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CCMUG: A Model for the Development of Mobile and Ubiquitous Games Focused on Chronic Diseases

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Dissertação apresentada como requisito parcial para a obtenção do título de Mestre em Computação Aplicada pela Universidade do Vale do Rio dos Sinos — UNISINOS

Advisor:
Prof. Dr. Cristiano André da Costa

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ABSTRACT

Chronic diseases are the main cause of mortality in the last few decades, accounting for 59% of all deaths in the world. It is possible to prevent the development of such diseases using tools and methods that instruct the population. One way to achieve this goal is by using games, since they make it possible to teach subjects to the users, without them actively knowing that they are learning new concepts. Through a mapping study, it was possible to identify existing works that employ games focused on chronic conditions, however these works cover a reduced range of these conditions, are mainly targeted towards a younger audience and the majority is of a specific genre, exergames. In this context, this work proposes a model, named CCMUG, for the development of mobile and ubiquitous games that address chronic diseases. The contribution of our work is the definition of a model for the development of games for awareness focused on chronic diseases, subdividing the model into components with relationships between them. Unlike the related work considered, there are no restrictions regarding the type of game, target audience and chronic disease addressed. The model aids in the development of games of the most varied genres, for different chronic conditions and individuals of all ages. We conceived the design and developed a mobile game focused on HIV/AIDS, based on the model proposed in this work. We then conducted a individual evaluation with a group of Digital Games undergraduate students of Universidade do Vale do Rio dos Sinos (Unisinos), with the objective to qualify the design of the game. The results obtained show that the game assumes its role of entertaining the players and teaching them concepts regarding the chronic condition. Furthermore, we identified aspects of the design to be improved in the development of the game prototype. Afterwards, we conducted a second evaluation, employing the focus group methodology, with a group of six students who participated in the first evaluation. The aim of this evaluation was to identify if a narrative should be used in the game and, if so, how it should be designed. The participants agreed that the use of a narrative would be beneficial in a game that tries to teach new concepts to the players, but it should be well elaborated. Through the focus group, we conceived a narrative for the game as well as additional features originated from the story. Then, we conducted an evaluation on the prototype after its development to assess the user enjoyment of the game. It was based on a modified version of EGameFlow, a survey that serves as a scale of measurement of the enjoyment and fun of the users in e-learning games. EGameFlow is divided in several dimensions that are assessed with the mean and standard deviation of the answers of the participants. The participants played the game and answered the questionnaire. Overall, all dimensions scored satisfactorily, showing that the prototype is considered to be fun and enjoyable for the players. The last evaluation of this work gathered opinions of game developers to ascertain the validity of our model, its components and relations for developing games focused on chronic conditions. This step occurred as a individual structured interview that followed a explanation of the proposed model and the developed prototype. There

were no requests to remove, add or drastically change any component of our model, only minor corrections were applied. Overall, the results are positive and all developers fully agree that our model can be used to develop games, mobile or ubiquitous, focused on chronic conditions without the restrictions identified in the related works. The results confirm that CCMUG can be used as a guideline to develop games in this context. However, more evaluations with different prototypes focusing on other chronic diseases are planned as future works.

Keywords: medical informatics. chronic diseases. chronic conditions. mobile games. ubiquitous games. serious games.

RESUMO

Doenças crônicas são a principal causa de mortalidade, representando 59% de todas as mortes do mundo. É possível prevenir o desenvolvimento da doença por intermédio de ferramentas e métodos que instruem a população. Uma forma de alcançar esse objetivo é utilizando jogos, visto que eles possibilitam ensinar assuntos sem que os usuários tenham consciência de estarem aprendendo novos conceitos. Através de um mapeamento sistemático, foi possível identificar trabalhos existentes que empregam jogos no âmbito de condições crônicas, entretanto tais trabalhos abrangem uma gama reduzida dessas condições, são principalmente direcionados para um público jovem e a maioria é de um gênero específico, exergames. Nesse contexto, este trabalho propõe um modelo, chamado CCMUG, para o desenvolvimento de jogos móveis e ubíquos com o foco em doenças crônicas. A contribuição do nosso trabalho é a definição de um modelo para o desenvolvimento de jogos móveis e ubíquos para conscientização focados em doenças crônicas, subdividindo o modelo em componentes com relações entre eles. Diferentemente dos trabalhos relacionados considerados, não há restrições quanto ao tipo de jogo, público-alvo e doença crônica abordada. O modelo auxilia no desenvolvimento de jogos dos gêneros mais variados, para diferentes condições crônicas e indivíduos de todas as idades. Foi concebido o *design* e desenvolvido um jogo móvel que aborda o tema HIV/AIDS com base no modelo proposto neste trabalho. Em seguida, realizamos uma avaliação individual com uma turma de graduandos de Jogos Digitais da Universidade do Vale do Rio dos Sinos (Unisinos), com o objetivo de qualificar o *design* do jogo. Os resultados obtidos constatam que o jogo concebido desempenha sua função de entreter os jogadores e ensiná-los conceitos sobre a condição crônica. Além disso, foram identificados aspectos do *design* a serem aprimorados no desenvolvimento do protótipo do jogo. Posteriormente, realizamos uma segunda avaliação, empregando a metodologia do grupo focal, com um grupo de seis alunos que participaram da primeira avaliação. O objetivo desta avaliação foi identificar se uma narrativa deve ser usada no jogo e, em caso afirmativo, como ela deve ser projetada. Os participantes concordaram que o uso de uma narrativa seria benéfico em um jogo que tenta ensinar novos conceitos aos jogadores, mas ela deve ser bem elaborada. Através do grupo focal, criamos uma narrativa para o jogo, bem como *features* adicionais originadas a partir dessa história. Em seguida, realizamos uma avaliação do protótipo, após o seu desenvolvimento, para avaliar a diversão do jogo pelo usuário. Essa avaliação foi baseada em uma versão modificada do EGameFlow, um questionário que serve como uma escala de medida do prazer e diversão dos usuários em jogos de aprendizado. EGameFlow é dividido em várias dimensões que são avaliadas através do desvio padrão e média das respostas dos participantes. Os participantes jogaram o jogo e responderam ao questionário. No geral, os resultados de todas as dimensões foram satisfatórios, mostrando que o protótipo é considerado prazeroso e divertido para os jogadores. A última avaliação deste trabalho reuniu opiniões de desenvolvedores de jogos para verificar a validade de nosso modelo,

seus componentes e relações para o desenvolvimento de jogos focados em condições crônicas. Este passo ocorreu como uma entrevista estruturada individual que seguiu uma explicação do modelo proposto e do protótipo desenvolvido. Não houveram solicitações para remover, adicionar ou alterar drasticamente qualquer componente do nosso modelo, apenas foram aplicadas pequenas correções. No geral, os resultados são positivos e todos os desenvolvedores concordam plenamente que nosso modelo pode ser usado para desenvolver jogos, móveis ou ubíquos, focados em condições crônicas sem as restrições identificadas nos trabalhos relacionados. Os resultados confirmam que o CCMUG pode ser usado como base para desenvolver jogos neste contexto. No entanto, mais avaliações com diferentes protótipos com foco em outras doenças crônicas estão planejadas como trabalhos futuros.

Palavras-chave: informática médica. doenças crônicas. condições crônicas. jogos móveis. jogos ubíquos. jogos sérios.

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LIST OF ACRONYMS

Unisinos	Universidade do Vale do Rio dos Sinos
CAPES	Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
WHO	World Health Organization
CCMUG	Chronic Condition Mobile/Ubiquitous Game
CPR	Cardiopulmonary resuscitation
GPS	Global Positioning System
AIDS	Acquired Immune Deficiency Syndrome
HIV	Human Immunodeficiency Virus
DM	Diabetes Mellitus
CVDs	Cardiovascular Diseases
SCT	Social Cognitive Theory
TTM	Transtheoretical Model
CCM	Chronic Care Model
RQ	Research Question
SQ	Statistical Question
GQ	General Question
IC	Inclusion Criteria
EC	Exclusion Criteria
MACO	Mobile Game Approach to Prevent Childhood Obesity
ECG	Electrocardiogram
NPAB	Nutrition and Physical Activity Behavior
PoA	Points of Actions
IT	Information Technology
2D	Two Dimensional
3D	Three Dimensional
NPC	Non-Player Character
TAM	Technology Acceptance Model

SD	Standard Deviation
API	Application Programming Interface

CONTENTS

1 INTRODUCTION

Chronic diseases are the main cause of mortality in the last few decades (QI et al., 2015), whereas these diseases and mental disorders account for 59% of all deaths in the world. It is assumed that this percentage will reach 60% by the year of 2020 and the highest incidences will be of cardiac, cerebrovascular and oncological diseases. By 2020, chronic conditions will be responsible for 78% of the global burden of disease in developing countries (WORLD HEALTH ORGANIZATION, 2002). Furthermore, chronic diseases cannot be cured completely, instead these diseases can be managed. Once a person is affected by a chronic condition, this leads to a reduced quality of life for the patient and a costly rehabilitation for the family of the patient and the society as a whole (QI et al., 2015) (XIAOSONG; GANG; YONG, 2015). That is because of the fact that the subject will need to be continuously monitored and treated (ATI; OMAR; HUSSEIN, 2015), resulting in a higher amount of medicines, healthcare professionals and supplies that will be allocated to manage the patient.

There is a wide range of chronic diseases, such as: asthma, heart disease, glaucoma, different types of diabetes (RAMKUMAR; PRAKASH; SANGEETHA, 2016), obesity which is officially recognized as a chronic disease by The American Medical Association since 2013 (CHRONIC CONDITIONS TEAM, 2013)(STONER; CORNWALL, 2014), hypertension, and many other. A considerable portion of these conditions, if not managed properly, often induce other complications to the individual, acting as risk factors. Hypertension is a risk factor to other complications including stroke, coronary heart disease, renal and heart failure (CHEN et al., 2016). Meanwhile, individuals that are defined as obese are more likely to suffer from stroke, cardiovascular disease, different types of cancer, insulin resistance and diabetes (STRULIK, 2014). Furthermore, obesity can also lead to psychological problems and functional limitations (SALEH, 2015). Another example is arthritis, which causes symptoms, such as inflammation (swelling), tenderness, and cysts or nodules at the joints, that consequently can make everyday activities difficult and painful (SHIN; WüNSCHE, 2013).

According to the Innovative Care for Chronic Conditions project, released by the World Health Organization (WHO), HIV/AIDS is characterized as a chronic condition (WORLD HEALTH ORGANIZATION, 2002). The human immunodeficiency virus (HIV) is a worldwide healthcare problem, affecting all countries of the world

(SOMYANONTHANAKUL; PLODGRATOKE, 2015). In Brazil, there is a large portion of the population that is HIV positive, despite the reduction in the incidence of the number of AIDS cases between the years 2002 and 2007, new cases continue to emerge in recent years (TAQUETTE, 2013), with an increase of 4% between 2010 and 2015 (AVERT, 2015).

1.1 Motivation

One approach to deal with the problem of high incidence of these chronic conditions is through technology (VIANNA; BARBOSA, 2014), specifically using games. Using games as a tool for learning and treatment improve adherence of the patients involved, because it prevents boredom and instills pleasure to the experience, whether it is a treatment or not (SOARES et al., 2016). Studies show that, in medical context, students prefer a game based approach rather than the traditional one (BOADA et al., 2015). The reason for this may be that, through games, it is possible to teach common and specific subjects to the users (MADEIRA et al., 2011), without them actively knowing that they are learning new concepts, as well as influence attitudes, beliefs and behaviors (BECKER, 2009)(PAPASTERGIOU, 2009)(MARCHETTI et al., 2015). Games characteristics include, but are not limited to, immersion, entertainment and motivation to perform physical and/or virtual tasks, depending on the game. Furthermore, an effective approach to reduce the incidence of conditions is through the education of the population. For instance, to reduce the probability of children becoming obese, it is important to teach them about diet, physical activity and energy balance (BOAVENTURA P., 2015), so that they know the effects of favoring the consumption of a certain type of food and the outcomes of a sedentary lifestyle.

Games as a learning tool have been applied in diverse areas, including corporate and military training, health, education, cultural training (REGO; MOREIRA; REIS, 2010). Boada et al. (2015) proposed a serious game called LISSA to serve as a complement of CPR[1] teaching and refresh CPR skills in an enjoyable way. Soares et al. (2016) developed a game for the rehabilitation of elderly people affected by frailty syndrome,

[1]CPR is a first aid key survival technique used to stimulate breathing and keep blood flowing to the heart (BOADA et al., 2015).

which is characterized by alterations such as sarcopenia[2], dynapenia[3], imbalance, immobility, and decrease in the level of physical activity. Boaventura P. (2015) proposed a mobile interactive game, named Nutribuddy, designed to improve nutrition literacy and, thus, prevent obesity in youngster. Similarly, a multidisciplinary team of researchers designed and developed a sedentary game for health, called "Gustavo in Gnam's Planet", with the objective to improve knowledge on and enhance consumption of healthy foods in adolescents (MARCHETTI et al., 2015).

However, to the best of our knowledge, there is not yet a model, to serve as a guideline, embodying features that foster immersion and, therefore, provide an environment for learning for the players. Instead, each team develops its game following its own guidelines of what a game should be composed of, its characteristics and features and how they relate.

1.2 Research Question

Based on the established motivation, this work aims to answer the following research question:

"What would be the characteristics and requirements of a model for the development of **mobile** and **ubiquitous games** for awareness focused on **chronic diseases**?"

A game is an activity with entertainment purposes, separated from the day-to-day life, governed by a set of predefined rules where the players enter in a conflict with each other or with the game itself, resulting in a quantifiable outcome Salen and Zimmerman (2004). If a game uses a digital video screen, it is characterized as digital (KHALIQ; PURKISS, 2015). Furthermore, a mobile game is a game developed to be played on mobile devices (TANIAR, 2008), whereas ubiquitous games integrate the concept of ubiquitous computing into gameplay (FROMMEL et al., 2016)(SAMODELKIN; ALAVESA; VOROSHILOV, 2016).

The two important aspects of chronic diseases are: i) their long duration and ii) that, once contracted, they can not be cured, instead they must be managed, and the patients will be affected by the disease for the rest of their lives. Therefore, the first line of de-

[2]Sarcopenia is characterized by the gradual loss of muscle mass, muscle strength, and muscle quality (KWON; YOON, 2017).

[3]Dynapenia is the age-associated loss of muscle strength that is not caused by neurologic or muscular diseases (CLARK; MANINI, 2012).

fence against them is prevention, via vaccines. Not all chronic diseases have vaccines and, for these, prevention can be achieved with awareness, i.e. education of the population. Studies on the impact of education as a prevention method for different chronic conditions, such as diabetes (DUNKLEY et al., 2014)(AFABLE; KARINGULA, 2016), HIV (MERAKOU; KOUREA-KREMASTINOU, 2006), obesity (PÉREZ-ESCAMILLA et al., 2013) and hypertension (CAMPBELL; PETRELLA; KACZOROWSKI, 2006), show that a well instructed population is less prone to develop the disease, since they have knowledge regarding the disease, e.g. its way of transmission, dangers, burdens, risk factors and treatments. Thus, it is a challenge of this work to identify which features a game should employ in order to promote a powerful learning environment for the players, so that they feel absorbed in the game and motivated while losing the sense of effort and repetition and, thus enabling them to learn concepts through gameplay. Another challenge is how to organize a model for the development of these games in the scope of chronic diseases so that it comprises such features within it.

1.3 Objective and Methodology

The general objective of this dissertation is to present and evaluate a model to support the development of mobile and ubiquitous games for awareness in scope of chronic diseases. Our model, named Chronic Condition Mobile/Ubiquitous Game (CCMUG), employs the features identified as key elements to promote motivation and engagement of players within the game and enables the development of games without restriction to genre, the chronic condition addressed by the game and the age of the target group. These aspects represent a limitation identified in the related works, that of which the solutions can not be employed in other scenarios. In an environment were it takes a significant amount of time and effort to develop a game, adapt it into a learning tool and then evaluate the outcomes, it is important to propose universal solutions that can be used in different scenarios and reduce the development time. Even though there is an increase in the use of games focused on chronic diseases, we observed that the amount of conditions being addressed is still small. Meaning that there are a few diseases being focused and the solutions are shaped specifically for such diseases, so there would be a lot of work to adapt the them to other scenarios, if that adaptation is possible. Thus, we sought to create a solution that solves this limitation, enabling the development of

games with the correct features for different scenarios.

This dissertation is based on a mapping study and four evaluations, three focused on the prototype and one on the model. We first performed a search to ascertain whether there were mapping studies or other types of literature reviews addressing studies that propose mobile games focusing on chronic conditions. The retrieved studies target other areas of healthcare and, to the best of our knowledge, research on this specific is sparse. We then conducted the mapping study, based on the procedure described by Petersen et al. (2008), to identify the state of the art for such games and the validity of the model proposed in this work. Based on the research gaps obtained through the mapping study, we aim at proposing a model to serve as a standard for the development of mobile and ubiquitous games for individuals with chronic conditions.

We conceived a design and developed a mobile game based on the model proposed here and performed four evaluations. The first one was a individual evaluation conducted with a group of 21 students to qualify the game design and identify features that should be improved, modified and/or removed. The second evaluation was a focus group conducted with a group of six students who participated in the first evaluation. The objective of focus group was to define whether a narrative should be used for the game and, if so, how it should be designed. The third was conducted with 20 participants and employed the EGameFlow (FU; SU; YU, 2009) survey to evaluate the enjoyment and fun of the game. The last evaluation, performed with 15 participants, was focused on the model and occurred via a individual structured interview with game developer experts to ascertain the validity of our model as a guideline for the development of mobile and ubiquitous games focused on chronic diseases. Finally, we present the future works planned for this dissertation.

1.4 Text Organization

This dissertation is organized in six chapters. Chapter 2 presents essential background information for the work. Chapter 3 describes the mapping study conducted to retrieve related proposals, compares them considering relevant features for motivation and engagement in games and outlines the open issues, trends, gaps and challenges in this topic. Chapter 4 details the CCMUG model, its architecture and seven components. The design of a game based on our model and the technologies used in the development

of the prototype are described in Chapter 5. Chapter 6 details the evaluation methodology employed in this work, the experiments conducted and the results obtained. The final chapter, Chapter 7, presents the final considerations, an overview of this work and a summary of the articles elaborated.

2 BACKGROUND

This chapter describes some basic concepts related to this work in 4 sections. Section 2.1 provides a history background on games and digital games. Section 2.2 addresses the concept of mobile games. Section 2.3 details the aspects of ubiquitous computing and explains about the games that use this concept. Finally, section 2.4 focus on serious games and explains about games developed in the healthcare area, called games4health.

2.1 Games and Digital Games

To define what a digital game is, we must first understand the concept of games alone. French sociologist Caillois (1958) states that a game should have a set of six core characteristics: i) *free*, it is not an obligatory activity; ii) *separate*, it is independent from the day-to-day life; iii) *uncertain*, so the outcome of the activity is unpredictable; iv) *unproductive*, it does not accomplish anything; v) *rules*, the activity is governed by its own set of rules; and vi) *make-believe*, the activity has its own different reality. The author defines four types of play that, when combined, originate different games. *Agon* represents competition, *alea* change, *mimicry* (or *mimesis*) role-playing, and *ilinx* to alter perception. With this definition, Poker is characterized by both *agon* and *alea*.

Crawford (2003) defines that a game is an interactive piece of entertainment, made for money, with goals associated to it, in which the player competes against and may interfere with active agents. This definition was made through a set of dichotomies:

1. Creative expression is described as art if it is made for the purpose of its own beauty. On the other hand, it is described as entertainment if it is made for money;

2. A plaything is an interactive work of entertainment. If it has no interaction for the user, it would be characterized as a non-interactive entertainment, such as movies and books;

3. If a plaything has no goals associated to it, it is a toy. Otherwise, it is a challenge;

4. If a challenge has no active agent to oppose the player, it is a puzzle. If there is one or more, it is a conflict;

5. In a conflict, if the player may only outperform the opponent, without being able to actively attack or interfere, it is a competition. However, if attacks are allowed, it is a game.

According to Salen and Zimmerman (2004), "a game is a *system* in which *players* engage in an *artificial conflict*, defined by *rules*, that results in a *quantifiable outcome*.". The authors explain the primary ideas of the definition, which are system, players, artificial, conflict, rules and quantifiable outcomes. A system can be understood as a set of parts that shape a complex whole and, thus, it is clear that games are systems. They exemplify with the following excerpt:

> In a game of Soccer,for example, the players, the ball, the goal nets, the playing field, are all individual elements. When a game of Soccer begins these elements gain specific relationships to each other within the larger system of the game. Each player, for example, plays in a certain position on one of two teams. Different player positions have roles that interrelate, both within the system that constitutes a single team (goalie vs. forward vs. halfback), and within the system that constitutes the relationship between teams (the goalie guarding the goal while an opposing forward attempts to score). The complex whole formed by all of these relationships within a system comprises the game of Soccer.
>
> (SALEN; ZIMMERMAN, 2004)

Players interact with such system to experience the play of the game. The term *artificial* resembles the *separate* core characteristic defined by Caillois (1958), that is, games maintain a boundary from the real-life. Furthermore, all games incorporate a battle of powers, which may occur as a player against player battle or even player against the game itself. This definition also concurs that *rules* are an important aspect of games, since they are responsible for providing the structure of which play emerges. The last idea refers that a *quantifiable outcome* is what differentiates a game from other lesser formal play activities, that at the end of the game, the player must have the distinction that he/she has either won or lost or received some kind of reward.

The common aspects that these definitions share is that a game is an entertainment activity with its own independent reality, coordinated by a set of rules that often comprises a defined goal. Another aspect is that games must have some type of conflict, either between players or between the player and the game itself. As stated by Khaliq and Purkiss (2015), a digital, or video, game can be defined as "a game ... that uses a digital video screen of some kind, in some way.". Similarly, Wiemeyer and Kliem (2012)

declares that “digital games are games played on electronic devices working with microprocessors.”. Through games, it is possible to teach common and specific subjects to the users (MADEIRA et al., 2011), without them actively knowing that they are learning new concepts, as well as influence attitudes, beliefs and behaviors (BECKER, 2009)(PAPASTERGIOU, 2009). Another advantage is that games are not age or gender restricted, meaning that any person may play them, some with a little more help than the others.

2.2 Mobile Games

Mobile games is a category of games developed to be played on mobile devices, such as smartphones, tablets and portable consoles. Mobile games can be defined as embedded, downloaded or networked games played on hand-held devices (TANIAR, 2008). This definition encompasses games developed for portable consoles that do not have network connection, such as Game Boy Advance, or even for other devices, such as calculators. The key element of this type of games is portability (TANIAR, 2008), rather than network functionality. However, the built-in 4G wireless network and Global Positioning System (GPS) features on these devices have enabled the mobile games category to grow.

Another element that differentiates mobile games from other platform games, such as computer or console games, is the simplicity. This characteristic emerged from the storage, processing, and graphics limitations of early versions of mobile phones. Although the smartphones and, with them, their capacity are constantly evolving, simplicity remains a predominant characteristic of mobile games, with some exceptions. Furthermore, due to its portability, mobile games are generally developed with the casual user in mind, that is, players that enjoy short game sessions to be played on their spare time (TANIAR, 2008). Compared to other genres of games that require longer gaming sessions, such as role playing games or first person shooters, mobile games appeal to a broader public. This category is continuously growing: in 2014, 69% and 75% of gross revenue from iOS and Android devices come from games, while the mobile gamer is prone to spend an average of 14 US dollars per transaction (V. M. MOREIRA; FILHO; RAMALHO, 2014).

2.3 Ubiquitous Computing and Games

The concept of Ubiquitous computing was first presented by Weiser (WEISER, 1999) in his article entitled “The Computer for the 21th Century”, where the author expresses his opinion on the computers of the next century Weiser (1999). For Weiser, the computers of the future would become imperceptible in a way that the users would consume the resources provided by the computers without active consciousness. Weiser stated that the concept of an ubiquitous computing system is established on two central aspects: ubiquity and transparency. The first aspect, ubiquity, refers to the availability of the system, that the system is readily available to be interacted with by the users, whenever and wherever they need it. Transparency indicates that the application is non-intrusive and integrated into the everyday environment of the user.

One example provided by the author is writing, a technology that enables the transmission of ideas between generations and that surpasses the capacity of human memory. This is considered to be an ubiquitous technology because, after acquiring it, the user may use it at all times and anywhere without effort, as well as because the user does not focus on the process of writing, but rather on the content of the text. One contemporary example of ubiquitous computing is the smartphone. If a person is waiting in line at the market and, while waiting, this person periodically checks his/her phone for new messages. When he/she realizes that no new messages have been received, he/she puts the smartphone back in his pocket. This is ubiquitous computing. The smartphone is present and available to the users all the time, it is continuously functioning in the background and only comes to the foreground, i.e. the users become aware of it, when it is required by them, before going into background again with a smooth transition.

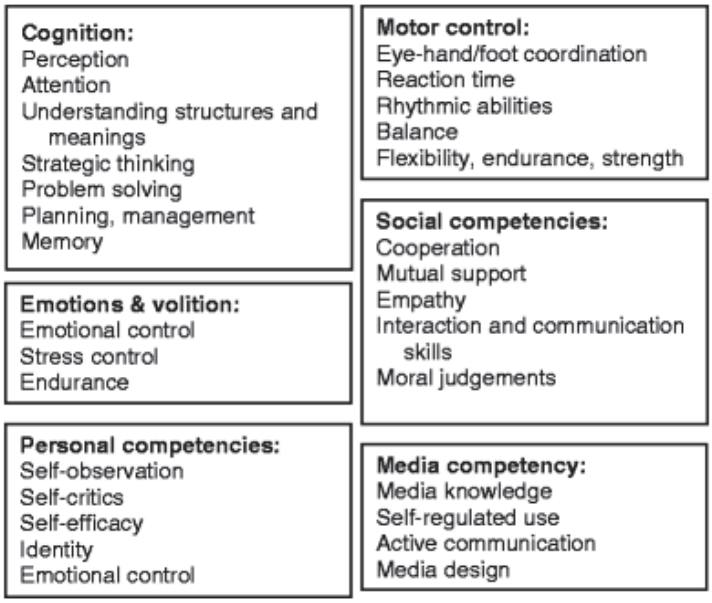
Ubiquitous games, in turn, integrate the concept of ubiquitous computing (BUZETO et al., 2013), which computers have become so integrated into the lives of people that they are in fact inseparable from it, virtually invisible (COSTA; YAMIN; GEYER, 2008). These games use technologies that surround players to build games, incorporating the real world with the virtual, so that players engage in physical activities and, these, produce results in the game world (FROMMEL et al., 2016)(SAMODELKIN; ALAVESA; VOROSHILOV, 2016). Stèphane et al. (2007) defines ubiquity in games as the game interacting with the player at non dedicated locations through non dedi-

cated objects or concepts of real life. An example of this type of game is *Pokémon Go*[1], which employs ubiquity and augmented reality concepts along with the features of new smartphones to provide players with experience within and outside the game.

2.4 Serious Games and Games for Health

Serious games is a category of games designed with a main purpose other than entertainment (SAMARASINGHE et al., 2017)(REGO; MOREIRA; REIS, 2010). The purpose is, generally, related to education, training, advertising, research and health (WIEMEYER; KLIEM, 2012). Serious games focus on enhancing the learning process of the players by the means of their motivation (HAMZA et al., 2016).

Figure 1 – Competencies that can be enhanced by serious games.



Source: Wiemeyer and Kliem (2012).

On the other hand, games developed and published by companies of the gaming

[1] http://www.pokemongo.com

industry, such as Ubisoft[2], EA Games[3], Blizzard[4] and Id Software[5], focus on the entertainment, to increase the sales for the company. Serious games may also aid in the development of mental abilities and skills, including strategy, mental calculation and decision making (ANDRÉS et al., 2014). Another advantage of these games is that they have the potential to address competencies illustrated in Figure 1 without neglecting key elements to the game like fun, flow, motivation and immersion (WIEMEYER; KLIEM, 2012).

Games for health is a category of serious games, thus inheriting the main characteristic of serious games: that a game is developed with a purpose different from entertainment. Games for health comprises games developed for various purposes in healthcare, such as rehabilitation, education (for example, to inform the players about good and bad eating habits), prevention and training of professionals (GUO; SINGER; BASTIDE, 2014) (MARCHETTI et al., 2015). One example of the applicability of this category is to use a game for the potential of providing motivation to its user to execute a series of repetitive exercises in a case of motor rehabilitation (SMEDDINCK; HERRLICH; MALAKA, 2015). Another example is to develop a game for health to be employed as a persuasive tool alter the behaviors and/or attitudes of the player (ORJI; VASSILEVA; MANDRYK, 2014), in this case it could be a game to modify the eating and exercising habits of obese children.

These games may employ one of the two following approaches for its creating: explicit or implicit (HUSSAIN; COLEMAN, 2014). In the explicit approach, the game is developed in a way that the player knows that the purpose of the game is to teach him something. On the other hand, the implicit approach disguises this purpose by means of gameplay mechanics.

[2] https://www.ubisoft.com
[3] https://www.ea.com
[4] http://us.blizzard.com
[5] http://www.idsoftware.com

3 RELATED WORK

We decided to perform a mapping study on mobile games for patients of chronic diseases (SÁ et al., 2017) for two main reasons: i) identify the state of the art for such games and ii) identify the validity of proposing a model for the development of them. Through this method, we were able to determine open issues, trends, gaps and challenges in this topic. However, before performing this study, we first conducted a search to ascertain whether there were mapping studies or other types of literature reviews already published on this topic.

3.1 Literature Reviews on Healthcare

DeSmet et al. (2014) made a systematic review and meta-analysis on the effect of interventions that use serious digital games to improve sexual health behavior. The authors conducted a search for the articles on four databases: Web of Science, CINAHL, PsycINFO, and PubMed. They searched for studies that employed serious digital games and whether immersive and health-promoting game features were incorporated. Furthermore, they investigated the overall effectiveness of serious digital games to promote sexual health behavior using meta-analysis. The number of articles retrieved, initially 7192, was reduced to 7 after employing the inclusion and exclusion criteria, such as removing duplicates, non-qualifying articles based on title, abstract or full text and the absence of a control condition. The goals of these game studies were as follows, from most to least occurring: i) delay sexual initiation among teenagers, ii) decrease sexually transmitted and HIV infections, iii) increase relationship skills and improve resistance against sexual coercion, iv) prevent unintended pregnancy and v) increased condom-protected sex. The results showed that the games had a positive, but small, overall effect on behavioral determinants, and due to the low number of games that successfully satisfied the inclusion criteria, more research is required to better conclude whether the use of serious games on sexual health-promoting behavior is effective.

The study conducted by Graafland, Schraagen and Schijven (2012) consists of a systematic review of current serious games used for training medical professionals. The overall goal of the authors was to identify whether serious games have value for training medical professionals, specifically those resident in the surgical field. In order to do so,

they established two main objectives: i) assess the background of serious games for the purpose of training professionals and their usability in surgical training and ii) assess the validity of serious games as a teaching method. They searched the articles on five different databases: PubMed, Embase, the Cochrane Database of Systematic Reviews, PyschInfo and CINAHL. The search recovered 1151 articles of which 25 were found to be relevant, describing 30 serious games. These games were split into i) those developed for specific educational purposes (17 games) and ii) commercial games useful, but not developed specifically, for developing skills relevant to medical personnel (13 games). The authors identified various educational purposes within the games: train treatment of burn injuries, train decision steps in a virtual operating room, triage, basic life support, team training, and others. Of the 30 games, six had a process of validation. Of these six games, three were developed for team training in critical care and triage, while the other three were commercially available games applied to train aparoscopic psychomotor skills. Moreover, no game had effectively completed a full validation process for the purpose of use. The authors concluded that these methods of interactive learning, in this case the use of serious games, may be applied to train technical and non-technical skills relevant to surgical field, but the games that are developed for this must be adequately validated before integration.

The study performed by Costa et al. (2015) has a generic disposition when compared with the other two aforementioned, considering it does not focus on a specific field in the medical area. It consists of a systematic review on games for healthcare. The main goal was to verify the different possibilities of use and the benefits of games applied in healthcare. To search the articles, the authors included four databases: Science Direct, IEEE Xplore, BioMed Central and PubMed. Of the initial count of 894 retrieved articles, only 99 were accessed. According to the authors, there was an increase of approximately 450% in publications in the usage of games on healthcare since 2009. The results showed the areas where the games are most used: rehabilitation of patients with brain damage, cerebral palsy, the reduction of the risk of fall and therapies for overweight people.

Matias and Sousa (2016) conducted a literature review on mHealth (mobile health) for behavior change to prevent chronic diseases. Their objective was to discover what behavior change theories and models support mHealth interventions in chronic disease interventions. The authors searched for articles on four databases: Science Di-

rect, Google Scholar, Scielo and PubMed. This search was limited to noncomunicable chronic diseases, particularly diabetes mellitus (DM), cardiovascular diseases (CVDs) and obesity risk. CVDs include hypertension, coronary artery disease, and congestive heart failure. A total of 26 articles were selected by the authors, and the most referred theories were the Social Cognitive Theory (SCT), the Transtheoretical Model (TTM) and the Chronic Care Model (CCM). A basic premise of SCT is that people learn not only through their own experiences, but also by observing the actions of others and the results of those actions (MATIAS; SOUSA, 2016). The TTM has a concept of stages of change, which describes the sequence of steps to successfully change behavior: pre-contemplation; contemplation; preparation; action; and maintenance. Finally, the premise of CCM is that people can be better-attended and can live more healthily - and that in parallel, the health care costs can be reduced with the radical change in the model of health care (MATIAS; SOUSA, 2016). The authors concluded that interventions based on theory or explicitly described theoretical constructs were effective to influence change behavior through mHealth. Furthermore, despite the potential of mHealth, such applications must have attention to its design and its authors must conduct rigorous clinical trials in order to prove the effectiveness of mHealth.

The studies mentioned above do not specifically target chronic conditions, they focus on other areas of healthcare. The mapping study presented here targets these conditions while addressing the use of mobile games and highlighting the standard features in order to establish the state of the art for such games. This work will be useful for future research performed this field of study and future development of games on this topic.

3.2 Method

The systematic mapping is a method which involves the literature search in order to ascertain the nature, the extent and the quantity of published studies, called primary studies, in a specific field of interest (SOUSA BORGES et al., 2014). Following this context, the systematic mapping performed on this article was conducted based on the procedure described by Petersen et al. (2008), according to which, there are five essential steps to be followed:

(i) Definition of research questions;

Table 1 – Research questions.

Reference	Question
General Questions	
GQ1	Which chronic diseases are being addressed by mobile games?
GQ2	What is the current state of the art for mobile games focused on patients in the scope of chronic diseases?
GQ3	Are there models/frameworks to develop these games?
GQ4	Which methods are used to validate the research?
GQ5	What are the challenges found in these studies?
Statistical Questions	
SQ	Where have the researches been published?

Source: Created by the author.

(ii) Performing the search for relevant primary studies;

(iii) Screening the articles;

(iv) Keywording of abstracts;

(v) Data extraction and mapping.

The purpose of the research questions is to guide the study, delineating the field of interest and what will be searched for. Thus, since we set out to ascertain the use of mobile games in healthcare, more specifically games that focus on patients that are affected by chronic diseases, our six research questions (**RQs**), one of which is a statistical question (**SQ**), were elaborated as shown in Table 1.

The next step was to establish the inclusion (**IC**) and exclusion (**EC**) criteria based on the defined research questions. The criteria determines the studies that will be selected to advance to the next stage during the systematic mapping filtering and the ones that will be removed. Both types of criteria are important because they aid to narrow down the amount of primary studies which will answer the **RQs**. The following criteria were devised (**IC** = inclusion criteria, **EC** = exclusion criteria):

- **IC1** - Articles proposing mobile games focused on patients with chronic diseases;

- **IC2** - If several articles reported the same study, only the most recent article was selected;
- **EC1** - Articles that were not produced in English;
- **EC2** - Duplicated articles;
- **EC3** - Title outside the investigated context;
- **EC4** - Abstract outside the investigated context, articles consisting of a literature review and related, articles characterized as grey literature;
- **EC5** - Articles that do not address chronic diseases;
- **EC6** - Articles that do not use/propose mobile games;
- **EC7** - Articles that use/propose games not focused on patients;
- **EC8** - Articles that do not employ/propose a model or framework.

To conduct this study, five databases were included: IEEE Xplore, ACM Digital Library, PubMed, Springer and ScienceDirect. The search string used in the databases was created by first defining the major terms and then the synonyms for those terms. The majors terms are “game" and “chronic". The synonyms for “game" are “games", “video game" and “video games", whereas the synonyms for “chronic" are “chronic disease", “chronic disorder", “chronic condition" and “chronic illness". It is necessary to highlight that we did not include the term “mobile" since this term will always appear combined with the term “game" or its synonyms. The last search date was Janurary, 12th 2017.

Table 2 illustrates the strings employed in the databases to search for articles related to the research questions. Two relevant remarks must be emphasized about these strings: i) we included the terms “obesity", “diabetes" and “HIV", which are categorized as chronic diseases, because a relevant number of articles that propose games in the field of chronic diseases do not use the term “chronic" or its variations, but instead use the name of the disease itself. The reason that only these three were used during the search is that these are chronic diseases with high incidence in the world and there is a limited amount of terms one can employ to search the databases; ii) we excluded the terms “game

Table 2 – Searches in databases.

Database	Search
IEEE Xplore	((“game" OR “games" OR “videogame" OR “videogames") AND ((“chronic" OR “chronic disease" OR “chronic disorder" OR “chronic condition" OR “chronic illness") OR (“obesity" OR “diabetes" OR “HIV"))) NOT (“game changing" OR “game changer" OR “changing the game")
ACM Digital Library	(“game" “games" “videogame" “videogames" -“game changer" -“game changing" -“changing the game") AND acmdlTitle:(“chronic disorder" “chronic disease" “chronic illness" “chronic condition" “obesity" “diabetes" “HIV") AND recordAbstract:(“chronic disorder" “chronic disease" “chronic illness" “chronic condition" “obesity" “diabetes" “HIV")
PubMed	((“game"[Title/Abstract] OR “games"[Title/Abstract] OR “videogame"[Title/Abstract] OR “videogames"[Title/Abstract]) AND (“chronic"[Title/Abstract] OR “chronic disease"[Title/Abstract] OR “chronic disorder"[Title/Abstract] OR “chronic condition"[Title/Abstract] OR “chronic illness"[Title/Abstract] OR “obesity"[Title/Abstract] OR “diabetes"[Title/Abstract] OR “HIV"[Title/Abstract])) NOT (“game changer"[All Fields] OR “game changing"[All Fields] OR (changing[All Fields] AND game[All Fields]))
Springer	((“game" OR “games" OR “videogame" OR “videogames") AND ((“chronic" OR “chronic disease" OR “chronic disorder" OR “chronic condition" OR “chronic illness") OR (“obesity" OR “diabetes" OR “HIV"))) NOT (“game changing" OR “game changer" OR “changing the game")
ScienceDirect	((“game" OR “games" OR “videogame" OR “videogames") AND ((“chronic" OR “chronic disease" OR “chronic disorder" OR “chronic condition" OR “chronic illness") OR (“obesity" OR “diabetes" OR “HIV"))) AND NOT (“game changing" OR “game changer" OR “changing the game")

Source: Created by the author.

changer", “game changing" and “changing the game", because they do not necessarily express the use of games. Table 3 shows both the initial and final number of search

Table 3 – Initial and final distribution of the publications according to database.

Database	Initial Results	Final Results
IEEE Xplore	151	14
ACM Digital Library	14	3
PubMed	576	0
Springer	396	0
ScienceDirect	152	0

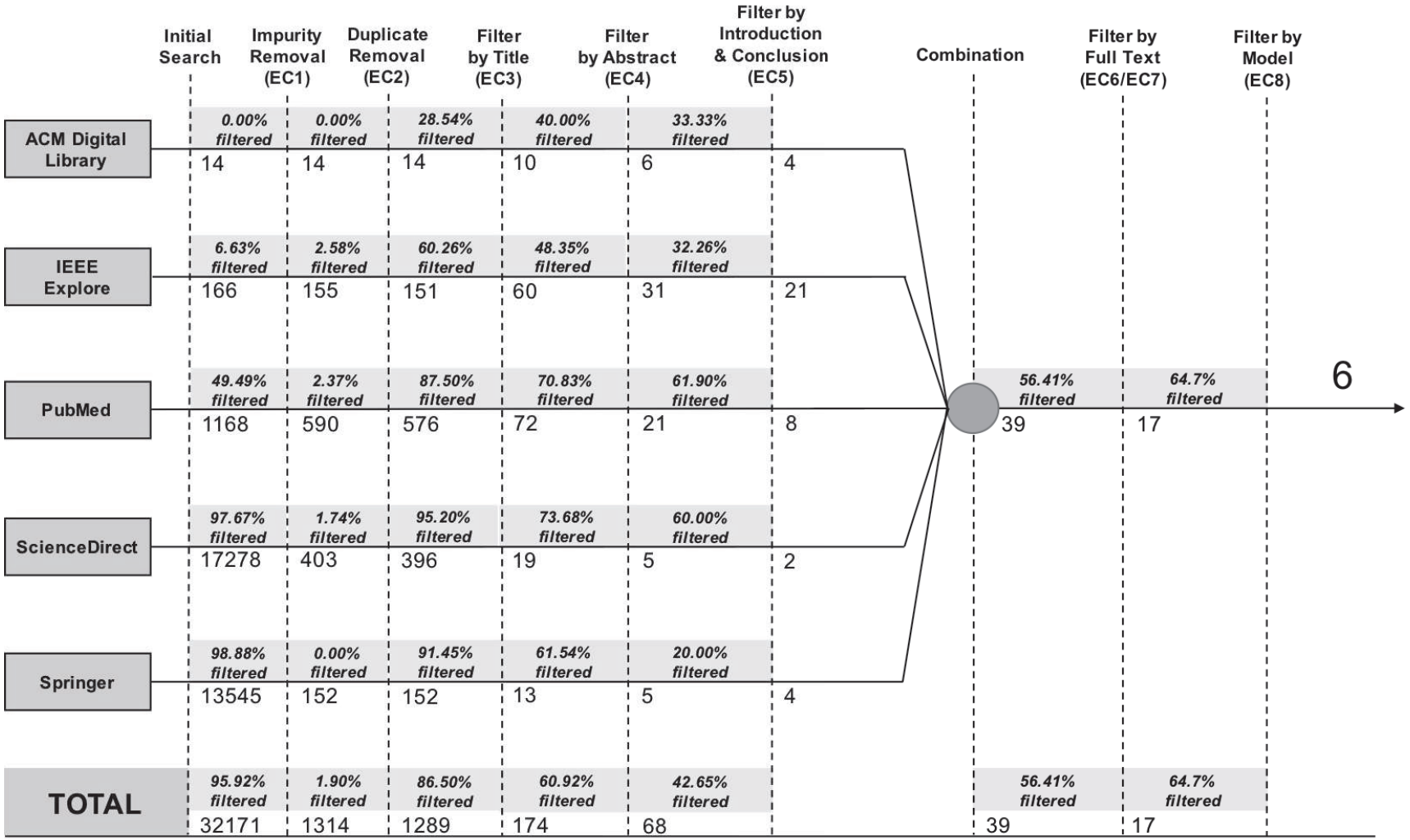
Source: Created by the author.

results per database.

The articles selection occurred in January and February 2017 and we did not restrict search by publication date. Figure 2 illustrates the selection process of the studies retrieved. As it can be seen, the selection process encompasses six filtering steps. Using the strings denoted in Table 2 resulted in a total of 1289 studies during the first steps of the search, with no filter applied. Afterwards, the inclusion and exclusion criteria, mentioned above, were applied to narrow down the number of studies. In the first step, the Impurity Removal step, **EC1** was employed, meaning that at the end of this step only articles produced in English remained. Then, we removed the existing duplicates (**EC2**), which were 25 occurrences dispersed in IEEE Xplore, PubMed and ScienceDirect. Afterwards, we commenced the Filter by Title step, in which **EC3** was applied: 86.5% of the 1289 articles were removed, resulting in 174. The next step, Filter by Abstract, employed **EC4**, started with those 174 articles and had 68 remainders. We followed one additional rule during the Filter by Title and Filter by Abstract steps: we only removed articles that we were completely confident that were not within the investigated context. When there was doubt whether the article was relevant or not, it would be passed to the next filtering step, where it would be more thoroughly reviewed and, if it was the case, removed.

Next, the articles were filtered by introduction and conclusion through **EC5**, resulting in a total of 39 articles. Finally, in the Filter by Full Text step we employed **EC6** and **EC7** while screening all 39 articles completely, this step narrowed the number of articles from 39 to 17. These 14 articles had the following characteristics: they

Figure 2 – Study selection process.



Source: Created by the author.

were produced in English, had the text within the investigated context, did not consist of literature reviews and/or grey literature, addressed chronic diseases and used and/or proposed mobile games which were focused on patients.

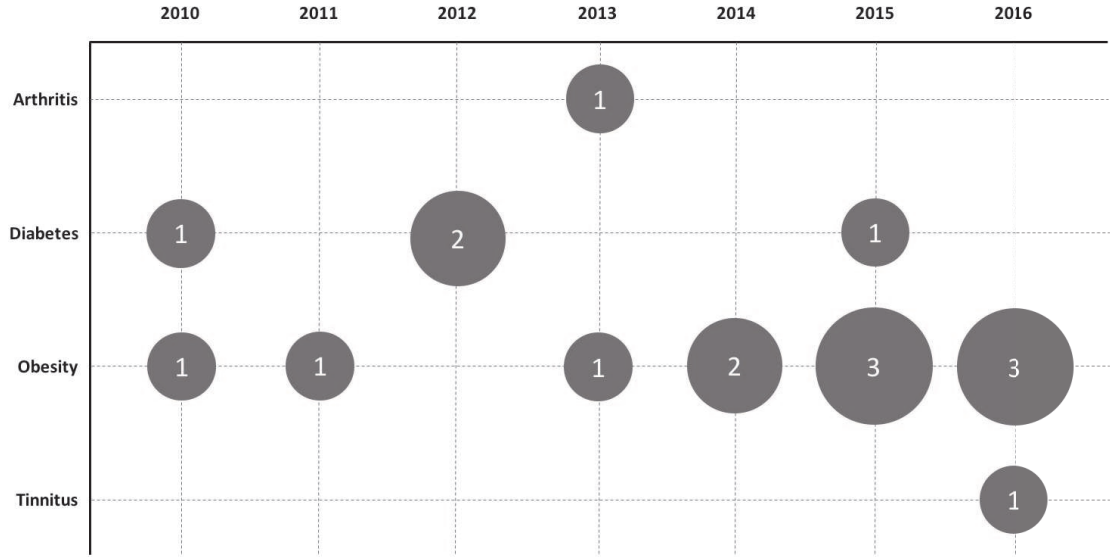
3.3 Results

We employed additional filters on the Impurity Removal step for the following databases: PubMed, ScienceDirect and Springer. These three databases returned a considerable higher number of articles when we employed the search strings denoted in Table 2, because they encompass a wider range of areas of research. Thus, we had to apply another layer of filters to narrow down the number of articles. PubMed comprises citations for biomedical literature, life science journals, and online books; we applied filters of specific article types, text availability and to exclude articles that were not related to humans. ScienceDirect provides access to scientific and medical research, it comprises Physical Sciences and Engineering, Life Sciences, Health Sciences, and Social Sciences and Humanitie. The filters applied on this database were related to the topic of the articles: of all the topics that were available, we selected the ones that more precisely represented the types of studies that we were trying to retrieve, which were the “hiv" and “obese" topics. Springer includes scientific documents that are distributed throughout a wide spectrum of disciplines, such as Architecture and Design, Astronomy, Chemistry, Computer Science, Law, Philosophy, Statistics, and many more. Therefore, we delimited the search for articles within the Computer Science discipline, specifically the Information Systems and Applications subdiscipline.

3.3.1 Statistical Question

Figure 3 shows that the years with most publications are 2015 and 2016 with four studies, followed by 2010, 2012, 2013 and 2014 with two studies. Lastly, 2011 had one work published. Overall the amount of publications since the first year, 2010, is remaining steady on two publications per year, when in 2015 this number doubled to four publications and this number persisted during 2016. Moreover, the chronic condition that is being most addressed over the years, 11 studies of the 17, is obesity, present on articles every year, except in 2012. The second chronic condition being addressed is

Figure 3 – Publications per year according to the chronic condition focused on the articles.



Source: Created by the author.

diabetes, 4 of the 17, in the years of 2010, 2012 and 2015. Two more conditions exist: arthritis in 2013 and tinnitus in 2016.

More than half of the studies, 82% (14 articles), were published by IEEE Xplore. Followed by ACM Digital Library, who published the remaining 18% (3 articles) of the total. Thus, answering the statistical question (**SQ**) defined in Table 1. By analyzing where the studies were published, we can identify that the two venues to search research on mobile games focused on patients with chronic diseases are IEEE Xplore and ACM Digital Library. Moreover, 12 of the 17 articles were published in conferences, while the other 5 articles were published in symposiums.

Table 4 shows the h5-index and h5-median of the conferences where the articles were published. The h5-indexes and h5-medians presented in Table 4 were obtained through the Google Scholar Metrics[1], which is currently based on Google's index as it was in June 2017. As stated by Google, the h-index of a publication is "the largest number h such that at least h articles in that publication were cited at least h times each", additionally the h-median is "the median of the citation counts". Finally, the h5-index

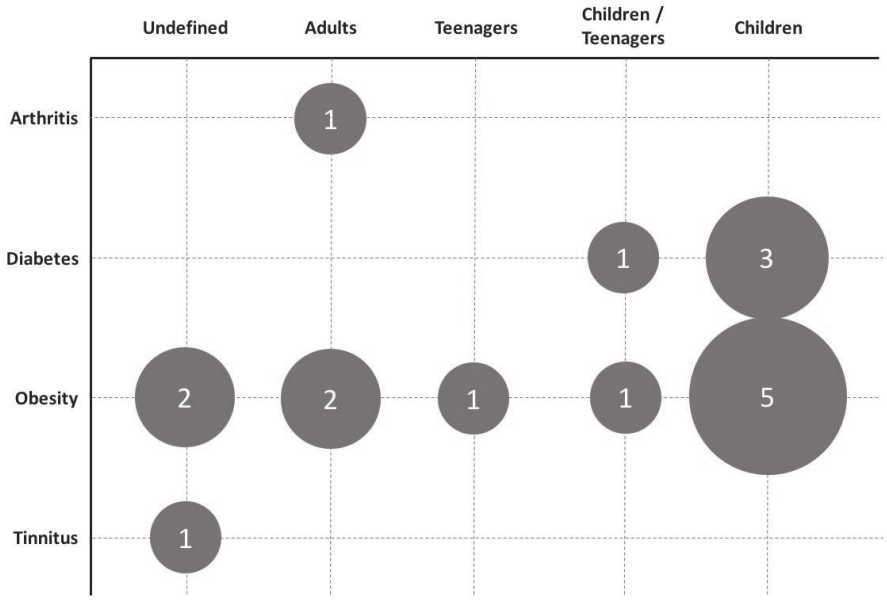
[1] `https://scholar.google.com/intl/en/scholar/metrics.html`

Table 4 – H5-index and h5-median of the conferences where the articles were published.

Articles	Conference	h5-index	h5-median
(GLASEMANN; KANSTRUP; RYBERG, 2010)	(DIS) Designing Interactive Systems	31	42
(KIM et al., 2011)	(TEI) Tangible, embedded, and embodied interaction	23	33
(BROX et al., 2012)	(MindTrek) International Academic MindTrek Conference	11	18
(CLAWSON; PATEL; STARNER, 2010)	(ISWC) International Symposium on Wearable Computing	19	30
(STACH; SCHLINDWEIN, 2012)	(PerCom) International Conference on Pervasive Computing and Communications	25	37
(LENTELINK et al., 2013)(AMRESH et al., 2016)(MAYR et al., 2016)	(SeGAH) International Conference on Serious Games and Applications for Health	7	12
(SHIN; WüNSCHE, 2013)	(IVCNZ) Image and Vision Computing Conference	11	14
(ALMONANI et al., 2014)	(ICCOINS) International Conference on Computer and Information Sciences	7	10
(AL-QURISHI et al., 2014)	(ICME) International Conference on Multimedia and Expo	18	21
(HARRIS et al., 2015)	(AINA) International Conference on Advanced Information Networking and Applications	24	29
(KARIME et al., 2015)	(MeMeA) International Symposium on Medical Measurements and Applications	14	24
(MANSART et al., 2015)	(ISM) International Symposium on Multimedia	12	14
(SALEH, 2015)	(WTS) Wireless Telecommunications Symposium	10	22
(SCHICKLER et al., 2016)	(CBMS) International Symposium on Computer-Based Medical Systems	14	24
(LUHANGA et al., 2016)	(ICMU) International Conference on Mobile Computing and Ubiquitous Networking	8	13

Source: Created by the author.

Figure 4 – Publications arranged by chronic condition and target group focused on the articles.



Source: Created by the author.

and h5-median of a publication are the h-index and h-median of the articles that were published in the last five complete calendar years.

3.3.2 General Question 1

The research question **GQ1** *"Which chronic diseases are being addressed by mobile games?"* is answered by analyzing Figure 4, which illustrates the publications arranged by chronic condition and target group identified in the articles. Three articles, two of them focusing on obesity and the other one on tinnitus, did not specify the target group, therefore they were classified as Undefined. The only article on arthritis had adults as the target group. While obesity is present across all target groups, it can be seen that there is a focus on targeting the youth, specially children. Studies on diabetes also focus on children. This is due to the fact that both obesity and diabetes on children, if not treated properly, lead to an increased risk of developing other complications on adulthood. Another reason is that, on early ages, these conditions are more easily managed than later on. To overcome obesity, for example, adults need to work considerably harder than

children, since they might be obese for some time and require drastic changes in eating habits, exercises and diet. Also, some extreme cases of obesity can only be reduced with surgical means. Chronic conditions affect people of all ages, while the studies on this area are focusing on a younger audience.

Table 5 – Overview of mobile games developed for patients with chronic diseases.

Reference	Game Description	Genre	Platform
Glasemann, Kanstrup and Ryberg (2010)	The 'food quiz' game is a simple training game designed for mobile smartphones and is to be used by young diabetics. The players have to select the correct amount of bread units based (10 to 12 gram carbohydrates in food) on the description and a photograph of the food.	Quiz	Mobile smartphones. OS not specified.
Kim et al. (2011)	The Grocery Hunter is used by kids when accompanying their parents on shopping trips. The system provides the child with a clue about a healthy grocery store item located in the vicinity, and the child must search for this item. Once the child has found what they think is the appropriate item, they simply scan the item with the Grocery Hunter.	Puzzle	Custom mobile platform.
Brox et al. (2012)	The players use different types of transportation, in a race to get to the goal first. The game tricks the players into unknowingly using their knowledge about insulin – fuel is food, oil/air is insulin and speed is exercise level.	Racing	Smartphones, OS not specified
Clawson, Patel and Starner (2010)	Dancing game that uses wireless 3-axis accelerometers that are worn around the ankles of the players to record their movement. The mobile smartphone is used to control the game and to display graphics.	Dancing	Android
Stach and Schlindwein (2012)	Players build their castle with a protective wall around it by entering the value of a blood sugar level (BSL) measurement for the first time. From then on, the location of each measurement will become a tower point to give more scoring points and more protection against mysterious Dark Forces. The objective of the game is to protect the castle and earn as many points as possible. Thereby, the player is forced to walk around and measure the BSL regularly.	Exergame	Web based
Lentelink et al. (2013)	A exergame that strives to stimulate players to stay active. They receive rewards in the form of credits for completing a daily goal. As the players achieve daily goals, they are rewarded with extra credits and a higher level and which may also result in the character losing weight (the avatar gets slimmer). At the end of the week the remaining stored steps will be deleted and the game will start again with new daily and weekly goals.	Exergame	Android
Shin and Wünsche (2013)	A golf simulation game in which users have to perform two types of exercises: a swing to simulate a drive or put, and walking to the current position of the ball. A game consists of three, six or nine hole courses. Users can play against each others or play alone and try to improve their own score.	Simulation	Android
Almonani et al. (2014)	A series of different mini-games that teach children healthy eating habits, some games do not involve activities and others do, such as jumping and running.	Mini-games	Smartphones, OS not specified
AL-Qurishi et al. (2014)	Exergame in which obese patients compete against each other. The player with most stars wins. To collect stars users have to run in real world.	Exergame	Android
Harris et al. (2015)	All games are basic 2D arcade games, with play mechanics that range from *Angry Birds* to *Pokémon* and *Bubble Pop*. Each game uses the gaming interface to teach about the topic of that particular game.	Mini-games	Smartphones/ tablets, OS not specified
Karime et al. (2015)	A flying cow has to avoid obstacles that are encountered on the way by jumping over them. The users have to keep up with the speed of the cow during the game by moving their steps in a certain speed. They can also make the cow avoid the obstacles by jumping on the floor.	Exergame	Android
Mansart et al. (2015)	It employs a game story and the physical activity of the users with associated energy expenditure information as a motivational support for encouraging people to initiate their exercise routines. It utilizes GPS technology to keep track of the outdoor activities of the users.	Exergame	Android
Saleh (2015)	Treasury Hunt Game. Treasures are hidden in everyday environments, such as parks, school or shopping centers. Different physical exercises such as walking, running, etc. are integrated into the game flow. The game will ask the user to perform a certain physical activity under certain conditions and at certain location in order to gain some scores.	Exergame	Smartphones, OS not specified
Schickler et al. (2016)	Patients act as photographers instead of fighters. More precisely, patients must detect animals based on corresponding sounds. They change the heading of their smart mobile device to locate the source of the sound and they take a picture. They win points if they successfully photographed the animal.	Simulation	iOS/ Android/ Windows Phone
Mayr et al. (2016)	In Aquamorra, the players assume the role of a young human-like character of either gender, who crash-landed their spaceship on a strange liquid planet inhabited by three competing families, the Aquamorra. The players must find a way out of this world.	Adventure	iOS/Android
Amresh et al. (2016)	The players need to help the superhero to rescue his parents. The superhero needs to eat healthy, eat balanced and eat on-time. The super hero also needs to perform the correct exercises and activities to stay healthy. The narrative then breaks several times during a day long mission to ask the child to assist the superhero and make the appropriate choices.	Interactive narrative	Portable device/Computer
Luhanga et al. (2016)	HappyInu is a 3-level Android game that we developed where players adopt and care for a pet puppy over 30 days. At the end of the 30 days a dog competition takes place where the two healthiest puppies win cash rewards.	Pet-care	Android

Source: Created by the author.

Table 6 – Overview of features per game.

Reference	Customization	Immediate Feedback	Rewards	GPS	Social Aspects	Multiplayer
Glasemann, Kanstrup and Ryberg (2010)	✗	✓	Virtual Points	✗	✗	✗
Clawson, Patel and Starner (2010)	✗	✓	✗	✗	✗	✗
Kim et al. (2011)	✗	✓	✗	✗	✗	✗
Brox et al. (2012)	✗	✓	✗	✗	✓	✓
Stach and Schlindwein (2012)	✗	✗	✗	✓	✗	✗
Lentelink et al. (2013)	Avatars	✓	Virtual Points	✗	✗	✓
Shin and Wünsche (2013)	✗	✓	✗	✓	✗	✓
Almonani et al. (2014)	✗	✗	✗	✗	✗	✗
AL-Qurishi et al. (2014)	✗	?*	?*	✓	✗	✗
Harris et al. (2015)	Avatars	✓	Virtual Points	✗	✗	✗
Karime et al. (2015)	✗	✓	✗	✗	✗	✗
Mansart et al. (2015)	?*	?*	Health knowledge	✓	✓	✗
Saleh (2015)	✗	✓	Virtual Points	✓	✓	✓
Schickler et al. (2016)	Number of animals	✓	✗	✗	✗	✗
Mayr et al. (2016)	Upgrades for the ship	?*	Virtual Points	✗	✗	✗
Amresh et al. (2016)	✗	?*	Real world prizes	✗	✗	✗
Luhanga et al. (2016)	Different breeds of dogs	?*	Cash and Virtual Points	✗	✗	✗

*A question mark indicates missing information, some game features could not be coded because of insufficient information in the article.

Source: Created by the author.

3.3.3 General Question 2

Analysing Tables 5 and 6 we can properly define the current state of the art for mobile games addressing patients with chronic conditions and, thus, answer **GQ2**. Table 5 contains the descriptions of the games proposed/developed in the articles, as well as genre and platform. The games range from simple minigames where the players

indirectly learn about healthy eating habits, dancing games to encourage exercise, interactive narratives, golf simulations to treat arthritis, pet-care games, photography simulations, and different types of exergames (when players are required to physically move and perform real world activities in order to play the game (BOULOS; YANG, 2013)). The 10 different game genres identified are listed as follows, from least to most amount of occurrence for that genre in the 17 articles: Exergame (n=6), Simulation (n=2) and Minigames (n=2), Quiz, Puzzle, Racing, Dancing, Adventure, Interactive Narrative and Pet-care (n=1). Given this heterogeneity, in both game genres and core features and description of these games, it is possible to assert that there is no particular trend in games developed for patients with chronic diseases in general. Rather, we can identify a trend on games developed for obesity: these games are frequently developed as exergames, 5 of the 11 (45,45%) games for obesity. Moreover, Android appeared 9 times as the platform for the games, while its competitor, iOS, appeared two times and Windows Phone once.

Table 6 shows an overview of the game features used to accurately determine the state of the art for such games. The minority of the games (n=5) allow players to customize certain aspects of them and, when it occurs, the customization options are limited and scarce. As customization options, players can change the appearance of their avatars (LENTELINK et al., 2013) (HARRIS et al., 2015), the number of animals available to photograph (SCHICKLER et al., 2016), buy upgrades for their ships (MAYR et al., 2016) and choose between different breeds of dogs to take care of (LUHANGA et al., 2016). Immediate feedback is when the players are promptly advised about the outcomes of their actions, visually, through audio/text or any other means. This feature is present in 10 of the 12 game studies that had sufficient information to ascertain its presence or absence. Rewards are used by less than half (n=8) of the articles and the standard type of rewards provided to the players are virtual points, often used to buy in-game goods and improvements. Two articles offered real world prizes and/or cash as a motivator for the players. Five studies employ GPS as a core mechanic on their games, for example, the actions the users must perform on the studies of AL-Qurishi et al. (2014) and Stach and Schlindwein (2012) , walking and running, are enabled through GPS. Three studies integrate social aspects in their games, such aspects are the possibility of the players to share and compare their results with others. Moreover, four games enable players to compete with each other through the use of multiplayer features. Therefore, the state of the art is characterized by games that present immediate feedback to the players and offer little to no user customization. When there is a reward system, it usually provides virtual points to the players. Additionally, the games rarely use GPS features as core game mechanics, enable the players to compete with each other and share/compare their results with others.

3.3.4 General Question 3

After peer reviewing the articles, we identified that six articles (35%) proposed models/frameworks to develop games, answering **GQ3**. The first study, proposed by Almonani et al. (2014), describes a mobile gaming approach to prevent childhood obesity. The main goal of the MACO framework is to use persuasive technologies, in this case mobile games, to induce children to be physically active and eat healthily. The system consists of two components, the first includes coursewares whereas the second component includes games, all related to healthy eating habits and physical activities. In the first stage, the players must enter their profile data, such as name, gender, age, weight and height. All this data is loaded into the system before starting the game. The second step is to calculate the points of the players. Initially the users have access to the coursewares, in which they must answer questions and with each correct answer, points are accumulated. The next stage of MACO, e.g. physical activity games, will be enabled when the players accumulate 10 points. The persuasive approach is applied in this component to encourage them to eat healthy and perform physical activities.

The article of AL-Qurishi et al. (2014) presents a framework whose objective is to support the treatment of obesity. The framework is structured to allow in-game activities to be created and provided to the player by therapists. In this way, it is divided into three components. The component of the therapist is where therapists can register new patients/players, monitor them, create matches and provide guidance. The player component is the mobile application, the game, which allows the players to receive instructions from the therapist and play the games. This application is connected to ECG sensors via Bluetooth, and such sensors transmit the heart rate data to the cloud. The last component is called service, responsible for connecting, transmitting, receiving and manipulating the data. This framework allows therapists to define activities, such as running from point A of the city to point B, which use the GPS features of mobile smartphones. Another important point is the competitive aspect, so that in some activities the players must compete to decide who can reach the final destination first.

The study proposed in Saleh (2015) describes a multiplayer and pervasive gaming system designed to encourage young people in the rehabilitation process of obesity, to increase social activities and to help them stay healthy. The system the system captures and processes physical phenomena, daily body activities and contextual information from the environment, as well as transmit the sensory data to a remote server autonomously. The system observes several phenomena such as blood pressure, body temperature, heart rate, blood glucose level, body movement, physical location, altitude, among others. These sensors form a network of body sensors that follows the player. The mobile smartphone used by the user acts as a gateway for the transmission of sensory data to the outside world.

The system proposed by Harris et al. (2015) aims to encourage patients to use technologies for the development and management of chronic diseases, in this case diabetes

and obesity. The system, named "Integrated Personalized Health Coach," collects information about the diet, exercise and medication of the patients as well as biometric information, including weight and diabetes status (glucose and A1C level). In addition, it approves certain actions suggested to the children. Initially, the system operates based on some standard recommendations and then adapts itself to better serve a specific child. All data is stored and processed by a cloud application, responsible for correlating changes in diet and exercise with the corresponding medical data. The system tries to optimize the actions of the child in order to obtain the best medical results, the child is rewarded in the game for positive results.

The authors of Karime et al. (2015) proposed a system which aims to encourage children in particular and users in general to interact with mobile-based games by performing a number of exercises. The idea is to replace the traditional mobile touching interaction with other means that promote physical activity. The system consists of two gait measuring tools that integrates a number of sensors necessary for gait and movement measurement, called SmartInsoles, that can be placed inside the shoes, a heart rate monitor, and a special software game developed to encourage children to perform jumping and running activities.

Finally, Schickler et al. (2016) describes a generic framework for serious games allowing clinical interventions in the auditory domain. The addressed condition of the article is Tinnitus, that is, the perception of a sound in the absence of a corresponding acoustic stimulus. The framework is divided into the following components: i) the “repository" component allows the management of scenarios and levels; ii) the “feedback & evaluation component", in turn, allows to configure feedback options for players and patients; iii) the “data logger" component stores all the data collected in a database, iv) the “sensor and device" management component covers technical issues of the necessary mobile sensors in relation to the peculiarities of the different mobile platforms, and v) there is a component responsible for the 3D audio characteristics.

3.3.5 General Question 4

GQ4 questions which methods are currently used to validate these researches. We discovered that the prevailing method contains three phases: training the user, gameplay, and follow-up survey. Initially, users are presented with an explanation of the game, its mechanics and, if available, the in-game tutorial. Afterwards, they must extensively play the game, exploring its features and menus, for a determined amount of time, this can last from 30 minutes to 3-4 hours. Finally, they are asked to fill out a survey. The survey frequently assess the usability of the game, how easily and efficiently the user can achieve certain actions and goals within the game (KORHONEN; KOIVISTO, 2006). Another topic commonly evaluated is the satisfaction/enjoyment of the users. Some variations of this three phase method included pretest surveys, group interviews and the addition of open ended questions on the post-test surveys. Finally, one study employed

Table 7 – Overview of the challenges reported in the studies.

Reference	Challenges
(ALMONANI et al., 2014) (BROX et al., 2012) (HARRIS et al., 2015) (MAYR et al., 2016) (SALEH, 2015) (STACH; SCHLINDWEIN, 2012)	No evaluation performed.
(AL-QURISHI et al., 2014) (KARIME et al., 2015) (MANSART et al., 2015)	?*
(GLASEMANN; KANSTRUP; RYBERG, 2010)	Young people had difficulties recognizing and learning from digital representations of food items, estimating specific food/portion sizes and handling numbers (estimation and calculation).
(KIM et al., 2011)	Some children found the questions presented in the game too hard, while others found them too easy.
(CLAWSON; PATEL; STARNER, 2010)	The participants had trouble configuring the sensors.
(LENTELINK et al., 2013)	How to make the game more engaging and appealing for the users, since the results showed that some users think the game would become boring after a while.
(SHIN; WüNSCHE, 2013)	Difficulty to determine the parameters required to compute the driving distance of the ball after a swing and how to motivate the users to walk more instead of swinging from a fixed location.
(SCHICKLER et al., 2016)	Difficulty to develop 3D audio features for the different mobile operating systems.
(AMRESH et al., 2016)	Challenges with the aspect of families completing the game at home. While the authors identified families that had internet access at home to complete the game, very few actually did.
(LUHANGA et al., 2016)	Certain features were ignored because the participants felt they were burdensome or occurred at inappropriate times. Some users had difficulties engaging with the puppy, because they preferred other pets instead of dogs. The study timing, since it coincided with the Christmas break and many students traveled back to their hometowns. Finally, the platform and language of the game, Android and English, while the participants were Japanese students and most were iPhone users.

*A question mark indicates missing information, some challenges could not be coded because of insufficient information in the article.

participatory design and another used experts to evaluate the gameplay, mobility and usability of the game.

3.3.6 General Question 5

Of the 17 articles, only 8 (47.06%) reported challenges faced during the conduction of the studies, see Table 7 for an overview of these challenges. To answer **GQ5**, we observed that the challenges the authors faced in these studies were all specific to each case, we did not identify a common challenge shared across the articles. Not all articles had sufficient information regarding the obstacles faced during the research. Among the challenges discovered are: how to make carbohydrate counting fun for children/teenagers (GLASEMANN; KANSTRUP; RYBERG, 2010); how to properly present visual representations of food so that children may correctly estimate sizes and, thus, practice carbohydrate counting (GLASEMANN; KANSTRUP; RYBERG, 2010); difficulty to formulate health related questions that children can understand and answer (KIM et al., 2011); struggle of the users to adjust and configure external sensors used in the study (CLAWSON; PATEL; STARNER, 2010), which resulted in the participants thinking that the sensors were not functioning properly; complications to develop specific 3D audio features required by the game on the different mobile operating systems (SCHICKLER et al., 2016); how to make de game appealing for the users so that they fell motivated consume it (LENTELINK et al., 2013) (AMRESH et al., 2016) (LUHANGA et al., 2016); ; how to properly simulate the golfing experience and motivate elders to execute the physical activities that the game proposes (SHIN; WüNSCHE, 2013).

3.4 Main Models

As shown in Figure 2, we employed one additional filter, the Filter by Model step, to the final 17 results retrieved from the mapping study. This step makes use of **EC8**, which eliminates the studies that do not propose models or frameworks whatsoever. We identified six articles that proposed models or frameworks for developing games that focus on chronic conditions. In this section the models are explained in detail.

3.4.1 Mobile Game Approach to Prevent Childhood Obesity

The first article, proposed by Almonani et al. (2014), describes a mobile gaming approach to prevent childhood obesity. The main goal of the MACO framework is to use persuasive technologies, specifically mobile games, to induce children to be physically active and eat healthily. MACO teaches its users about healthy eating habits and suggests physical activities through a fun game courseware to motivate children to adapt their eating habits and start exercising. MACO consists of two main components, the

Figure 5 – Unhealthy food example one.

Source: Almonani et al. (2014).

Figure 6 – Unhealthy food example two.

Source: Almonani et al. (2014).

first includes a courseware whereas the second comprises games, all related to healthy eating habits and physical activities. The courseware comprises “My healthy food”, “It is time to eat”, and “My active kids”.

In the first stage of MACO the player must enter his profile data, such as name, gender, age, weight and height. Next, the system asks the user to select a game and level from the available options. Finally, the player chooses between dynamic and static user options for the default system. All this data is loaded into the framework before starting the game. The second step is to calculate the points of the player. Initially the user has access to the courseware, in which he/she must answer questions and with each correct answer, points are accumulated. The next stage of MACO, e.g. physical activity games, will be enabled only when the player accumulates 10 points. Otherwise, the user must play the courseware until acquiring the necessary points to unlock the physical activity games. The persuasive approach is applied in this component to encourage the player to eat healthy and perform physical activities.

A system prototype was developed to evaluate the proposed framework, composed by two components: persuasive mobile courseware and persuasive mobile game. The courseware is divided in two modules. The first module has two games entitled “My healthy foods” and “It is time to eat” and introduce children to healthy food while explaining the schedule for eating. Reminders are provided for healthy breakfast, lunch

and dinner. Information regarding the outcomes of eating healthy or unhealthy are provided via text and images to the player before the games is started. During the games, children learn about both unhealthy and healthy foods as shown in Figures 5 and 6. The second module functions similarly as the first one, but instead focuses on the importance of being physically active and the outcomes of obese and active children. It is during this module that MACO attempts to teach the children about the disadvantages of being sedentary.

The second component of the prototype comprises two modules, the first one is the "Healthy Food Game" while the second contains different physical activities games. In the "Healthy Food Game", both healthy and unhealthy foods drop down from the top of the screen and the players must tap the healthy foods. Each correct guess accumulates one point and when they gather a total of 10 points they have two options: to proceed to the next level of this game or advance to the next module, i.e. the physical activities games. This module, on the other hand, requires the players to exercise and perform physical activities on a small room. The activities can either be performed on a fixed location or by moving in the real world. These games are presented to the players as simple tasks to be performed, such as jumping and running. Through this prototype, the children are persuaded to exercise and learn about healthy foods without realizing it.

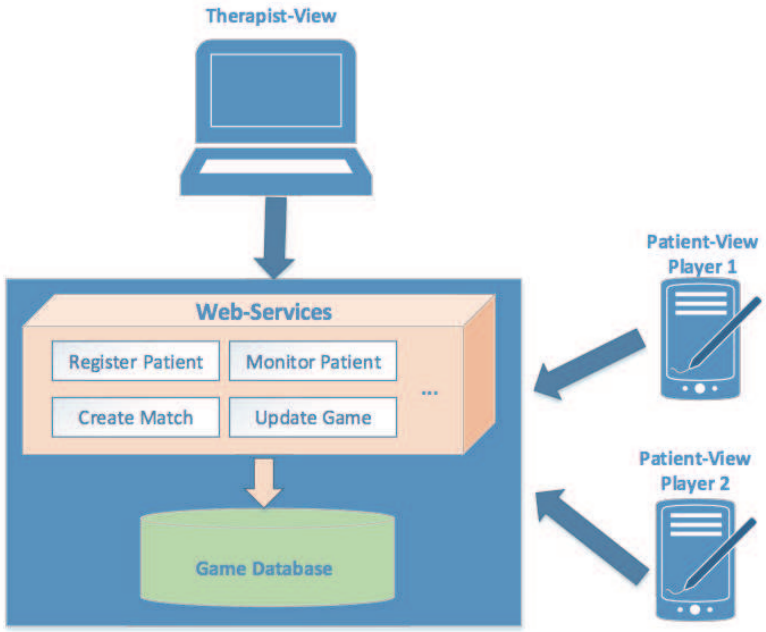
3.4.2 StarsRace

The article of AL-Qurishi et al. (2014) presents a framework whose objective is to support the treatment of obesity. The framework is structured to allow in-game activities to be created and provided to the player by therapists. Therefore, it is divided into three components, also called views, as shown in Figure 7. The "therapist" or "caregiver" component is where the therapists can register new patients/ players, monitor their performance, create matches according to the profile of the patient and provide guidance and recommendations. Additionally, the application may suggest the therapist the distribution of groups based on the profiles of the players.

The "player" component is the mobile application, the game, which allows them to receive instructions from the therapist, interact with other players and play the games. Moreover, the mobile app is continuously monitoring the speed of the users in order to properly categorize their state in one of the following: ideal, normal or abnormal. For example, if the application detects that the player is moving at a high speed, it would determine its state as abnormal: the player may be using a car or train to move around in the city, since it is highly improbable that he/she is running with such speed. This application is connected to the ECG sensors via Bluetooth, and such sensors transmit the heart rate data to the cloud.

The last component, named "service", is responsible for connecting, transmitting, receiving and manipulating the data. This component comprises a group of web services that are used to manage the data of the player. The web services are as follows: *register*

Figure 7 – A Mobile Serious Games Architecture.



Source: AL-Qurishi et al. (2014).

service used by therapists to register new patients; *authentication service* responsible for authenticating both the player and the therapist while maintaining their privacy; *monitor service* used by the therapists to monitor the performance of their patients; *game manager service* which manages the game sessions; *recommending service* which helps the therapist by recommending locations and/or challengers based on the profiles of the patients; and *reporting service* which generates the performance report and game statistics based on all the data collected from the game and the ECG sensors.

The mobile serious game developed in this study, entitled "StarsRace", is a collaborative game designed as a contest and championship. The game inputs and interactions are recorded by the movement of the player in the world, via GPS. The game measures the distance traveled by the player, rather than having a step count, the time taken to reach a destination, the Base Metabolic Rate and the Body Mass Index. The sequence of the steps executed during a StarsRace match are as follows:

1. Therapist define obese patients as players;
2. Therapist starts the championship by creating a match between two select players;
3. The match uses geolocations, shown in the map as stars, defined by the therapist;
4. Both players use their smartphones to login and authenticate into the game;

5. Both players accept the pending match assigned to them by their therapist;

6. The match starts and both players must collect as many stars as possible. To do so, the player simply arrive at a geolocation to collect the star;

7. Finally when all stars are collected, the game stops the match and calculates the winner and the loser.

This framework allows therapists to define activities, such as running from point A of the city to point B, which use the GPS features of mobile phones. Another important point is the competitive aspect, so that in some activities the players must compete to decide who can reach the final destination first.

3.4.3 Adaptive Ubiquitous Mobile Gaming System

The work of Saleh (2015) describes a multiplayer and pervasive gaming system designed to encourage young people in the process of obesity rehabilitation, increase social activities and help them stay healthy. The system is designed to support the development of a variety of games, each specific to different target groups as identified by obesity therapists. The system can capture and process physical phenomena, daily body activities and contextual information from the environment, as well as transmit that sensory data to a remote server autonomously. The system observes several phenomena such as blood pressure, body temperature, heart rate, blood glucose level, body movement, physical location, altitude, among others. The user can be either mobile or static and these sensors form a network of body sensors that follows the player. The mobile phone used by the user acts as a gateway for the transmission of sensory data to the outside world using mobile data communication services.

The system is not yet fully conceived, but the authors intend to design the system in such a way that the smartphone runs an application in the background of the OS. After signing up, the user will be presented with a list of different games in which he/she can participate in. Moreover, the authors conceived the design of a game named "Treasure Hunt Game" as shown in Figure 8. After selecting the game, in this case the treasure hunt, the user will be presented with the long-term mission of the game along with explanations on how to achieve it. There will be two game modes, the non-collaborative and the collaborative mode. The difference is that in the non-collaborative mode the instructions are given by the personal therapist, whereas in the collaborative mode a therapist will set the goals for a class of user and the game itself will develop specific plans with activities and exercises tailored to each user based on their profile and context.

The game will distinguish five different lifestyles, each with five levels the player can achieve. To advance through the levels, the player must acquire points and show an improved Nutrition and Physical Activity Behavior (NPAB). The scores are determined

Figure 8 – The map shown to the user.

Source: Saleh (2015).

by a variety of factors, such as: exercise performance of the user, the success of adapting to a reference NPAB, involvement in the game, initiating competitions with others, level of participation and willingness to provide information for food intake.

Treasures are hidden across everyday environments and the game scenario is designed by the therapists by creating and editing Points of Actions (PoA). Each PoA represents a location that contains either the treasure or a hint to it and will present a set of physical activities set by the therapist that the user must perform in order to go through that specific PoA. Furthermore, the therapist can define a mandatory sequence of PoA in order to instill a certain activity to the user, meaning that the player must go through all of the PoA in that specific order and perform the activities within them. Also, the system will be able to determine a similar route with similar PoA to resolve the situations in which the player will not be able to perform a specific route determined by the therapist.

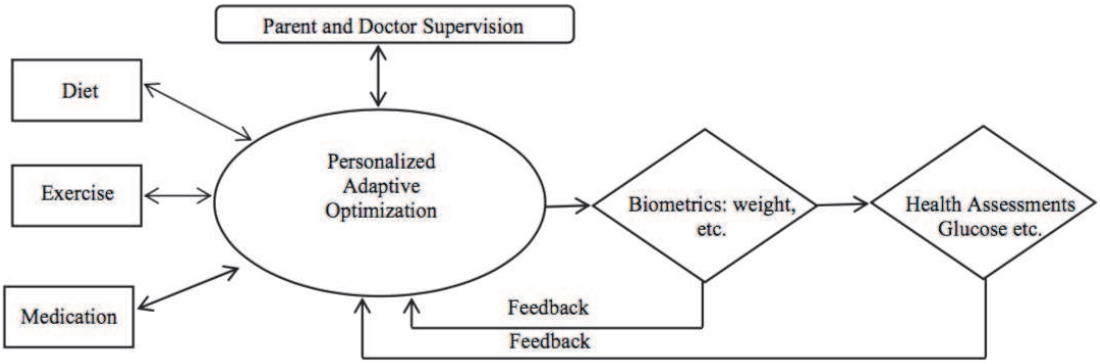
Finally, the system will encourage the players to keep playing the game and motivate them to continue their exercising plans on long term by providing awareness and feedback regarding their personal performance. This will occur via the visualization of the current total score of the user in comparison with the average and best scores, as well as a representation of the player with the best score for each specific exercise.

3.4.4 Integrated Personalized Health Coach

The system proposed by Harris et al. (2015) aims to encourage patients to use technologies for the prevention and management of chronic diseases, in this case diabetes and obesity. This tool was built based on a lifestyle intervention used in a real clinic, which includes five themes: i) think about your drink — choose water and eliminate sweet beverages, ii) make your plate colorful — increasing fruits and vegetables, iii) snack attack — choosing healthy snacks, iv) pay attention to proportions and v) eat at home - trouble shooting eating out.

The system, called Integrated Personalized Health Coach, collects data related to the patient, such as diet, exercise, and medications, as well as biometric data, including weight and diabetes status (glucose and A1C level). The data is collected in different ways. Exercises are captured by the accelerometers from the smartphones. Dietary intake is logged through the smartphone camera, as well as food descriptions made by the patients, via text or voice. Furthermore, the smartphone records the medications and supplements taken. All data is stored and processed by a cloud application, responsible for correlating changes in diet and exercise with the corresponding medical data.

Figure 9 – Architecture of the Integrated and Personalized Diabetes Coach for Children.



Source: Harris et al. (2015).

The system initially operates on the basis of some standard recommendations based on the nutrition protocol used in Youth Diabetes Prevention Clinic and then adapts to better serve a specific child. While being used, the system makes temporal correlations between food, exercise and health condition. For example, if a user is correctly following a diet and doing exercises but still cannot lose the required weight, the system will coach the child to reduce the amount of food or change its components. Moreover, under the supervision of parents and physicians, the tool approves certain actions suggested to the children. The architecture of the system is shown in Figure 9.

The second component of the system is comprised of different games developed to

encourage participation, reinforce progress, and teach specific skills and strategies identified by the medical partners to improve outcomes. The system seeks to optimize the actions of the child in order to obtain the best medical results, the child is rewarded in the game for positive results. All games are basic 2D arcade games, each with different mechanics and focusing on teaching about a specific topic. These games range from: a game based on *Angry Birds*[2] to teach the child how to react to glucose monitor readings; a game employing the mechanics of *Bubble Bobble* about ketone management; a game to teach about dietary issues related to the diagnosis of diabetes; a game that uses mechanics of the *Pokémon*[3] games to debate sensitive topics, such as depression, eating disorders, bullying and other; and finally a game that explores various situations a child may face in a typical day.

3.4.5 A Modular Mobile Exergaming System with an Adaptive Behavior

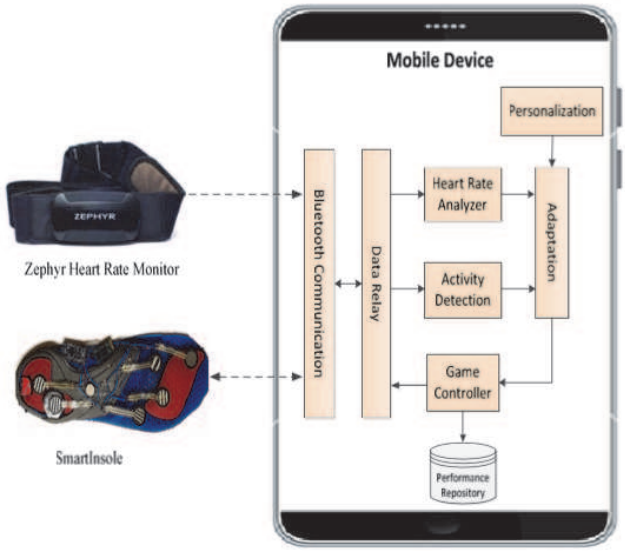
The authors of Karime et al. (2015) propose a system that aims to encourage users, particularly children, to interact with mobile games by performing a series of exercises. The exergaming system uses a mobile device to enable the user to perform jumping and running activities while interacting with a game specifically developed for that purpose. To do so, the system employs a user interface named "SmartInsole" to detect the legs movements of the players and a heart monitor to monitor the their heart rate. The intensity of the exercises required from the players is adjusted online, so that it leads them to achieve the desired heart rate of an effective exercise.

The idea is to replace the traditional interaction, touching the smartphone screen, with other means that promote physical activity. The system consists of i) two step measurement tools that integrate a number of sensors required for motion measurement, called "SmartInsoles", that can be placed inside the shoes, ii) a heart rate monitor, and iii) a mobile game developed to encourage children to perform physical exercises such as jumping and running. All activities required from the player during the game are one dimensional, i.e. the players remain in the same place while performing the exercises. Jumping is characterized by the user moving both feet off the floor at the same time, while running is when his feet move off the floor in an alternating fashion. Figure 10 shows the underlying system architecture along with the input devices that interact with it.

The "Jumpy Cow" game was developed and designed to run on Android devices. In the game, a cow has to avoid various obstacles that come from the right side of the screen by jumping over them. While playing the game, the users must keep up with the speed of the cow by moving their feet alternately in a speed equal to the speed of the cow. If the players fail to do so, the cow will eventually disappear from the screen. Alternately,

[2] `https://www.angrybirds.com`
[3] `http://www.pokemon.com`

Figure 10 – The proposed system architecture.



Source: Karime et al. (2015).

if the speed of the user is higher than the required speed, the game will notify the user asking him to slow down. The score is decreased if the cow hits any obstacle during the game and a tactile feedback is triggered on the "SmartInsole" sensors.

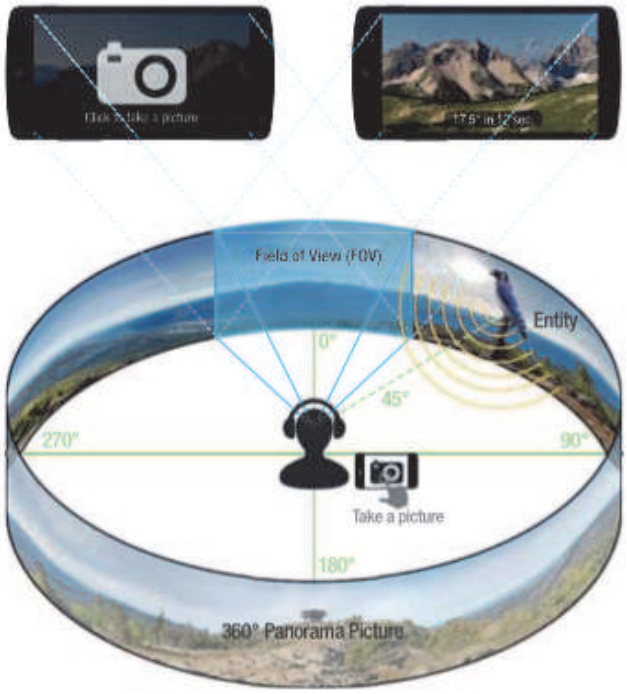
3.4.6 Using Mobile Serious Games in the Context of Chronic Disorders: A Mobile Game Concept for the Treatment of Tinnitus

Schickler et al. (2016) describes a generic framework for serious games allowing clinical interventions in the auditory domain. The chronic condition focused in the article is Tinnitus, that is, the perception of a sound in the absence of a corresponding acoustic stimulus. The framework is divided into the following components: i) the "repository" component allows the management of scenarios and levels; ii) the "feedback & evaluation" component, in turn, allows to configure feedback options for players and patients. IT experts may integrate evaluation algorithms, while medical experts may configure which parameters will be included for the feedback given to the player; iii) the "data logger" component stores all the data collected in a database; iv) the "sensor and device management" component covers technical issues of the necessary mobile sensors in relation to the peculiarities of the different mobile platforms; and v) the "3D audio" component is responsible for the 3D audio characteristics.

The data collected by the "sensor and device management" component must be comparable among different mobile operating systems. To ensure this, this component em-

ploys several filters to gathered data, such as filters to mitigate the sensor noise and enable players to point the device to the animal. Another issue encountered was how to provide similar game behavior of the sensors on all operating systems. Each OS revealed important differences, i.e. Android and Windows Phone enable the developers to manually select the required sensors, while iOS does not offer this feature. To overcome this, the authors defined the "sensor and device management" component, responsible for abstracting such technological differences. Figure 11 shows the architecture of the proposed framework.

Figure 11 – Tinnitus game concept.



Source: Schickler et al. (2016).

The game developed to train the directional hearing ability of patients places the players in the role of photographers that must take photos of animals distributed in the game world. Patients must detect the animals based on the corresponding sounds. The game generates a farm containing the animals randomly positioned within it. The players cannot see the animals until they correctly take the pictures. Patients must relate their own position to the position of the animal by rotating their body and, to verify the position of the animal, they take a picture. If the picture shows the animal, they succeed, otherwise they fail and to win the game the players must detect all animals. Additionally, players can configure the number of animals that will be present in the game and whether the background sounds are enabled or not.

Table 8 – Comparison of the features of the models/frameworks.

Features	**Almonani et al. 2014**	**AL-Qurishi et al. 2014**	**Saleh 2015**	**Harris et al. 2015**	**Karime et al. 2015**	**Schickler et al. 2016**
Chronic Condition	Obesity	Obesity	Obesity	Diabetes e Obesity	Obesity	Tinnitus
Target Group	Children	?*	Children/ Teenagers	Children	Children	?*
Supports Ubiquity	✗	✗	✓	✗	✓	✗
Customization	✗	✗	✗	Avatars	✗	Nº of animals
Immediate Feedback	✗	?*	✓	✓	✓	✓
Rewards	✗	?*	Virtual Points	Virtual Points	✗	✗
Uses GPS	✗	✓	✓	✗	✗	✗
Social Aspects	✗	✗	✓	✗	✗	✗
Multiplayer	✗	✗	✓	✗	✗	✗
Prototype Platform	Smartphones	Android	Smartphones	Smartphones and tablets	Android	iOS/Android/ Windows Phone

*A question mark indicates missing information, some game features could not be coded because of insufficient information in the article.

Source: Created by the author.

3.5 Comparison

Through Table 8 it is possible to delimit the state of the art of mobile and ubiquitous game models with a focus on chronic diseases. Three chronic diseases were identified, which are obesity, diabetes and tinnitus. Obesity is present in 5 of the 6 studies, while both other conditions have only one study that addresses them. Another prevalence observed is in the target group: of the four studies that indicate its target group, three indicate it as children and the other as children and teenagers. In addition, only two models employ GPS and support ubiquity, i.e. make use of information from sensors to integrate the real world with the virtual world or the other way around. It was not possible to establish a unanimous platform: two models were developed for Android, three define the platform only as smartphones/tablets and one was developed for Android, iOS and Windows Phone.

Regarding the gameplay characteristics, two models allow customization of certain aspects of the game by the player, and when this occurs, the range of options is limited. Most studies, 4 of 6 studies, provide immediate feedback to the player. Rewards are used in only two studies, and in either case they occur in the form of virtual points frequently used for acquiring goods and improvements within the game. Finally, only one study allows players to compete with each other and employs social aspects in their model, which are sharing and comparing results with other players.

3.6 Research Gaps

Even though researchers are addressing the subject of chronic diseases through mobile games, this is a relatively unexplored area due to various reasons. The results show that the studies focus on a younger audience rather than proposing solutions for a wider range of ages. It is important to research and introduce solutions that encompass all of the age groups, given that chronic diseases do not only affect young people, but rather affect individuals of all ages. Additionally, the amount of chronic conditions being addressed is still small, we identified a trend that researchers are focusing exclusively on diabetes and obesity, while other conditions are not being researched. One example is HIV, a worldwide healthcare problem that was not addressed by any of the retrieved articles. Furthermore, the amount of publications in this field of interest is steady with an increase in the last two years, but the overall number is not a considerable one.

The overarching goal of these games is to teach the players about healthy eating habits and exercising. The majority of games and models proposed by the articles, 11 of 17 (64,7%) games and 4 of 6 (66,66%) models, encompass less than half of the 6 features described in Table 6. These features directly affect the engagement of the players. For instance, enabling the players to customize certain aspects of the game, e.g. by the means of avatars, has a payoff in terms of increased engagement and feelings of presence in the game (NG; LINDGREN, 2013). Moreover, feedback plays a role of both motivation and learning in gaming (HUSSAIN; COLEMAN, 2014). Similarly, clear and properly timed rewards in the game can effectively motivate the user to continue playing it (III, 2004), while failing to provide rewards has the opposite effect, players are likely to grow frustrated and try something else. Finally, by integrating social aspects such as sharing and comparing results, inviting friends and competing with them have the capacity to motivate continued user compliance and facilitates social engagement loops (MILLER; CAFAZZO; SETO, 2016).

The motivation and engagement of the players is fundamental to an optimal gaming experience—when they are absorbed in the game, they gain powerful satisfaction from solving the challenges withing it while losing the sense of effort and repetition (KE; XIE; XIE, 2016). Only few of these game features that influence motivation and engagement of the players are being employed, which is worrisome since motivation, in games for learning, is responsible for enabling the players to learn through gameplay. Moreover, as a result of chronic diseases not being curable and their long duration, the only mean of protection is to prevent them. Often, prevention through vaccines does not exist, meaning that it can only be achieved with knowledge about the disease. By instructing the population, they are less prone to develop such diseases, since they have knowledge regarding them, e.g. their way of transmission, dangers, burdens, risk factors and treatments. If the a learning game is unable to motivate the player, then it is not providing an environment that makes the player susceptible for learning. If this is the case, it is failing to teach the users about the disease so that they can prevent it, ulti-

mately failing its objective. Thus, another challenge is to use these features to promote a powerful learning environment for the players and, therefore, raise awareness for the chronic disease being focused. In this context, our model integrates these features in its components and enables the development of mobile and ubiquitous games of any genre that address chronic diseases without restricting the target audience.

4 CCMUG MODEL

In this chapter, we explain the CCMUG model in details in two sections. Section 4.1 presents the project decisions, denoting the objective of our model, which research gaps it solves and which it does not. Section 4.2 describes the proposed architecture and the steps performed to conceive it, while Section 4.3 details each of the components separately.

4.1 Project Decisions

To provide an overview of the CCMUG model, we present four definitions that are essential for this work:

1. A digital game is an interactive program that enables one or multiple players to engage with the content primarily for entertainment purposes (MARSTON; HALL, 2016);

2. A mobile game is an embedded, downloaded, or networked game which is played on a handheld device, such as mobile phones and portable consoles (TANIAR, 2008);

3. A ubiquitous, or pervasive, game combines the properties and advantages of both the physical and virtual world to provide an enhanced experience to the player (HINSKE et al., 2007);

4. A chronic disease is a condition characterized by its long duration, gradual changes over time and lack of cure (MARTIN, 2007).

We focused the conception of this model on chronic diseases and its characteristics, hence it is safe to say that we focused the scope of this project entirely on this type of diseases. However, we realize that the model, as it is today, may be employed for the development of other types of conditions, thus it is not restricted to chronic conditions. It is important to emphasize that all evaluations and the prototype were employed in the scope of chronic diseases. We can not guarantee that the model will be effective for the development of games in other scopes, but it may work. There is a need for new

evaluations and prototypes focused on other conditions, in order to ascertain the validity of the model in these cases.

The main objective of this work is to propose a model to serve as a standard for the development of mobile and ubiquitous games for awareness that address chronic conditions. In order to do this, we had to conceive a model that solves the limitations identified in the related works, which are: the lack of features that engage and motivate the player and the restrictions regarding the chronic condition, the game genre and the age of the end user. In this way, both developers and researches may employ it in the development of games of the most varied genres, including, but not limited to, endless runners, exergames, interactive narratives, simulation games, puzzles, quizzes, platform, among others. Similarly, the generic character is also applied to the chronic condition, meaning that the CCMUG model encompasses chronic conditions in general, rather than focusing on specific diseases, such as diabetes and obesity. This enables the use of our model for the development of games that focus on a variety of chronic conditions, from hypertension and obesity to HIV. Moreover, we conceived this model with no target group in mind, that is, we did not restrict CCMUG to a specific age or range of ages for the players, thus eliminating some of the constraints identified in the related works.

This generic approach is important since this group of conditions comprises a wide diversity of diseases, each with its specific symptoms, treatments, consequences, tests, complications and affected group. If we were to developed a model focused on one condition alone, it would take a great amount of time and work to adapt the model for a different condition when necessary. Designing a model that, from the beginning, is already prepared to be employed for the development of games focused on different diseases was a planned decision to propose a solution for this worldwide healthcare issue.

4.2 Proposed Architecture

Our first step to create the model was to identify the essential features that a game must possess in order to engage players and provide an environment for both fun and learning. The features identified as essential are: customization, immediate feedback, rewards, social aspects and multiplayer. These features have been selected because

they actively influence the level of engagement and motivation of the players towards the game. The more absorbed the players are in the game, the more easily they learn its content unconsciously, gaining satisfaction from solving the challenges and losing the sense of effort and repetition (KE; XIE; XIE, 2016). Immersion is a key element for games, even more for games designed for teaching subjects to the players rather than pure entertainment. Immersion occurs when the players do not notice the time passing by, become unaware of people or events surrounding them, empathize with the characters, or even when they get scared or excited because of something that happened in-game (MADIGAN, 2015). Immersed players tend to enjoy the gaming experience at a higher level and, consequently, are inclined to absorbing concepts presented by the game, i.e. immersed players are more likely to learn during gaming than players that are not immersed at all.

In regard of the customization feature, if the players are able to customize certain aspects of the game they have an increased sense of engagement and of presence in the game (NG; LINDGREN, 2013). One example of achieving this is using in-game avatars and allowing the players to change its appearance to their liking. Immediate feedback, in turn, actively motivates the players to continue to play the game while providing important cues to the outcomes of their actions within it (HUSSAIN; COLEMAN, 2014). The feedback explains whether the users are making the right choices and, if not, it provides useful information on how they can improve their choice making. Also, this feature shows the players that their actions have an impact on game. Similarly to immediate feedback, providing rewards in the game can instigate the users to continue playing (III, 2004). While the motivation originated from feedback is focused on the users improving themselves and/or their knowledge about a specific topic, the motivation from rewards is the reward itself, i.e. the satisfaction that the players did a good job and therefore they were rewarded for it. The rewards must be properly timed: the game should not reward the users for every action they perform, but rather the pace of the rewards must be accurately defined so that the game rewards the players only when they deserve it. However, if no rewards are provided, the players may grow frustrated and, therefore, lose interest in the game. Finally, social interaction between players is another feature that influence a user to consume a game (MILLER; CAFAZZO; SETO, 2016). The fact that friends are playing and interacting with one another is a motivation itself for the user to start or continue consuming a game. This can be achieved with

actions such as sharing and comparing results, inviting friends and even competing with others.

In order to conceive our model, we defined the basic components required for the development of games for awareness, such as components responsible for storing information and handling the game logic. Then, we adapted our model based on the features we identified earlier by adding new components and/or modifying existing ones. Finally, we adjusted these components specifically to mobile and ubiquitous aspects, so that CCMUG would enable the development of such types of games.

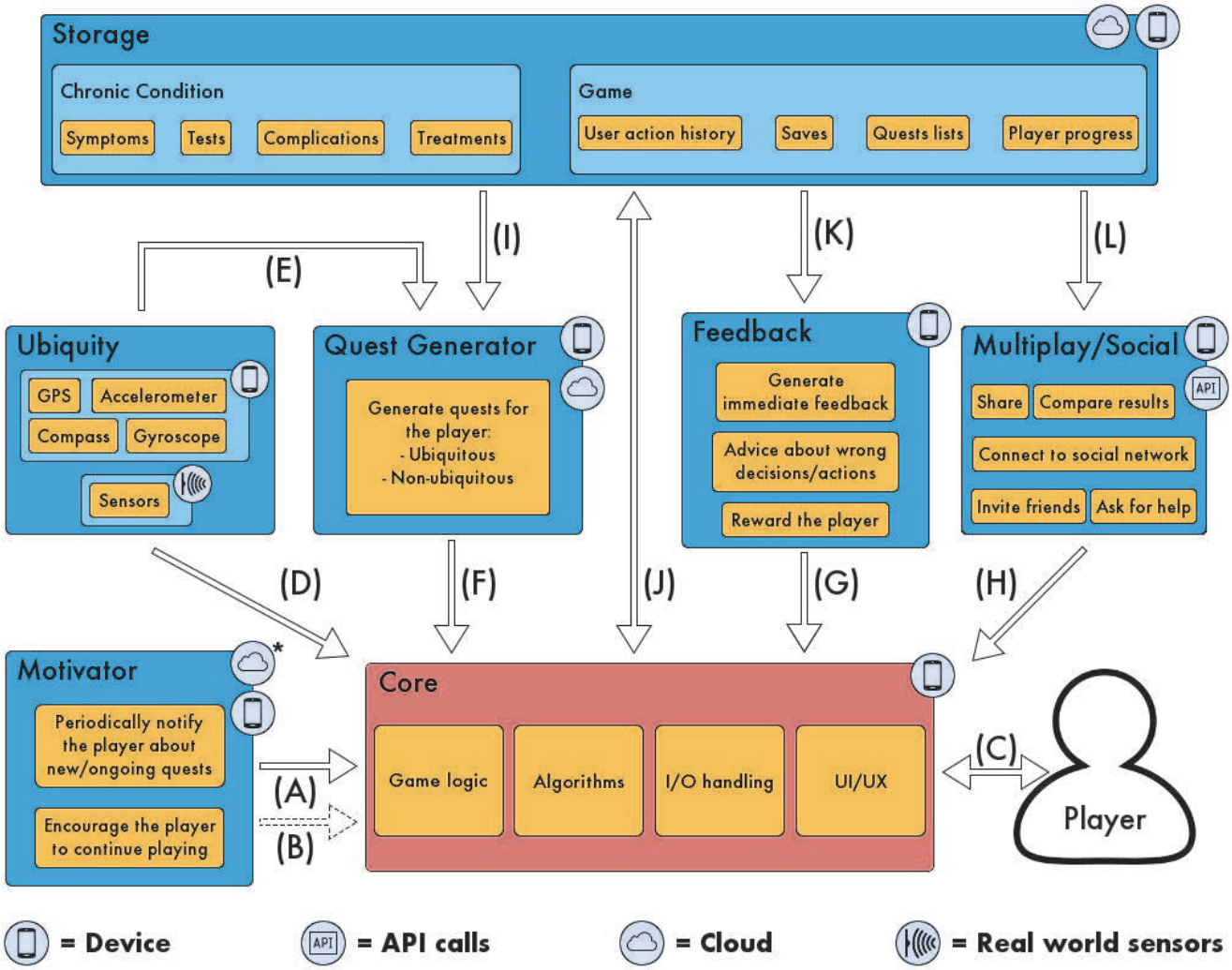
Figure 12 presents the architecture of the proposed model and illustrates some of the main features of each component. The components are represented by the rounded squares with dark blue background, while the features have yellow background. Some components are partitioned (Storage and Ubiquity). Each partition describes an aspect/concept or a group of aspects/concepts, within the component that encompasses it, that has a sufficient amount of unique characteristics to justify its separate categorization. Additionally, the characteristics visually described in Figure 12 do not represent the full extent of features handled by the components, instead they depict the overall responsibilities. Finally, the model defines where each component should be implemented when developing a game. There are two options: on the device or in the cloud. For instance, the Storage may be implemented either on the device or in the cloud, whereas the Feedback should be implemented on the device.

The arrows in the Figure 12 illustrate the exchange of information between components. For instance, an arrow that has the “A” component as its source and targets the “B” component symbolizes the transmission of data from the “A” component to the “B” component, thus “A” transmits to “B”, but “B” does not transmit to “A”. Likewise, a two-sided arrow symbolizes that both the components “A” and “B” transmit and receive data from each other. For instance, the Storage component sends data to both the Quest Generator (arrow *I*, Figure 12) and the Core, but only receives from the latter of which (*J* arrow, Figure 12).

4.3 Components

The model comprises 7 distinct components, each with its specific functionalities and responsibilities. Subsections 4.3.1 to 4.3.7 describe each component of the model

Figure 12 – Architecture of the proposed model, the arrows represent the exchange of information between the components.



Source: Created by the author.

in detail.

4.3.1 Core

The Core is responsible for all game logic, gameplay, UI/UX, input and output management, etc. It is the core of the game: any feature of the game that is not contained

in any of the other components should be implemented here. Thus, it is depicted with a different color, red, from the other components of the model, which are blue. Examples of such features are, but are not limited to physics, collision detection and handling, sprite and 3D model management, movement of the characters, inventory system, artificial intelligence and NPC behavior, upgrades and power-ups, algorithms for the game mechanics, lightning effects, animations, audio management, among others.

This is the only component that directly interacts with the players, receiving their inputs and actions, treating them and generating the corresponding output, such as images and sounds. This component can be programmed entirely by the developers, but usually they will adopt an existing game engine and build the game around it, making use of the available features and only developing the game itself and some specific features. This is due to the fact that game engines exist to abstract the details of developing typical game-related tasks, like rendering, physics, and input, so that developers can focus on creating the game. There are game engines for developing 2D games, others focus only on 3D, and others enable the development of both 2D and 3D games. Examples of famous game engines are Unity3D[1], Unreal Engine[2], CryEngine[3], Lumberyard[4] and GameMaker[5]. Usually this component consists of several programming classes, each responsible for a single feature or a group of similar features. For instance, a class that represents the enemies in the game and manages their attributes and behaviors could be programmed and, if so, it would belong to this component. Similarly, a class that comprises all path-finding algorithms employed in the game would also belong to this component. In this case, the class would have different algorithms, such as A* and Dijkstra, that serve the same goal: plot the shortest route between two points.

The interaction with the player is represented in Figure 12 by the arrow *C*. The Core represents the core of the game and is the only component that directly sends/receives any type of data with/from the players. For instance, if a component needs to display a message or receive an input from the players, it must communicate with the Core which will, in turn, check whether it already has the necessary information within it, and if so return it to the component, or if there is a need to interact with the players.

[1] `https://unity3d.com`
[2] `https://www.unrealengine.com`
[3] `https://www.cryengine.com`
[4] `https://aws.amazon.com/lumberyard`
[5] `https://www.yoyogames.com/gamemaker`

4.3.2 Motivator

The role of the Motivator is to keep the players engaged and motivated in the game, so that they do not stop playing it. Although this is an important aspect of any type of game, for educational games this is crucial, since their sole purpose is to teach players concepts through gameplay. For the game to achieve its goal, users must learn new concepts via the game, and for users to be able to learn through gameplay, they must first consume the game. It is difficult for educational games to maintain the attention of the users, even more games developed for mobile platforms. Hence the existence of a component responsible for this task. As represented by arrow *B* in Figure 12, this is the only component that transmits information to the Core without a request. All other components only respond to calls from the Core, while the Motivator, apart from responding to calls, has the freedom to send data to the Core.

One example of a feature that makes users open the game again is the notification system of smartphones: the game may periodically send notifications about new missions and the progress of those already existing. Whenever a new mission or information about an old mission comes up, this component will transmit the data (*A* and *B* arrows, Figure 12) to the Core which, in turn, transmits it to the users. For instance, in a game where the main objective of the players is record their blood glucose levels during quests to progress in-game, the Motivator would be responsible for sending them messages through the notification feature present on smartphones. These messages would inform the users that a quest has appeared nearby or that a quest the they previously tried to perform, but failed, has reappeared. By constantly reminding the players about their ongoing and new objectives in game, they are indirectly encouraged to continue playing.

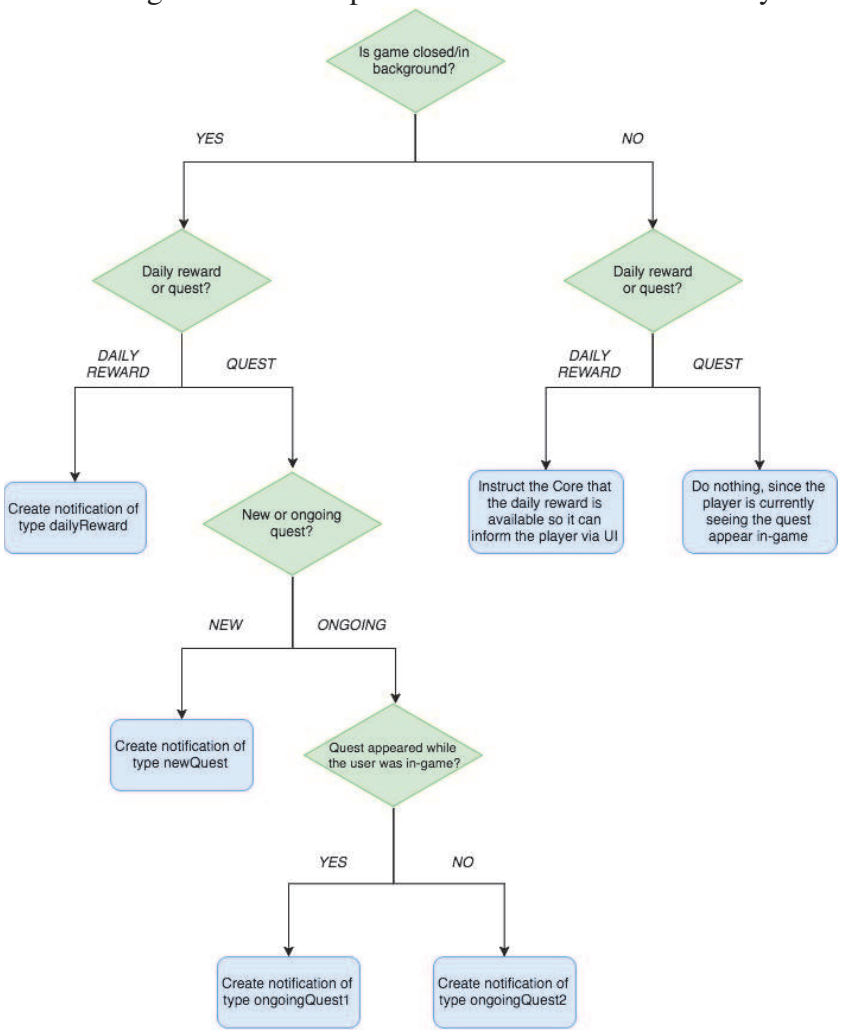
The casual games genre has prevailed and succeeded in the growing mobile gaming market as a result of its main feature, short gaming span, and the characteristics of its target platform, smartphones. Other characteristics of casual games is that they are designed to be relatively easy to learn/play and employ simple mechanics (POWLEY et al., 2016). Games developed for smartphones must be designed to be played in short gaming sessions rather than demand extensive and continuous interaction from the players, because smartphones are hand-held devices used for various daily activities and, thus, a game cannot require the players to use their device solely to play for a

long time. Additionally, games drain the battery of the device faster than other applications. On the other hand, this genre of games often does not succeed on gaming focused platforms, or consoles, designed for consumers with the sole purpose of playing video games.

Retaining the attention of the players is a challenging task in games. In mobile games, this task is specially challenging due to the fact that, generally, these are casual games, that is, they demand a short time investment from the players. This means that the users will not be playing the game in longer sessions, rather they will play in shorter sessions and, if so, they are more likely to lose interest in the game, since they spend less time interacting with it. Therefore, games that focus on shorter sessions of play must employ unique techniques, taking into account the target platform, to foster motivation and engagement. As mentioned above, one way to achieve this is to use the built-in notification feature of the smartphones. However, such notifications must be performed with caution, since sending a large number of them to the players may act the reverse role, that is, disturb them and, consequently, discourage them from continuing consuming the game. On the other hand, a low number of notifications may not be enough to catch the attention of the players and keep them engaged in the game. Another example is the usage of daily rewards often implemented in mobile games. These prizes, as the name suggests, are given to players for opening the game and occur in a recurrent manner. That is, each time they log into the game, they receive a new reward and each recurrent reward is better than the last one. However, there are rules to this feature: i) it has a time-span, limiting the player from receiving more than one prize in a defined number of hours/days (1 per day or 1 each 12 hours); and ii) if the players fail to log-in in a lapse of time after its release, they receive the lowest reward (that of the first day) and must climb their way to better rewards from the beginning. Figure 13 illustrates the algorithm for the features of the Motivator component exemplified here.

The features and techniques that will be used to motivate the players must be all implemented on this component, the Motivator. This component could be developed to run as a separate thread from the main thread responsible for running the game loop, because it is independent from the Core. The Motivator does not communicate with any other components other than the Core, and this communication is unilateral, the Core receives data from the Motivator, but does not transmits to it. It is recommended to develop this component on the device rather than in the cloud due to both its constant

Figure 13 – Example of the Motivator functionality.



Source: Created by the author.

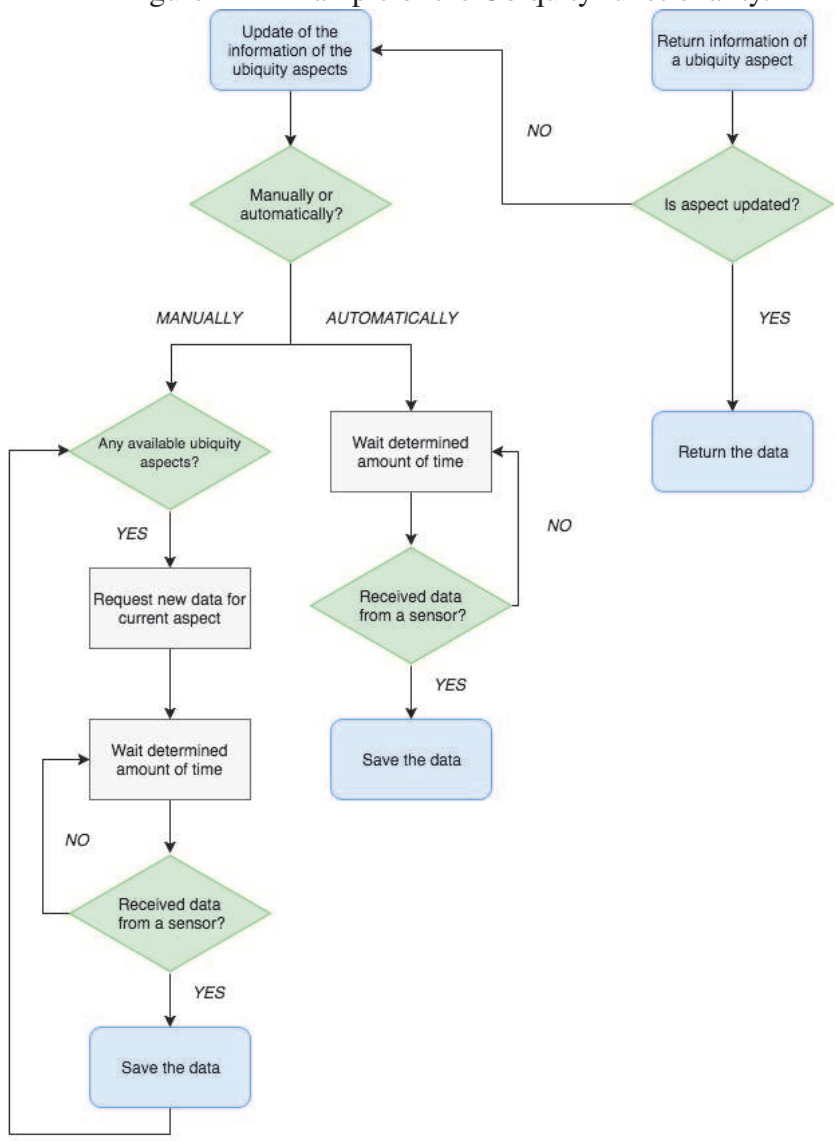
communication with the Core and its obligation to function without internet connection. If the Motivator were to be developed in the cloud, it would not be able to properly function and, therefore, motivate the players. For instance, assume the user travels for a week to a cabin in the middle of the woods that does not provide internet connection. In this case, the game installed on the smartphone would not be able to receive notifications from the Motivator, developed in the cloud, and thus the user would be more likely to forget about the game during his/her vacation. Whereas if the Motivator is developed on the device, it could schedule the notifications without requiring internet connection.

4.3.3 Ubiquity

This component follows the concept of ubiquitous computing, that computers have become integrated into the lives of people that they are in fact inseparable from it, virtually invisible (COSTA; YAMIN; GEYER, 2008), it operates in the background of our daily lives. The Ubiquity component is responsible for controlling the availability of the ubiquity aspects within the game. It manages all the available ubiquity aspects by keeping a list containing each of them along with their pertinent data. It also interacts with the sensors available within and outside the smartphone. For instance, in a game that uses the geolocation of the players, the GPS coordinates, as an ubiquitous aspect, the Ubiquity component would contain an item with all recorded GPS coordinates of the user. When requested, this component returns a list of these aspects and their corresponding data (arrow *E*, Figure 12) to the Quest Generator. It also transmits data to the Core (arrow *D*, Figure 12), since the ubiquity aspects are not exclusively used for quests, but can be used for other elements in the game. Figure 14 illustrates the algorithm for the features of the Ubiquity component exemplified here.

This component encompasses both the ubiquity aspects restricted to the smartphone: GPS, accelerometer, compass and gyroscope, as well as those outside the scope of the device, which are connected with the device via Bluetooth or other communication methods. The Ubiquity must maintain a list specifying all aspects of ubiquity available for the game to use along with all pertinent information of such aspects. To do this, it is responsible for periodically updating this information, be it from ubiquitous aspects contained in the smartphone or in the real world. It ensures that, when requested, the ubiquity information is available and up-to-date for the other components. Examples of ubiquity aspects in the real world are body sensors for gait and movement measurement, heart rate monitoring, blood pressure, body temperature, blood glucose level, among others. Additionally, this component also covers those sensors used for collecting data from the environment itself, such as the temperature or the air humidity of a room. In this case, body sensors and those distributed in the real environment and responsible for capturing data communicate directly with this component. This communication can occur through RFID, Wi-Fi and Bluetooth. In this way, this component acts as a gateway between the sensors, built-in and standalone, and the Quest Generator, which will use their data to generate missions for the players.

Figure 14 – Example of the Ubiquity functionality.



Source: Created by the author.

As shown in Figure 12, the Ubiquity component must be developed on the device, because there are built-in sensors that cannot be implemented in the cloud. Another reason is that data is continuously collected from the sensors, so if this component were to be developed in the cloud, it would consume too much bandwidth. Moreover, if the Quest Generator, were to be developed in the cloud and the Ubiquity on the device, the

transmission of data from the latter to the former would need to be performed only when necessary, rather than periodically, in order to reduce the bandwidth consumption.

4.3.4 Quest Generator

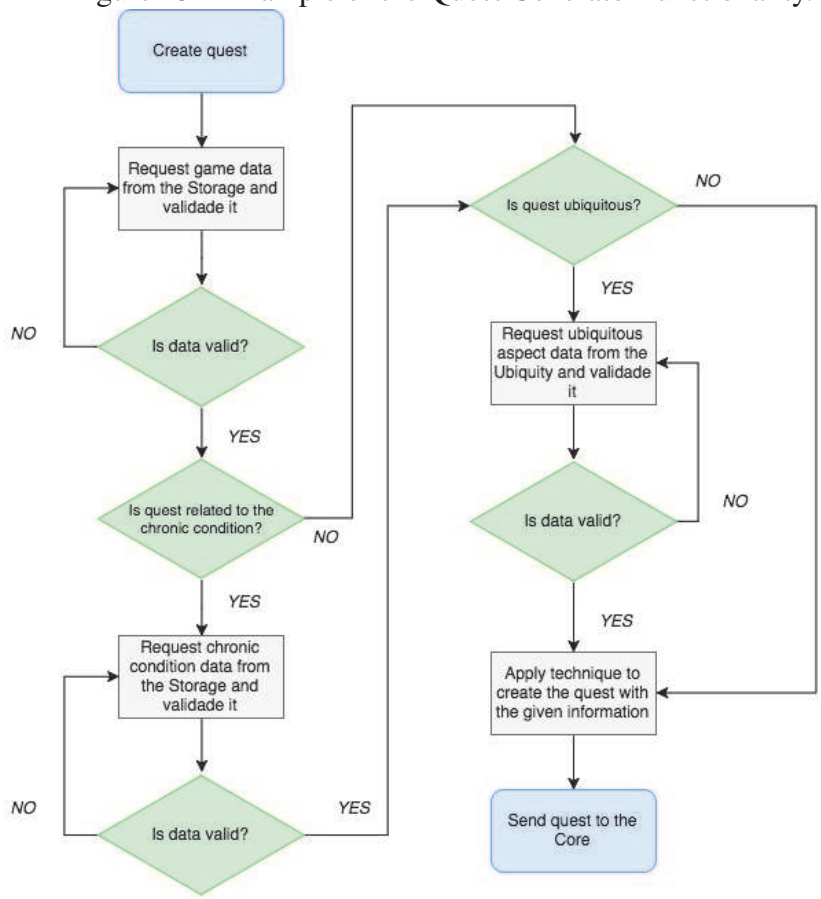
A quest is characterized by goals, a set of tasks that provide challenge to the players and a score/reward that must be awarded to them if they successfully perform these tasks (HOWARD, 2008). Quests challenge the players to achieve certain goals within the game and are an important mechanism to progress the narrative, if there is one (LIMA; FEIJó; FURTADO, 2014). Furthermore, quests are directly tied to the story-line present in the game, meaning that the story progresses as the quests are completed by the players (SULLIVAN et al., 2012).

Even if the game does not have an explicit narrative, quests are employed to guide the players within the game and provide resources for them to establish their own narrative. For instance, assume a game that does not provide a story, character introduction nor any other means of narrative. This game only provides one quest to the players: to jump as much as possible in a rhythmic manner in order to lose weight. In this case, the players could imagine that the reason for the character to jump is that he/she is training for an competition, or that he/she lost a bet and this is his/her punishment, or even that he/she is threatened to do so by a villain.

The function of the Quest Generator is to generate the game quests, or missions, through data provided by the Ubiquity and Storage components. As mentioned earlier, the list of available ubiquity aspects is provided by the Ubiquity component. While the Storage transmits data related to the chronic disease and the game to the Quest Generator (arrow *H*, Figure 12). Then, the component must generate a quest taking into account the information of the game, such as genre and gameplay mechanics, and the information of the chronic disease along with the available ubiquity aspects. The generator may create: ubiquitous and non-ubiquitous quests related or not to the focused chronic condition. After being generated, the quest must be sent to the Core, (arrow *F*, Figure 12), which will apply it in the game. Figure 15 illustrates the algorithm for the features of the Quest Generator component exemplified here.

This component can be developed on the device or in the cloud, e.g. as a set of algorithms. If the algorithms for generating the quests are costly in processing or time-

Figure 15 – Example of the Quest Generator functionality.



Source: Created by the author.

consuming on the device, the solution would be to implement them in the cloud to speed-up the process. On the other hand, if the algorithms are light and do not consume too much time to execute, they could be implemented on the device in order to reduce the bandwidth consumption.

4.3.5 Feedback

To the purpose of our work, we define three types of feedback: i) immediate feedback, ii) progress feedback and iii) completion feedback. In the first type, the feedback is provided to the players immediately after they perform an action in-game. This type of feedback is commonly employed to inform the players that an action has been suc-

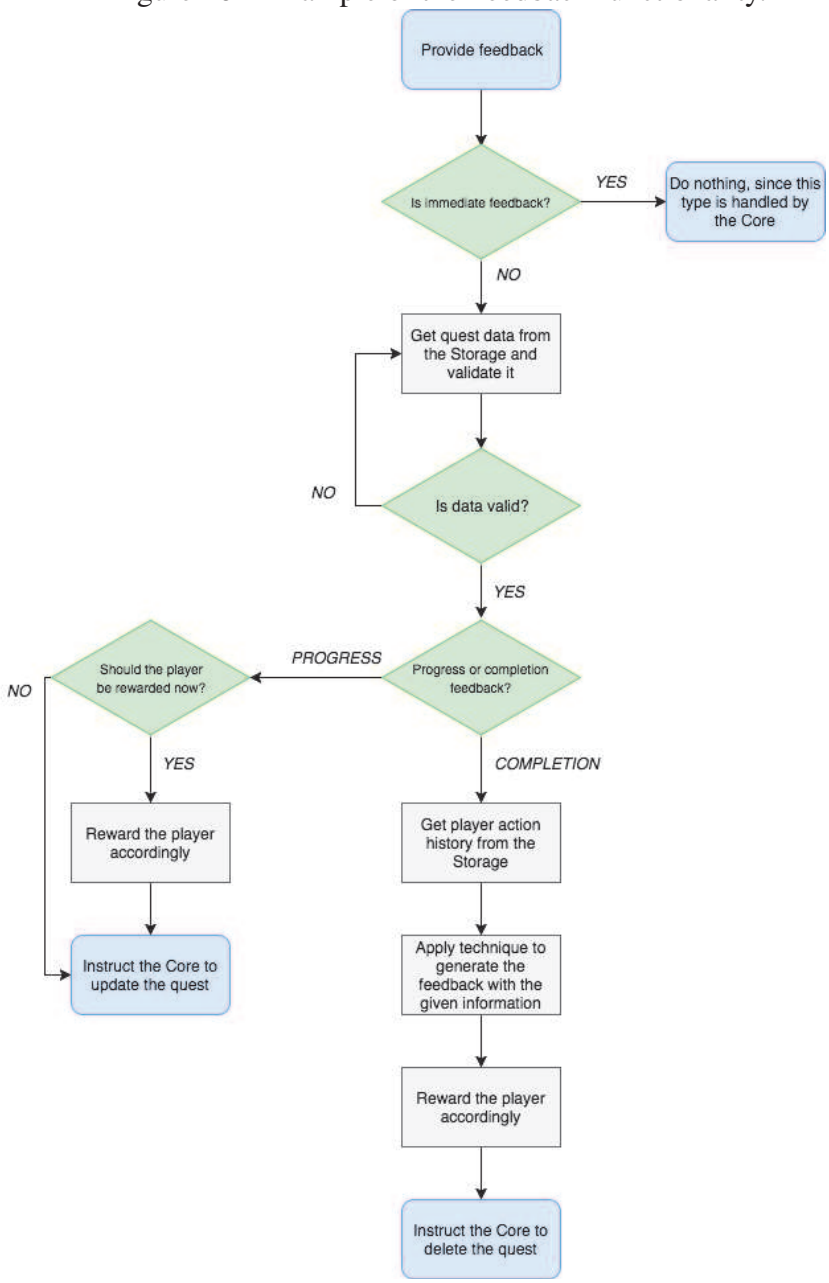
cessfully computed by the game. Examples of immediate feedback are audio feedback. For instance, in a dungeon crawler game when the players activate a switch that opens a door in a distance. There is no way for the players to know what has changed on the scenario, because the door is not in their viewing space. By adding a sound when the switch is activated indicates to the players that something happened, hence the name immediate feedback. The second type, progress, displays the progress of missions in-game, usually via a check list that is always present on the screen or that may be accessed through menu. This check list may, for example, record the progress of the players in their current quest: in a quest that they must visit four different locations, the check list would display the number of locations already visited comparing it with the total number of locations.

The completion feedback occurs immediately after the conclusion of a mission and must generate a complete summary of the quest, describing to the players its development and outcomes. It is important to provide this feedback in both successful missions and those that have failed. If the players successfully complete a quest, the component will reward them. Otherwise, the component should provide a report containing all actions taken by the players during the mission, informing which decisions were wrong, why they were wrong and advising the users about them. Figure 16 illustrates the algorithm for the features of the Feedback component exemplified here.

The overall purpose of the Feedback component is to serve as an assessment tool for the actions of the players and to guide them through the quests. This component also manages and records the progression of the players in quests. Thus, it must comprise at least two of the types identified above: progress and completion feedback. The immediate feedback type should not be handled by this component, because it is already managed by the Core, since this type of feedback is used in the basic actions of the players and these actions are handled by the Core. Due to its constant communication with the Core, as a result of the progress type of feedback, the Feedback component must be developed on the device in order to reduce the bandwidth consumption.

This component is directly tied to the aspect of chronic conditions. As already mentioned, this category of diseases is characterized by its long duration. Whereas other conditions can be cured when detected, this type can not be cured, but rather managed by the affected individual. As a result of this, the only mean of protection against such diseases is prevention. Prevention can be achieved with vaccines against

Figure 16 – Example of the Feedback functionality.



Source: Created by the author.

the given disease, for example, Hepatitis B which, if not vaccinated, can develop to the chronic type. Another way of achieving prevention is through the instruction of the population, i.e. the citizens learn about the disease, its way of transmission, its dangers

and burdens, its risk factors, its treatments, whether it has a vaccine or not, and any relevant information.

For instance, evidence suggests that pragmatic diabetes prevention programs directed at teaching the participants about aspects of the condition are effective, where researches found significant reductions in diabetes and cardiovascular risk factors, such as blood glucose and some cholesterol measures (DUNKLEY et al., 2014). Furthermore, the systematic review performed by Afable and Karingula (2016), to identify approaches to prevent and manage diabetes, shows that education programs targeted at individuals from risk groups for diabetes report evidence of efficacy. Another example is the peer education method employed in HIV prevention for young people. Studies show that, when compared with the control group, students that participated in this type of intervention were empowered to increase their personal responsibility and adopt safer sexual practices (MERAKOU; KOUREA-KREMASTINOU, 2006), thus incresing their prevention towards this condition. In regard of obesity, education is also considered to be a key factor for its prevention (PÉREZ-ESCAMILLA et al., 2013). Hypertension, a chronic disease that can develop in obese patients, is another condition preventable by programs formed to improve public and patient awareness and knowledge of hypertension (CAMPBELL; PETRELLA; KACZOROWSKI, 2006) Thus, if the population is instructed about a certain disease, they are less prone to expose themselves to it, since they have knowledge regarding the specifics of the disease. This is not a issue for other diseases with treatments that can completely cure the patient, but for chronic diseases, that when contracted can not be cured, knowledge about the disease is an important, and in cases the only, prevention method. This is when the Feedback steps in, it is via this component that the players learn about the disease and its peculiarities and aids the players to become aware as to how to prevent it. Thus, the Feedback is directly tied to this aspect of awareness and prevention that, often, is the only protection against chronic conditions. All these methods aim to aid prevent the population via education.

This component also compares the actions performed by the players during the mission with the actions expected for the mission to succeed, this information is provided by the Storage (arrow *K*, Figure 12), since it holds all information pertinent to the game. When the comparison is completed and the feedback generated, it is sent to the Core, which will be present to the players through, for example, a message or pop-up (arrows *G* and *C*, Figure 12).

4.3.6 Multiplayer/Social

This component is in charge of coordinating the social and multiplayer aspects of the game, the MS (Multiplayer/Social) component should control any and all social or multiplayer functionality available in the game. An example of such features would be allowing the players to connect to social media, such as Facebook [6] or Twitter [7] and interact with friends that already play the game or even friends that do not know it. The users could share their mission results after completion in social media, compare the results with other players, ask friends for help solving a particular mission they are stuck in.

The users could also invite new players to the game and, for each new user, they could earn rewards. Rewarding users for successfully inviting new players could be characterized as a way to motivate the players to continue consuming the game. The reason to not implement this feature on the Motivator is because motivation is not the main goal of this feature, but rather to promote interaction between players. The motivation alongside with the advertisement of the game and the increase of the playerbase are consequences of implementing this feature, but are not its primary objective. Features that are conceived with the sole purpose of fostering motivation must be developed on the Motivator. In this case, the Feedback would need to be invoked by the Core once the players successfully invite new users to the game and, thus, the Feedback would reward them properly.

For its operation, the MS has access to the information contained in the Storage, such as the progress of the players and their overall score in the game, and communicates with the Core (arrows *L* and *H*, Figure 12). It is recommended to develop this component on the device, since the common features encompassed by it (e.g. sharing, inviting, asking for help) are usually implemented as direct calls between the game and the respective social media, without requiring the use of a server.

However, there is one exception: in the development of games that allow real-time multiplayer. In these cases, the matches between players could use peer-to-peer communication or a server in the cloud. In the former situation, one of the players would act as the host and the others would connect to him/her in order to play. Assume a game

[6] `https://www.facebook.com`
[7] `https://twitter.com`

where the players must compete with each other running on the real world to determine which one arrives first at a certain destination. Employing peer-to-peer in this scenario, the first user (U1) who starts searching for opponents in the game would be assigned the host role, while the upcoming users (U2, U3, ...) would connect to U1 to start a match. This configuration could compromise the match if U1 has poor internet connectivity or if his/her device stops functioning due to software/hardware limitations, dropping the match and ruining the experience for every player involved. On the other hand, using a server would solve this problem, at a higher maintenance cost: if an user has poor connectivity or his device stops functioning, he/she would be the only one dropped from the match while the others would still continue to play. In this case, it would be necessary to implement this specific feature, real-time multiplayer, in a server on the cloud, but the other features could still be developed on the device. This component could be further developed and expanded to fully cover these aspects, since they are not within the scope of our current work.

4.3.7 Storage

As its name suggests, Storage is the component that stores and manages all information and data in the game. As a result, there is direct bilateral communication between the Storage and the Core (arrow *J*, Figure 12). This data is divided into two categories: data related to the chronic condition and data related to the game. The first category includes all information pertinent to the chronic disease, such as symptoms, complications resulting from that condition, tests for the diagnosis of the disease, treatments, among others. The second category, in turn, manages information related to the game, such as user action history, save files, missions lists, player progress, NPCs information, and so on.

This component may be implemented in the device, e.g. as a class using data structures, or in the cloud, e.g. as a database. An efficient practice is to implement the Storage and Quest Generator components in the same environment, that is, both on the device or both in the cloud, even though this practice is not mandatory. This efficiency occurs as a result of the proximity and frequency of communication between the components. A game that requires a small amount of information about the chronic condition may implement this component in the device itself, as it does not demand a high storage

capacity. In an opposite scenario, it would be advantageous to implement it in the cloud because the amount of storage required would be greater and, thus, the game will not occupy a considerable amount of internal memory of the device.

When implemented in the cloud, another efficient and advantageous practice would be to maintain a temporary copy on the device of the most frequently requested information, similarly to a cache. Since the Storage is directly transferring its information to four of the other six components of the model, it will be bound to happen multiple requests of the same data from different components. With a temporary copy, future requests for this same data could be delivered faster without the need to further consume bandwidth communicating with the cloud. Nonetheless, this approach has its downsides: the developers would need to update the local cache every time the information in the cloud changed. Furthermore, the data to be allocated in the cache must be chosen carefully due to the reduced storage space of the device. These decisions should be made based on the specifications of each project.

5 IMPLEMENTATION

In this chapter, we detail the our prototype that was developed based on CCMUG. Firstly, all mechanics/features of the game are detailed, the design is presented through text description and screen-shots and the decisions made during development due to the scope and time constraints are explained. Then we describe implementation specifications, as well as the technologies selected for the development of such prototype, we also explain reasoning for choosing them.

5.1 Game Design

We elaborated the design of a mobile game, defining its characteristics, features and gameplay mechanics. The design was conceived based on the model proposed here, considering that when the game were to be developed, it should match the model. Initially, we created mock-ups for the main screens of the game that were used as guidelines during the development of the prototype, see Figure 17. In order to better explain the concept of the game, screen-shots of the game are presented.

Figure 17 – Initial mock-ups created for the prototype.

Source: Created by the author.

The game serves as an awareness tool for the players in regard of HIV/AIDS and

addresses aspects involved in this condition, such as: symptoms, prevention, testing, treatment, complications, impacts on the life of the patients, patient care, and so on. All these information regarding this condition was based on the Clinical Protocol for Monitoring and Treatment of People with HIV/AIDS in Primary Health Care (SECRETARIA ESTADUAL DA SAúDE DO RIO GRANDE DO SUL – COORDENAçãO ESTADUAL DE DST/AIDS UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL – TELESSAúDERS/UFRGS, 2016). It was developed for mobile phones and uses the GPS feature of these devices as a main gameplay mechanic. The players assume the role of a physician who must attend patients and perform the correct diagnosis of them in relation to HIV/AIDS. The players must, through appointments, identify patients who must perform tests for the diagnosis of the condition, as well as instruct them in relation to the disease, define appropriate treatments and accompany them in their treatment.

Figure 18 – The main screen of the game, it shows the map that uses the GPS feature.

Source: Created by the author.

According to Figure 18, players are represented on the map with a simple totem

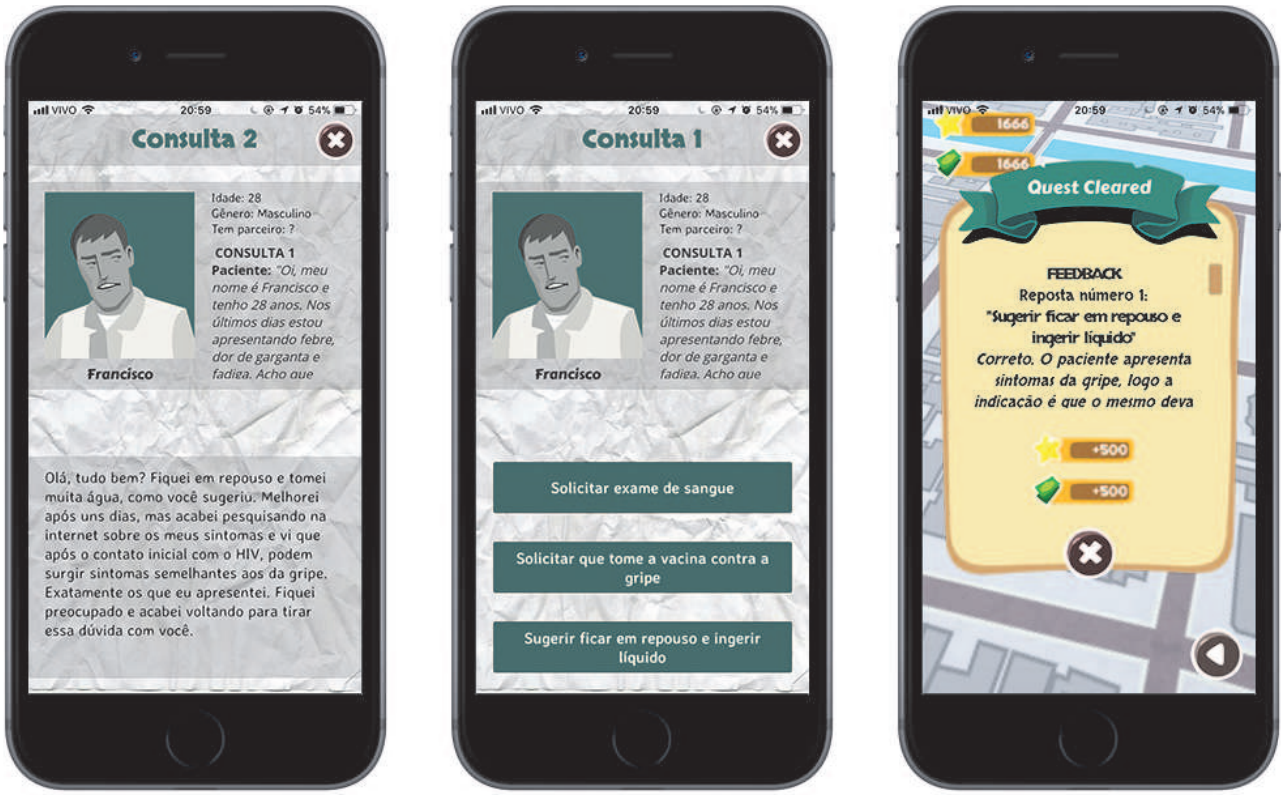
located in the center of the screen. Patients, or missions, are represented on the map as totems with a question mark and, during the game, different patients will be unlocked on the map. To initiate an appointment, the users must move around in the real world so that their totem is located in the vicinity of a patient, similarly to the game *Pokémon GO* [1]. Then, a "Start" button will appear on top of the nearby quest and the players must tap this button to start an appointment with this specific patient. The button on the lower right corner of the screen, when tapped, expands to a menu containing different options. Currently, the options are for display only, i.e. the buttons display fixed pop-up messages, but do not work as intended. For example, the Facebook icon does not log-in to Facebook to enable social media features. This is a result of the current build of the prototype not having features to be showed on this menu. Nevertheless, the menu was developed for new features that are planned to be implemented in future works.

In the first appointment, the players do not have access to all information related to the patient, such as: name, age, gender, whether the patient has a partner or not, risk behaviors, medical history, among others. This information must be obtained by the players through interaction with the patient. Every consultation has a dialogue between the players and the patient, where he/she describes symptoms, situations and his/her daily routine to the physician, see Figure 19A. At key points in the appointment, the users must make decisions which will, in turn, affect the course of the conversation. These decisions are displayed to the users as 19B shows. For instance, a decision may restrict the type of information the patient is willing to share with the physician. Another decision may simply end the current consultation with the patient.

Each recurring appointment with a patient presents important information from the last appointments, simulating a real consultation with a physician, as the information beside the picture of the patient in Figures 19A and 19B show. The decisions taken by the players in previous consultations directly affect the life of the patient and, therefore, have an impact on the upcoming appointments. Currently, there is only one mission related to HIV with three consultations, but it is intended to have more missions as future works and not every mission will be related to HIV. Some missions can be solved with just one consultation, others will require more. The players receive points when completing a mission, that is, completely consulting with a patient through all required appointments. When a mission is completed, the users receive an feedback about the

[1] `http://www.pokemongo.com`

Figure 19 – Other game screens.



Source: Created by the author.

decisions taken during the care of the patient in question. The game informs the correct decisions on each consultation and rewards the players accordingly, while advice is provided for each decision, regardless of being wrong or right. This occurs, because it is important not only to teach the players when they fail, but also to reaffirm their right decisions and explain why they made the correct choice given each context. Furthermore, the game sends notifications to the mobile phone of the players. There are three types of notifications, all of which are triggered when the game is closed or in background: i) notifications to inform on new patients that appeared nearby while the players were outside of the game; ii) notifications to prompt the players regarding patients that they had already seen, but did not consult with; and iii) notifications to warn the players about patients who have returned for a new consultation.

Figure 17 shows the initial designs crafted for the game, which were used as guidelines during the development of the prototype, while Figures 18 and 19 illustrate the final version of the game. Overall, we were able to maintain the main feel and aspect of the initial concepts, which were employed in the two first evaluations. Almost all features initially envisioned for the game were implemented in the final version of the prototype. The only features removed, due to the scope and time constraints of the project, were the ones related with social interaction and multiplayer. It is important to emphasize that our design evolved from its first concept to the final version through the feedback received during the first two evaluations, which were performed solely on the concepts and design of the game.

5.2 Prototype

We considered two engines to developed the prototype: Unity3D[2] or GameMaker[3]. Unity3D enables the creating of both 2D and 3D games, while GameMaker is focused on developing 2D only games. GameMaker uses its own programming language (GML), while Unity3D offers developers C# or JavaScript as programming languages. After researching each engine and analyzing its features, we decided to use Unity3D over GameMaker for different reasons: it supports both 2D and 3D development and we were planning to use a mixture of the two on our prototype; it enables cross-platform development and we aimed to deploy our project on iOS and Android; and finally because of the experience and familiarity of use of the authors with this engine.

Initially we were planning on developing specific components with different technologies, e.g. Storage in the cloud using Firebase[4], which is compatible with Unity3D and provides a series of features, such as automatic capacity scaling, automatic real-time data synchronization, automatic server maintenance, data storage, user authentication, messages and push notifications. Moreover, we were considering implementing a cache system to maintain a readily accessible copy of the information contained in the Storage, thus solving issues related to the frequency of communication between it and the Quest Generator. However, these approaches were deemed time consuming and, af-

[2] https://unity3d.com
[3] https://www.yoyogames.com/gamemaker
[4] https://firebase.google.com

ter considering the scope and time constraints of the project, we ultimately decided to search for existing solutions for each component (SDKs, frameworks, etc) and, if none were found, we developed our own solution directly on Unity3D.

We did not develop a server or API, all components were fully implemented inside unity and are represented as GameObjects containing scripts written in C#. Unity's GameObjects[5] are the fundamental objects in Unity that represent every element of the game. They do not accomplish much in themselves, instead they act as containers for Components, which implement the real functionality. For example, to create a object to serve as a light source, we must attach a Light component to a GameObject. In our case, we created GameObjects for each component and attached scripts for its functionality. Some components are composed by a GameObject with only one script, some have more than one script, and some comprise other technologies.

This is the case with the Storage, which contains a GameObject with scripts and two JSON files. Each JSON file[6] describes one category of information stored, chronic condition (CCJSON) and game (GJSON). For both JSON files we implemented a serializable class in C# so that Unity's JSON serializer is able to pack and unpack data to a text-based format easily. Classes that do not conform to the serializable protocol can not be converted to or from the JSON format. Both JSON files are read-only, because Unity has a restriction for saving files on mobile devices: it is only allowed to save documents on a specific path, the Application Data, to enable data persistence and the developer can not deploy files to this path through Unity's editor. Additionally, the path that the developer has access in the editor is not allowed to be accessed through code in mobile devices and, thus, the files in it can not be updated. This is not a problem for the CCJSON, since it is only used to load information related to the disease and there is no need to update it later on, i.e. the scripts read the file and convert it to serializable classes inside the Storage that, then, are used for the game. On the other hand, the information related to the game, the GJSON, must be saved after in-game modifications. Since we are not allowed to access the path of GJSON at run-time, GJSON is used only the first time the game is opened in the device, then it is converted to serializable classes to be used in-game. From this point forward, a new updated JSON is created and saved at the appropriate path, Application Data, and the game only uses this document for the

[5] https://docs.unity3d.com/Manual/class-GameObject.html
[6] https://www.json.org/

information of the game.

Ubiquity is the only component we found a existing solution which was the Mapbox SDK[7]. Mapbox is a location data platform for mobile and web applications, which provides building blocks to add location features like maps, search, and navigation. It offers SDKs for iOS, Android, Web and Unity3D and is used by companies such as Aribnb, IBM, Pinterest and CNN. After importing the package provided by Mapbox and installing it, we followed the tutorials and created different GameObjects to cover the necessary Mapbox features for our case. As a result of the architecture of the SDK for Unity3D provided by Mapbox, this was the only component, other than the Core, to be represented by more than one GameObject. We employed features that procedurally load map map images on demand and access the current location of the user. With Mapbox's package, the implementation of these features was done without much effort. For the social and multiplayer aspects of the game, we conceptualized features in which players could share their results on social media, invite friends, view the ranking of other users, compare results and ask friends for help during an appointment. As a result of the scope and time constraints of the project we opted to removed the Multiplayer/Social component. If we had developed this component, we would focus exclusively on Facebook and adopt the SDK provided by Facebook[8] itself to integrate the game with social media and implement the multiplayer features initially envisioned. This component would be implemented with a single script that directly calls the API endpoints provided by the Facebook SDK. This is set as future works for this prototype.

The Quest Generator and Feedback were each developed as a single GameObject with scripts attached to it. To generate the quests, we did not employ artificial intelligence techniques, rather we opted for a simpler approach. We make use of determined rules that act as filters and are applied on top of information related to the chronic condition, game and ubiquitous aspects to generate a quest, which in turn is sent to the Core to be handled in the main loop of the game. The implementation of the Feedback is also as determined rules, but in this case they act upon information related to the quest, the user action history and the chronic condition to generate a feedback and reward the player accordingly. The Motivator, too, is a GameObject with scripts, but it also has the autonomy to transmit information to the Core without its request. All other components

[7] `https://www.mapbox.com/unity`
[8] `https://developers.facebook.com/docs/unity/gettingstarted`

only respond to requests made by the Core, while this component is able to send data without them. This autonomy is a result of the main goal of this component, which is to motivate and engage the player. To do so, it must have the freedom to contact the player at anytime. One example is the notifications which can occur even when the game is closed. However, it is important to remind that, although it has autonomy to try to contact the player, this contact must be validated by the Core, since it is the only component that directly communicates with the user.

Finally, the Core was implemented with a series of GameObjects, each with its own scripts. We followed the general architecture defined in the model: a set of similar features must be comprised by a single GameObject. One example of this is that we created a GameObject containing various scripts responsible for generating and handling the UI of the game, including buttons, pop-ups, alerts, etc. Other example is the GameObject that manages the error logs at run-time. Or even the GameObject that manages the sprites of the game, responsible for their proper loading, organization and initialization.

6 EVALUATION

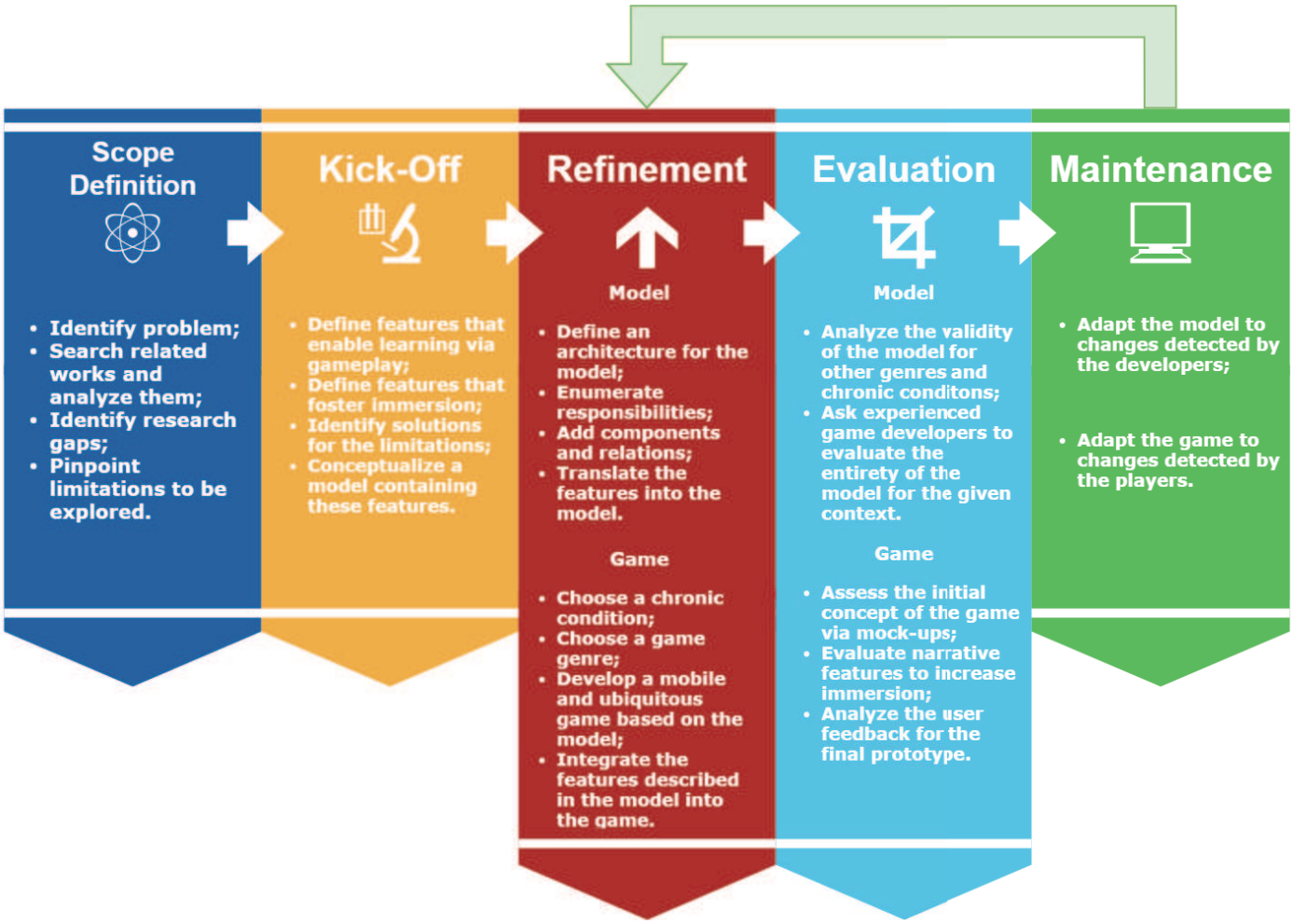
This chapter presents the evaluations carried out in our work, which includes three evaluations focused on the developed prototype based on the model proposed in this dissertation and one evaluation focused on the dissertation itself. The results of each evaluation, along with a discussion are also presented.

6.1 Evaluation Methodology

We adopted four different steps to evaluate this work. In the first step we aimed to qualify the design we conceived for the game through the opinion of participants, identifying aspects to be improved, removed and/or modified. The second step was characterized by the conduction of a focus group in order to define whether a narrative should be used for the game and, if this was the case, which narrative should be adopted. The third evaluation was conducted after the development of the prototype, to assess the user enjoyment of the game. The final step gathered opinions of game developer experts to ascertain the validity of our model, its components and relations for developing games in the scope presented on this dissertation. This steps are represented as the Evaluation banner of Figure 20, which illustrates all steps performed for creating the CCMUG model and the prototype presented here. Through the evaluations performed we gathered feedback and possible changes that were analyzed and, if deemed necessary, were adapted into our model and the prototype.

The first step consisted of an individual evaluation applied on undergraduate students of the Game Development graduate course at Universidade do Vale do Rio dos Sinos (Unisinos). Its objective was to qualify the game design, identifying necessary changes for the final game to provide an enjoyable experience to the user. Firstly, the participants were given a description of the game in the form of texts and mock-ups. Then, they were asked to answer a questionnaire containing 15 Likert statements which evaluated the game design. With the feedback of the participants we were able to identify changes to the game design, as well as the possibility to conceive a narrative for the game. After applying the changes into the prototype, we created a narrative for the game and decided to evaluate it.

Figure 20 – Methodology used for developing the CCMUG model and its prototype.



Source: Created by the author.

The second step occurred as an focus group (ACHARGUI; ZAOUIA, 2016) consisting of six of students that have participated in the individual evaluation. With the presence of a member of the research team, a set of questions were asked to the participants, serving as a guide for the discussion. The goal of the focus group was to define whether a narrative should be used for the game and, if so, how it should be composed. The audio of the discussion was recorded and it lasted 35 minutes, enough time for all participants to contribute with their views.

The third step was conducted with 20 participants, where they played the game and,

afterwards, answered the EGameFlow (FU; SU; YU, 2009) questionnaire elaborated to be used as a scale to measure the enjoyment of the users in e-learning games. EGameFlow aids the developers and game designers to understand the strengths and flaws of the game from the point of view of its players. It consists of eight dimensions: Concentration, Goal Clarity, Feedback, Challenge, Autonomy, Immersion, Social Interaction and Knowledge Improvement. Each dimension is comprised by several items, which are analyzed to determine the overall grade of the dimension. The participants must choose an answer in a scale from 1 to 7 for each item, representing their experience in playing the game. The final score for the dimension is obtained from the average of the scores of its items.

In the final step, a individual structured interview (ANDERSEN; GROTE, 2015) was conducted with 15 experienced game developers. Similarly to the EGameFlow evaluation, the audio of all interviews was recorder so that later transcriptions could be performed and analyzed. Initially, the participants answered questions about their personal and professional profile. Then, the model, its components, its features and relations were explained in detail by a member of the team through images. The participant had freedom to ask any questions so that the model could be fully understood. Then, the individuals had to answer a survey containing 13 questions elaborated to assess the overall validity of our model. Open-ended questions were asked as a final step to ascertain the necessity of performing minor and drastic changes to our model.

6.2 Individual Evaluation

The individual evaluation was conduced with a group of undergraduates of the Game Development course at Unisinos, in order to qualify the game design through the opinion of the participants, identifying features/aspects of the game design to be improved, removed, and/or modified to provide a fun and enjoyable end-user experience. The decision to carry out the evaluation with this class was made, since these students have specialized knowledge in the development of games, so their opinions contain a higher degree of technical basis when compared with students of other technological courses. A total of 21 students participated, all men between 18 and 34 years old.

The questionnaire, distributed to the participants through *Google Forms*[1], was di-

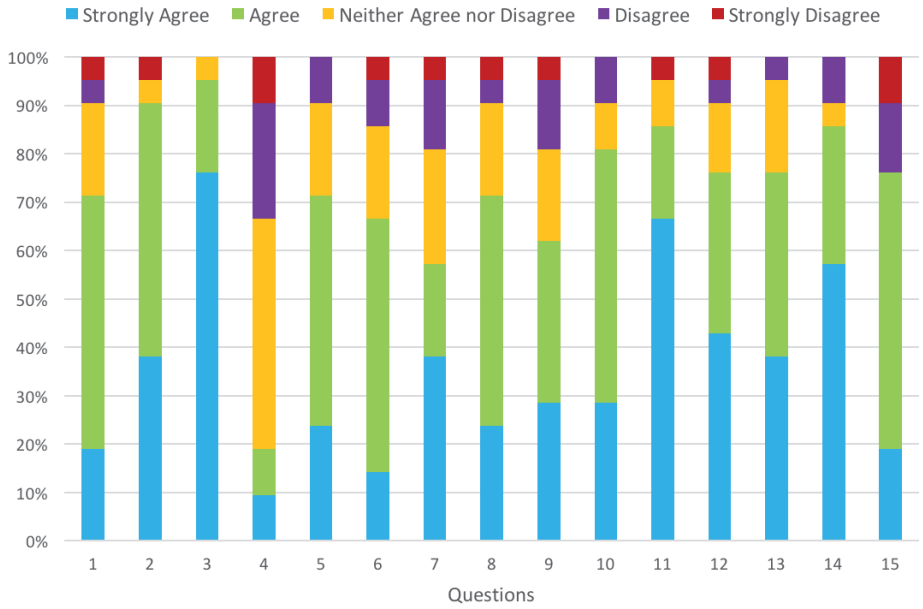
[1] `https://www.google.com/forms/about`

Table 9 – Statements used in the evaluation questionnaire.

Type of Evaluation	Statements
Gameplay mechanics	1 - The mechanics of patient consultation are interesting; 2 - Using notifications to inform the player about new/recurring patients portrays the functioning of real-life appointments; 3 - Providing feedback at the end of each mission is important to the player; 4 - The use of GPS makes the game more attractive; 5 - Notifications add value to the game.
Social aspects	6 - Sharing results adds value to the game; 7 - Comparing the scores of the players adds value to the game; 8 - Inviting friends adds value to the game; 9 - Asking friends for help during a consultation adds value to the game.
Visual aspects	10 - The distribution of the elements on the map screen is correct; 11 - The distribution of the elements in the appointment screens is correct; 12 - The color palette used is consistent with the game proposal.
Overall game proposal	13 - The game proposal is able to reconcile entertainment with a serious theme, HIV/AIDS; 14 - I can learn about HIV/AIDS through play; 15 - I am interested in playing this game.

vided into two sections: i) a description of the game through texts and images and ii) 15 statements to evaluate the game design, see Table 9. Each question had five Likert format response options (LIKERT, 1932) as follows: 1 - Fully Disagree, 2 - Partially Disagree, Indifferent, Partially Agree and 5 - Fully Agree. The students were motivated to follow the think-aloud protocol, that is, to say whatever comes into their minds (YAMADA et al., 2016). In both sections of the evaluation team members were present, answering questions and noting opinions and comments expressed by the participants. Furthermore, the questionnaire presented two additional fields that request for the age and gender of the participant and, in the end, an open question that instigates the opinion of the participant.

Figure 21 – Percentages of answers to each evaluation question.



Source: Created by the author.

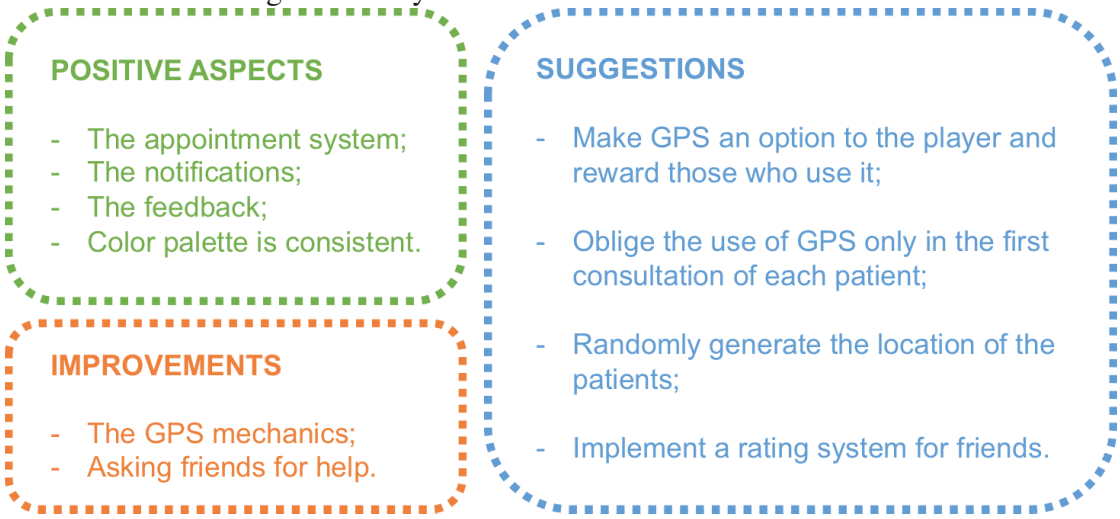
6.2.1 Results

Figure 21 shows that there was a general acceptance of the game mechanics, mainly the system of appointment, feedback and notifications. The mechanic that presented the worst result was the use of GPS, specifically the obligation of the players to move in the real world. Through the answers of the participants to the open question, it was possible to identify ways to improve this mechanic. One participant suggested obliging the players to use the GPS only in the first consultation of each patient. Another commented that GPS should not be imposed on the players, but rather that it should be an option to them and the game should reward those who use it. It was also suggested that patients do not always stay in the same location, i.e. that there is a random generation of the place where patients appear on the map, new or recurring ones.

The social aspects were also accepted by the students, the only concern being regarding the request of help from friends during a consultation. The concern is if friends select the wrong answer purposely in order to induce the player to error. As a solution, a rating system for friends was suggested, allowing the players to discern which friends

are trustworthy and which are not. There were no suggestions or comments regarding the visual aspects and, according to the results, it is possible to observe that the reception of them by the participants was positive. Finally, the participants received the overall proposal of the game in a positive way, showing interest in playing the game, agreeing that the proposal combines entertainment with the HIV/AIDS theme and, that using the game, it is possible for the end user to learn about this chronic condition.

Figure 22 – Synthesis of the individual evaluation.



Source: Created by the author.

Figure 22 shows a synthesis of the individual evaluation. The results are satisfactory and indicate that, in general, the design is appropriate and exerts its function of entertaining the players and teaching them concepts about the chronic condition, in this case HIV/AIDS. However, as future work, it is necessary to implement the suggestions of the participants regarding GPS and the mechanics of requesting help from friends, thus increasing the degree of acceptance of the game. In addition, it is required to conduct a new evaluation that uses a prototype developed based on the design proposed here, and analyze the results.

6.3 Group Evaluation

We conducted a focus group as the second evaluation. This type of evaluation consists of gathering a group of people to discuss specific research topics with the presence

Table 10 – Questions of the focus group.

Number	Question
1	How this serious ubiquitous game for HIV was first perceived by you?
2	Do you believe that a serious game can be fun as well as teach concepts to the player?
3	Do you think that narrative is an important aspect in games?
4	Which is better, in your opinion, for a serious game: to create a story to engage the player or define it as a simulation and not elaborate a narrative?
5	What do you think about the story of a physician struggling to take care of his family?
6	What changes would you suggest to this story?

Source: Created by the author.

of a member of the research team, which acts as a mediator. One advantage of employing the focus group methodology is the depth and complexity of the responses generated, since the interaction between participants may stimulate debates and discussions of opinions (ACHARGUI; ZAOUIA, 2016). The information is generated through the interactions between the participants, which expose their expose their personal opinion to the whole group (ARTHUR et al., 2012)(RITCHIE et al., 2013). When compared to an one-on-one interview, a focus group is more cost effective (OGBEIFUN; MBOHWA; PRETORIUS, 2016) and it enables the evolution of the discussion, because when a new opinion is presented, the group will consider this opinion in a future contribution to the discussion (RITCHIE et al., 2013).

Ritchie et al. (2013) defines that, for any area of research, the optimal number of participants is from six to eight, whereas Ogbeifun, Mbohwa and Pretorius (2016) states that a typical session should contain between four and twelve participants. A group larger than twelve may generate more ideas than a smaller group, but a group this large becomes difficult to be managed (OGBEIFUN; MBOHWA; PRETORIUS, 2016).

We approached the same group of participants of the individual evaluation to participate in this focus group. The selection of the participants sought to maintain the amount suggested by Ritchie et al. (2013) and Ogbeifun, Mbohwa and Pretorius (2016), therefore we gathered a total of six students. Moreover, we defined a set of questions that were used to guide the discussion, shown in Table 10. The goal of this focus group

was to define whether a narrative should be used for the game or not. This decision was made based upon feedback received from the first evaluation, where some participants stated that if the game has a narrative, it is recommended to elaborate an interesting one to engage the player rather than create a superficial story merely for the purpose of having one.

Thus, we conceived a narrative for the game as follows:

"The player assumes the role of a physician of a fictional country. The physician has just assumed his new job on the hospital and should attend patients in order to earn his living. He is rewarded based upon the amount of appointments performed a day, so he will receive his salary at the end of each day. The reward received for each consultation depends on the correct choices the players made during the appointment with the patient, they will earn a higher payment for a consultation in which all their choices were successful than in a consultation where they made wrong choices. At the end of the day the players will be presented with a summary of the family expenses, which include money spent on food, water, school, groceries, house repairs, medical treatment, among others. Additionally, periodically the game will randomly generate events that will either reward or punish the players, e.g. their fridge could break, resulting in a higher expense for that day, so the players would have to pay for a new one".

This adds a resource managing aspect to the game where the players should manage their expenses with their daily wage, while being aware that, at any given time, unplanned events could happen. This could further engage the users in the game, since they will be actively managing their resources so they could provide for their family. This narrative was based on the game Papers Please[2], which puts the players in the role of an immigration inspector that should control the flow of people entering the fictional country of Arstotzka.

The focus group was conducted with a group of six male students between 18 and 23 years that participated in the first evaluation. All participants in the study had already completed the Script class of the Game Development course at Unisinos, which covers themes related to the creation of narratives for digital games. Additionally, 50% of the students were currently in the second semester of the course, while the other half were in the third semester. Thus, we can assume that all the participants had sufficient knowledge in the elaboration of narratives for games. The focus group began with the

[2] http://papersplea.se

appreciation of the researcher for the participation and an explanation of how the group discussion would be conducted. The questions that would guide the discussion were presented, and all were informed that the discussion would be recorded in audio so that the researcher could later perform the transcription and analysis of the conversation. The discussion lasted 35 minutes, enough time for all participants to participate and state their views on all questions raised.

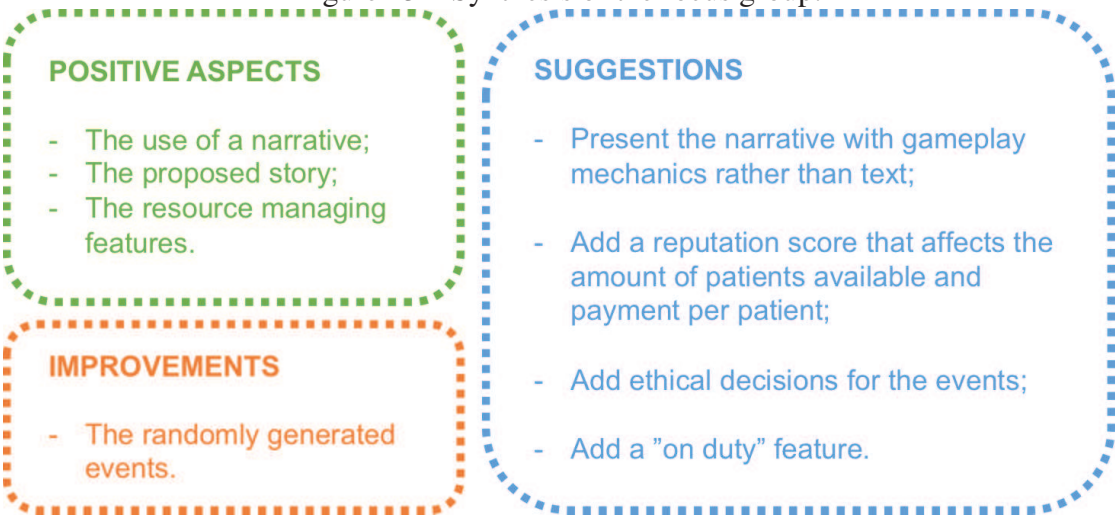
6.3.1 Results

The group, when asked about their first impressions regarding the ubiquitous game for HIV, was intrigued by the game proposal and its mechanics of consultation. They stated that it is important to propose solutions for this issue and that the approach of using games to teach the population about diseases could have a positive result, since games often successfully achieve the goal of teaching the players new concepts. They declared that games developed with the main objective to instruct the player could be also entertaining, but in order to achieve this, interesting gameplay mechanics and a well-structured narrative would be necessary. To exemplify the importance of storytelling in games, the group began discussing different games that, in their view, successfully managed to create engaging narratives, such as Undertale[3], Portal 2[4] and The Witcher 3: Wild Hunt[5]. On the other hand, the group mentioned games that managed to deliver an enjoyable and appealing experience to the player without a well-structured narrative, such as Diablo III[6], Overwatch[7] and Rocket League[8].

When asked the question number 4 (see Table 10), the participants concluded that, depending on the situation, using a narrative on serious games may be either a good or a bad approach. They did not explain this conclusion, but we speculate that it occurred because there is a category of serious games that are developed with the goal of training professionals in an area. For instance, a car dealer hires a company to develop a game to train the communication skills of their employees. In this case, the game is a sim-

[3] http://undertale.com
[4] http://www.thinkwithportals.com
[5] http://thewitcher.com/en/witcher3
[6] https://us.battle.net/d3/en
[7] https://playoverwatch.com
[8] https://www.rocketleague.com

Figure 23 – Synthesis of the focus group.



Source: Created by the author.

ulation and the use of an elaborate and well-grounded narrative is not necessary since, generally, the consumption of such games is imposed by the company on its employees and, consequently, it is not required to adopt additional methods to engage and motivate the player. On the other hand, games with a social bias need to employ these methods to attract and maintain players.

The group showed interest for the proposed narrative of a physician who is struggling at his new job to provide for his family. They stated that this story could motivate the player to continue playing, since it appeals to something everybody can relate to, which is to worry about your loved ones and try to protect them. They also affirmed that the randomly generated events, emerged from the narrative, could increase the "replayability" of the game and, consequently, the engagement of the player. According to Brewer (2017), "replayability is considered to be a major factor in the long-term enjoyment of a video game". In gaming, the term "replayability" refers to the quality of the game of being suitable for or worth playing more than once. Many games are appealing during the first play-through, but after that, the players tend to lose interest in the game due to its fixed solutions and linear paths. To overcome this, developers employ techniques to randomly generate content for the game, resulting in a variety of content and gameplay and, thus, motivating the players to play more than one time (BREWER, 2017)(DART; NELSON, 2012)(NICKEL et al., 2012).

Finally, the participants suggested new features based on the narrative. The only recommendation to the story itself was to introduce it to the player with the least amount of text possible and try to expose the narrative through gameplay mechanics. One of which was to add a reputation score that increases each successful consultation the players perform and influences the amount of payment they will receive per appointment and the frequency of patients who consult with them: the higher reputation the users have, the higher their payment after attending a patient and the amount of available patients for them to attend. Another suggestion was to add ethical decisions for the players to make via events, and these decisions would affect their reputation. For instance, the players could be presented with the choice of providing fake medical certificates for a patient in exchange of extra money. This decision would carry a risk factor for the users, because if they are discovered, their reputation would dramatically decrease. The last feature proposed by the group was to periodically offer the players to be on duty. They would have a limited amount of time to perform a number of consultations and, if successful, they would earn a higher amount of money. Figure 23 shows a synthesis of the focus group.

6.4 EGameFlow Evaluation

This evaluation was conducted with 20 people and based on the developed prototype. It was conducted in a span of three weeks, partially in person and partially online via Skype, based on the availability and preference of each participant. In both derivations, the first step was to give a detailed explanation of the game and its features to the participants. Any and all questions were solved before continuing to the next step, this was made to ensure that the players understood the context of the game, its features, its purpose and how to play it.

The game was deployed on whichever platform, iOS or Android, the user chose. If online and on Android, the *Apk* was sent to the player with instructions on how to install it on the device. If online and on iOS, the users were asked for an email and then given access to the game via *Testflight*[9], Apple's platform for testing early versions of applications and collect valuable feedback without the need to publish it on the store. If in person, the participants were given an iPhone 6 with the game installed for them to

[9] `https://developer.apple.com/testflight`

test.

During gameplay, members of the team were available to answer the questions of the participants. All participants played the prototype to its full extension, meaning that they completed the three consultations for the only patient available on the game. They were asked to replay the quest until completion: if they failed during the first two consultations, the quest was generated again so that the player could finish it. This step of the evaluation took between 10 to 15 minutes for each participant and to finish.

In the final step, the participants were asked to answer a questionnaire based on EGameFlow, a scale proposed by Fu, Su and Yu (2009) to measure the enjoyment offered by games designed to teach its users. The effectiveness of such types of games is directly related to the enjoyment it instills on its players, because enjoyment may serve as an incentive to the learning initiative of the users (FU; SU; YU, 2009). EGameFlow aids the developers and game designers to understand the strengths and flaws of the game from the point of view of its players. It consists of eight dimensions: Concentration, Goal Clarity, Feedback, Challenge, Autonomy, Immersion, Social Interaction and Knowledge Improvement. Each dimension is comprised by several items, which are analyzed to determine the overall grade of the dimension. The participants must choose an answer in a scale from 1 to 7 for each item, representing their experience in playing the game. The final score for the dimension is obtained from the average of the scores of its items.

We employed a modified version of EGameFlow with the following dimensions: Concentration, Feedback, Challenge, Autonomy, Immersion and Knowledge Improvement. Goal Clarity was removed because of two main reasons: i) we knew beforehand that if this dimension were to receive a low score, it would be due to the fact that our prototype had no tutorial due to the scope of the project, and ii) if this dimension were to receive a high score, it would be because of the explanation the participants were given before playing the game, and not because of features of the prototype. Additionally, we opted to removed the Social Interaction dimension, since our prototype had no multiplayer or social interaction features developed due to the scope and time constraints of the project.

Hence, our questionnaire was divided in two sections. In the first section, the participants were asked to inform their age and gender, while the second section was comprised of the six dimensions and a total of 30 items distributed through them. Table 11 shows

the modified scale of EGameFlow we employed in this evaluation. Column “Item no.” of Table 11 shows an identification for each of the questions and was created to serve as a reference to be used for the discussion of the results.

Table 11 – Modified scale of EGameFlow.

Factor	Item no.	Content
Concentration	C1	Most of the gaming activities are related to the learning task
	C2	No distraction from the task is highlighted
	C3	Generally speaking, I can remain concentrated in the game
	C4	I am not distracted from tasks that the player should concentrate on
	C5	I am not burdened with tasks that seem unrelated
	C6	Workload in the game is adequate
Feedback	F1	I receive feedback on my progress in the game
	F2	I receive immediate feedback on my actions
	F3	I am notified of new tasks immediately
	F4	I am notified of new events immediately
	F5	I receive information on my success (or failure) of intermediate goals immediately
Challenge	H1	The game provides “hints” in text that help me overcome the challenges
	H2	The difficulty of challenges increase as my skills improved
	H3	The game provides new challenges with an appropriate pacing
	H4	The game provides different levels of challenges that tailor to different players
Autonomy	A1	I feel a sense of control and impact over the game
	A2	I know next step in the game
	A3	I feel a sense of control over the game
Immersion	I1	I forget about time passing while playing the game
	I2	I become unaware of my surroundings while playing the game
	I3	I temporarily forget worries about everyday life while playing the game
	I4	I experience an altered sense of time
	I5	I can become involved in the game
	I6	I feel emotionally involved in the game
	I7	I feel viscerally involved in the game
Knowledge Improvement	K1	The game increases my knowledge
	K2	I catch the basic ideas of the knowledge taught
	K3	I try to apply the knowledge in the game
	K4	The game motivates the player to integrate the knowledge taught
	K5	I want to know more about the knowledge taught

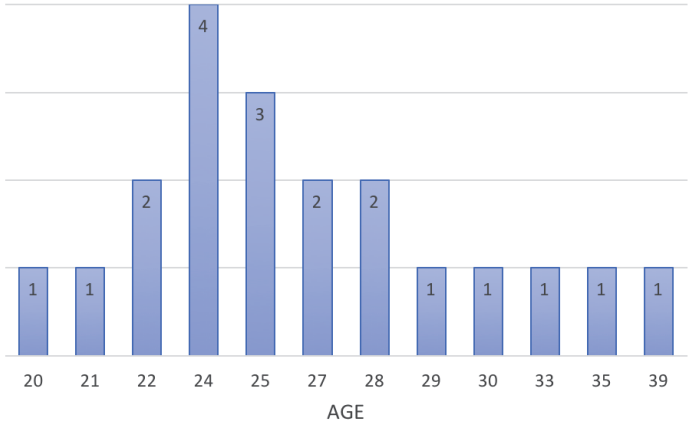
Source: Created by the author.

6.4.1 Results

As mentioned before, we were able to gather a total of 20 individuals that participated in this evaluation and, through the questions of the first section of the evaluation, we determined the basic profile of the participants. Of the 20 individuals, 15 (75%) are men and 5 (25%) are women. The participants are between 20 years and 39 years, with

an average of 26.6 years. Via Figure 24, it is possible to visualize the full extent of the ages of the participants: the mode is 24 years with 4 occurrences, followed by 25 years with 3 occurrences, then is 22, 27 and 28 years all with 2 occurrences and, lastly, 20, 21, 29, 30, 33, 35 and 39 years all with only 1 occurrence. Although there is a mode, the sample for this evaluation is diverse in regard to the age of the participants, especially when taking into account the difficulty to find eligible individuals with significant experience on game development.

Figure 24 – Ages of the participants (Prototype Evaluation).



Source: Created by the author.

After playing the game, they were asked to fill out a modified version of the EGameFlow questionnaire, which was comprised with the questions present on Table 11. The questionnaire was divided in 6 sections, with each section representing one dimension of EGameFlow. Figure 25 shows all answers of the participants for each item of the survey, refer to column "Item no." on Table 11 for the abbreviations used in the figure. As mentioned before, the participants were asked to answer our modified version of EGameFlow, comprised by the items denoted on Table 11. To do so, following the guidelines of EGameFlow, they had to evaluate the game by choosing an answer for each item in a scale from 1 to 7, with 1 being the lowest possible rating and 7 the highest. Analyzing Figure 25, we can observe that concentration and knowledge improvement were the best rated dimensions, followed by feedback, autonomy, challenge and immersion. For concentration, 90% of the answers for the items C1, C3, C4 and C5 scored with 6 or more, while this percentage lowers to 85% for C2. For knowledge

Table 12 – Statistics of the prototype.

Factor	Mean	Standard Deviation
Concentration	6.408	.966
Feedback	5.920	1.323
Challenge	4.663	1.922
Autonomy	5.800	1.312
Immersion	4.286	1.961
Knowledge Improvement	6.660	.685

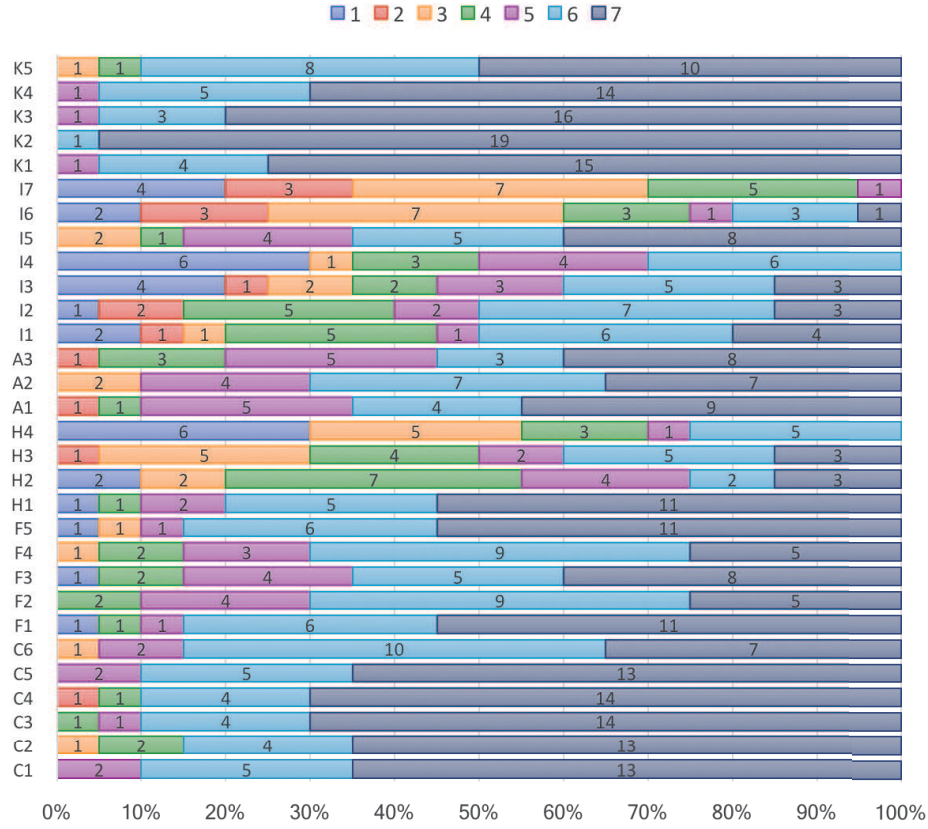
Source: Created by the author.

improvement, all participants rated K2 with 6 or above, 95% rated K1, K3 and K4 with 6 or more, this percentage lowers to 90% for K5.

For autonomy, the highest score was for A2: 70% scored this item with 6 or more. Next A1, with 65% and lastly A3 with 55%. The scores for the feedback were higher: the lowest for this dimension was F3, with 65% of the answers being 6 or above. This percentage raises 70% for F2 and F4 and 85% for F1 and F5. On the other hand, challenge showed mixed results, the highest being H1 with 80% of the answers rated with 6 or 7. For the other items, 45%, 50% and 30% of the participants scored, respectively, H2, H3 and H4 with 5 or above. Lastly, item I5 received the highest score for immersion dimension, with 85% rating this item with 5 or more. For the items I1, I2, I3, and I4 were rated by 55%, 60%, 55% and 50% of the participants with 5 or above. Items I6 and I7 gathered the lowest results for this dimension: 65% of the participants rated I6 with 3 or lower, this percentage raises to 70% for I7. The authors of EGameFlow (FU; SU; YU, 2009) do not analyze these results individually, since they are indirectly addressed in their proposition of evaluating the dimensions through mean and standard deviation.

Following the guidelines established by Fu, Su, and Yu (2009) , we generated Table 12 which illustrates the means and standard deviations (SDs) for each dimension of our developed prototype. The intention to generate mean and standard deviation is that these values make it easy to interpret and even compare results for various games, or even different versions of the same game, assessed with the same scale. Additionally, by analyzing these values, it is possible to quickly determine the strengths of the game, as well the aspects that should be improved. The best possible result for a dimension is to

Figure 25 – Percentages of answers of each evaluation item.



Source: Created by the author.

have a mean of 7 with a standard deviation of .0, meaning that all participants evaluated all items of the dimension with the highest grade possible (7). The higher the mean, the better the dimension scored. As for the standard deviation, when accompanied by a high mean, the lower its value, the better is its result, because the responses of the participants in that dimension do not differ much from the average, which is high.

Overall, all dimensions were scored with a mean above 4.286, more than half of the scale. This results are satisfactory given the context of the prototype: even though the game had limited features and some of the features envisioned during the early stages of development had been removed due to scope and time constraints of the project, no dimension received a significantly low score. Examining Table 12, we can identify 3 levels of results.

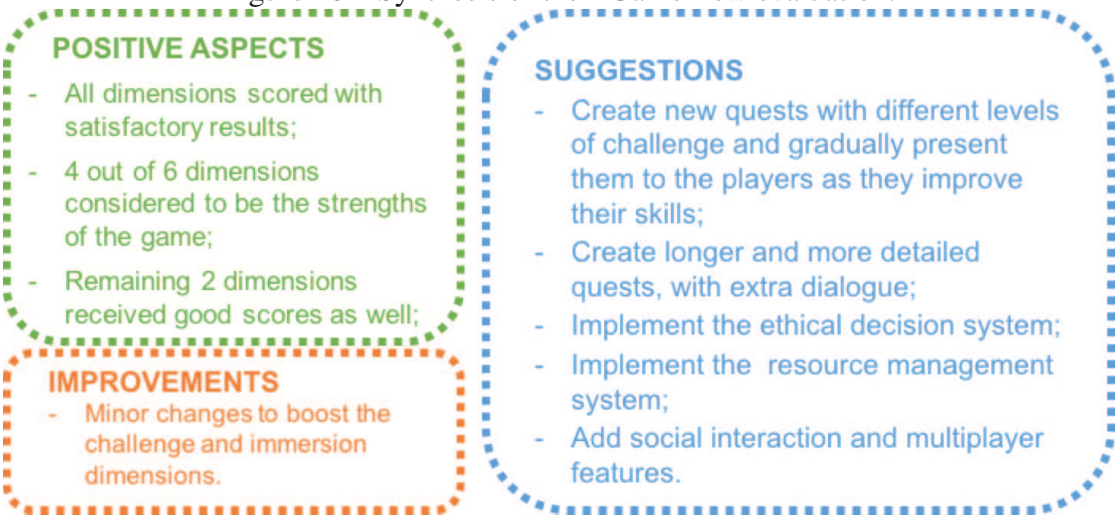
The first level covers the dimensions that received the best results, close to 7, and consequently are considered as the major strengths of the game. The second level represents the dimensions that have received satisfactory results, but not as close to the maximum score as the first level. These dimensions can also be considered strengths and could be improved in new versions of the prototype. In the last level are the dimensions that received the lowest results, being the ones that should be prioritized for improvements in the next versions. It is important to emphasize that no dimension received significantly low results to the point of considering them bad dimensions. On the contrary, all dimensions were scored satisfactorily, except that those present at level 3 present more room for improvement than the other levels.

Knowledge improvement and concentration compose the first level, with the mean of knowledge improvement being the highest at roughly 6.6 on a 7 point scale. Its SD scored the lowest at .685, implying that there was low divergence from the mean. With this, one of the strengths of the game is its ability to convey new information and concepts to the players, i.e. the game can be used as a knowledge improvement tool in regard of its theme: HIV. Concentration was scored with a mean of 6.408 and SD of .966, the second best result of the dimensions. Thus, another strength is that our game is able to retain the users' attention, providing activities that encourage their concentration and diminish the stress that comes from the learning overload. Generally, these learning activities may lower the concentration the users have on the game. So it is safe to affirm that the activities, or quests, of our prototype were properly created, with a correct proportion of learning aspects and gameplay aspects, hence the results obtained for this dimension.

Feedback, with a mean of 5.92 and SD of 1.323, and autonomy, with a mean of 5.8 and SD of 1.312, constitute the second level. These dimensions, scored with means roughly below 6, can be considered also as strengths of the game, but, if possible, they may be further developed in new versions of the game, but it is not mandatory. Our game allows the players to determine the gap between the current stage of knowledge and the knowledge required for ultimate completion of the current task (quest) being performed by the players. Another characteristics verified by the results of the autonomy dimension are: the users are encouraged to take initiative in playing the game and the game asserts total control over their actions and choices within it.

The last level is composed by challenge, with a mean of 4.663 and SD of 1.922, and

Figure 26 – Synthesis of the EGameFlow evaluation.



Source: Created by the author.

immersion with a mean of 4.286 and SD of 1.961. Our prototype had only one patient, i.e. quest, with three consultations. This explains the lower result obtained in challenge, since it represents the ability of the game to offer challenges that fit the users' level of skills. One way to improve this dimension is to create new quests with different levels of difficulty to cover different in-game skill levels. Furthermore, immersion could also be improved with a wider array of quests, since it represents the state of immersion the players sensed during gameplay. Longer and more detailed quests, coupled with the implementation of some features that were cut in the development of the game, e.g. the ethical decision system or the resource management system envisioned in the focus group, could further improve the sense of immersion of the players. Nevertheless, the results obtained in this level are satisfactory given the context of scope and time constraints of the project. Figure 26 shows a synthesis of the EGameFlow evaluation, denoting the positive aspects and improvements observed for our prototype, as well as suggestions to achieve those improvements.

6.5 Developer Evaluation

As the final evaluation of this dissertation, we employed an individual structured interview with 15 game developers with proven experience in the area. This type of

interview has predefined questions and answears (ANDERSEN; GROTE, 2015) and the person responsible for conducting the interviewing reads out each question and, sometimes, the possible answears to the interviewee, while checking which answer the participant chose (KVALE; BRINKMANN, 2009). This way, one can ensure that every interview is presented with exactly the same structure, the same questions in the same order (PATTON, 1990) (PERSONNEL MANAGEMENT, 2012). Thus, comparisons can be made with confidence between different sample subgroups and survey periods (LINDLOF; TAYLOR, 2002). Generally, the choice of answers is close-ended, nevertheless open-ended questions can be included within a structured interview.

We decided to adopt this methodology as a result of different reasons: i) we performed literature researches and concluded that, to the best of our knowledge, there is a lack of proper evaluation methods to assess conceptual models conceived to serve as a base and standard for the development of games; ii) the results of our mapping study confirmed the lack of proper evaluation methods. Furthermore, it showed that the prevailing method of evaluation is to train the users, ask them to play the game and then answer a follow-up survey (see Section 3.3.5), which is not applicable to properly evaluate a model of this kind; iii) one possible method to evaluate a model of this kind is to develop various games with different scenarios based on our model and, consequently, assess whether it accomplished its objective. This approach was unfeasible due to time and manpower constraints of the project. Therefore, we opted to assess our model via structured interviews with game developers, since they have specialized knowledge in this field to determine whether our model may be used to accomplish its objectives, i.e. if CCMUG may be employed as a basis in the development of games in this scope.

Similarly to the modified EGameFlow method we employed to assess the prototype (Section 6.4), this evaluation occurred in a span of two to the three weeks, partially in person and partially online via Skype, based on the availability and preference of each participant. The interview was led by a team member following the guidelines for this type of interview, i.e. the interviewer followed the same structure for each participant. The member read all questions and possible answer choices in the same order, while checking the answers that the participants chose. Additionally there were key moments in the interview that the participant could ask questions to the interviewer. The audio of all interviews was recorded so that the researcher could later perform the transcriptions and analyze the conversations, if needed.

Table 13 – Questions to determine the profile, experience and participation of the developer.

Factor	Item no.	Content	Type
Profile	PF1	(OPTIONAL) State your name	Text
	PF2	State your age	Number
	PF3	State your gender	Multiple Choice
	PF4	(IF APPLICABLE) State your level of education	Multiple Choice
	PF5	State your course	Text
	PF6	State the position that best describes your role in game development	Multiple Choice
Experience	E1	State your experience with game development	Multiple Choice
	E2	State your experience with game development for mobile platforms	Multiple Choice
Participation	P1	Creating the design/concept of the game	Likert Scale
	P2	Performing tests to identify bugs	
	P3	Solving the bugs identified in the codes	
	P4	Programming the game and its mechanics	
	P5	Creating and managing the art assets	
	P6	Creating and managing the audio assets	
	P7	Publishing the game	

Source: Created by the author.

The interview was divided into four sections: profile of the developer, model explanation, survey and suggestions and final considerations. Initially, the participants were informed about the nature of the evaluation, their responsibilities, rights and collaboration in the study. Then, we asked the participants general questions to determine their profile. They stated their age, gender and level of education, while the name was optional. Finally, they answered questions that sought to determine their experience in game development (multiple choices) and their participation in the various stages of the process: each question had five Likert format response options (LIKERT, 1932) as follows: 1 - No Participation, 2 - Limited Participation, Average Participation, Sufficient Participation and 5 - Full Participation. The questions asked during this section of the interview are denoted in Table 13. Similarly to Table 11, the column "Item no." was created to serve as a reference between Table 14 and the figures of the results that will be presented, since the caption of the images would not fit in the same without the creation of these abbreviations. At the end of this step, they had time to ask any questions that have come up so far before proceeding to the next.

Then, the model was explained in detail for the developer. To do so, they were given the image of the model while the member described it. Each component, its features, its relations and specific terms related to this dissertation, such as ubiquity, were explained in detail extensively for the model to be fully understood. The scope of the project, as

Table 14 – Script of Structured Interview.

Item no.	Content
M1	The model can be used to develop games for mobile devices
M2	The model can be used to develop games that use sensor information (Ubiquity component)
M3	The model can be used to develop games for other platforms without applying drastic changes
M4	The model can be used in different Engines (e.g. Unity, Unreal, GameMaker) without applying drastic changes in it
M5	The relationships between the components are consistent with those present in the architecture of a digital game
M6	The development environment for each component of the model (cloud or device) is consistent with a real mobile game development environment
M7	The model encompasses the basic features necessary for the development of a game focusing on chronic diseases
M8	The model can be used to develop games with themes focused on chronic diseases (Storage component)
M9	There is justification for creating a component responsible for generating feedback for the user (Feedback component)
M10	There is justification for creating a component responsible for keeping the user engaged and motivated to return to the game (Motivator component)
M11	There is justification for creating a component responsible to generate the quests (component Quest Generator)
M12	Through the "Multiplayer/Social" component, I can develop multiplayer features, provided they are not real-time
M13	Through the model, it would be possible to develop a mobile or ubiquitous game with a theme focused on chronic diseases

Source: Created by the author.

well as its peculiarities and nuances, were also clarified. At the end of this step, they had time to ask any questions that have come up so far before proceeding to the next. The participants were then asked to answer a survey containing 13 questions elaborated to assess the validity of our model, its components and relations for developing games in the scope proposed in this dissertation. Each question had five Likert format response options (LIKERT, 1932) as follows: 1 - Fully Disagree (FD), 2 - Partially Disagree (PD), Indifferent (I), Partially Agree (PA) and 5 - Fully Agree (FA).

Finally, the participants were asked open-ended questions to ascertain the necessity of removing, modifying or adding any component in our model to properly accomplish

its objectives stated at the start of the interview. Also, the final open-ended question asked the developer for opinions, suggestions and additional criticism that were not addressed in the interview and that they felt was relevant to declare. The script of the structured interview is denoted Tables 14 and 15. Similarly to the other tables, the column "Item no." of Table 14 was created to serve as a reference between the table and the figures of the results that will be presented, since the caption of the images would not fit in the same without the creation of these abbreviations.

Table 15 – Additional questions to evaluate the model.

Content	Type
Would you remove any components from the template?	Yes/No
If so, which component and why?	Open-ended
Would you modify any component of the model?	Yes/No
If so, which component and why?	Open-ended
Would you add any components to the template?	Yes/No
If so, which component and why?	Open-ended
Any suggestions or additional criticism?	Open-ended

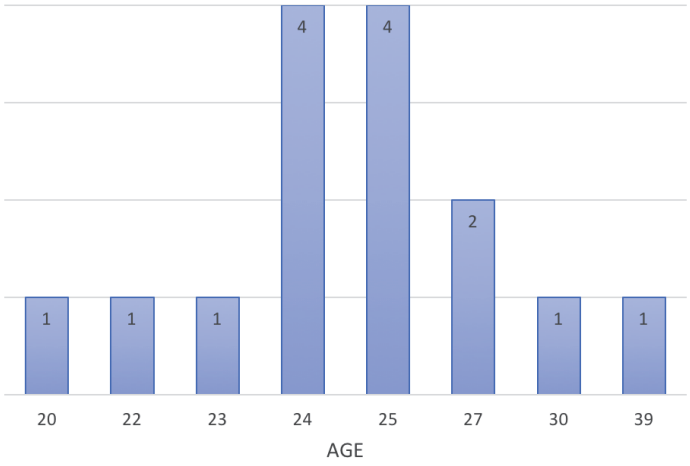
Source: Created by the author.

6.5.1 Results

Through social media and direct contact, we were able to gather a total of 15 participants that fit the inclusion criteria of this evaluation, which were: i) have experience in game development and ii) have experience in game development for mobile platforms. The questions asked during the first section of the interview (see Table 13) were aimed at determining their profile, experience in game development and participating in each stage of this process. We were able to identify a prevalence of men in our sample (PF3), constituted of 14 (93%) men and 1 (7%) woman. However, to the best of our knowledge, this does not influence the results obtained in this evaluation.

Figure 27 shows full extent of the ages of the participants. The answers to PF4 show

Figure 27 – Ages of the participants (Prototype Evaluation).



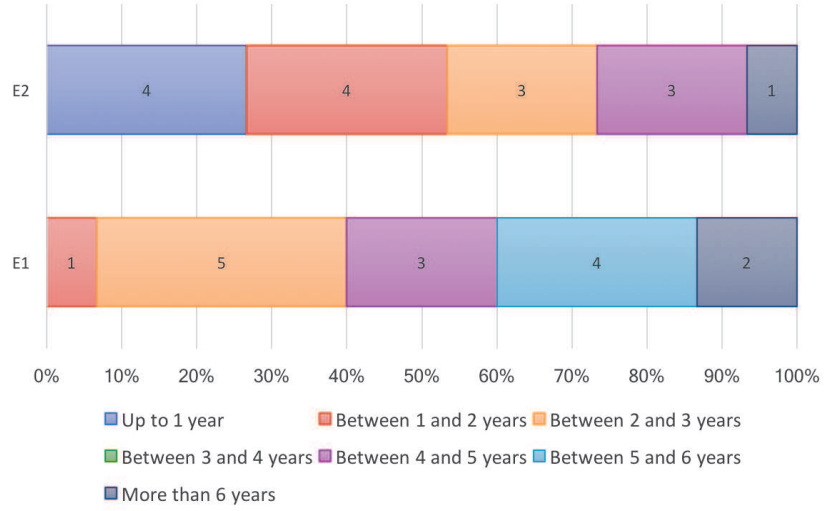
Source: Created by the author.

that the average age of our participants is 25.6. We can also identify that 24 and 25 years prevail and that the participants are between 20 years and 39 years. The results of PF3 shows that the majority, 11 out of 15 (75%), of participants have a bachelor's degree. Of these 11, 3 are currently pursuing a master's degree, 1 has already finished his/her master's and 1 is currently pursuing a doctorate degree. The remaining 6 are all pursuing their bachelor's degree. Through PF5 we identified that 8 (57.1%) have pursued an academic degree on game development, 4 (28.6%) focused on applied computer, 1 (7.1%) on computer science and 1 (7.1%) on information systems. All participants are currently studying on an academic level topics related to technology and all courses have programming as part of the curriculum, thus it is safe to assume that the participants have previous experience and general knowledge at programming.

PF6 refers to the position that best describes the role of the participants in their game development careers: 12 (80%) described themselves as game programmers, 1 (6.67%) as an artist, 1 as (6.67%) as a tester and 1 (6.67%) as a DevOps developer, which is responsible to develop and manage the online and back-end infrastructure of a game. Thus, it is safe to assume that the participants have familiarity with programming. Furthermore, the prevalence of programming roles may be due to the courses of the participants, since they mainly are focused on the hands-on programming.

Figure 28 illustrates the stated experience of the participants on game (E1) and mo-

Figure 28 – Experience on game and mobile development of the participants.

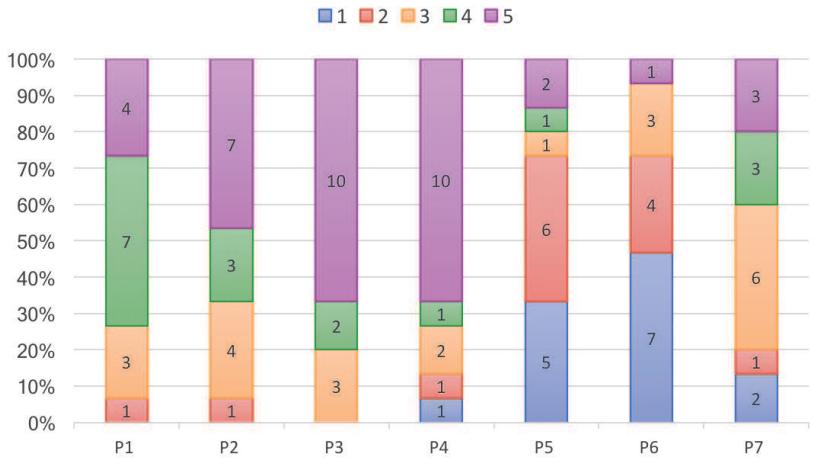


Source: Created by the author.

bile development (E2). In relation to E1, the results show that the participants have significant experience with game development with 9 (60%) participants reporting to have more than 4 years of experience. Of the remaining 6 (40%), 5 stated to have between 2 and 3 years and 1 up to one year of experience. The answers to E2 show the overall reduced experience of the participants with the development of games for mobile platforms when compared with the standard platforms. Only 4 (26.7%) reported to have more than 4 years of experience, this number is below half when compared with E1. Of the remaining 11 (73.3%) that reported to have up to 3 years of experience, 3 stated to have between 2 and 3 years, 4 between 1 and 2 years and 4 up to 1 year. Despite the reduced experience with mobile games, all participants reported to have knowledge in the development of such games.

Figure 29 represents the participation of the individuals in the stages of the game development process, refer to column "Item no." of Table 13 for the abbreviations of the x-axis of this figure. We can identify a trend of the participants being familiar with tasks focused around aspects of game design (P1) and programming (P2, P3 and P4). In relation to P1 and P4, 73.4% of the sample stated that they have sufficient participation (4 in a scale of 5) or full participation in creating the concept/design of the game and programming the game and its mechanics. 66.7% stated at least sufficient

Figure 29 – Results for the participation in the various stages of the game development process.



Source: Created by the author.

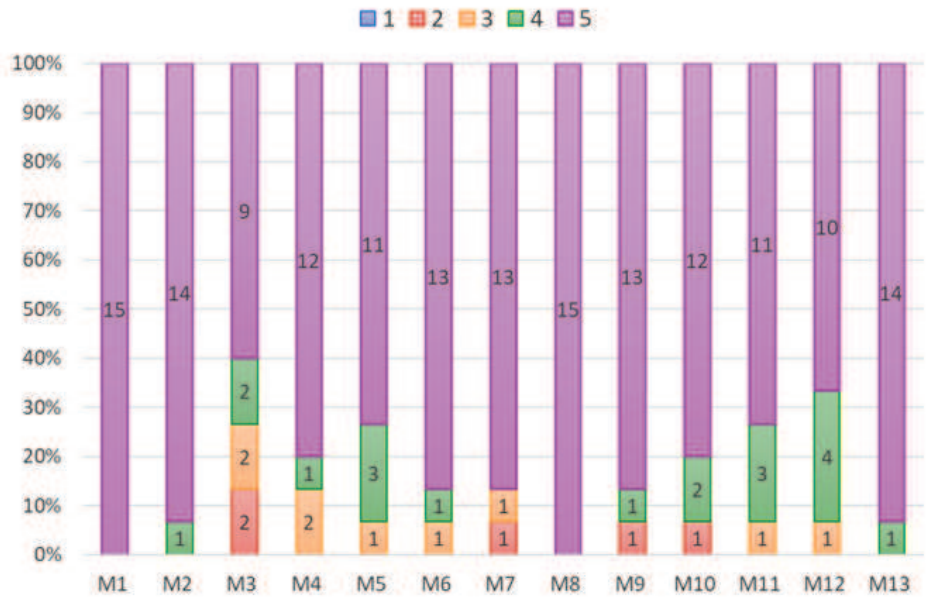
participation in performing tests to identify bugs in the game (P2), while 80% have active participation in solving the bugs identified (P3).

Following the trend, the majority of the sample have low participation on the artistic aspects of game development. 73.4% of the sample stated either no participation at all or limited participation in creating and managing the art and audio assets of the game. The last item, P7, which refers to the publishing of the game, has a greater distribution of responses over the 5 possible choices. 40% have average participation, 40% stated either sufficient participation or full participation, while the remaining 20% reported limited to no participation at all.

The survey, containing the questions of Table 14, was employed to ascertain the validity of our model for developing games focused on chronic diseases. Observing Figure 30, we can verify the overall positive results obtained through the opinions of the game developer experts that participated. Refer to column "Item no." of Table 14 for the abbreviations of the x-axis of this figure. Three items (M3, M4 and M7) received less than 90% of acceptance with M3 being the only item scored with less than 80%. All developers fully agree that our model encompasses the basic features to develop games in this scope (item M7 with 13 FA, 1 I and 1 PD) and that it can be used to develop games for mobile devices (item M1 with 15 FA) with themes focused on chronic diseases (item

M8 with 15 FA). They also agree that using our model, it would be possible to develop mobile or ubiquitous games that focus on chronic conditions (item M13 with 14 FA and 1 PA).

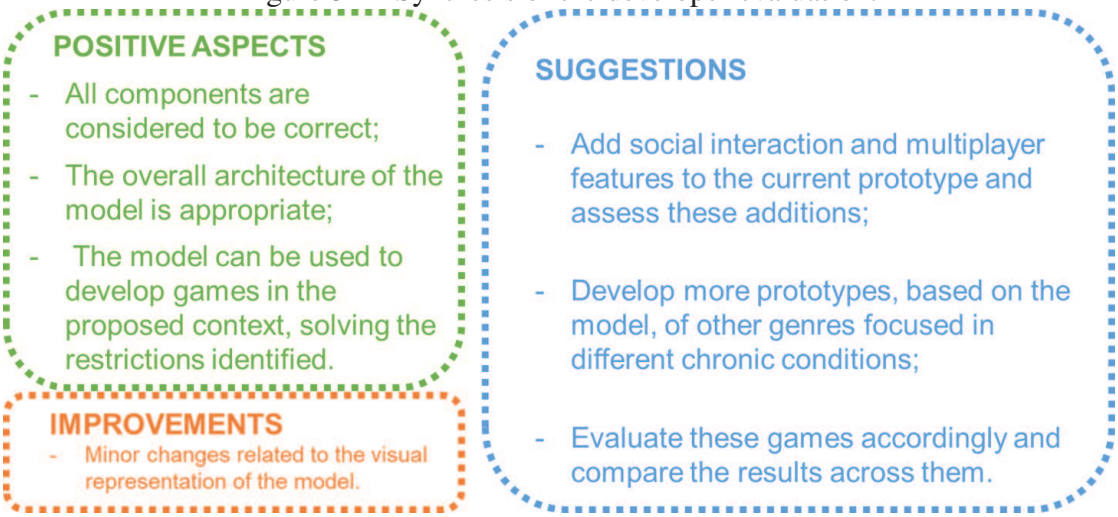
Figure 30 – Results of the questions asked to the participants to evaluate the validity and usability of the model.



Source: Created by the author.

The participants also agree that our model, via the Ubiquity component, covers the use of sensor information in the development of games (item M2 with 14 FA and 1 PA) and that the Multiplayer/Social component enables the development of multiplayer features, given that they are not real-time (item M12 with 10 FA, 4 PA and 1 I). Furthermore, the development environment for each component and its relationships are correct and consistent with a real-world environment of development (item M5 with 11 FA, 3 PA and 1 I; M6 with 13 FA, 1 PA and 1 I). Furthermore, they stated that there is justification for creating components responsible for generating feedback for the user (item M9 with 13 FA, 1 PA and 1 PD), keeping the user engaged and motivated to return to the game (item M10 with 12 FA, 2 PA and 1 PD) and generating the quests of the game (item M11 with 11 FA, 3 PA and 1 I). It is a consensus that our model can be employed in different game engines without applying drastic changes to it (item M4

Figure 31 – Synthesis of the developer evaluation.



Source: Created by the author.

with 12 FA, 1 PA and 1 I). The worst results obtained were for item M3: even though 73.3% of the participants agree that CCMUG may be used to develop games for other platforms, some of them stated that it would require significant changes to the model.

Finally some participants suggested minor changes during the last section of the interview, when asked the questions denoted in Table 15. All comments and suggestions were analyzed to ascertain their validity and decide whether they would be implemented or not. Overall, there were no requests, by the participants, to remove, add or drastically modify existing components. Hence, this section did not result in considerable changes to the model, only minor corrections. Figure 31 shows a synthesis of the developer evaluation, denoting the positive aspects and improvements observed for our model, as well as our suggestions of future works. After considering the comments, the adjustments deemed valid and necessary, see Figure 31, were applied to the model, these being:

- Adding "cloud" as a possible development environment for the Motivator;
- Creating arrow *"B"* to represent the autonomy of the Motivator, see Figure 12;
- Changing Engine to Core, so that readers better understand the responsibilities of the component;
- Creating a communication between the Ubiquity and the Core;

- Adding a new icon representing the API calls in the Multiplayer/Social, so that readers better understand the component.

It is important to emphasize that these modifications were performed after the development and evaluation of the prototype. Since they are minor changes, they do not influence the basis of our model and, thus, it was not required to adjust or rebuild the prototype. Accordingly, these changes do not compromise the evaluation for the prototype. Finally, these results, combined with our experience with the development of the prototype, confirm that CCMUG can be used as a guideline to develop games in this context. However, more evaluations with prototypes, based on our model, focusing on different chronic conditions are needed and set as future works.

7 FINAL REMARKS

In this dissertation, we first conducted a search to ascertain whether there were mapping studies or other types of literature reviews on games for chronic diseases already published. Albeit literature reviews in other areas of healthcare were retrieved, to the best of our knowledge, the amount of studies on this subject is sparse. Therefore, we performed a mapping study, based on the procedure described by Petersen et al. (2008), to ascertain the use of mobile games in healthcare, specifically games focusing on chronic conditions developed to teach its users. The mapping study returned 17 studies of this nature, of which 6 propose models or frameworks for developing games that focus on chronic diseases. The studies were analyzed according to 5 features considered important for motivating and engaging the players in a game, which are: i) customization, ii) immediate feedback, iii) rewards, iv) social aspects and v) multiplayer. We found out that few of these studies employ these features that promote a powerful learning environment for the players. Furthermore, feedback is an important tool in learning games, because it is responsible for teaching new concepts and reinforcing existing ones for the users. Since chronic conditions can not be cured, but rather managed by the patient after contracted, and most of these diseases do not have vaccines against them, the instruction of the population is, often, the only mean of protection against such diseases. If the population learns about the disease and its specifics, they are less prone to expose themselves to it. This is not an issue for other diseases that can be treated and cured after contraction, but for chronic conditions, after the contraction, there is no cure: the patient must live with the disease. Thus, it is worrisome that a proper feedback, explaining which of their choices were wrong or right and why, is not being generated for the players on these games.

We then proposed CCMUG, a model to serve as a standard for the development of mobile and ubiquitous games that address chronic conditions. We conceived the model to solve the limitations identified in the related works, which are: i) the lack of features that engage and motivate the player to consume the game and ii) the restrictions related to the chronic condition, the game genre and the age of the end user. CCMUG may be employed for the development of games of the most varied genres, e.g. exergames, puzzles, quizzes or simulation. Our model was conceived without a specific chronic

Table 16 – Comparison of the features of the models/frameworks.

Features	**CCMUG**	**Almonani et al. (2014)**	**AL-Qurishi et al. (2014)**	**Saleh (2015)**	**Harris et al. (2015)**	**Karime et al. (2015)**	**Schickler et al. (2016)**
Chronic Condition	Any	Obesity	Obesity	Obesity	Diabetes e Obesity	Obesity	Tinnitus
Target Group	Any	Children	?*	Children/ Teenagers	Children	Children	?*
Supports Ubiquity	✓	✗	✗	✓	✗	✓	✗
Customization	✓	✗	✗	✗	Avatars	✗	Nº of animals
Immediate Feedback	✓	✗	?*	✓	✓	✓	✓
Rewards	✓	✗	?*	Virtual Points	Virtual Points	✗	✗
Uses GPS	✓	✗	✓	✓	✗	✗	✗
Social Aspects	✓	✗	✗	✓	✗	✗	✗
Multiplayer	✓	✗	✗	✓	✗	✗	✗
Prototype Platform	iOS/Android	Smartphones	Android	Smartphones	Smartphones/ tablets	Android	iOS/Android/ Windows Phone

*A question mark indicates missing information, some game features could not be coded because of insufficient information in the article.

Source: Created by the author.

disease or target group in mind, it may be employed on the development of games for different conditions and end users. This generic approach is important since the group of chronic diseases comprises a wide array of conditions, each with its specific characteristics and affected group. CCMUG includes components, modeled by this generic approach, that use the features identified as important for the engagement of the players. Table 16 shows a comparison between the model proposed here, CCMUG, alongside the models retrieved from the mapping study.

We elaborated the design of a mobile game, its characteristics, features and gameplay mechanics. The main screens of the game were created through mock-ups. This design was conceived based on the model proposed here, considering that when the game were to be developed, it should match the model. We performed an individual evaluation conducted with a group of 21 undergraduates of the Game Development course at Unisinos with the purpose of identifying features and aspects of the design to be improved, removed and/or modified. Afterwards, another evaluation was applied on the design, this time with a focus group of 6 participants to define whether a narrative should be used for the game and which narrative should be adopted. These two procedures resulted in a new design with the applied modifications. We proceeded to develop

the prototype based on the new version of the design and following the guidelines of our model. The game serves as an awareness tool for the players in regard of HIV/AIDS and addresses aspects of this condition. During development some modifications to the original design of the game were necessary. Mainly, we removed the social interaction and multiplayer aspects of the game, due to the scope and time constraints of the project. With the prototype developed, we performed a final evaluation based on EGameFlow, a scale proposed by Fu, Su and Yu (2009)to measure the enjoyment offered by games designed to teach its user. This scale is divided in different dimensions and each is evaluated by its mean and standard deviation.

We employed a modified version of EGameFlow to that better suits our context. In our version, the survey is divided into Concentration, Feedback, Challenge, Autonomy, Immersion and Knowledge Improvement, each with items in a Likert format. Overall, no dimension received a low score: all of them scored scored above 4.2, more than half of the scale, with the lowest score being that of Immersion, with a mean of 4.286. We identified 3 levels of results: i) dimensions that received the best results, close to 7, and consequently are considered to be the major strengths of the game; ii) dimensions that received satisfactory results, but not as close to the maximum score as the first level. These can also be considered strengths of the game; iii) dimensions with the lowest results that should be prioritized for improvements in the next versions of the prototype. Knowledge Improvement, Concentration, Feedback and Autonomy are considered the strengths of our game. The participants feel that our game has the ability to convey new information and concepts to them as well as retain their attention with activities that encourage their concentration and diminish the stress originated by the learning overload. Our game also allows the players to determine the gap of knowledge between the stages of the quest. They also state that they are encouraged to take initiative in playing the game gives total control for the players. Moreover, the participants feel that the challenge imposed by the game and the its overall feel of immersion could be improved. This is a result of the prototype having only one patient with three consultations. The results of this evaluation show that our game successfully employs the features that promote a learning environment for the players and that CCMUG can be used as a guideline for the development of games for awareness in this context. However, there is still room for improvement: the Challenge and Immersion dimensions must be prioritized in newer versions of the game by creating a wider array of quests and making them more detailed

and longer. The addition of features that were cut in the development, such as the ethical decision system or the resource management system, could further improve the sense of immersion of the players.

The final evaluation occurred as an individual structured interview with 15 game developers experts. The evaluation was divided into four sections: profile of the developer, model explanation, survey and suggestions and final considerations. Through the first section we were able to identify that the participants have significant experience in game development and mobile game development. All of them have familiarity with programming, have studied/are studying on academic level topics related to technology and all courses have programming as part of the curriculum. After explaining the mode, we gathered the opinion of the participants about our model via a survey containing items in a Likert format. Of the 13 items, only three received less than 90% of acceptance, with only one item below 80%, which is considered to be a positive outcome. The developers agree that our model can be used a base for the development of games for mobile devices focused on chronic diseases. They agree that the global architecture, with the development environment for the components is correct and consistent with a real-world scenario. Furthermore, in their opinion, each component of our model is correctly designed and there is justification for the creation of the components. it is a consensus that CCMUG can be used in different game engines without applying drastic changes to it. However, some participants (13.35%) feel that it may require significant changes to the model so that it can be used in the development of games for other platforms. Few minor changes that do not affect the architecture of CCMUG were suggested by the participants and applied to the model.

7.1 Contributions

Below is the list of articles that have been accepted and published, of which the authors of this dissertation have participated in the last two years:

1. **Published**: SÁ, K. C.; MARTINS, M. G.; COSTA, C. A.; BARBOSA, J. L. V.; RIGHI, R. R. . A Mapping Study on Mobile Games for Patients of Chronic Diseases. Journal of Medical Systems, 2017;

2. **Published**: DE SA, KEVIN CARDOSO; VIELITZ, FELIPE LAUERMANN;

DAMASCENO, FABIO RAFAEL; ANDRE DA COSTA, CRISTIANO; RIGO, SANDRO JOSE; DA ROSA RIGHI, RODRIGO. A proposal of knowledge base for applications in the scope of HIV/AIDS. In: 2016 XLII Latin American Computing Conference (CLEI), 2016, Valparaíso. 2016 XLII Latin American Computing Conference (CLEI), 2016. v. 1. p. 1-486;

3. **Published**: SÁ, K. C.; WICHMAN, M. H. ; MARTINS, M. G. ; COSTA, C. A. . Gerando Cenários Procedurais Adaptáveis em Um Jogo Mobile. In: I Simpósio Latino-Americano de Jogos, 2016, Araranguá. Anais do 1º Simpósio Latino Americano de Jogos (SLAT 2016), 2016. v. 1;

4. **Published**: WICHMAN, M. H.; MORAES, B. D. O. ; SÁ, K. C.; OLIVEIRA, R. R.; OLIVEIRA, R. R. . PukaPuka: Auxiliando o Letramento Através de uma Plataforma Colaborativa de Jogos. In: I Simpósio Latino-Americano de Jogos, 2016, Araranguá. Anais do 1º Simpósio Latino Americano de Jogos (SLAT 2016), 2016. v. 1;

We are currently writing two articles related to this dissertation. They are in the final steps of writing, expected to be finished and submitted to international journals in the next months. The first article is related to the developed prototype based on the model proposed in this dissertation. It will present and discuss the results of the three evaluations performed on the prototype, which are the individual evaluation, the focus group and the modified version of EGameFlow. The second article is related to the model proposed in this dissertation and focus on the results of the individual structured interview performed with the game developers.

The results gathered from the prototype evaluation show that our game, based on CCMUG, is considered to be enjoyable by its players, while also teaching them new concepts via gameplay without turning the experience boring. This also indicates that our model can be successfully used as a guideline for the development of games for awareness focused on chronic diseases. The results from the developers evaluation, in turn, confirm this indication. All participants, with proven experience in game development and mobile game development, agree that the architecture of our model enables the development of such games and also state that they can use our model to achieve this. No significant changes were asked by the developers, only minor ones that do not

change the overall architecture of CCMUG. This reinforces our observation that CCMUG is correctly constructed and covers the necessary features to develop games in this scope. It is safe to assume that CCMUG may be employed to support the development of mobile and ubiquitous games for awareness that focus on chronic conditions. Thus, our contribution is a model that aids developers and researches in the creation of games for awareness focused on chronic diseases. CCMUG solves the restrictions identified in the related works, that of which limit the developed games to a specific genre, target audience and/or chrocnid conditions. Furthermore, the model employs the features considered to be important for fostering immersion of the players ingame and, thus, CCMUG enables a environment for them to actively learn concepts through gameplay.

7.2 Future Works

As future works for this project, we intend to implement the Multiplayer/Social with its features into the game and then evaluate it similarly to the other components. Furthermore, features that directly and indirectly influence the immersion and challenge of the game will be prioritized on newer versions, since these were the dimensions with the lower scores. To do so, new and longer quests will be developed. Not only quests related to HIV, but also related to other non-chronic conditions so that the players do not feel that the game is mainly focused in one disease. Features related to the second level, comprised by feedback and autonomy, will also be focused in order to obtain higher results for this dimensions. Concentration and knowledge improvement showed the best results and will be the last focused dimensions as a result of their overall statistics. After applying changes to improve these dimensions, new evaluations on the prototype will be conducted. We also plan to develop new prototypes, of different genres and focusing on other chronic conditions. This is to reaffirm that our model may be employed to develop games for a wider array of chronic conditions and that it has no restriction in regards of the genre of the games it can develop. After conceiving these prototypes, we will evaluate them accordingly and compare the results across them. We will also perform one additional evaluation on both the prototype and the model, were we will ascertain whether they are clinically accurate and portray the medical information correctly. This evaluation will make use of the opinion of physicians experts in this subject and it also

aims at pinpointing flaws of the game and model in order to correct them. Finally, we are currently writing two articles, one focused on the prototype and one on CCMUG, that will be submitted to journals this year, resulting in a total of 6 articles wrote during the making of this dissertation.

REFERENCES

ACHARGUI, A.; ZAOUIA, A. Hosted, cloud and saas, off-premises erp systems adoption by moroccan smes: a focus group study. In: INTERNATIONAL CONFERENCE ON SCIENCES OF ELECTRONICS, TECHNOLOGIES OF INFORMATION AND TELECOMMUNICATIONS (SETIT), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 344–348.

AFABLE, A.; KARINGULA, N. S. Evidence based review of type 2 diabetes prevention and management in low and middle income countries. **World J Diabetes**, [S.l.], v. 7, n. 10, May 2016.

AL-QURISHI, M. S. et al. Starsrace: a mobile collaborative seriuos game for obesity. In: IEEE INTERNATIONAL CONFERENCE ON MULTIMEDIA AND EXPO WORKSHOPS (ICMEW), 2014., 2014. **Anais...** [S.l.: s.n.], 2014. p. 1–5.

ALMONANI, E. et al. Mobile game approach to prevent childhood obesity using persuasive technology. In: INTERNATIONAL CONFERENCE ON COMPUTER AND INFORMATION SCIENCES (ICCOINS), 2014., 2014. **Anais...** [S.l.: s.n.], 2014. p. 1–5.

AMRESH, A. et al. Design, implementation and evaluation of a game-based intervention targeting latino children for improving obesity outcomes. In: IEEE INTERNATIONAL CONFERENCE ON SERIOUS GAMES AND APPLICATIONS FOR HEALTH (SEGAH), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1–8.

ANDERSEN, K.; GROTE, F. Giantsteps: semi-structured conversations with musicians. In: ANNUAL ACM CONFERENCE EXTENDED ABSTRACTS ON HUMAN FACTORS IN COMPUTING SYSTEMS, 33., 2015, New York, NY, USA. **Proceedings...** ACM, 2015. p. 2295–2300. (CHI EA '15).

ANDRÉS, P. M. L. et al. Timemesh: producing and evaluating a serious game. In: XV INTERNATIONAL CONFERENCE ON HUMAN COMPUTER INTERACTION, 2014, New York, NY, USA. **Proceedings...** ACM, 2014. p. 100:1–100:8. (Interacción '14).

ARTHUR, J. et al. **Research methods and methodologies in education**. first. ed. [S.l.]: SAGE Publications, 2012. (EBL-Schweitzer).

ATI, M.; OMAR, W.; HUSSEIN, A. S. Integration framework of chronic disease management system and a recommender system in the united arab emirates. In: IEEE INTERNATIONAL SYMPOSIUM ON SIGNAL PROCESSING AND

INFORMATION TECHNOLOGY (ISSPIT), 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 570–574.

AVERT. **Hiv and aids in brazil**. 1st. ed. [S.l.: s.n.], 2015. https://www.avert.org/professionals/hiv-around-world/latin-america/brazil.

BECKER, K. Yet another magic bullet: a tool for assessing and evaluating learning potential in games. In: CONFERENCE ON FUTURE PLAY ON @ GDC CANADA, 2009., 2009, New York, NY, USA. **Proceedings...** ACM, 2009. p. 1–2. (Future Play '09).

BOADA, I. et al. Using a serious game to complement cpr instruction in a nurse faculty. **Computer Methods and Programs in Biomedicine**, [S.l.], v. 122, n. 2, p. 282 – 291, 2015.

BOAVENTURA P., F. P. A. C. F. J. G. G. L. R. B. S. G. P. C. L. S. P. A. J. Nutribuddy - an interactive digital game for obesity prevention in youngsters. In: IX INTERNATIONAL CONFERENCE ON ICT IN EDUCATION - CHALLENGES 2015, 2015. **Proceedings...** [S.l.: s.n.], 2015. p. 42–51.

BOULOS, M. N. K.; YANG, S. P. Exergames for health and fitness: the roles of gps and geosocial apps. **International Journal of Health Geographics**, [S.l.], v. 12, n. 1, p. 18, 2013.

BREWER, N. Computerized dungeons and randomly generated worlds: from rogue to minecraft. **Proceedings of the IEEE**, [S.l.], v. 105, n. 5, p. 970–977, May 2017.

BROX, E. et al. User centric social diabetes game design for children. In: PROCEEDING OF THE 16TH INTERNATIONAL ACADEMIC MINDTREK CONFERENCE, 2012, New York, NY, USA. **Anais...** ACM, 2012. p. 291–293. (MindTrek '12).

BUZETO, F. N. et al. uos: a resource rerouting middleware for ubiquitous games. In: IEEE 10TH INTERNATIONAL CONFERENCE ON UBIQUITOUS INTELLIGENCE AND COMPUTING AND 2013 IEEE 10TH INTERNATIONAL CONFERENCE ON AUTONOMIC AND TRUSTED COMPUTING, 2013., 2013. **Anais...** [S.l.: s.n.], 2013. p. 88–95.

CAILLOIS, R. **Les jeux et les hommes**: le masque et le virtige. first. ed. [S.l.]: Gallimard, 1958. (Idées (Gallimard)).

CAMPBELL, N. R.; PETRELLA, R.; KACZOROWSKI, J. Public education on hypertension: a new initiative to improve the prevention, treatment and control of hypertension in canada. **Can J Cardiol**, [S.l.], v. 22, n. 7, p. 599–600, May 2006.

CHEN, R. et al. Patient stratification using electronic health records from a chronic disease management program. **IEEE Journal of Biomedical and Health Informatics**, [S.l.], v. PP, n. 99, p. 1–1, 2016.

TEAM, C. C. **Obesity is now considered a disease**. 1st. ed. [S.l.: s.n.], 2013. https://health.clevelandclinic.org/2013/06/obesity-is-now-considered-a-disease/.

CLARK, B. C.; MANINI, T. M. What is dynapenia? **Nutrition**, [S.l.], v. 28, n. 5, p. 495–503, may 2012.

CLAWSON, J.; PATEL, N.; STARNER, T. Dancing in the streets: the design and evaluation of a wearable health game. In: INTERNATIONAL SYMPOSIUM ON WEARABLE COMPUTERS (ISWC) 2010, 2010. **Anais...** [S.l.: s.n.], 2010. p. 1–4.

COSTA, C. A. da; YAMIN, A. C.; GEYER, C. F. R. Toward a General Software Infrastructure for Ubiquitous Computing. **IEEE Pervasive Computing**, [S.l.], v. 7, n. 1, p. 64–73, 2008.

COSTA, T. H. et al. A systematic review on the usage of games for healthcare. In: IEEE 5TH INTERNATIONAL CONFERENCE ON CONSUMER ELECTRONICS - BERLIN (ICCE-BERLIN), 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 480–484.

CRAWFORD, C. **Chris crawford on game design**. first. ed. Thousand Oaks, CA, USA: New Riders Publishing, 2003.

DART, I.; NELSON, M. J. Smart terrain causality chains for adventure-game puzzle generation. In: IEEE CONFERENCE ON COMPUTATIONAL INTELLIGENCE AND GAMES (CIG), 2012., 2012. **Anais...** [S.l.: s.n.], 2012. p. 328–334.

DESMET, A. et al. A systematic review and meta-analysis of interventions for sexual health promotion involving serious digital games. **Games for Health Journal**, [S.l.], v. 4, n. 2, p. 78–90, Nov 2014.

DUNKLEY, A. J. et al. Diabetes prevention in the real world: effectiveness of pragmatic lifestyle interventions for the prevention of type 2 diabetes and of the impact of adherence to guideline recommendations. **Diabetes Care**, [S.l.], v. 37, n. 4, p. 922–933, 2014.

FROMMEL, J. et al. 2084 safe new world: designing ubiquitous interactions. In: ANNUAL SYMPOSIUM ON COMPUTER-HUMAN INTERACTION IN PLAY, 2016., 2016, New York, NY, USA. **Proceedings...** ACM, 2016. p. 53–64. (CHI PLAY '16).

FU, F.-L.; SU, R.-C.; YU, S.-C. Egameflow: a scale to measure learners' enjoyment of e-learning games. **Computers & Education**, [S.l.], v. 52, n. 1, p. 101 – 112, 2009.

GLASEMANN, M.; KANSTRUP, A. M.; RYBERG, T. Making chocolate-covered broccoli: designing a mobile learning game about food for young people with diabetes. In: ACM CONFERENCE ON DESIGNING INTERACTIVE SYSTEMS, 8., 2010, New York, NY, USA. **Proceedings...** ACM, 2010. p. 262–271. (DIS '10).

GUO, J.; SINGER, N.; BASTIDE, R. Design of a serious game in training non-clinical skills for professionals in health care area. In: SERIOUS GAMES AND APPLICATIONS FOR HEALTH (SEGAH), 2014 IEEE 3RD INTERNATIONAL CONFERENCE ON, 2014. **Anais...** [S.l.: s.n.], 2014. p. 1–6.

HAMZA, A. et al. Serious games for vocational training: a compared approach. In: IEEE/ACS 13TH INTERNATIONAL CONFERENCE OF COMPUTER SYSTEMS AND APPLICATIONS (AICCSA), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1–8.

HARRIS, A. et al. Integrated and personalized diabetes coach for children. In: IEEE 29TH INTERNATIONAL CONFERENCE ON ADVANCED INFORMATION NETWORKING AND APPLICATIONS WORKSHOPS, 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 31–35.

HINSKE, S. et al. Classifying pervasive games: on pervasive computing and mixed reality. In: PERVASIVE GAMES, C. MAGERKURTH AND, 2007. **Anais...** [S.l.: s.n.], 2007.

HOWARD, J. **Quests**: design, theory, and history in games and narratives. first. ed. [S.l.]: A K Peters/CRC Press, 2008.

HUSSAIN, T. S.; COLEMAN, S. L. **Design and development of training games**: practical guidelines from a multidisciplinary perspective. [S.l.]: Cambridge University Press, 2014.

III, R. R. **Game design**: theory and practice. 2. ed. [S.l.]: Jones & Bartlett Learning, 2004.

KARIME, A. et al. A modular mobile exergaming system with an adaptive behavior. In: IEEE INTERNATIONAL SYMPOSIUM ON MEDICAL MEASUREMENTS AND APPLICATIONS (MEMEA) PROCEEDINGS, 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 531–536.

KE, F.; XIE, K.; XIE, Y. Game-based learning engagement: a theory- and data-driven exploration. **British Journal of Educational Technology**, [S.l.], v. 47, n. 6, p. 1183–1201, 2016.

KHALIQ, I.; PURKISS, B. A study of interaction in idle games perceptions on the definition of a game. In: IEEE GAMES ENTERTAINMENT MEDIA CONFERENCE (GEM), 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 1–6.

KIM, H. et al. Grocery hunter: a fun mobile game for children to combat obesity. In: FIFTH INTERNATIONAL CONFERENCE ON TANGIBLE, EMBEDDED, AND EMBODIED INTERACTION, 2011, New York, NY, USA. **Proceedings...** ACM, 2011. p. 317–320. (TEI '11).

KORHONEN, H.; KOIVISTO, E. M. I. Playability heuristics for mobile games. In: CONFERENCE ON HUMAN-COMPUTER INTERACTION WITH MOBILE DEVICES AND SERVICES, 8., 2006, New York, NY, USA. **Proceedings...** ACM, 2006. p. 9–16. (MobileHCI '06).

KVALE, S.; BRINKMANN, S. **Interviews**: learning the craft of qualitative research interviewing. second. ed. [S.l.]: SAGE Publications, 2009.

KWON, Y. N.; YOON, S. S. Sarcopenia: neurological point of view. **Journal of Bone Metabolism**, [S.l.], v. 24, n. 2, p. 83–89, may 2017.

LENTELINK, S. J. et al. Healthy weight game!: lose weight together. In: IEEE 2ND INTERNATIONAL CONFERENCE ON SERIOUS GAMES AND APPLICATIONS FOR HEALTH (SEGAH), 2013., 2013. **Anais...** [S.l.: s.n.], 2013. p. 1–8.

LIKERT, R. A technique for the measurement of attitudes. **Archives of Psychology**, [S.l.], v. 22, n. 140, p. 1–55, 1932.

LIMA, E. Soares de; FEIJó, B.; FURTADO, A. L. Hierarchical generation of dynamic and nondeterministic quests in games. In: CONFERENCE ON ADVANCES IN COMPUTER ENTERTAINMENT TECHNOLOGY, 11., 2014, New York, NY, USA. **Proceedings...** ACM, 2014. p. 24:1–24:10. (ACE '14).

LINDLOF, T.; TAYLOR, B. **Qualitative communication research methods**. third. ed. [S.l.]: SAGE Publications, 2002.

LUHANGA, E. T. et al. Happyinu: exploring how to use games and extrinsic rewards for consistent food tracking behavior. In: NINTH INTERNATIONAL CONFERENCE ON MOBILE COMPUTING AND UBIQUITOUS NETWORKING (ICMU), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1–7.

MADEIRA, R. N. et al. Designing personalized therapeutic serious games for a pervasive assistive environment. In: IEEE 1ST INTERNATIONAL CONFERENCE ON SERIOUS GAMES AND APPLICATIONS FOR HEALTH, 2011., 2011, Washington, DC, USA. **Proceedings...** IEEE Computer Society, 2011. p. 1–10. (SEGAH '11).

MADIGAN, J. **Getting gamers**: the psychology of video games and their impact on the people who play them. first. ed. [S.l.]: Rowman & Littlefield Publishers, 2015.

MANSART, C. et al. Go run go: an android game-story application for aiding motivation to exercise. In: IEEE INTERNATIONAL SYMPOSIUM ON MULTIMEDIA (ISM), 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 407–410.

MARCHETTI, D. et al. Preventing adolescents' diabesity: design, development, and first evaluation of "gustavo in gnam's planet". **Games For Health Journal**, [S.l.], v. 4, n. 5, p. 344–351, oct 2015.

MARSTON, H. R.; HALL, A. K. Gamification: applications for health promotion and health information technology engagement. In: NOVÁK, D.; TULU, B.; BRENDRYEN, H. (Ed.). **Handbook of research on holistic perspectives in gamification for clinical practice**. Hershey: IGI Global, 2016. p. 78–104. (Advances in Medical Technologies and Clinical Practice).

MARTIN, C. M. Chronic disease and illness care. **Canadian Family Physician**, [S.l.], v. 53, n. 12, p. 2086–2091, 2007.

MATIAS, N.; SOUSA, M. J. Mobile health as a tool for behaviour change in chronic disease prevention: a systematic literature review. In: IBERIAN CONFERENCE ON INFORMATION SYSTEMS AND TECHNOLOGIES (CISTI), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1–6.

MAYR, S. et al. A serious game to treat childhood obesity. In: IEEE INTERNATIONAL CONFERENCE ON SERIOUS GAMES AND APPLICATIONS FOR HEALTH (SEGAH), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1–6.

MERAKOU, K.; KOUREA-KREMASTINOU, J. Peer education in hiv prevention: an evaluation in schools. **European Journal of Public Health**, [S.l.], v. 16, n. 2, p. 128–132, 2006.

MILLER, A. S.; CAFAZZO, J. A.; SETO, E. A game plan: gamification design principles in mhealth applications for chronic disease management. **Health Informatics Journal**, [S.l.], v. 22, n. 2, p. 184–193, 2016.

NG, R.; LINDGREN, R. Examining the effects of avatar customization and narrative on engagement and learning in video games. In: COMPUTER GAMES: AI, ANIMATION, MOBILE, INTERACTIVE MULTIMEDIA, EDUCATIONAL SERIOUS GAMES (CGAMES), 2013 18TH INTERNATIONAL CONFERENCE ON, 2013. **Anais...** [S.l.: s.n.], 2013. p. 87–90.

NICKEL, A. et al. Interval training with astrojumper. In: IEEE VIRTUAL REALITY WORKSHOPS (VRW), 2012., 2012. **Anais...** [S.l.: s.n.], 2012. p. 161–162.

OGBEIFUN, E.; MBOHWA, C.; PRETORIUS, J. H. C. Complementing a delphi exercise with a focus group session. In: IEEE INTERNATIONAL CONFERENCE ON INDUSTRIAL ENGINEERING AND ENGINEERING MANAGEMENT (IEEM), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1269–1273.

ORJI, R.; VASSILEVA, J.; MANDRYK, R. L. Modeling the efficacy of persuasive strategies for different gamer types in serious games for health. **User Modeling and User-Adapted Interaction**, [S.l.], v. 24, n. 5, p. 453–498, 2014.

PAPASTERGIOU, M. Exploring the potential of computer and video games for health and physical education: a literature review. **Comput. Educ.**, Oxford, UK, UK, v. 53, n. 3, p. 603–622, Nov. 2009.

PATTON, M. **Qualitative evaluation and research methods**. third. ed. [S.l.]: SAGE Publications, 1990.

PÉREZ-ESCAMILLA, R. et al. Education for childhood obesity prevention across the life-course: workshop conclusions. **Int J Obes Suppl**, [S.l.], v. 3, n. Suppl 1, p. S18–S19, Jun 2013.

PERSONNEL MANAGEMENT, U. S. O. of. **Structured interviews**: a practical guide. first. ed. [S.l.]: CreateSpace Independent Publishing Platform, 2012.

PETERSEN, K. et al. Systematic mapping studies in software engineering. In: INTERNATIONAL CONFERENCE ON EVALUATION AND ASSESSMENT IN SOFTWARE ENGINEERING, 12., 2008, Swinton, UK, UK. **Proceedings...** British Computer Society, 2008. p. 68–77. (EASE'08).

POWLEY, E. J. et al. Semi-automated level design via auto-playtesting for handheld casual game creation. In: IEEE CONFERENCE ON COMPUTATIONAL INTELLIGENCE AND GAMES (CIG), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1–8.

QI, J. et al. Towards knowledge driven decision support for personalized home-based self-management of chronic diseases. In: IEEE 12TH INTL CONF ON UBIQUITOUS INTELLIGENCE AND COMPUTING AND 2015 IEEE 12TH INTL CONF ON AUTONOMIC AND TRUSTED COMPUTING AND 2015 IEEE 15TH INTL CONF ON SCALABLE COMPUTING AND COMMUNICATIONS AND ITS ASSOCIATED WORKSHOPS (UIC-ATC-SCALCOM), 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 1724–1729.

RAMKUMAR, N.; PRAKASH, S.; SANGEETHA, K. Data analysis for chronic disease -diabetes using map reduce technique. In: INTERNATIONAL CONFERENCE ON COMPUTER COMMUNICATION AND INFORMATICS (ICCCI), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 1–5.

REGO, P.; MOREIRA, P. M.; REIS, L. P. Serious games for rehabilitation: a survey and a classification towards a taxonomy. In: IBERIAN CONFERENCE ON INFORMATION SYSTEMS AND TECHNOLOGIES, 5., 2010. **Anais...** [S.l.: s.n.], 2010. p. 1–6.

RITCHIE, J. et al. **Qualitative research practice**: a guide for social science students and researchers. 2. ed. [S.l.]: SAGE Publications, 2013.

SÁ, K. C. de et al. A mapping study on mobile games for patients of chronic diseases. **Journal of Medical Systems**, [S.l.], v. 41, n. 9, p. 138, Jul 2017.

SALEH, M. Adaptive ubiquitous mobile gaming system for youth obesity rehabilitation. In: WIRELESS TELECOMMUNICATIONS SYMPOSIUM (WTS), 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 1–6.

SALEN, K.; ZIMMERMAN, E. **Rules of play**: game design fundamentals. [S.l.]: Books24x7.com, 2004.

SAMARASINGHE, H. A. S. M. et al. Serious games design considerations for people with alzheimer's disease in developing nations. In: IEEE 5TH INTERNATIONAL CONFERENCE ON SERIOUS GAMES AND APPLICATIONS FOR HEALTH (SEGAH), 2017., 2017. **Anais...** [S.l.: s.n.], 2017. p. 1–5.

SAMODELKIN, A.; ALAVESA, P.; VOROSHILOV, A. A platform for pervasive games for research. In: INTERNATIONAL CONFERENCE ON MOBILE AND UBIQUITOUS MULTIMEDIA, 15., 2016, New York, NY, USA. **Proceedings...** ACM, 2016. p. 335–337. (MUM '16).

SCHICKLER, M. et al. Using mobile serious games in the context of chronic disorders: a mobile game concept for the treatment of tinnitus. In: IEEE 29TH INTERNATIONAL SYMPOSIUM ON COMPUTER-BASED MEDICAL SYSTEMS (CBMS), 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 343–348.

ALINE COLETTO SORTICA BIANCA BICCA FRANCO, D. Z. L. E. H. J. K. B. J. S. L. M. G. P. S. M. R. A. N. K. T. F. **Clinical protocol for monitoring and treatment of people with hiv / aids in primary health care**. [S.l.: s.n.], 2016.

SHIN, Y.; WüNSCHE, B. C. A smartphone-based golf simulation exercise game for supporting arthritis patients. In: INTERNATIONAL CONFERENCE ON IMAGE AND VISION COMPUTING NEW ZEALAND (IVCNZ 2013), 2013., 2013. **Anais...** [S.l.: s.n.], 2013. p. 459–464.

SMEDDINCK, J. D.; HERRLICH, M.; MALAKA, R. Exergames for physiotherapy and rehabilitation: a medium-term situated study of motivational aspects and impact on

functional reach. In: ANNUAL ACM CONFERENCE ON HUMAN FACTORS IN COMPUTING SYSTEMS, 33., 2015, New York, NY, USA. **Proceedings...** ACM, 2015. p. 4143–4146. (CHI '15).

SOARES, A. V. et al. A serious game developed for physical rehabilitation of frail elderly. **Neurophysiologie Clinique/Clinical Neurophysiology**, [S.l.], v. 46, n. 4, p. 281, 2016.

SOMYANONTHANAKUL, R.; PLODGRATOKE, P. Tatf: test and treat follow-up system of hiv carriers in thailand. In: ELECTRICAL ENGINEERING/ELECTRONICS, COMPUTER, TELECOMMUNICATIONS AND INFORMATION TECHNOLOGY (ECTI-CON), 2015 12TH INTERNATIONAL CONFERENCE ON, 2015. **Anais...** [S.l.: s.n.], 2015. p. 1–4.

SOUSA BORGES, S. de et al. A systematic mapping on gamification applied to education. In: ANNUAL ACM SYMPOSIUM ON APPLIED COMPUTING, 29., 2014, New York, NY, USA. **Proceedings...** ACM, 2014. p. 216–222. (SAC '14).

STACH, C.; SCHLINDWEIN, L. F. M. Candy castle #x2014; a prototype for pervasive health games. In: IEEE INTERNATIONAL CONFERENCE ON PERVASIVE COMPUTING AND COMMUNICATIONS WORKSHOPS, 2012., 2012. **Anais...** [S.l.: s.n.], 2012. p. 501–503.

STèPHANE, N. et al. Creating multiplayer ubiquitous games using an adaptive narration model based on a user's model. In: DIGRA 3907 - PROCEEDINGS OF THE 2007 DIGRA INTERNATIONAL CONFERENCE: SITUATED PLAY, 2007. **Anais...** The University of Tokyo, 2007.

STONER, L.; CORNWALL, J. Did the american medical association make the correct decision classifying obesity as a disease? **The Australasian Medical Journal 2014**, [S.l.], p. 462–464, Nov 2014.

STRULIK, H. A mass phenomenon: the social evolution of obesity. **Journal of Health Economics**, [S.l.], v. 33, p. 113 – 125, 2014.

SULLIVAN, A. et al. The design of mismanor: creating a playable quest-based story game. In: INTERNATIONAL CONFERENCE ON THE FOUNDATIONS OF DIGITAL GAMES, 2012, New York, NY, USA. **Proceedings...** ACM, 2012. p. 180–187. (FDG '12).

TANIAR, D. **Mobile computing**: concepts, methodologies, tools, and applications: concepts, methodologies, tools, and applications. [S.l.]: Information Science Reference, 2008. (Contemporary research in information science and technology).

TAQUETTE, S. R. Epidemia de hiv/aids em adolescentes no brasil e na França: semelhanças e diferenças. **Saúde e Sociedade**, [S.l.], v. 22, p. 618 – 628, 06 2013.

V. M. MOREIRA Átila; FILHO, V. V.; RAMALHO, G. L. Understanding mobile game success: a study of features related to acquisition, retention and monetization. **SBC Journal on Interactive Systems**, [S.l.], v. 5, n. 2, 2014.

VIANNA, H. D.; BARBOSA, J. L. V. A model for ubiquitous care of noncommunicable diseases. **IEEE Journal of Biomedical and Health Informatics**, [S.l.], v. 18, n. 5, p. 1597–1606, Sept 2014.

WEISER, M. The computer for the 21st century. **SIGMOBILE Mob. Comput. Commun. Rev.**, New York, NY, USA, v. 3, n. 3, p. 3–11, July 1999.

WIEMEYER, J.; KLIEM, A. Serious games in prevention and rehabilitation—a new panacea for elderly people? **European Review of Aging and Physical Activity**, [S.l.], v. 9, n. 1, p. 41–50, 2012.

ORGANIZATION, W. H. **Innovative care for chronic conditions**. 1st. ed. [S.l.: s.n.], 2002. http://www.who.int/chp/knowledge/publications/iccc globalreport.pdf.

XIAOSONG, L.; GANG, S.; YONG, C. Design and development of the web-based health and chronic disease assessment management system. In: INTERNATIONAL CONFERENCE ON INFORMATION TECHNOLOGY IN MEDICINE AND EDUCATION (ITME), 2015., 2015. **Anais...** [S.l.: s.n.], 2015. p. 72–75.

YAMADA, T. et al. Evaluating explanation function in railway crew rescheduling system by think-aloud test. In: IIAI-AAI, 2016., 2016. **Anais...** [S.l.: s.n.], 2016. p. 991–994.