Gamification as a motivational tool in a diabetes lifestyle coaching application

A research on the application of gamification in the interface of a diabetes coaching app

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Bachelor thesis

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04/07/19

Abstract

This paper describes the design process of an app interface for people with Diabetes Mellitus type 2 (DMT2). The goal of the app is to support people with DMT2 in managing their diabetes and obtaining/maintaining a healthy lifestyle. The aim of this research is to design an attractive and interactive interface. This will be achieved through the implementation of gamification and personalized design. Above all, this should also enhance the motivation of the user in using the app, as well as committing towards a healthy lifestyle.

The first prototype of the app is based on the literature on gamification, personalization and real user experience. From this, requirements are derived that serve as the fundament of the design. These requirements translated into the game elements of a goal and point setting system, feedback elements and an avatar. Following, an iterative design process including an evaluation with the target group resulted in the final prototype and requirements. The end result shows a prototype including the game elements and a re-design of the interface. In further research, there could be looked at how motivating the gamified interface is compared to other applications.

Acknowledgments

Now that the beginning of my academic life is coming to an end, I would like to take a moment to look back on the process of writing this thesis and thank a few people who helped me achieve this result.

First, I want to thank the people from ZGT and the Univeristy of Twente for making it possible for me to work on this project. Especially, I want to thank my supervisors Niala den Braber and Janet van den Boer who guided me through this process and helped me whenever they could. I also would like to thank Miriam Vollenbroek-Hutten for making it possible for me to do this project.

I would also like to thank all the participants of my evaluation who took their time to invest in testing my prototype with them. Also, the people who helped me answer my questions in a fast way on Facebook and Reddit and provided me with insider knowledge on the topic.

Last, I want to thank my support group of family and friends. Especially my parents and my close friend Marise van Noordenne who took their time to read my work and discuss the topic with me, but also for providing me with distraction if I overworked myself.

Thank you all,

Fay Beening

Amsterdam, July 5th 2019

Table of Contents

Table of Figures

Chapter 1 - Introduction

Diabetes is a major public health concern. With more than 800.000 people in the Netherlands that have Diabetes Mellitus type 2 (DMT2), this accounts for up to 4% of the citizens ("Steeds meer mensen met diabetes" n.d.). In the coming years, this will increase due to a rise in overweight people, increased inactivity and nutritional changes ("Volksgezondheidenzorg," n.d.). Diabetes is a chronic disease characterized by the inability to naturally regulate glucose levels with insulin. Overweight people and elderly people are more prone to getting DMT2. The chance of developing DMT2 decreases by maintaining a healthy weight, regular exercising and healthy eating. These lifestyle changes are found to be more effective than the first line medication metformin used to treat diabetes (Diabetes Prevention Program Research Group, 2002; Knowler et al., 2003). Being diagnosed with DMT2 means a lifetime of check-ups, medicine, self-monitoring and self-managing for patients. In the last decade, mHealth has been a great source to find applications to help these patients guide them in the self-managing of their disease. However, many of the current mHealth interventions do not design with the involvement of the end-user, although this might be most effective (McCurdie et al., 2012).

With all new researches every day in this field, there can be a lot more achieved to help these patients monitor and manage their type 2 diabetes better. The Diameter, an app being developed by researchers of the University of Twente and the hospital of Almelo, aims to help coach patients into (new) healthy lifestyle habits. For this, personalized coaching will use the continuously measured data of the patient. The glucose measurements, physical activity, their meals and medication is registered for a relatively, if desired, short amount of time. Though, the main problem is that monitoring this data feels time-consuming for the patient and is often forgotten, increasing the chance of incomplete data. This can be solved by addressing the motivation of each individual patient. The use of gamification elements is an often used tool to enhance motivation and engagement in different settings (Dominguez et al., 2013; Marczewski, 2013).

This research aims to develop an interface that motivates DMT2 patients to commit to a healthy lifestyle with gamification and good personalization. With the main research question: **‘What would an interface that motivates diabetes type 2 patients to commit to a healthy lifestyle with gamification look like?’**

First, a description of the current state of the app as well as a basis of the concept gamification. This raises the question about the current state of gamification in the diabetes context. In the second part,

this question is answered by literature, highlighting the pitfalls of previous projects and opportunities in new ones. From this, initial requirements are derived that are in the ideation to create a first concept of the interface. This is tested and evaluated by the target group for usability in the specification phase. In the realization phase, the final prototype is presented. This method has taken inspiration from the Creative Technology Design Process by Mader & Eggink (2014). The goal will be a gamified user interface for the Diameter.

Chapter 2 – Theoretical framework

Before an interface can be made, it is important to take a closer look at what is already known. This means that the current state of the Diameter and gamification will be looked at. This serves as a base on the forthcoming sections, where there is literature research conducted on the current use of gamification in diabetes applications.

2.1 Context analysis

First, the current requirements of the Diameter are derived from the study done by den Braber et al. (2019). After this, an explanation of the concept of gamification is given, including commonly used frameworks.

2.1.1 The Diameter requirements

Focussing on the essence of the Diameter, it can be described as a personalized coaching system where the patient can manage their food intake, physical activity (PA), glucose values and medication. All these values can give clearer insights into their lifestyle habits in relation to glucose values and also provide diabetes health care professionals information on the self-managing of the patient. The personal coaching system bases its coaching on the values the application receives and gives tailored advice to the patient and adapt to the patients changing lifestyle. den Braber et al. (2019) reviewed existing mHealth applications that can monitor food intake, PA or glucose values to determine their strengths, weaknesses and explore functionalities to build upon in the Diameter. The requirements for the usage

of the app are split between the different measurements, food, PA and glucose values. In Figure 1 version 0.2.2 of the Diameter app are shown.

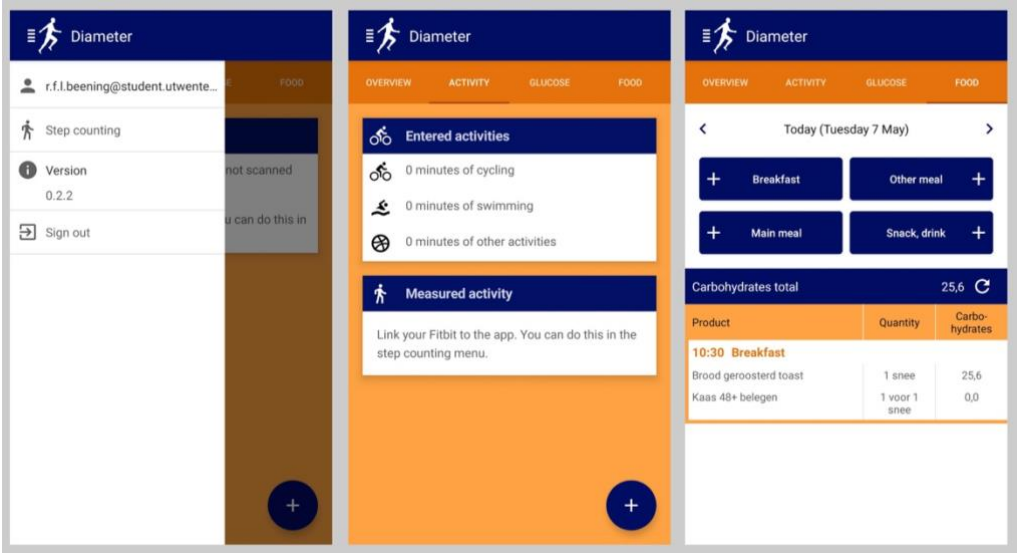


Figure 1- Version 0.2.2 of the Diameter

Food

Monitoring food intake is one of the most time-consuming activities of diabetes apps, as each food element must be put in manually and separately in the correct amounts. For this, a requirement is set up to apply a simple form of deep learning to get to know the patterns of the users. In case of monitoring their food, frequently used products and meals will be placed at the top of the list, lessening the burden of searching particular food items. Also, portions are applied to food products like, for example, slices of bread. Incomplete food registration is an often encountered problem when it comes to dinners, therefore, predefined components (vegetables, carbs, (vegetarian) meat and complementariness) are set to help them remember to register all consumed dinner. The same counts for beverages, it is asked for each consumed meal if the patient drank something.

The information collected must include the number of carbs consumed during the day as this gives important information to the user and the specialist. Also, it is important for the user to see their daily calorie intake and see how much they have left and have burned this is also the case with the amount of fat and proteins, this data is stored per day.

For the monitoring of food, it is especially important that it can be done without an internet connection, as the input will be most accurate and reduces the burden for the patient to do it at a later time. The Dutch Food Composition Table is used as the database of products. It contains 2300 mainly Dutch

products. Information on the food choices made is also provided to give the patient more insight. An all-time available guideline into how to register your food will be available to support the patient.

Physical activity

The PA of the patient plays an important role in improving and managing their diabetes. In order for the app to know that PA is conducted, an activity tracking needs to be worn. To avoid people forgetting to wear their activity tracker the app will send a reminder to do so if it does not receive data for a period of time. Next, to the activity tracker, it is possible to manually track the PA as not all sports are compatible with the system.

Glucose values

For a diabetes patient, their glucose values are the most important. For them, and also for the specialist, it is needed to know how the patient responds to certain factors and to possibly recognize patterns. For this, an overview of the glucose values per day with percentages of hypo-, hyper- and normoglycemic events next to the glucose variability is important for them to reflect upon and could also provide information on values, targets and variability. For this specific part, it is important that each patient can put in their own glucose thresholds.

For measuring the glucose values a flash continuous glucose measurement device is used and compatible with the app is the FreeStyle Libre. To let this system function properly, the patient is frequently asked to scan their sensor to reduce the risk of data loss. For this also compatibility with new sensors of the FreeStyle Libre is needed as these change every 2 weeks. For the patients who do not use the FreeStyle Libre, the option to manually register their values obtained from a finger prick can also be inserted.

2.1.2 Gamification

In order to apply gamification correctly, there needs to be an understanding of the concept as well as the knowledge of the frameworks that can be used. One of the most commonly used definitions of gamification is "The use of video game design elements in non-game contexts" by Deterding, Dixon, Khaled, and Nacke (2011). The differences between the several game design practices, serious gaming (where the game is the basis of a learning method) or playful design (where it is not about the game) should be clarified to better understand this definition. Figure 2 gives an overview of these differences as described by Deterding et al. (2011). There can be clearly seen gamification is about the game elements and not the whole game.

Figure 2- Gamification quadrant with serious games, gamification and playful interaction

With gamification, it is important to keep in mind that it should not be a complete game, but rather taking elements that make a certain game fun and involving and applying it to, in this case, an app. As stated by Deterding (2012) "Gamification is really a motivational design problem, one that can be best solved with design thinking and design processes."

The MDA framework is a method to successfully design games and gamified systems (Hunicke, Leblanc, & Zubek, 2004). It breaks down games into the tree levels: mechanics (rules), dynamics (system) and aesthetics ('fun') also referred to as the MDA framework. Mechanics is the level that contains all the elements like points badges and scores, where the dynamics are about the way the player interacts with these mechanics and what behavior they evoke. Lastly, are the aesthetics that are a big part of what makes a game 'fun'.

Robin Hunicke, Marc LeBlanc and Robert Zubek (2004) find 'fun' a narrow representation to describe what makes a game a fun game. They do not describe games as 'fun' but instead created a taxonomy to describe the combination of several aesthetic goals a game can have. These goals are listed below but are not limited to these:

1. *Sensation:* pleasing the senses
2. *Fantasy:* stimulating the imagination

3. *Narrative:* a compelling story
4. *Challenge:* constraints to make a game challanging
5. *Fellowship:* social framework
6. *Discovery:* mystery
7. *Expression:* personal experiences
8. *Submission:* past-time gaming

How the MDA framework is seen is different for the user as for the designer. Through the view of the designer, the MDA framework is perceived in order from mechanics to dynamics to aesthetics, where for the user it is the other way around. They will first feel the aesthetics work with the dynamics where the mechanics are only passively perceived. Because of this, the MDA framework can be seen as a chain where each element does only hold any value if the others are also valuable. In Figure 3 this connection between the designer, player and the MDA framework can be seen. This implies that strong collaboration with the target group could benefit to a good overall working design and game.

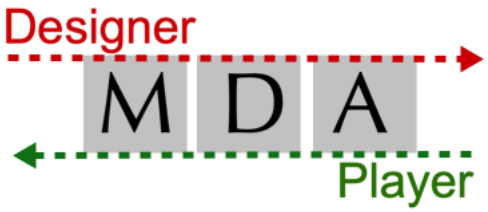


Figure 3 - Perspective player and designer as by Hunicke et al. (2004)

Not all people like all aesthetics of each game, this is determined by which player type they are. What type of gamer the end user also defines how the game will be played. No player is solely one type of player, but a dominant trait can be appointed. Richard Bartle (1996) wrote a paper on the most common

player types which were later used to design a framework as seen in Figure 4. This is the most used framework for game design and many other frameworks are based on this.

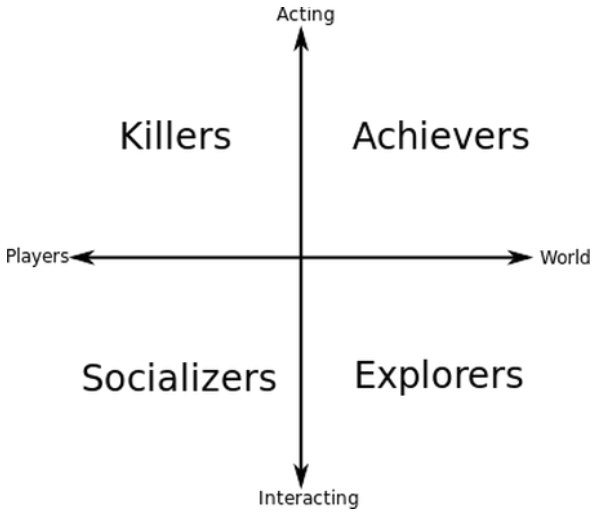


Figure 4- Player types by Richard Bartle (1996)

In this framework, there are 4 distinct players described. The achievers are about points and status. Their goal in games is to get the most badges and points and boast about them to their (in-game) friends. The killers are similar to the achievers only is the goal of the killer to ensure that other players lose. The explorers want to discover and go on adventures. They like surprises and want to unlock elements in games. Where the socializers like the interaction between players in games and collaboration with them.

These player types were largely based on patterns of social interaction that Bartle observed in the scenarios found in Multi-User Dungeons, or "MUDS" games. In this research, there will not be looked at MUDS or MMORPG (Massively Multiplayer Online Role-Playing) games. Therefore, another framework is introduced which is based on the one of Bartle called "HEXAD: A PLAYER TYPE FRAMEWORK FOR GAMIFICATION DESIGN" by Marczewski (2015). This framework consists of 6 user types and four basic instinctive types: achiever, socializer, philanthropist and free spirit. These players are specially designed to be used for gamification design. de Vette, Tabak, Dekker-van Weering, & Vollenbroek-Hutten (2015) link each of the types from Bartle (2011) to those of Marczewski (2015) a part of this chart is seen in Figure 5.

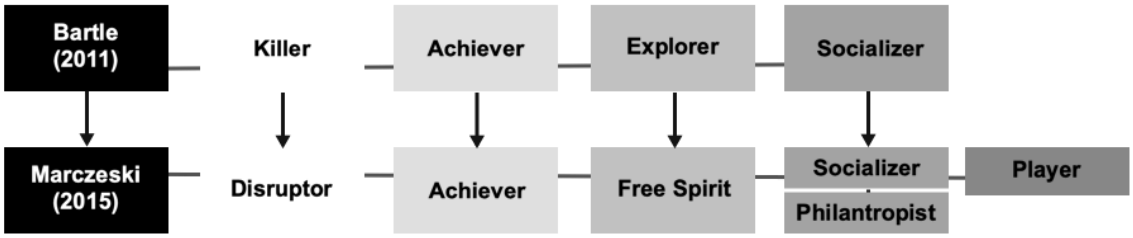


Figure 5 – Relation between Bartle's and Marczeski's player types as visualised by de Vette et al. (2015)

Each of the descriptions of the types is in a way similar, but the hexad is more from the perspective of instinctive motivation. In Table 1 the 6 user types with their motivations are listed, the first four are the basic intrinsic motivations.

To create a system for all types of users it is important to first focus on the four instinctive motivations and later add the player mechanics such as rewards, otherwise, the game will be solely relying on the reward. In Figure 6 you can see all user types and their motivation in relation to each other with accompanying game mechanics (Marczewski, 2015).

Table 1 - Player types and their motivation by Marczewski (2015)

Player type	Motivation
Socializers	Relatedness
Free spirits	Autonomy and self-expression
Achievers	Mastery
Philanthropist	Purpose and meaning
Players	Rewards
Disruptors	Change

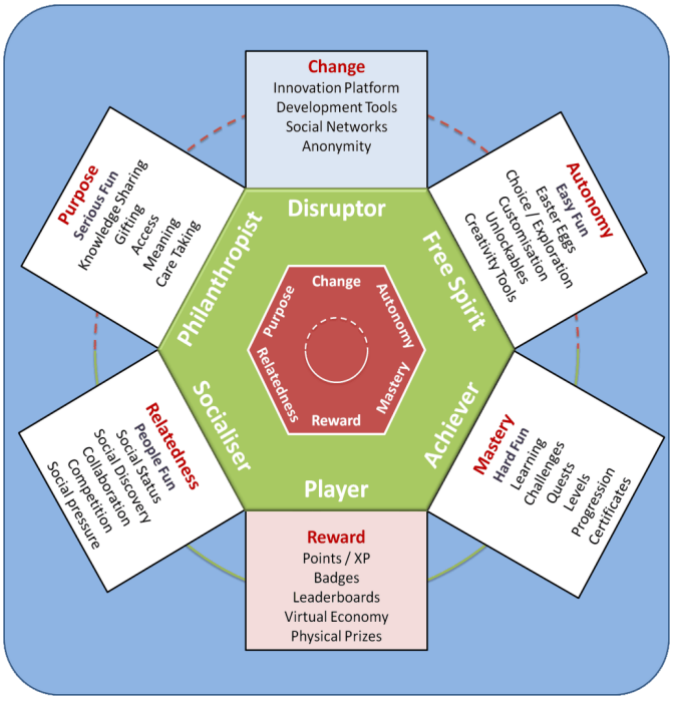


Figure 6- Marczewski hexad on player types (2015)

2.2 Literature State-of-the-Art

To get insight into how gamified applications for diabetes patients are currently designed and experienced, a literature study is done on personalized design and gamification. The goal of this review is to give an overview of the findings from previous literature about personalization and gamification their strengths and weaknesses in increasing motivation. In the first section personal constraints between patients in gamified diabetes, eHealth is discussed and second several game elements in this same context are reviewed. At the end also some findings from the Diameter are discussed in this context.

2.2.1 Research method for literature review

The search strategy is based on the sub-question that is: **'What are the strengths and weaknesses of gamified diabetes applications in terms of motivation?'** The question is split into the independent aspects gamification AND Diabetes AND application NOT necessarily motivation as gamification and personalization are already including this part. Four databases are searched: Scopus, Google Scholar, IEEE and PubMed. The search term that is used is stated below and in red the extra terms to find results explicitly on a personalized design.

(Gamification OR Gamified OR "Game element") AND (Diabetes OR prediabetes OR diabetic?) AND (application OR app? OR platform) AND (Individualization OR personalization OR "target group" OR "user-centered")

The goal of these keywords is to find examples of gamified diabetes applications that are actually tested. With the right results, it is possible to draw a conclusion based on different examples. Additional, there is a limit set for publication year to exclude the articles that are from before 2012 as these seem outdated for this particular topic. In Table 2 below the findings from the search engines are shown:

Table 2 - Search results per search engine

Search engine	Results	Results on personalization
Scholar	2600	1820
Scopus	30	4
IEEE	9	1
PubMed	14	2

Research on applications in the context of diabetes and gamification is what is looked for, but most of the results do not cover an application or diabetes specifically but do mention a relation between the two. In the end, around 40 articles are selected from all the results based on relevance and from this 17 are selected that explicitly have diabetes and gamification as their main research topic.

2.2.2 Personalised design in gamification

In the context of the paper, there can be constraints found between groups and individuals. Not correctly targeting of the user could be a cause of why the patient is feeling less motivated to complete a task as a lot of variables play a role in perceiving.

The first factor, age, is observed in the development of a platform by Akker et al. (2017) where they discovered there is an age-based constraint in their platform. The looks of the game were for a much younger audience than the targeted audience and this resulted in less motivation. These age-related constraints are confirmed by the research of Altmeyer, Lessel, and Krüger (2018), they discovered that the older age group (75+) prefer collaboration over competition as well that the group found badges and points meaningless and only creates more pressure. It should be taken into consideration that DMT2 is a disease with an average age of 66 and should have a specific type of gameplay to optimally motivate them.

Another factor is determined by the physical constraints of the patient. As DMT2 is more common to elderly people and the overweight population there are also physical constraints that could be taken into consideration in the development of gamified diabetes eHealth as Höchsmann (2018) notes, there is a risk in having game modes that are unsuitable for the person which results in ineffective training that could potentially do more harm than good. In the examined researches there is no mention of other physical constraints mentioned in combination with lack of motivation. Höchsmann (2018) his research is the only one mentioning a type of physical constraint. This challenges the assumption that physical constraints take an important role in the development of these applications.

The last factor is determined by more individualized constraints. The individualization in the level of knowledge and experience is an often-observed issue in the development stage of applications (Baranowski et al., 2016; Höchsmann, 2018; Klaassen et al., 2018). However, differences in preferences people have in the type of games is only mentioned once (Klaassen et al., 2018). This is interesting because different types of games have different perceived difficulty, but in the mentioned researches it

is not always clear if it is difficult because of game type or level. Notably, Akker et al. (2017) highlight the importance of the balance between challenging but not too difficult gameplay.

Personalization of the design process

To limit the constraints between users Altmeyer et al. (2018) point out that specific psychological characteristics of the user must be targeted, and game elements must be chosen in order to influence them. This personalized designing is also suggested by Theng, Lee, Patinadan, and Foo (2015), who state that making a connection between rewards and real-life goals for each individual, creates a more internal motivation instead of an external motivation. This results in more engagement of the user and potential long-term use. As the study of Höchsmann et al. (2019) suggest interdisciplinary design processes to increase internal motivation. Whereas Klaassen et al. (2018) claim there should be more research done about participatory design processes as they do not always lead to positive effects on health behaviors. Though there are some challenging statements, there can be concluded a design process focused on the differences between people can enhance the motivation of the user.

2.2.3 Gamification elements

There are multiple game elements that can be used in the context of gamification. Werbach and Hunter (2012) claim, as it is always a unique combination of science, art, and experience, a specific list of all game elements cannot be made. Though there are taxonomies made for the use of game elements, like the ones suggested by Hervas, Ruiz-Carrasco, Mondejar, and Bravo (2017) and Schmidt-Kraepelin, Thiebes, Tran, and Sunyaev (2018) and it is not limited to these. But to not exclude any game elements from this review there will be no taxonomy used in the following section.

One of the most recurring elements described in the literature is feedback mechanisms. Priesterroth, Grammes, Holtz, Reinwarth, and Kubiak (2019) discovered in a study done with 56 freely available self-management apps the game element feedback was applied in 50% of the cases. Klaassen et al. (2018) point out that applying feedback in a game is important to change behavior, which is the main goal of diabetes applications. Also, Nauta and Spil (2011) identify there are several levels of feedback that can be used as in point systems but also presented in graphs. Both of these studies show the use of the behavior change techniques by Michie et al. (2013) to select appropriate techniques and translate them into game elements such as “education and skills” and “goal setting and action planning”. As feedback on logged blood glucose data is key information for adequate blood glucose control for patients, it is a logical choice to implement this game element.

Game elements that are also used often in self-management applications are nudging and prompting. AlMarshedi, Wills, and Ranchhod (2015). notes that using the nudge theory and triggers may reinforce positive behavior in the self-management of diabetes. Nudging and prompting is also a technique often found in personal coaching apps to achieve higher motivation. As Lin et al. (2018) state prompting should be initially but be more flexible and less intrusive during different stages of use. Prompting is also observed by Garnett, Crane, West, Brown, and Michie (2015) as a technique to change the behavior of the user. Nudging and prompting seem to be an efficient technique to motivate the patient to change behavior.

Another commonly used element is reward; these could be digital but also tangible. Klaassen et al. (2018) discover that rewards offered by gamification tools can lead to short term improved behavior in diabetes patients. Digital rewards found in diabetes applications include gaming strategies, in which reaching game/real life goals and achievements are represented as game trophies or badges (Harris, Durresi, Tuceryan, & Hannon, 2015). A significant amount of applications mentioned in research describe tangible rewards and argue the potential tangible rewards could have (Bouras, Usop, & Popescu, 2018; Theng et al., 2015). As in the Mobiab system by Burda, Novak, and Schneider (2016) the motivation with rewards seem promising. More than one-third of the users of the system made use of the rewards system where they can redeem their points for things like blood glucose test strips. Theng et al. (2015) challenge that the dependence upon external rewards for motivation should be replaced by connections between the non-game activity and needs or goals in the user's life based upon the information. This will allow patients to have deeper engagement and make better use of their internal motivation. The use of internal motivation is not as much found as the use of external/digital motivation in game settings.

Furthermore, the use of social mechanics like support and competition is mentioned. Chronic diseases like diabetes are three times as likely to be diagnosed with depression ("Diabetes and depression," n.d.). In the research of AlMarchedi et al. (2015), this is addressed and is pointed out that the element of "fun" that gamification adds, contributes to the psychological aspects of dealing with diabetes. Also, Wu et al. (2017) report on the inclusion of social networking for the next generation of diabetes apps. It is not clarified what type of game mechanics suit this need. Baranyi, Willinger, Lederer, Walcher and Grechenig (2018) chose to use the social element of competition in combination with a leaderboard and avatar in its platform. Although there is made use of social game elements, it is not profoundly described and there is no elaboration on why the choice is made. There should be specific social game elements that work best in combination with the patients' social needs, but this is not present.

2.2.4 The Diameter

Den Braber et al. (2019) set requirements for the Diameter in term of measuring dietary intake, PA, and glucose levels by doing literature review, pilot studies and having expert meetings. Out of this, there were already some requirements mentioned in regard to overall personalization including preferences for specific lifestyle focuses, accessible language use and giving overviews of the patients their data. They also mentioned personalized targeting through glucose measuring which is in line with the earlier mentioned findings by Theng et al. (2015) about personalized goal setting in games. Also the differences in knowledge between patients that is mentioned by Baranowski et al. (2016), Höchsmann (2018) and Klaassen et al. (2018) is confirmed in this review as roughly 40% of the patients in one of the pilot studies correctly answered half of the questions about the influence of nutrition and exercise on glycemic control, diabetes complications and self-management. They found there is a need to give the patients more information about the influence of these factors and also insights about specific foods and their influence on the glucose values (den Braber et al., 2019). Matching the requirements listed by den Braber et al. (2019) with a gamified interface will optimize the usability and adoption of the application by the patients.

2.2.5 Discussion and conclusion

The results indicate that there are a lot of aspects that need to be taken into account when designing a gamified eHealth application for diabetics, but sufficient research on the reason behind the use of specific game elements in this particular context is not substantiated. Overall, there were similarities between the weaknesses mentioned in the findings of the researches. This indicates obstacles that are possibly harder to overcome when designing for this target group and should be taken more and earlier into consideration. A mentionable finding is that among these researches there is not always a distinction made between type 1 and type 2 diabetes and that the reason behind this is lacking. The differences in the self-managing, goals and age can be one of the determinants of why the previously designed applications were not as motivating as they could be. All the results gathered from this review should be taken into account when designing the interface for the Diameter. Though the results of this review are limited to the amount of literature available specifically on gamification for diabetes in eHealth, it should provide a sufficient overview of the findings in personalized design and gamification in this context.

By analyzing findings in previous literature about the personalization and the use of gamification to increase motivation in diabetics, there can be said there is no successful formula yet to optimize

motivation for a healthy lifestyle with a gamified diabetes eHealth application. To make full use of gamification in eHealth for DMT2 patients, further research must focus more on what this target group needs and want in terms of game elements and reaching their goals. In further research the question "How to develop an interface that motivates DMT2 patients to commit to a healthy lifestyle with gamification and personalization?" will be addressed with a focus on collaborative designing with all stakeholders.

Chapter 3 - Method

For the design of the interface for the Diameter, there was made use of a three-phase process. In Figure 7 this design approach is visualized. It is based on the Creative Technology Design Process by Mader & Eggink (2014) that consists of the 4 main components of ideation, specification, realization and evaluation. For this research, the evaluation was more appropriate to be in the middle of the process as opposed to being at the end. As was concluded from the literature, there was a desire to have user input earlier on in the process. This resulted in a participatory design approach that entailed regular contact with the user. Each component of the design process will be further elaborated in this chapter.

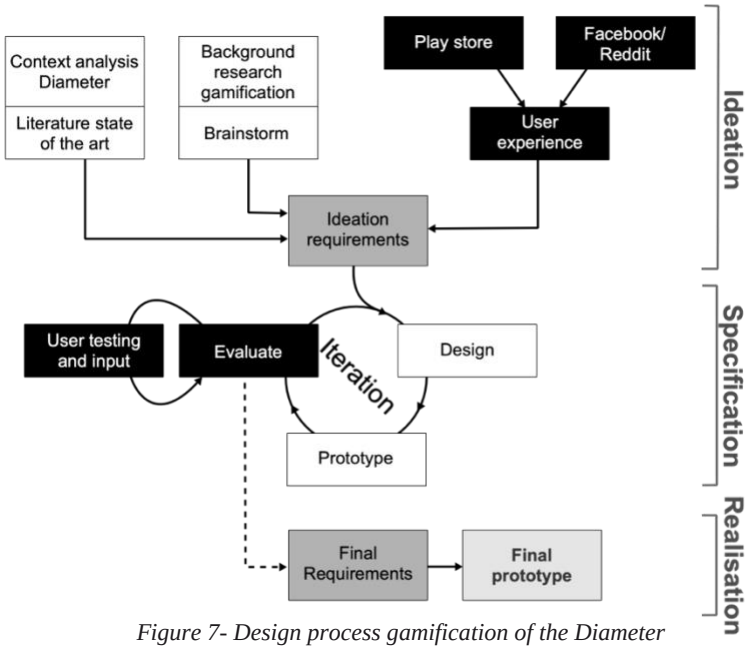


Figure 7- Design process gamification of the Diameter

In the ideation and realization phase, requirements were set-up as guidance for the design process. For this, the MoSCoW requirements prioritization method was used. This method gives clear guidelines of what the design needs to have to be successful and limits the risk of straying from the core of the project. In this prioritization method the design requirements were appointed to one of these elements of MoSCoW: must have(M), should have(S), could have(C), and would have(W).

3.1 Ideation

First, in the ideation, requirements were set up based on several input sources. It combined the earlier done research with input from the user group. As seen in Figure 7, the components Diameter requirements (paragraph 2.1.1) and Lliterature State-of-the-Art (paragraph 2.2) were combined to ensure a focus on the personalization and meeting the users their needs. To add to the gamification a brainstorm on player types was executed. The research on user experience was done with reviews and experiences on existing apps from Facebook and the PlayStore. This provided an answer on which game mechanics can be most attractive for the target group and what aspects of their diabetes management they find most important.

3.2 Specification

The specification relies on the iterative process of designing, prototyping and evaluating. The ideation requirements were the base of the first design and prototype. After the first design process feedback was gathered from the evaluation and taken into account when new ideas were generating. Prototyping was done in the program Adobe XD, it is a fast and easy to use program and was used throughout all the design phases. The evaluation was done with different groups over the design process. In the coming section, each of the phases of the iterative process will be elaborated on as well as the testing group and requirement prioritization. (“Design iteration brings powerful results. So, do it again designer!” n.d.)

3.2.1 Design

During the design phase, the system was designed to satisfy the requirements identified in the previous phases. Considering what was observed in the previous phase helps to empathize with the user and understand the problems better. This feedback from the evaluation was translated into meaningful insights and requirements. It describes a plan on implementation of the solutions into the Diameter. As a first base of the design the original beta version of the Diameter was used to build the new design upon. In Appendix I this mock-up of the Diameter can be found.

3.2.2 Prototype

In the prototype stage, the design choices were made into a low-fi prototype. Especially in the early stages of development, there was a focus on time efficiency. Having a low-fi prototype will allow for fast and easy adjusting of the design and give the participant more freedom to voice their opinions on

the design. As mentioned, this was done in Adobe XD, a program which allows to immediately design as you think and is flexible in use. The initial design of the beta version of the Diameter was used as a base for the prototypes.

3.2.3 Evaluation

The evaluation was divided into two parts consisting of a pre-evaluation and the main evaluation. This was done to prevent minor mistakes disrupting the main evaluation process where the focus is on the game aspects of the interface. This pre-evaluation, that can be found in Appendix II, was done with only one of the participants each iteration. This was done to get rid of minor usability mistakes and make it easier to later lay the focus on the design of the gamified interface in the main evaluation. The outline of the main evaluations can be found in Appendixes III-IV.

For these evaluations, a wide range of participants tested the interface. These also entailed the 'extreme users', in this case, the people with diabetes who never used a self-management app before. Some of the people only participated in one of the evaluations and others contributed to more evaluations.

3.3 Realization

At last, in the realization chapter, the final list of MoSCoW requirements was given based on the previous phases and the final prototype based on these. This section also provides more details on the transitions of the app that cannot be seen in the images.

Chapter 4 - Ideation phase

The goal of this phase is to create a base of what the application could be like. In this phase, it is important to already start acknowledging the users their needs and thoroughly understand the target audience and what success for an app would look like from their perspective. To gather this information the previously made theoretical framework (chapter 2) will be analyzed and the user experience is tested through communities and app reviews. The results will be requirements that are put into a MoSCoW Table. This should provide a sufficient base of the interface that can, later on, be tested by the target audience on usability and implementation.

4.1 Literature review

The first requirements can be found based on the previously done study by den Braber et al. (2019) in combination with the literature review findings in Table 3. The MoSCoW prioritization is applied, taking into account that certain requirements are dependent on the type of game mechanics used and their position can change in the future.

Table 3 - MoSCoW ranking on background research

Ranking	Requirement	Source
M	The use of game mechanics that enhances motivation - Targeting the four intrinsic motivations of Marczewski	Marczewski (2015)
M	Give a personalized experience to the user	Literature review conclusion
M	Meaningful feedback for the patient on their 'game' behavior	Literature review conclusion
S	Relate the goals of the patient to in-game goals (providing internal motivation)	Theng et al. (2015)
C	A balance between challenging but not too difficult gameplay	Akker et al. (2017)
C	Use behavior change techniques to obtain desired behavior (commitment to the app)	Michie et al. (2013)

W	Social game mechanics if specifically, desired by the target audience	Literature review

4.2 User experience

The usage of apps by the user group can be examined by looking at exsisting applications. Taking some of the most used apps for diabetes patients in the Netherlands from the PlayStore (MySugr, Diabetes dagboek, Diabetes:M, Suikerziekte) there can be looked at the reviews of the users (play.google.com). Examining the 10 'most useful' Dutch reviews (21-05-19) the findings can be combined in pros and cons found in Table 4.

Table 4 – Summary of pro's and con's of available diabetes apps

Pro	Con
Simple and clear graphs → More insights on your situation	Does not use color to indicate glucose values
Challenges are motivating	More room for notes needed

Overall the users were not really precise on why they liked a particular feature or what made them stick to this app. The answers mostly consisted of a like/dislike. Most of the users that gave a more detailed review mentioned the clarity and understandability of graphs as an important feature of why they liked a certain app. Also the con "does not use color to indicate glucose values" is related to the need of the user to have valuable and insightful feedback. This kind of feedback was also found while examining game behavior and mentioned as a must have in the MoSCoW requirement list.

These are the people that are using apps to manage their diabetes, but there are also many who do not use any digital tool and those who prefer using Microsoft Word or Excel to keep track of their diabetes. In a minor field study, 3 out of 6 of the patients did not use any app to manage their diabetes ('Diabetes type 2 ?? ……samen werken aan medicatievrij !!', Facebook). Stating an app most of the time offers a lot of functions they do not need. In this same group the trend of low carb diets is apparent, they supported people to not count their carbs as they should just avoid them. Options for leaving out certain elements of managing could be implemented to also support those who do not want to use some of the features. In Table 5 the requirements derived from this section can be found.

Table 5 - MoSCoW ranking on user experience

Ranking	Requirement	Source
M	Insightful feedback on their diabetes - Glucose values and variability, hypo-, hyper and normoglycemic events - Carbs, fat, protein and calories	PlayStore, Den Braber et al. (2016)
C	Opt-out options for functions	Diabetes type 2 ?? ……samen werken aan medicatievrij !! (Facebook)

4.3 Background research gamification

Now that it is clear why certain apps are used, what the most important features are, there can be thought about how gamification can reduce the feeling of 'excessive time investment'. A brainstorm is conducted with a wide spread of people to generate a mind map of what people associate with the word 'game' and also what they think the target age would like in games. In Appendix V, the full details of this mind map can be found. When looking at the associations people made with the word 'game' these can be connected to the player types by Marczewski (2015). Most of the mentioned connections they made are divided over three subcategories: challenge, competition and collaboration, each a motivational aspect of gaming. These can be linked to the player types, achiever, free spirits, philanthropist and socializer. Most of the games mentioned are simple games with 1 or two main mechanics not especially speaking to the philanthropist. The most games and also mechanics that are mentioned can be linked to the achiever, scoring points and having a challenge. When looking at the mindmap a few game mechanics can be derived. Resulting in the following game mechanics and dynamics:

- **Create meaning:** speak to the internal motivation by setting in game valuable goals (philanthropist).
- **Create a challenge:** give the feeling of wanting to gain and not wanting to lose by point/badge system (achiever).
- **Personalization:** give identity to parts of the interface, customization and creativity (free spirits).
- **Connection:** give the user the feeling of collaboration with the game, create an empathic environment (socializers).

All these mechanics and dynamics should be covered in the end design as found earlier a successful game is a game that speaks to every player type (Marczewski, 2015). In Table 6 the requirement can be found on these player motivations.

Table 6 - MoSCoW ranking on player types

Ranking	Requirement	Source
M	Speak to each player type - Meaning - Challenge - Personalization - Connection	Brainstorm, Marczewski (2015)

Chapter 5 - Specification phase

In this chapter, the requirements of the ideation phase will be translated into a design which will be further evaluated and iterated. A full overview of these requirements can be found in Appendix VI. This phase will result in multiple prototypes based on the current design of the Diameter. After 2 full iterations, there will be the third iteration only consisting of the design and prototype phase 3 after this the phase will be concluded.

5.1 Iteration 1

5.1.1 Design

With the requirements gathered until now, a first draft can be made of the interface with some gamified elements. Only the must-haves from the requirements will be covered for now.

The feedback mechanics seems to be most valued by the user and also be motivating. Showing this feedback in an insightful way can be combined with the personalized goals setting and this way create a game mechanic suitable for the player types achiever and philanthropist. As also stated in the requirements of den Braber et al. (2019), it is important for the user to see the number of carbs, proteins and fat consumed and see their calories consumed, burned and left. For this also DMT2 patients were asked what goals they set for themselves. They mentioned the following goals; staying in ketosis (low/no carb), decrease insulin usage, losing weight, increase fitness/activity and keeping a regular average in blood glucose. The values that can be used with its parameters are shown in Table 7. Medicine-related goals are for now excluded as a medical expert should be aware of the user wanting to change their medicine intake.

Table 7 - List of goals and sub-goals

Goal	Sub-goals
Activity	Walking Cycling Swimming Other

Nutrition	Carbohydrates Fat Protein Calories
Blood Glucose	Peaks Lower BG values at specific measure time
Weight loss	Percentages Weight

Each of these values can be used to create goals by the user. Completing these goals would serve as an internal reward for achievement. As Theng et al. (2015) suggest, relating the goals of the patient to in-game goals could create this internal motivation. This is why there is looked into making a bigger connection the goals by linking them to a relatable topic. For this, a reward system based on nourishing will be showing the user how they are doing on their goals. This can visualize how they are nourishing themselves and make it more tangible. In the initial phase, this will be based on caring for plants as these are they seem to be a simple visualizer of good care and bad care.

To work with the two must-haves of speaking to each player type and personalized experience. There is looked at achieving this personalization through a small avatar building option. As having a picture would not add any additional aesthetic to your profile, a very small builder option would achieve this extra personalization and add aesthetic. In Table 8 the avatar creator options are displayed

Table 8 - Avatar specification

Components	Customization
"Male/Female"	Lashes No Lashes
Skin complexion	Light Medium Dark
Hair length	Long Short

Hair Colour	Yellow Brown Red Black Grey
Eye Colour	Dark Brown Green Grey Blue

An avatar is a good option as this can also be used to create an emphatic environment in the app. Emotions of the avatar will show the user how well they are doing on their goals/plants and can give some small pointer and updates on how they are doing. Some basic emotions as neutral, happy and sad will be shown by the avatar. This is a big part of the socializer player as an emphatic environment motivates them to play.

5.1.2 Prototype

First, all components as described in the design phase are visualized in a systematic overview. In Figure 8 you can see how each component link together into a game system.

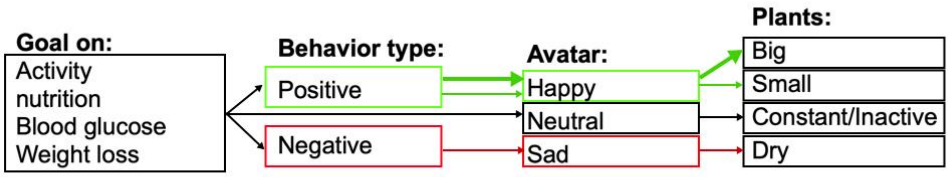


Figure 8 - Game system schematic version 1.0

Now the system is clear there is looked at how the plants can look like. In appendix VII several design ideas of the plant visualization can be found. The one that was chosen in the end seemed most clear and had the most potential of being implemented into the app interface without having to build in a whole theme around the design.

For the visualization of the avatar, the components as described in Table 8 were translated into real components. These components can be seen in Figure 9, where also the emotions sad, happy and neutral are shown on the heads.

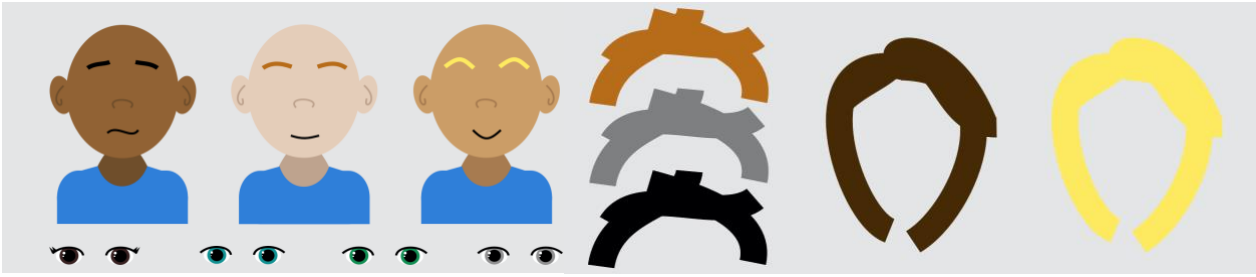


Figure 9 - Visualization avatar components

This results in the design shown in Figure 10. Also, changes on the looks of the design are adjusted to fit more in the modern app styles that are on trend. In Appendix I, a blank copy of the interface of the current beta version of the Diameter can be found. To re-design this interface there is looked at designs that are featured on several app interface design websites. These served as an inspiration that resulted in different re-designs on the layout these are found in Appendix VIII. Later also a color scheme generator (www.coolors.co) was used to create some different designs with the focus on color. In Appendix IX several of these combinations applied to the interface can be found. The color scheme that was eventually chosen is one with mostly oranges, these are most in line with Ziekenhuisgroep Twente logo but in a more modern way. Also in this prototype, the visualization of the data was shortly looked

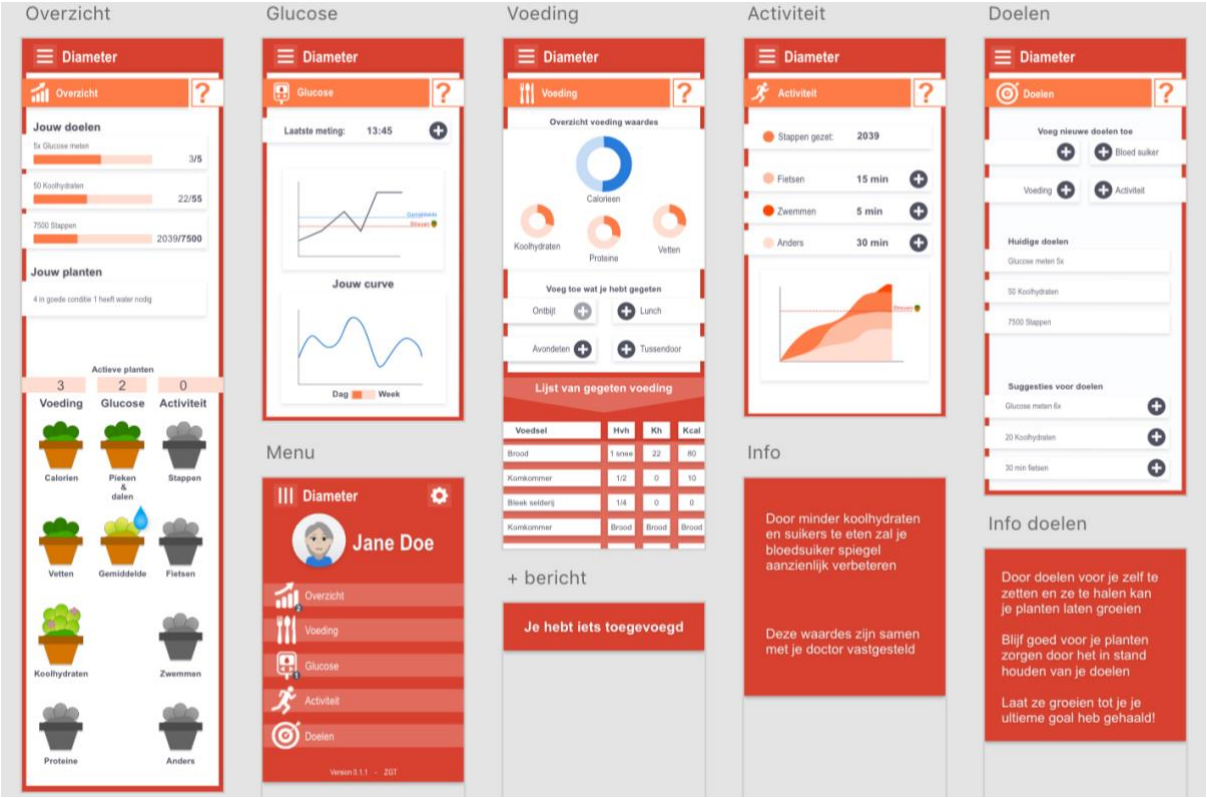


Figure 10 - Prototype gamified Diameter 1.0

at, as these do not exist in the current beta version. Though this data does not correspond to real data, the different graphs do show possible ways to visualize this in combination with the game elements.

5.1.3 Evaluation

Participants

This evaluation was done with 4 participants in total where 1 of those participants also did the pre-evaluation test. In Table 9 information on the participants are given.

Table 9 - Participants iteration 1

Participant	Age	M/F	App usage	Active/non-active in achieveing a healthy lifestyle for diabetes	Iteration participation
1	87	M	No	Non-active	1
2	85	F	No	Non-active	1
3	60	F	No	Active	1 (pre-evaluation), 2
4	60	M	No	Active	1, 2

Pre-evaluation

First, the prototype will be tested on functionality to later have the focus on the content, this pre-evaluation can be found in Appendix II As this app is more for the older generation than for the younger, there cannot simply be assumed digital icons get recognized. This was also the case with the menu indication in the upper left corner. This was not recognized as a way of opening the menu and should be reconsidered. This was the only functionality element that was not working as was predicted.

Main Evaluation

For this evaluation mostly the functionality of the game elements will be addressed and also how much/frequent the user would want to see them in the app. In Appendix III a more detailed description of this process can be found.

First, feedback on the game elements. The making of personalized goals was perceived well and also the visualization through the plants was mentioned as helpful, especially with the older participants (80+ years). There was observed it did take some time for them to understand how the plant system

worked, in the next design with a better and clearer design of the plants could make it more understandable. They also found it unclear on what conditions the plant would grow and when they would wilt. There was asked if they would like to compare the visualized data of their goals, but they thought this was not necessary and could be even confusing as it is not a competition between the goals.

It was apparent that the avatar was not implemented enough in the design as the tester did not realize it was there. After mentioning the existence, they said they would like it to have a more active role in providing information.

On the other questions, no distinct answers or comments were given for implementation or adjustments on the current prototype. Some of the participants did mention liking the colors of this app. It could be that they found it refreshing, as most health-related applications are more on the green and blue colors.

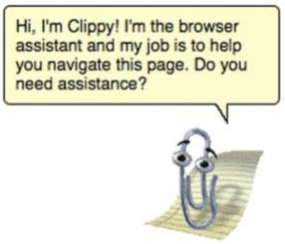
5.2 Iteration 2

5.2.1 Design

Taking the evaluation into account there will be looked at how the feedback can be translated into the new design. In Table 10 the problems that were encountered in the evaluation are listed with their proposed solutions.

Table 10 - Design problems and solutions iteration 1

Problem	Solution
Menu symbol unclear	There could be looked at more variation in this symbol if this makes a difference in clarity. The different alternatives for the menu symbol can be found in Figure 11.  *Figure 11- Three different menu visualizations*
Plants not clear (visualization)	The plants will start with only a pot, if not activated, when activated there will be a small plant, in the background you can see a shadow of how big the plant can get. Withering would mean the plant is on the verge of

	getting smaller again.It should be clear as this is what the reward makes it more long therm motivational.
Plants not clear (point system)	There should be a time to go with each goal as not each goal will be as easily achievable. A situation sketch can be given, but this should be eventually consulted with the medical professionals.
Avatar inactive	To get more out of the avatar it could be used as a guide throughout the app as seen in Microsoft Word with the paperclip (Figure 12). A similar approach will be used in the next prototype.  *Figure 12- Microsoft Clippy*

5.2.2 Prototype

First, the point system will be addressed. In Figure 13 the system can be systematically seen. The points people get when they complete a goal are based on the amount they set for themselves compared to where they are now in combination with how much time they want to take to complete this goal. The amount can be measured in numbers but also in percentages of where the user is currently situated an example of a goal could then be that the user weights 100 kilos and wants to lose 5% of their body weight in 1,5 month, but it could also be that the user wants to walk 8000 steps 5 days in a row.

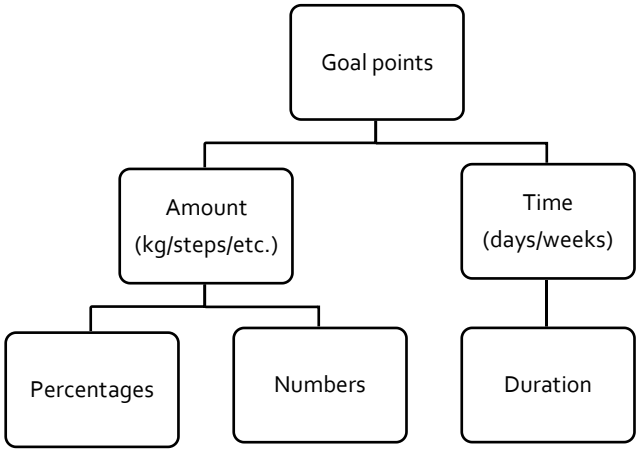


Figure 13- Factors determining goal points

These points will not be visible as points but be translated in a low, medium and high effort score. This will be convenient for the user as to set more realistic goals for themselves. In this case, a low effort score will be watering a plant or growing 1 level, a medium effort score will be growing 2 levels and a high effort score equals 3 levels of growth. In Figure 14 the game system as seen in the previous iteration is seen with the new components of difficulty and plant levels

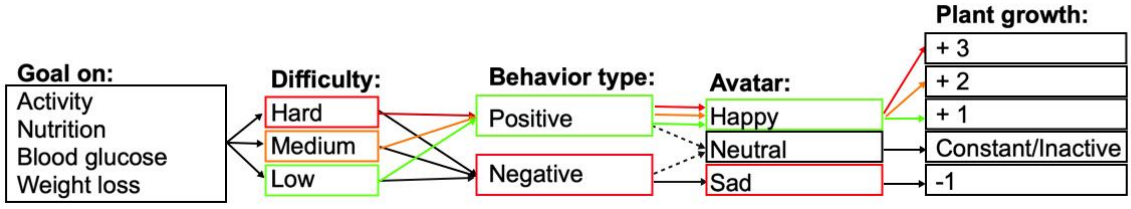


Figure 14 - Game system schematic version 2.0

For the designs of the plants, this means they will get more complex as to in the previous version. In the new design, it will be an empty pot for a not active goal, when activated there will be a small plant, in the background you can see a shadow of how big the plant can get which can be seen in Figure 15. Withering would mean the plant is on the verge of getting smaller again. This will make more clear the type of reward. This type of reward will motivate more as achieving a goal will not mean it will indefinitely be there, but still needs maintenance to keep the plant healthy. This results in 5 phases the plant can be in as the last plant will show the optimal condition of that particular goal.

Figure 15 - Plants to visualize the progress for the user of the app

Now the plant goals system and visualization are more defined, there should be looked at the implementation of the avatar. This is done by implementing the avatar in the upper right corner replacing the question mark that was there. Now the user can tap their avatar to get tips and help for the app. As for the menu symbol, the choice is made to change it into another format which will hopefully clarify it more for the less experienced app users. The prototype as of now can be found in Figure 16.

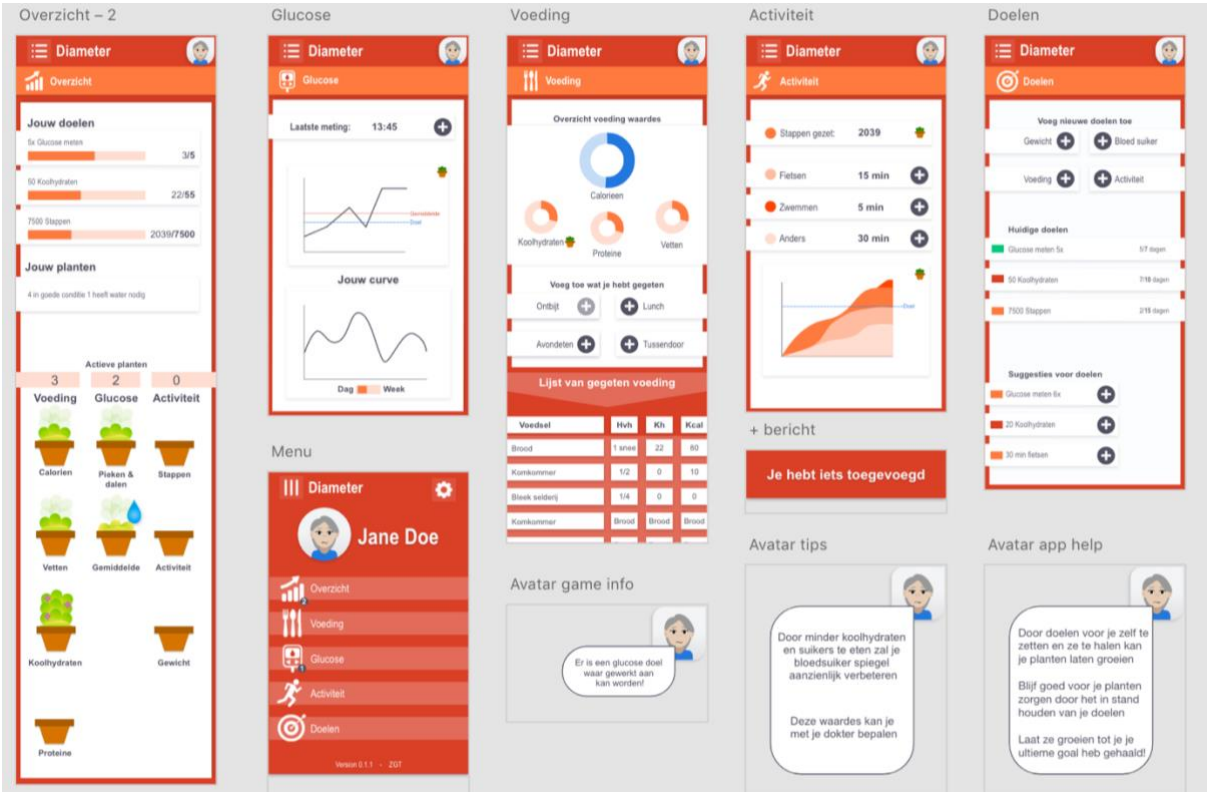


Figure 16 - Prototype gamified Diameter 2.0

5.2.3 Evaluation

Participants

In the following evaluation, 5 people participated. One out of the 5 participants also conducted the pre-evaluation test and 1 of the testers did not receive the background story on the app. In Table 11, the participants are listed each with their characteristics.

Table 11 - Participants iteration 2

Participant	age	M/F	App usage	Active/non-active in bettering diabetes	Iteration participation
3	60	F	No	Active	1, 2
4	60	M	No	Active	1, 2
5	58	F	Yes, 'mijn eetmeter'	Active	2 (pre-evaluation)
6	70	F	No, but mailings	Fluctuating	2
7	65	F	No	Non-active	2 (no background information)

Pre-evaluation

As in the first iteration first, the functionality of the prototype will be tested to ensure that the testing will not be hindered by prototyping mistakes. One of the things that did not work well on some of the pages was that the header disappeared underneath the main body. This was also the case with some of the plants. After this was fixed, everything seemed to be working fine.

Main Evaluation

When testing with the target group the implementation of the avatar was found more consistent and added value to the design as a 'helper' as opposed to the last evaluation. They did mention the avatar showing the 'awkward/sad' emotion and asked what other emotions the avatar showed. This is the case, but could not be implemented into the current prototype. Nevertheless, more clarity on how the game dynamics work should be provided. This also includes when/why plants are withering.

All participants agreed that a visualization of the progress by plants added to the aesthetics and was easy to understand. A participant did mention they would like to also get feedback in the form of direct encouragement. Such as a "well done" and "you did great".

Also, two of the participants mentioned the desire of having the health care provider setting their goals and thresholds. One mentioned this in the context of having someone observing at their progress and this will give them the motivation to keep working on the goals. The other mentioned it as a part of having the application be more tuned towards their needs as these are for everyone different.

In a meeting with one of the stakeholders, the desire of having the plants positioned directly in sight of the front page was mentioned. This in combination with an option to switch out the plants for other attributes, such as cars or kittens. As mentioned earlier in the design process the plants were initially chosen to visualize a caring aspect, but there should be taken into consideration that people could care more for their cars than for their plants.

To test the understandability of the (gamified) functions the last participant in this evaluation was not provided with the background information. The participant was able to explain what they were seeing and could link the several components together without any guidance

5.3 Iteration 3

5.3.1 Design

In the second evaluation in-depth feedback was given on the application. In Table 12 the experienced problems that were found during the evaluation can be found.

Table 12 - Design problems and solutions iteration 1

Problem	Solution
Plants need to be more in vision and other objects should be available	Plants can be placed more on the top of the process page, this will result in this page only consisting of the plants as the process of the goals will be moved toward the goal section to separate them more.
Healthcare professional intervention	As this is an app that would be provided by the hospital it should be possible to make the health care professional more involved. A quick

	survey in the app for the caregiver can be implemented so the goals that are suggested or more targeted towards the user. Also, the order on the 'goals' page will be adjusted to make the suggestions seem more leading.
Missing direct encouragement	This application will eventually be about personalized coaching, but this will be implemented later on by another team. In this design, this will therefore not be implemented as this is already being worked on.
Avatar emotions unclear	It is important to inform the user beforehand of all the functions instead of exploring the app. This could be caused by the fact the users are often older and less used to technology and these systems. An animation video, including some introductory questions, should be provided at the start of the app.

5.3.2 Prototype

The prototype below is a result of the previous design. This prototype should after this be transferred to a program that is capable of more interaction. As of now, the game dynamics have been prototyped but the game mechanics are not. In Figure 17 the final game system can be found. No alterations have been made to the direct system but the additional functionalities are visualized in the process.

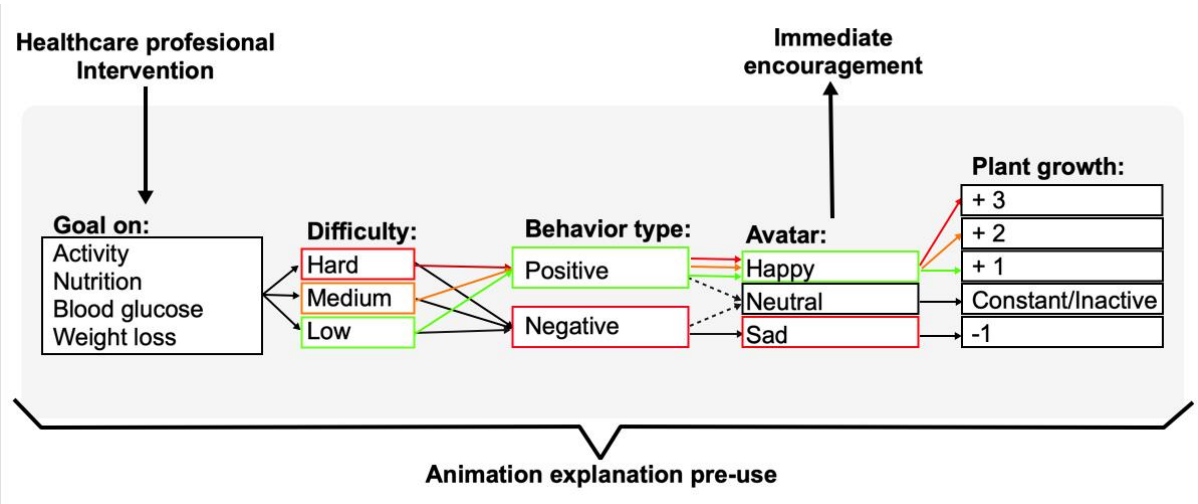


Figure 17 - Game system version 3.0

Additional to the design solutions that are implemented there was also more looked into the visualization of the data to give the app a more completed look. In Figure 18 the 3rd prototype is shown.

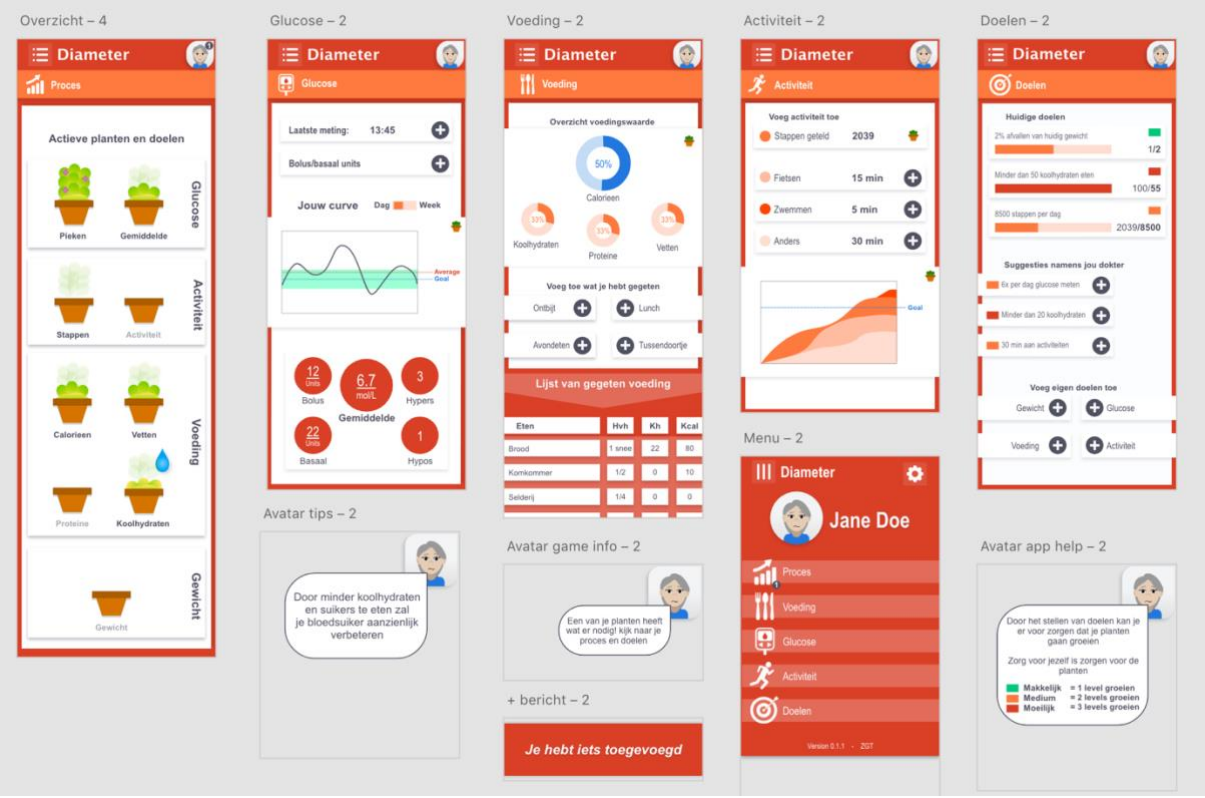


Figure 18 - Prototype gamified Diameter 3.0

As mentioned, there will be an animation at the start of the app. This animation is not directly a part of the interface but does belong to the aesthetics of the game. For now, only a list is provided of the possible elements that can be addressed in this animation:

- The goals and goal setting
- The plants as visualizers of the goals (this would be where there is asked if they would like to replace the plant by some other visualizer
- The plant icon indicating where a goal is active
- The avatar explaining when sad, neutral or happy.

Chapter 6 – Realization

In order to make this prototype a fully functioning application, some clarification on the functions are needed. Starting with the latest prototype seen in Figure 19, there can be seen that some more alterations have been made to the overall look and feel of the app. This was done to make it a more complete design, ready to be programmed. In Figure 20 the paths of the interactions can be seen as they were in the prototype. In Appendix X the Full-size version of these overviews can be found.

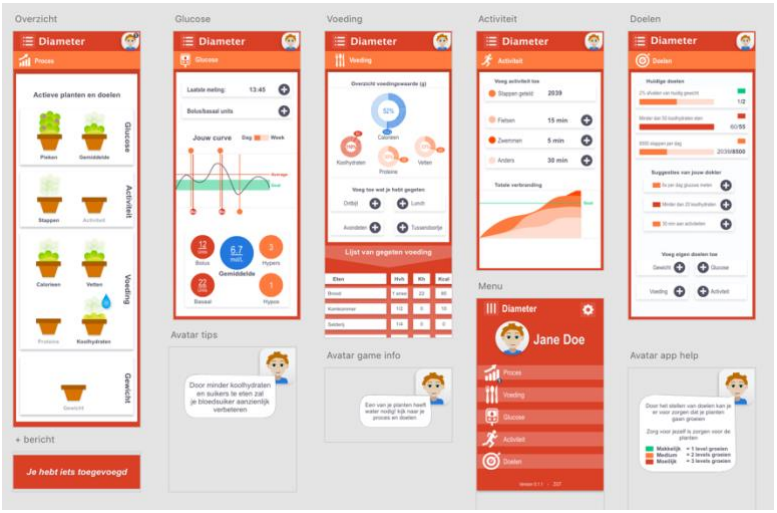


Figure 19 – Final prototype

Additional to these interactions, there are some that could not be visualized in Adobe XD but were mentioned and should be added to the next prototype:

- Real-time adding of values
- Processing of values into goals
- The settings page for the opt-out functions
- Editor for the avatar
- More diverse messages of the avatar
- Introductory animation (optional)

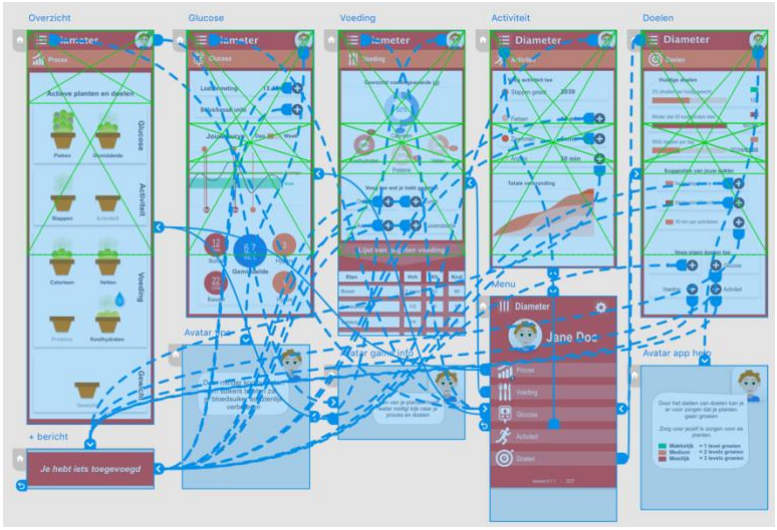


Figure 20 - Interaction flows of the final prototype

6.1 Final MoSCoW requirements

Revisiting the requirements gathered in the ideation phase, there can now be looked at what prioritization ranked correctly as a must have and if there are any requirements that can be added now the specification is done. The full table as derived from the ideation phase can be found in Appendix VI. In this table, the main must-haves were represented by mostly feedback and player types, which

were also the main focus of the specification. Further, in the end prototype, the should-have of relating the user's goals to the in-game goals was also implemented (plants/goals) as well as a balance between challenging and not too difficult gameplay (easy, medium, hard goals). After the specification phase, there should be a requirement added to this list. The should have "all-time access to an explanation on the application" as well as an "introduction to the app interface and game dynamics".

On the other hand, the behavior change techniques were not applied (yet) to this stage of the prototype as well as the opt-out functions, these were not explicitly addressed, but were found to be desired. The new requirements can be found in Table 13, where the new and adjusted are made visible in red.

Table 13- Final MoSCoW requirements of prototype

Ranking	Requirement	Source
M	The use of game elements that enhances motivation - Targeting the four intrinsic motivations of Marczewsk	Marczewski (2015), brainstorm
M	Give a personalized experience to the user	Literature review conclusion, Specification
M	Meaningful and insightful feedback game/diabetic	User experience, den Braber et al. (2019)
S	Relate the goals of the patient to in-game goals (providing internal motivation)	Theng et al. (2015)
S	All time access to explanation of the app	Specifiation
S	Introduction to the app interface and game dynamics	Specification
S	Opt-out options for functions	Diabetes type 2 ?? ……samen werken aan medicatievrij !! (Facebook), Specification

The requirements that are now left out, the could-haves, are mostly based on the game mechanics, these could not be tested in this stage of the prototype so left out of the final requirments list.

Chapter 7 – Conclusion

This research aimed to design and evaluate an interactive and attractive user interface for The Diameter that gives patients insight into their physical activity, diet and glucose values. Gamification was used as the tool to make the interface motivational for the user and interactive to use. The fundamental approach of gamification is enhancing the motivation of the user that interacts with it. Presently, only a passive interaction system of putting in data is available in the beta version of the Diameter app. To add to the motivation of this app, several game elements were applied.

To achieve this result a multitude of processes and frameworks were used to answer the following research question: **'What would an interface that motivates diabetes type 2 patients to commit to a healthy lifestyle with gamification look like?'**

To answer this question, firstly an analysis of the context was done. This contained an extension on the current state of the Diameter and a compact outline on gamification. Next, the literature State-of-the-Art on this subject was researched answering the following question *'What are the strengths and weaknesses of gamified diabetes applications in terms of motivation?'*. This information, combined with input from the target group, formed the ideation phase. Further iteration on the design was done in the specification phase concluding with final requirements and final design in the realization phase. In the end, the context analyses and early user involvement accounted for the main contributions to the design of this interface.

The end result of this design process is an answer to the main research question. This application is a product of the process which was focused on motivation by gamification and personalized design. This was achieved by the implementation of a point system, goal setting, avatar creating and insightful feedback. A balance between game elements and app was achieved in a subtle manner, not overpowering the importance of the other elements in the app. It is recommended to continue the development of this prototype to further evaluate the motivational aspect of this gamification.

Chapter 8 – Discussion and future work

The work presented in previous chapters showed a potential outcome of applying gamification to the concept of the Diameter to increase motivation. In the process of finding a suitable design, the basic principle of the Creative Technology Design Process by Mader & Eggink (2014) was used. 7 people with DMT2 are used in this qualitative design approach of the gamified interface. The end result of this research is a good representation of what a possible outcome of this research question could be. This newly designed interface is in its first stages and open for additional features and alterations. It only shows one way of implementation of gamification on to this interface. The reader should bear in mind that this research was not on finding the most effective way of using gamification, but to see how an interface with gamification could look like.

The end design came forth from following this design process with these 7 participants this influenced the eventual end result. Because of this, a prediction of how this app would turn out could not be formed previous to the start of the research.

Another possible explanation for this could be that the combinations for a gamified system are endless and depend on the creativity of the designer. Although the core of this interface is based on literature it is the question if this combination of mechanics, dynamics and aesthetics is the most effective combination, but could be effective nonetheless.

What you could also say this is a result of this specific designers choice and interpretations, if this research will be done again with a different designer, different answers on the research question will be the result. This does not make this answer wrong, but it is one of the many possible answers to this question.

This research can serve as an inspiration for further development of the Diameter, but could also be used to get insights on a design process in this specific field. In previous studies done in this context, not many details on the design process were available as well no substantiation on the design choices. This will give other design insight into this process.

It should be taken into account that due to time constraints, no extensive evaluation could take place. Some obstacles occurred during recruitment of participants which caused a delay. Even so, the participation of the participants was underestimated. The majority of the answers given on the questions was answered with a short answer not providing extensive input. The evaluations took longer than

anticipated as making the participant voice their opinion took a significant amount of time. When further research is done it is advised to have a group available for testing beforehand as this will avoid losing time when you need fast feedback. In this project, it was mostly resolved by contacting diabetes communities on diverse platforms. Though this resulted in some great ideas and input it is hard to formulate your questions to not influence their opinions and get the right answer.

To take it to the next stage a new prototype with more functionality should be made to evaluate the motivational aspect of this combination of gamified elements. Because of the time restraint, the scope of this research was limited and could not provide an answer on the long term motivation of the designed interface as the interface could not be made fully functional. Even if there was invested more time earlier in the process in programming a functional prototype, this would have been at the expense of exploring more ideas and the freedom the participant would feel when evaluating. Even so, as no previous app programming experience was present, this would take a significant amount of time to develop and as the designer this could result in avoidance of ‘kill your darlings’.

The advice for future work will be to further test the application on its motivational aspects. This can confirm the motivational capabilities of the gamification in the app. Further during the literature research not much was found on the topic of gamification for this specific target group, more research on age and games also gamification not much literature, a lot used in practice but not really tested especially in the health sector.

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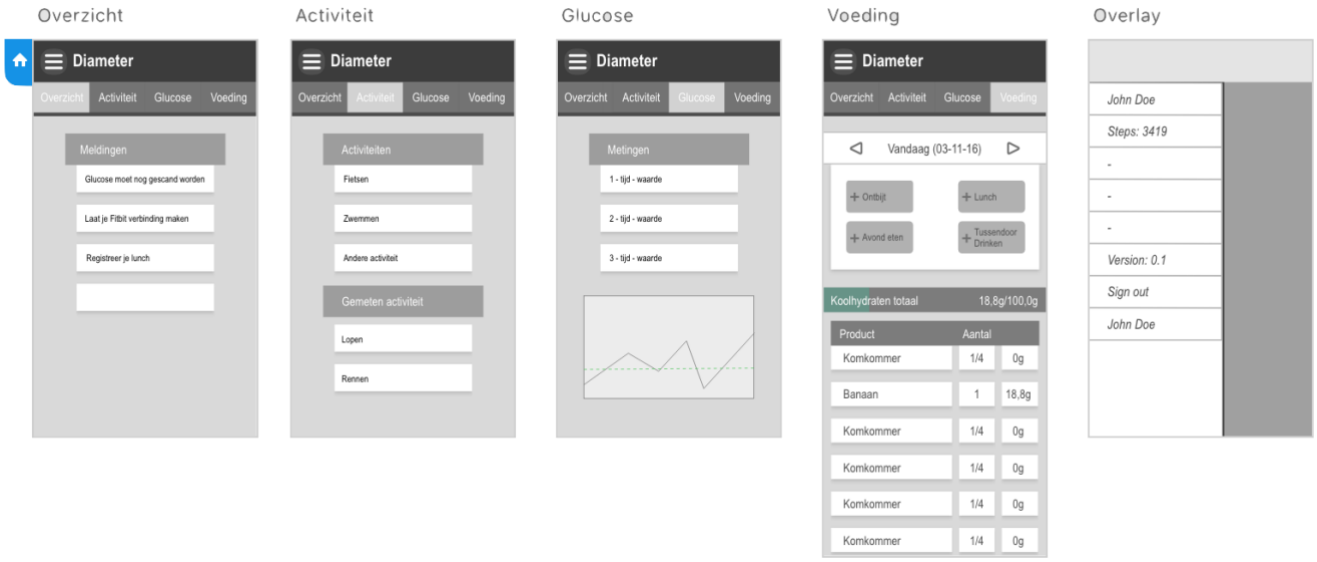
Appendix I

Mock-up version 0.2.2. Of the Diameter



Appendix II

Pre-evaluation testing

1. Set-up phone with the app interface
2. Give participants the instruction to search the via menu to other pages
3. Let them click on other functionalities
4. Observe if prototype functions properly
5. If any failures, fix and restart

Appendix III

Evaluation 1 user testing

What is tested → Usability, gamification features

Testing format → Informal and participatory

1. Introductions
2. Give them a small background story to inform the user of what they can expect. As a form of information provided in an app store. Below the provided information is given in dutch (as all participants will be dutch).

In deze kleine app word het verkrijgen van een gezonde leefstijl met diabetes een leuke taak.
Word je eigen gids in het behalen van je doelen om je leefstijl te verbeteren en beheer je gegevens op een overzichtelijke manier.
De Diameter bied jou de mogelijkheid in je eigen tempo en op je eigen manier te focussen op specifieke doelen ingestelt door jou zelf.
Al kan je misschien nog niet direct de verschillen voelen al maak je progres, deze app kan je laten inzien door middel van plantjes hoe je vorderingen gaan op gezondheids gebied.
Wat deze app bied?

- *Een gepersonaliseerde avatar met coaching*
- *Spelenderwijs doelen zetten en behalen*
- *Duidelijke weergave van uw gegevens*

3. Let them 'use' the app
4. The following questions will be asked to gather feedback.
    - How did you find the overall ease of use?
    - Were the (gamified) functions clear?
    - What did you think of the avatar, plants, goal setting?
    - What would do you think the different plants mean?
    - Are the visualizations clear?
    - What do you think of the looks of the app
    - Would you be interested in an app with these functions
5. Ask if they have anything to add that was not yet asked about
6. Thank them for participating

Appendix IV

Evaluation 2 user testing

What is tested → Gamification functionality

Testing format → Informal and participatory

1. Introductions
2. Give them a small background story to inform the user of what they can expect. As a form of information provided in an app store.

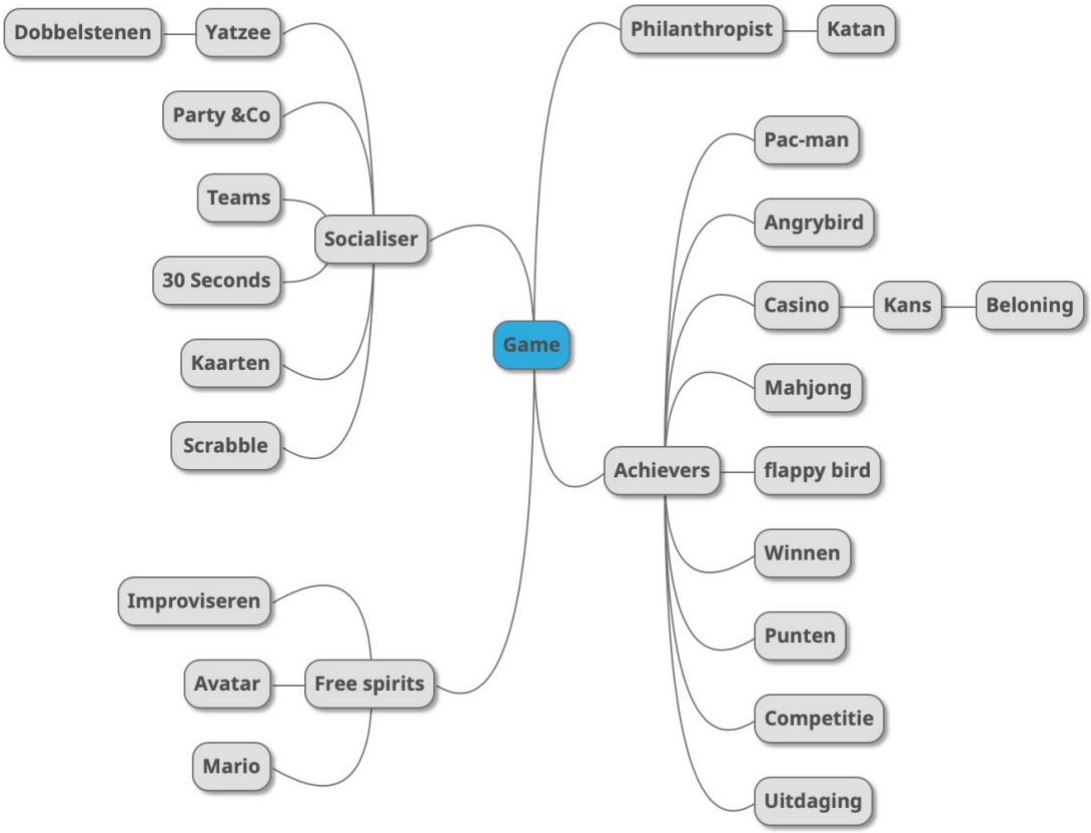
In deze kleine app word het verkrijgen van een gezonde leefstijl met diabetes een leuke taak.
Word je eigen gids in het behalen van je doelen om je leefstijl te verbeteren en beheer je gegevens op een overzichtelijke manier.
De Diameter bied jou de mogelijkheid in je eigen tempo en op je eigen manier te focussen op specifieke doelen ingestelt door jou zelf.
Al kan je misschien nog niet direct de verschillen voelen al maak je progres, deze app kan je laten inzien door middel van plantjes hoe je vorderingen gaan op gezondheids gebied.
Wat deze app bied?

- *Een gepersonaliseerde avatar met coaching*
- *Spelenderwijs doelen zetten en behalen*
- *Duidelijke weergave van uw gegevens*

3. Let them 'use' the app
4. The following questions will be asked to gather feedback.
    - How did you find the overall ease of use?
    - Were the (gamified) functions clear?
    - What did you think of the avatar, plants, goal setting?
    - What would do you think the different plants mean?
    - Are the visualizations clear?
    - Would you be interested in an app with these functions
5. Ask if they have anything to add that was not yet asked about
6. Thank them for participating

Appendix V

Mind Map on games



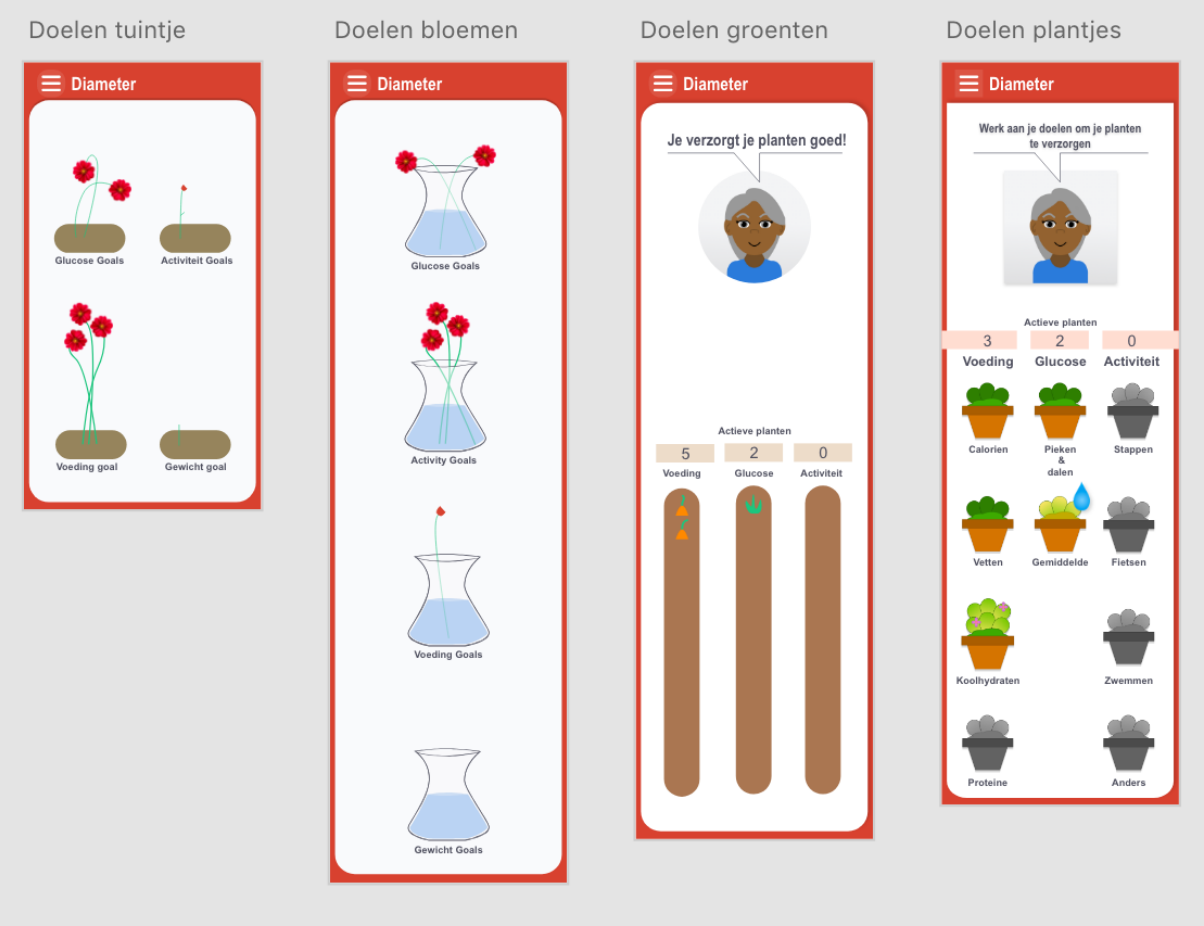
Appendix VI

MoSCoW requirements ideation phase

Ranking	Requirement	Source
M	The use of game elements that enhances motivation - Targeting the four intrinsic motivations of Marczewski	Marczewski (2015)
M	Give a personalized experience to the user	Literature review conclusion
M	Meaningful feedback for the patient on their 'game' behavior	Literature review conclusion
M	Insightful feedback on their diabetes - Glucose values and variability, hypo-, hyper and normoglycemic events - Carbs, fat, protein and calories	Play store, Den Braber et al. (2019)
M	Speak to each player type - Meaning - Challenge - Personalization - Connection	Brainstorm, Marczewski (2015)
S	Relate the goals of the patient to in-game goals (providing internal motivation)	Theng et al. (2015)
C	A balance between challenging but not too difficult gameplay	Akker et al. (2017)
C	Use behavior change techniques to obtain desired behavior (commitment to the app)	Michie et al. (2013)
C	Opt-out options for functions	Diabetes type 2 ?? ……samen werken aan medicatievrij !! (Facebook)
W	Social game mechanics if specifically, desired by the target audience	Literature review

Appendix VII

Several plant designs tested for implementation



Appendix VIII

Verschillende menu's

Appendix IX

Different color cobinations

Appendix X

Full version final prototype with interaction flows