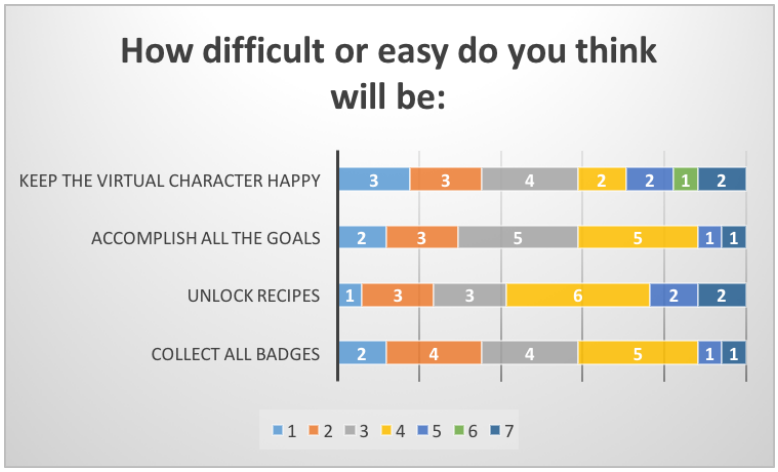

Figure 8.5: Reward difficulty

Awareness

The awareness section is intended to evaluate only the virtual character and its impact about food and exercise.

Most of the participants agreed on the fact that the virtual character has achieved its purpose of raising awareness. Even though the participants felt related to the character as if they were feeding themselves, they had mixed thoughts about using the character to balance a diet. This is because the participants ”eat different things” that are not in the list of meals for the character.

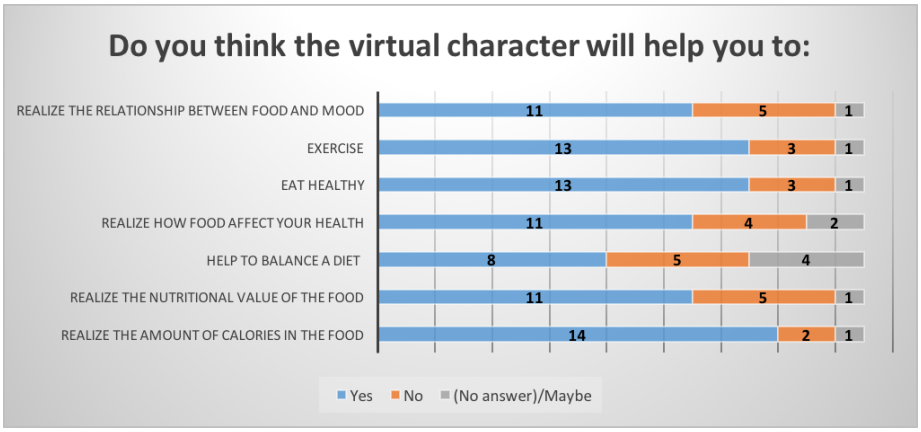

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Figure 8.6: Awareness with the Virtual Character.

General Questions

This section looks to investigate how the users feel about the app in general terms. It consisted in three questions about the usefulness of the app and design. The results show that 82% of the participants find the app useful, and 64% will use the app to improve their lifestyle. The design satisfied their wishes in terms of requirements and functionality.

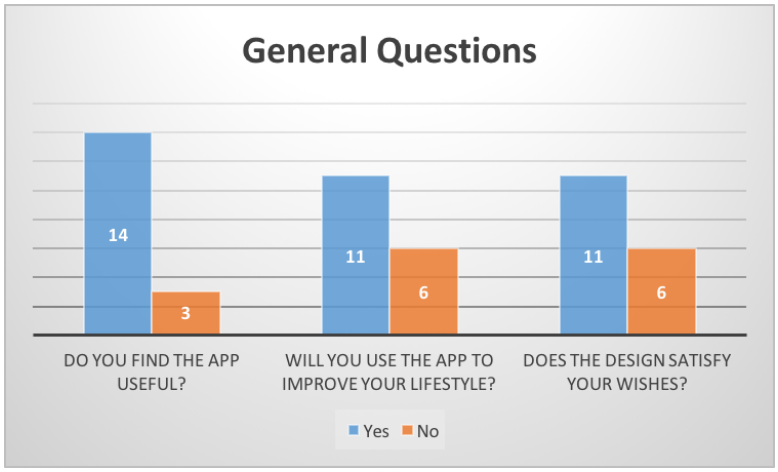

Figure 8.7: General Questions

8.4.3 Presentation

The participants expressed their interest in the virtual character as a way to encourage learning and awareness in children. They agreed that the ”Tamagotchi approach” can be helpful to show consequences in a safe environment. They also found the cognitive conflict as a powerful teaching strategy and a ”powerful mechanism to destabilize misconceptions and then build the new knowledge into solid foundations”.

Chapter 9

Discussion

This chapter restates the research questions, discusses and answers them based on the evaluation done in chapter 8. It also explores factors and limitations that might affect them.

9.1 Discussion of Research Questions

RQ1: Do children feel motivated to change their nutrition habits when mood changes are represented?

With the data gathered from the evaluation, this project has the potential to motivate and make users learn about healthy lifestyles. The persuasive cues such as the virtual character and understanding the user behavior prove to be the most effective.

The virtual character is perceived as a social actor, for some users it is a representation of themselves, for others it is a teacher and a guide. The character's humor and feelings are a great motivator for the users since they appeal to the thinking behind food. It is here where the cognitive conflict becomes so important: it makes the users ask "why?" to the reactions of the character.

This cognitive conflict can be illustrated with participants feeding ice cream to the character with the intention to make it happy, but instead the character becomes sad and fat. The reason of the character becoming sad and fat is because ice cream is in the "junk food" category lowering the happiness status. The participants needed to leave behind their conceptions

about junk food and realize that fruit (and healthy food in general) is what makes the character happy.

This cognitive conflict is a complex strategy and needs to be used carefully. The data shows that users can easily get annoyed or frustrated because they hold to their own misconceptions and they don't want to break them.

RQ2: Can the "Tamagotchi approach" help the user to feel more aware about nutrition, mood and exercise?

The results show that at least 50% of the participants think the virtual character can raise awareness about food, mood and exercise. However, the social role of the character is really important in this aspect. The user will feel more aware when they identify themselves with the character. They use the character to see the consequences of their choices and the character will provide a safe environment. This can motivate the user to try new meals or exercises if the character reacts having a good mood and status.

If the role given to the virtual character is a teacher or a guide, then the user is more likely to learn from it. The consequences applied to the character help the user to understand what is healthy and what is not. By breaking misconceptions, the user can become more aware of what she/he eats, how much she/he exercises and how the mood is affected.

The users criticize the lack of social interactions for the character and minimum customization, as they would like to have other ways to make the character happy. Involving social interactions will have reduced the impact of the cognitive conflict and most likely the users would adopt the role of social experience seekers. A peak of this tendency is found during the first workshop. The participants have a clear idea of the social interaction and the items they would like to have to customize the character but they did not have ideas regarding the character's functions. This means that the users would prefer to focus on the physical appearance of the character (including clothes, accessories and possessions) instead of realizing the food-mood relationship.

If the social interaction is represented in a way of competition among other users' characters, then the users will adopt the role of achievers. This competition can motivate the user to have a happy and healthy character in comparison with the others. To achieve this, the user must create strategies and understand how nutrition, mood and exercise relate to each other.

RQ3: Can mood, nutrition and exercise combined together help chil-

dren to improve their current lifestyle?

The evaluation shows that 82% of the participants find the application useful and 64% would use it to improve their lifestyle. Despite these good numbers, the real impact needs to come from the application in practice. The difference between being a useful app and being used by the participants rely on the fact that, the target group is already a healthy one and that they probably don't need to improve, but rather stay on track.

The application will need to be tested for a prolonged amount of time in children with different lifestyles and different environments, for example in a country where children obesity is significantly higher that in Norway. A detailed track should be performed in order to know if the lifestyle was improved.

9.2 Limitations

9.2.1 Tool limitations

The prototyping tool used in this project had a few limitations in functionality. These limitations hindered the development of a better look and feel for the prototype. One of these limitations was the lack of native android components, in order to use dropdown list, iOS components had to be used.

Another limitation was the lack of emergent screens, these had to be built from scratch and they did not function well within layers. So more screens than needed had to be built in order to represent them.

The third limitation was that the project could have not been customized to one type of phone. So, the application had to be tested in the same type of phone as it was set in the project. The screen resolution did not adapt itself to the phone screen when other sizes of screens were used.

The persistence of the data limited the design. As there was no proper database where to store the user and status data, variables had to be used to show changes across the prototype application. However, variables were also limited in the used tool, they could have been used in text areas but not in the character's progress bars. To reflect the status in these bars, they had to be rebuild and change their value every time the user clicked on a radio button associated to food or exercise.

The last limitation was the lack of memory and CPU management for the application. This was a bit troublesome when testing in devices with

different hardware specifications. Old phones struggled with animations and transitions, whereas better phones had just a bit of lag between screens.

9.2.2 Methodology limitations

The quantitative data from this project comes from questionnaires and the qualitative data from the workshops and participants' comments and notes.

The quantitative data method comes with the challenge of designing clear questions that cannot be misunderstand. The questions that asks openly for the participant's opinion resulted in blank data most of the times, because they thought it was not mandatory to answer them. Checking all the questionnaires while with the students has been difficult due to the amount of time available. The questions where the users had to choose a score gave neutral data. Questions in a Yes/no format or with well-established options gave the most meaningful information since the users had to actually think about the options and choose one.

The qualitative data had to be reviewed while the participants were there. Notes and comments were mostly ambiguous because the ideas were not written in detail. The participants preferred to explain in detail and draw/write just what they think illustrated the whole idea.

Another limitation is that the questionnaires were mostly tailored to the users. The evaluation questionnaire was meant to know if everything that the users wanted were considered and how they feel about it. This tailoring would have made it difficult to evaluate the design with other participants than the others from the first workshop.

9.2.3 Evaluation limitations

One of the challenges in the evaluation was to have proper phones to run the application, five phones were set up but they all had different technical specifications and screen resolutions. This together with the limitations of the prototyping tool created delay in the transitions, blank spaces in the screens, smaller icons and some of the phones even crashed. These influenced the answers from the questionnaire and the participants' comments.

Another limitation was the duration of the workshops. The participants had just a few minutes to test the application and write their impressions. The application walk-through had to be done as fast as possible and with

only the main concepts. This could have lead the users to not know where and how to use all the features.

Chapter 10

Conclusions

This chapter presents the general conclusions of the project and the contributions made and give recommendations for future work.

10.1 Conclusions

This project explored the potential of pervasive games to support healthy lifestyles. It provides feedback about behavior and knowledge about a healthy lifestyle. The project gives an insight of motivational factors that can be used to change a user's behavior. Thus, fulfilling the objectives of this research.

The research questions are answered and provide indicators that show the potential of mixing mood, nutrition and exercise in a pervasive game.

The project shows interesting results on a cognitive level and can be used as the prototype of a new powerful learning tool. IT people and the target group reacted in the same way when they did not get the expected results while feeding the character. This is an indication that this kind of projects can be used not only for children but also for grown up people.

The project received positive feedback from the target group and from industry people showing that this project can be adapted to different target groups and areas such as nutrition, biology, learning, prevention, therapy and awareness.

This project was developed as a preventive game, with the aim to raise awareness and give all the needed information to the user. However, it

ended up being much more. It has the potential to be used as a learning tool since informed choices need to be made, as well as a therapeutic game. It can be included in both categories (Preventive and Therapeutic) because it monitors the user's physical activity and creates a safe environment for the users to reflect themselves in the character.

10.2 Contributions

The contributions given by this project are:

- Propose to add the influence of the mood to exergames and games for health
- 3-way solution to support healthy lifestyles (Nutrition, Exercise and Mood)
- Cognitive conflicts generated by the user's choices to generate new and solid knowledge
- Design of a pervasive game using the "Tamatgochi" and exergame approach
- Proposed to add persuasive design to change user's behavior

So far, pervasive games have been explored in only one area, either nutrition (either simulation or monitoring) or exercise, but not combined together. A new aspect which previous games have not considered is the mood as a consequence of the nutritional habits.

This project tries to start a new path within pervasive games, it is not only about monitoring the user's activities or keeping a character happy just because it got food. This project is about raising awareness and generate knowledge in the most "human" alike way. This means that brain processes, nutrition facts, health and amount of exercise should be considered to generate the most adequate reaction in the character.

10.3 Future Work

This project can be improved in terms of new requirements given by the target group, listed below:

- Consider the sleep activity for the character.
- Add more activities for the character, such as visit friends.
- Make the game multiplayer
- Show the mood changes in the character's avatar.
- Change screen colors depending on the users mood and health.
- Add more characters to choose from
- Customize the character with the settings in the profile screen.
- Categorize the food in junk/healthy or Desserts/Meals/Drinks, etc.
- Add more food options
- Make the exercise function more dynamic. Use hand movements to exercise the character.

Further proposed improvements are an adaptation of the app for parents and teachers, while make it more children friendly towards younger users.

Improvements can also be made in terms of motivation.

- Multiplayer and competition can be a good way to motivate the user to play the game.
- Different levels in the exercise section for the character can simulate a better level of fitness.
- The character can eat the same as the user, if the users provides a picture of the food, as well as exercise if the users gives a proof that she/he has also done it. These elements from the user's daily life can help to engage the user in a deeper level and motivate it to use the app.

Iterative approach for further development is encourage as well as increase user interactivity within the virtual environment. Discussion and reflection among stakeholders can increase the ultimate effect. (De Freitas et al., 2010)

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Appendix A

Requirements Questionnaire

We're developing a mobile game (app) to encourage a healthy lifestyle – to help you be more active and eat better. We would really like to know what you would like in this game.

Nutrition Module

1. In your own words, describe what does healthy eating means to you.

---

2. When talking about healthy eating, what will be more interesting for you:
   [ ] To learn how to balance a diet
   [ ] To see consequences of how food affect your health
   [ ] Both

3. If you chose the consequences of how food affects your health, how would you like the game to show it to you?:
   [ ] As an image of a physical body
   [ ] As an indication of your mood (Emotional)
   [ ] Both

4. Are you aware that eating healthy can drastically change your mood and improve your way of life?
   [ ] Yes [ ] No [ ] Not sure

Exercise Module

5. Which kind of physical activities do you currently practice? (You can select more than one answer)
   [ ] Running [ ] Biking [ ] Swimming
   [ ] Football [ ] Handball [ ] Skiing [ ] Other_____

6. What kind of information would you like to have about the activities you do? (You can select more than one answer)
   [ ] Number of steps you take [ ] Number of calories burnt
   [ ] Distance you've moved [ ] Other_____

What would you like in a game (or a mobile app) to encourage you to lead a healthy life?

7. The game will consist of an exercise and a nutrition module. Would you like them to be:

   [ ] Separated modules [ ] Modules related to each other [ ] Don't care

8. How will you relate the your physical activity with what you eat? Give some examples. You can be very creative here.

---

9. Where would you prefer to play the mobile game to encourage you to be healthy?

   [ ] Indoors (house environment) [ ] Outdoors

   [ ] Both

10. Do you prefer a game where:

    [ ] You are the only player (single player)

    [ ] You can compete against other players within the game (you are able to see how your scores compare with others)

11. Would you like to have challenges in the game?

    [ ] Yes [ ] No

12. If yes, which kind of challenges would you like to have?

---

13. In the game, would you like to:

    [ ] Take care of yourself as a character

    [ ] Take care of another character (a pet)

Thankyou 

Appendix B

Requirements charts

B.1 Charts from the Requirements questionnaire.

B.1.1 Nutrition Module

Question 0

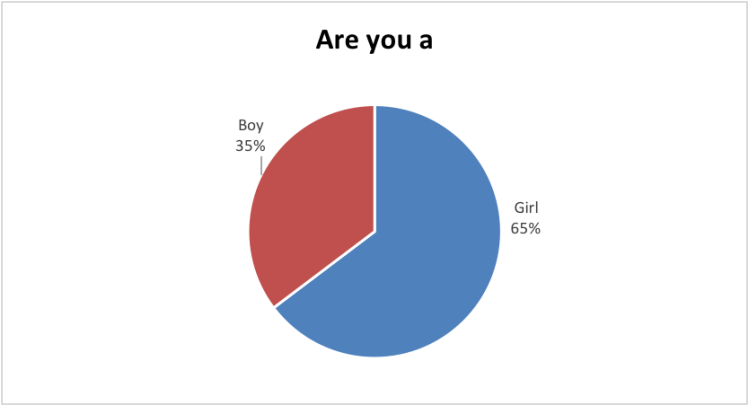

Figure B.1: Participants' sex

Question 2

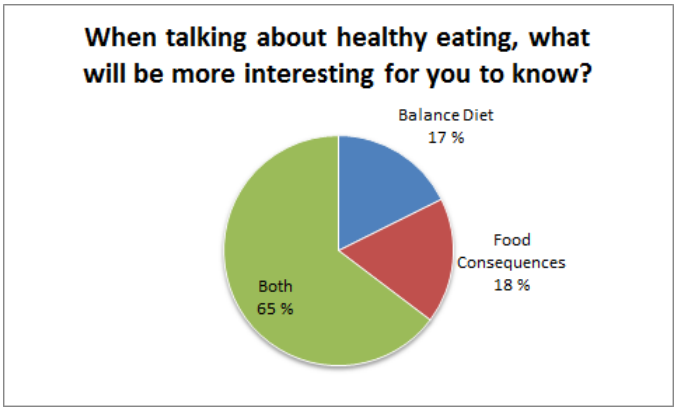

Figure B.2: Question 2 percentages

Question 3

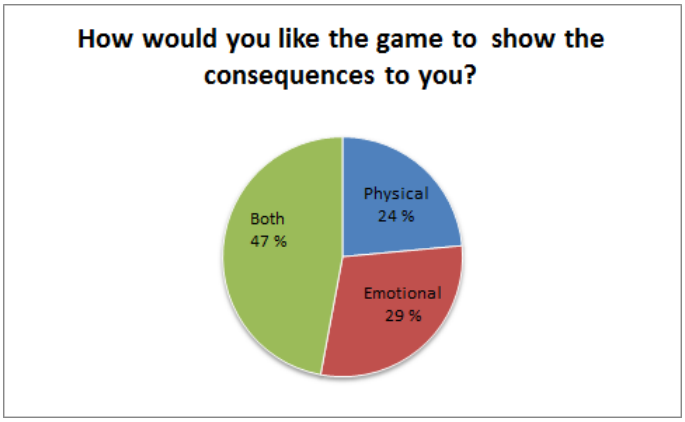

Figure B.3: Question 3 percentages

Question 4

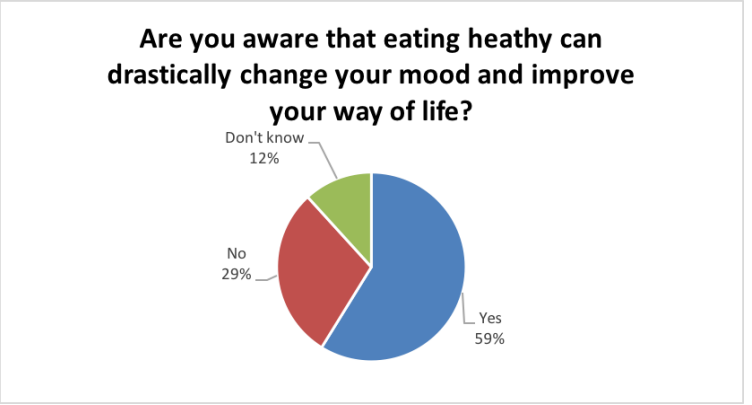

Figure B.4: Question 4 percentages

B.1.2 Exercise Module

Question 5

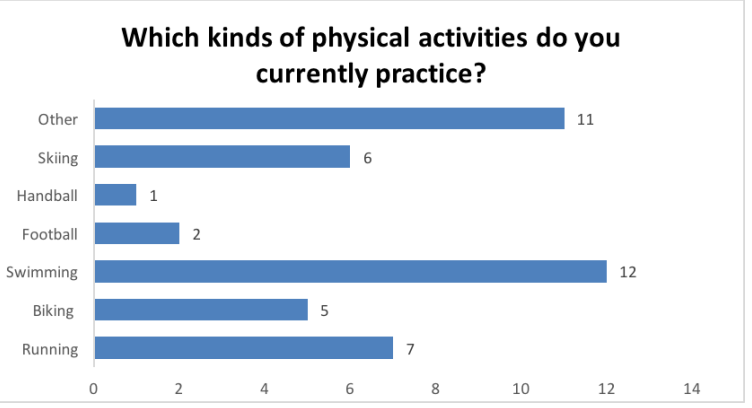

Figure B.5: Question 5 percentages

Question 6

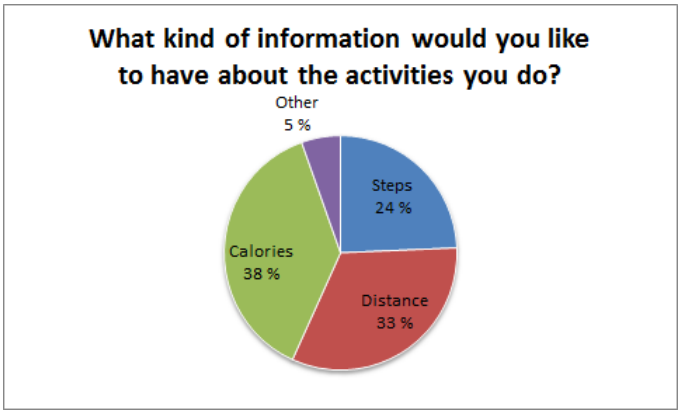

Figure B.6: Question 6 percentages

B.1.3 Game Design

Question 7

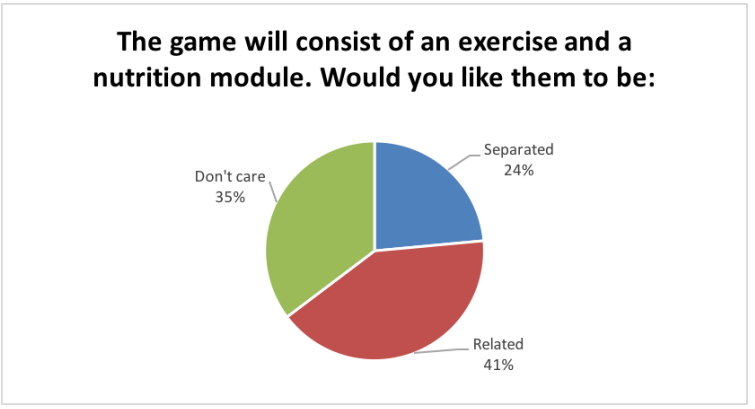

Figure B.7: Question 7 percentages

Question 9

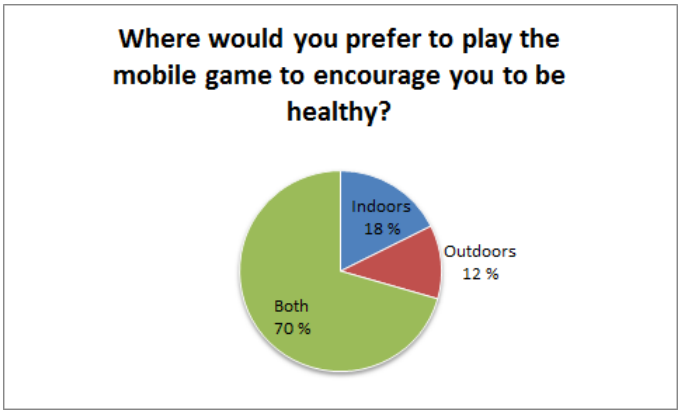

Figure B.8: Question 9 percentages

Question 10

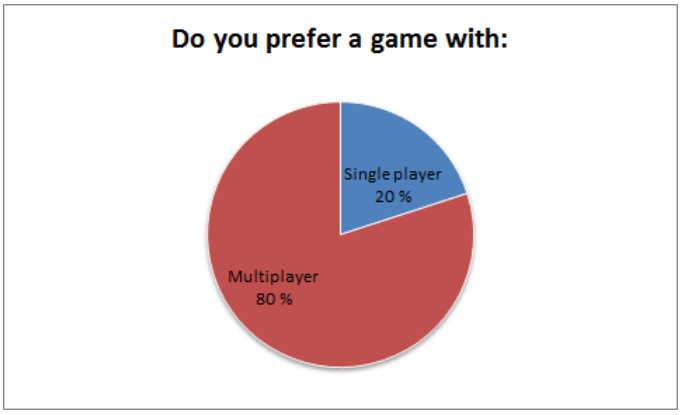

Figure B.9: Question 10 percentages

Question 11

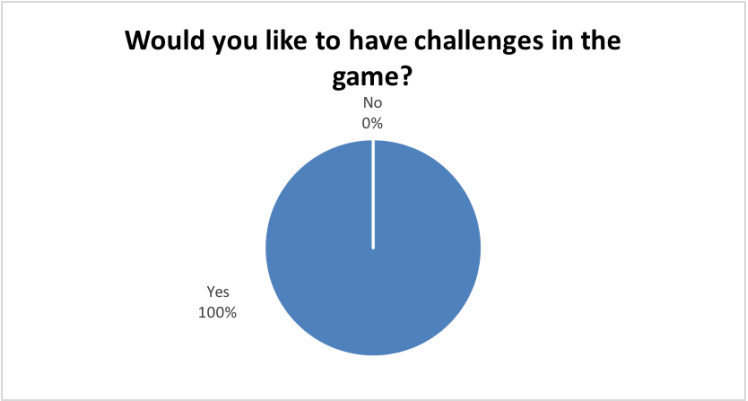

Figure B.10: Question 11 percentages

Question 12

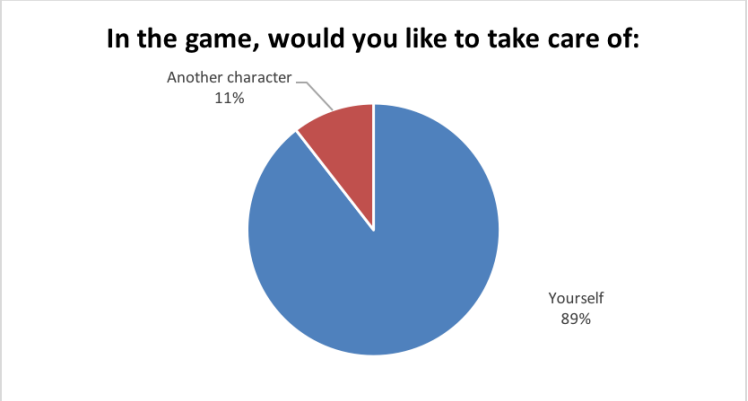

Figure B.11: Question 12 percentages

Appendix C

Walk to the moon chart

Activity to Steps Conversion Chart

	Average steps per minute*	
Activity	**Male**	**Female**
Badminton	136	136
Ballet Dancing	118	127
Basketball (game)	212	145
Basketball (leisurely, non-game)	165	163
Bicycling (BMX or mountain)	236	218
Boxing, competitive	222	209
Boxing, non-competitive	131	125
Canoeing	106	106
Cheerleading	100	100
Circuit Training (General)	212	199
Cycling (Road)	212	199
Cycling, stationary (light)	142	145
Cycling, Stationary (moderate)	189	181
Cycling, Stationary (vigorous)	283	254
Dancing (General)	118	109
Dancing Ballroom (Fast)	118	109
Dancing Ballroom (Slow)	71	73
Fencing	182	182
Football (Casual)	189	181
Football (Competitive)	260	225
Frisbee	91	91
Golf (General)	118	109
Gymnastics	121	121
Handball	364	364
Hiking	182	182
Hockey (Field and Ice)	242	242
Horse riding	121	121
House Cleaning	90	90
Ice Skating	189	181
Judo & Karate	260	254
Kayaking	152	152
Kickboxing	290	280
Lacrosse	242	242
Lawn mowing (non ride-on)	151	151
Martial Arts	303	303
Pilates	94	91
Rock/Mountain Climbing	273	273

Activity to Steps Conversion Chart

Roller Skating	212	212
Rowing	189	181
Rowing Machine	212	212
Rugby	303	303
Sailing/windsurfing	91	91
Scuba Diving	212	212
Skateboarding	152	152
Skiing	165	145
Softball	152	135
Spinning	200	200
Squash	364	364
Step Class	272	272
Surfing	91	91
Swimming (Backstroke)	189	181
Swimming (Butterfly)	283	272
Swimming (Front crawl)	212	199
Table Tennis	121	121
Tennis	212	199
Trampoline	90	90
Volleyball	118	91
Water Aerobics	121	121
Water Polo	303	303
Wheelchair Basketball	165	163
Wheeling	101	101
Wrestling	165	146
Yoga	71	54
Zumba	148	148

Chart adapted from http://www.purdue.edu/walktothemoon/activities.html

*Please be aware that this conversion chart is an estimation of average steps per minute. If you would like more accurate record of your activity please visit the Useful Links page for information on downloadable apps and pedometers.

Simply multiply the number of steps by the number of minutes active to calculate your total steps. You can then either log them as steps on the Log Your Miles page or use the converter to change them to miles or Kilometres.

Appendix D

Evaluation Questionnaire

We're developing a mobile game (app) to encourage a healthy lifestyle – to help you be more active and eat better. We would really like to know what you think about the current design

Are you a?

a) Boy b) Girl

Usability.

We want to know how easy or difficult was for you to perform the following tasks:

	Very Difficult 1	2	3	4	5	6	Very Easy 7
1. Add an extra activity:							
2. Add a goal:							
3. Feed the virtual character							
4. Exercise the virtual character							
5. Check your activities overview							
6. Navigate across the application							

Engagement

Please tell us if you wanted the following features:

	Yes	No
1. To have a virtual character		
2. To feed the virtual character		
3. To exercise the virtual character		
4. To see your current performance		
5. To see how you performed previously		
6. To see your improvement based on the day before		
7. To see your latest achievements		
8. To see your goal progress		
9. To add extra exercise activities		
10. To add goals		
11. To have a 3 weeks training section		
12. To have a recipes section		
13. To collect badges		

If there are any features that you wanted but that the are not mention in the list, please write them:

Do you agree in the way the following features were designed:

	1 strongly disagree	2 disagree	3 neutral	4 agree	5 strongly agree
1. Virtual character					
2. Feed of the virtual character					
3. Exercise of the virtual character					
4. Visualization of current performance					
5. Visualization of previous performance					
6. Comparison of performance with the day before					
7. Visualization of latest achievements					
8. Add goals					
9. Add extra exercise activities					
10. Visualization of goal progress					
11. Training routine section					
12. Recipe section					
13. Badges collection					
14. Distribution of objects					
15. Colors and appearance					
16. Navigation					

How can we improve the design?

Motivation & Reward

Tell us how motivated you feel with:

	Highly motivated	Somewhat motivated	Not at all motivated
1. Having your latest achievements in the main screen			
2. See your goal completion percentage			
3. Have badges to unlock			
4. Have recipes to unlock			
5. Taking care of the virtual character			
6. Keeping the virtual character happy			

Which kind of features that are not included in the design will make you feel motivated?

How difficult or easy do you think will be:

1. Collect all the badges							
2. Unlock recipes							
3. Accomplish all the goals							
4. Keep the virtual character happy							

Awareness

Do you think the virtual character will help you to:

	Yes	No
1. Realize the amount of calories in the food		
2. Realize the nutritional value of the food		
3. Help to balance a diet		
4. Realize how food affect you health		
5. Eat healthy		
6. Exercise		
7. Realize the relationship between food and mood		

Do you find the app useful?

a) Yes b) No

Will you use the app to improve your life style?

a) Yes b) No

Does the design satisfy your previous requirements?

a) Yes b) No

Is the design better or worst than what you had in mind?

a) Better b) Worst

If you have any comments regarding the app design or functionality, please write them:

Thank you 

Appendix E

Prototype

The online version of the prototype can be found in:

https://almavalencia.proto.io/share/?id=7b714cc4-2c8b-44bd-8443-724a5aae1e61&v=11