

Uppsala University



Innovation Game: A Summer School
Applying Serious Game Design in
Health Care and Education
3HI001 43100

“DIA BEAT IT!”
Serious Game for Patients with
Type 2 Diabetes

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1. Introduction

1.1. Global Situation

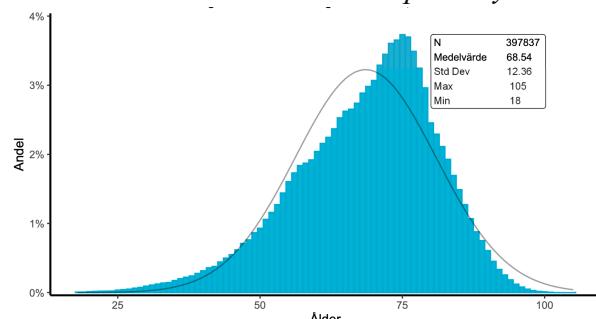
Diabetes is a chronic disease that appears either when the pancreas does not produce enough insulin (hormone regulating sugar) or when the body cannot effectively use the insulin it produces (WHO, 2021).

While type 1 diabetes is associated with insufficient production of insulin, thus patients are required to administer injections daily, type 2 diabetes is related to ineffective usage of insulin. In 2021, 537 million adults (20-79 years) were living with diabetes (IDF Diabetes Atlas, 2021).

In Sweden, about 5 % of the population has diabetes (Svenska Diabetesförbundet, 2022). Most cases are type 2, resulting in 90 % in Sweden (Svenska Diabetesförbundet, 2022) and over 95 % Worldwide of all registered diabetes cases (WHO, 2021).

Figure 1 shows that in 2021, the mean age of patients with diabetes in primary care was 68.54 years old. However, its onset is noticeable even at the beginning of adulthood (18 years old) and emerges with age. However, with increasing age, diabetes emerges with prolonged complications, or even premature death (IDF Diabetes Atlas, 2021). Thus, interventions at very early stages could be the most effective way to prevent people from complications.

Figure 1
Adults with diabetes in Sweden primary care in 2021



Note. Adapted from “Årsrapport 2021 års resultat” by Nationella Diabetesregistret, 2021. p. 47.

Diabetes increases the damage to the heart, blood vessels, eyes, kidneys, and nerves and is highly associated with death (WHO, 2021). In 2021 Diabetes was associated with 6.7 million deaths (1 every 5 seconds)(IDF Diabetes Atlas, 2021).

Global report on diabetes (2016) emphasizes the economic impact due to diabetes, which includes direct medical costs, indirect costs associated with productivity loss, premature mortality, and the negative impact of diabetes on nations' gross domestic product (GDP).

1.2. Risk Factors, Treatment, and Prevention

Type 2 diabetes is often associated with lifestyle factors, which reduce insulin sensitivity. Among these factors are overweight, physical inactivity, a fiber-poor diet, the use of tobacco, and psychosocial stress (Östenson et al., 2010). Thus, the primary treatment, which reduces insulin resistance, includes increased physical activity, a fiber-rich diet (containing a maximum of 30 percent fat (primarily mono- and polyunsaturated) and 50–60 percent complex carbohydrates), and stopping smoking tobacco (Östenson et al., 2010). Similar activities are recommended to prevent type 2 diabetes (Östenson et al., 2010). Östenson et al. (2010) overviewed several studies and emphasized that physical activity is the method associated with a significant impact on preventing type 2 (Östenson et al., 2010). General recommendations for physical activity in type 2 diabetes (Figure 2) include basic activity, aerobic fitness training, and strength training. Thus, 30 minutes of basic activity, such as walking outside could be one of the first steps in preventing type 2 diabetes from unpleasant disease consequences.

Figure 2
General recommendations for physical activity in type 2 diabetes

Type of training	Examples of activities	Frequency	Intensity	Duration
Basic activity	Walking, climbing stairs, gardening. It is also desirable to increase standing/walking time at work and at home.	Daily	So talking is still possible, 30–50% of maximal oxygen uptake; 12–13 acc. to Borg's scale.	> 30 min.
Aerobic fitness training	Nordic walking, jogging, cycling, swimming, skiing, skating, fitness class/aerobics/dance, ball sports, rowing.	3–5 times/week	Until out of breath Begin slowly and gradually increase to 40–70% of maximal oxygen uptake; 13–16 acc. to Borg's scale*.	20–60 min.
Strength training	Movements using the body as resistance, resistance bands, weights, weight/resistance equipment.	2–3 days/week	Until or near muscular exhaustion for each exercise**.	8–10 exercises, with 8–12 reps of each exercise

Note. * Level of exertion may need to be reduced in the case of retinal, renal or cardiovascular complications as well as autonomic dysfunction; ** Replace with easier exercises in the case of retinal, renal or cardiovascular complications. Adapted from "Diabetes mellitus – type 2 diabetes" by C. G. Östenson, K. Birkeland, and J. Henriksson, in C. J. Sundberg, A. Jansson, C. Edling, & M. Wadman (Eds.), Physical Activity in the Prevention and Treatment of Disease, 2010, Trends in Ecology & Evolution, 37(3), p. 350. Copyright 2010 by Professional Associations for Physical Activity, Sweden (Yrkesföreningar för Fysisk Aktivitet, yfa).

1.3. Health Belief Model

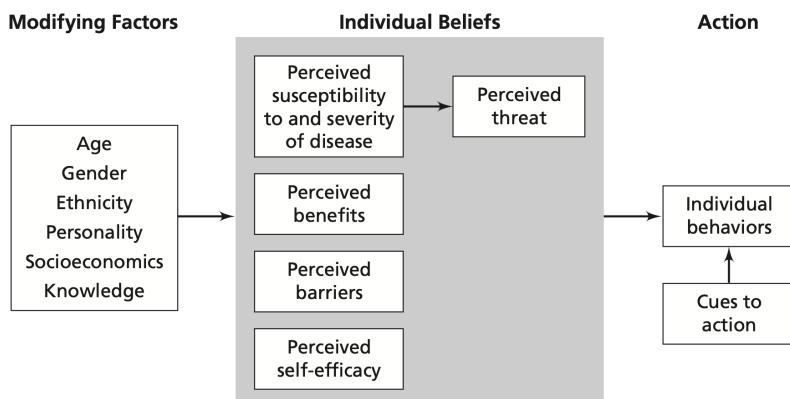
One of the most used models in interventions seeking to change problematic behavior is the *Health Belief Model* (Figure 3). The behavioral change model promotes four individual belief constructs:

1. *Perceived susceptibility* (beliefs about the possibility of getting a disease) and perceived severity (perceiving the seriousness of the disease) (perceived susceptibility and perceived severity can be combined and labeled as a perceived threat)
2. *Perceived benefits* (understanding the positive side of the treatment)
3. *Perceived barriers* (the potentially harmful elements)
4. *Perceived self-efficacy* (the belief that a person can successfully behave is a way to achieve specific outcomes in certain situations (Champion & Skinner, 2008).

Among other variables are *cues to action* (readiness to take action) and *modifying factors*, such as age, gender, ethnicity, personality, socioeconomic status, and knowledge. Focusing on all or several factors can lead to favorable behavioral changes.

Figure 3

The Health Belief Model



Note. Adapted from “The health belief model” by V. L. Champion and C. S. Skinner, in In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behavior and health education: Theory, research, and practice* (pp. 49). Jossey-Bass. Copyright 2008 by John Wiley & Sons, Inc.

1.4. Gamification and MDA-O Framework

Recently serious games or gamified solutions started to be used more often for interventions for people helping them to change problematic behavior. These solutions are supported by MDA-O framework (Mechanics, Dynamics, Aesthetics, Outcomes) (Browning, 2016). Mechanics are all rules and various methods for interaction with the game, creating specific behaviors (dynamics), emotional responses (aesthetics), and real-world results of serious games (outcomes). Due to the inclusion of outcomes into the frame, serious games or gamified solutions are different from entertainment games; they have a particular intended outcome - to change behavior, attitude, increase knowledge and so on (Browning, 2016). Asadzandi et al. (2020) reviewed gamified solutions for diabetic people and concluded that these applications have a great capacity to change and improve the behavior of patients with diabetes.

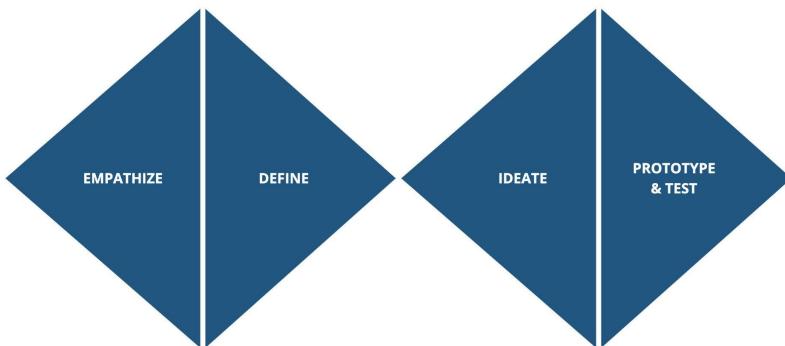
1.5. Current Project

This project aims to develop a serious game or gamified solution for people with type 2 diabetes by increasing self-efficacy to engage in outdoor activities, such as daily walking and increasing knowledge about healthy eating. We are targeting an age group of people 30-50 years who have been recently diagnosed with diabetes type 2 and who will get the suggestion to use our application through their physician as a part of their treatment. Our customer is the healthcare sector, financed by local governments or municipalities, that is taking care of diabetes patients. We are also targeting customers without diabetes who can buy our merchandise (t-shirts, cookbooks, etc) branded with our logo and receive the game complementarity.

2. Design Thinking Process

We used the design thinking double diamond five-phase development method (Figure 4) throughout our design process. We started out by empathizing with our customer and end-user, then moved ahead with defining the problem we wanted to solve, then worked on our ideas towards this problem, and finally started to visualize these ideas as tangible prototypes. After prototyping, we could present our ideas to our end users and test if they will work as we expected them to work, and ask how the users feel about them. According to the feedback we got from the testers we were able to improve our prototype and return to the ideate and prototype phase. During our iteration process, we were moving between these three phases several times.

Figure 4
Design thinking Double Diamond process model



2.1. Empathizing and Defining

To get to know our end users better we contacted our mentor Cecilia Josefsson who is working as a diabetes nurse at Uppsala University Hospital and doing her Ph.D. thesis in the Uppsala University Department of Women's and Children's Health. Even though most of the people in Sweden do get their diabetes type 2 diagnosis in their seventies, the risk of being diagnosed with diabetes type 2 is threatening people nowadays already in their thirties

(Nationella Diabetesregistret, 2021). According to C. Josefsson (personal conversation, 15.08.2022). It is important to start off with changing a sedentary lifestyle and unhealthy habits as early as possible because in the thirties the life expectancy of diabetes patients is high and they have much more to gain. Therefore our focus while designing the serious game for diabetes type 2 patients was on the age group of 30-50 years old.

In order to empathize with our end-user, we imagined how he would look like and what kind of feelings, thoughts, and interests he would have - we created a user persona to describe him (Figure 5).

Figure 5
User persona

The user persona for Lars Löfven is a detailed character profile. At the top, there is a photo of a smiling man with a cap and backpack. The persona is named 'Lars Löfven' and is described as 'concerned about his health and wants to create better habits to take control of the diabetes disease.' The persona includes sections for Brief description, Persona Main Job (Main goals), Personality, Interests, Tech savviness, Gains, and Frustrations.

- Brief description:**
 - 35 years old
 - Lives in Uppsala
 - Works as a finance consultant (mostly remote)
 - He doesn't have a family yet
 - Lives alone in his apartment
 - Likes hamburger and french fries
 - Often watching Netflix after work
 - Doesn't know how to prepare meals
- Persona Main Job (Main goals):**
 - He would like to lose weight, exercise more, have more energy, start a family, eat diabetes friendly healthy foods
- Personality:**
 - Lazy, doesn't do sports regularly
 - Quite conservative
- Interests:**
 - Likes going to pubs with his friends on the weekends.
 - Loves fishing as a hobby.
- Tech savviness:**
 - Food delivery daily
 - Uses Netflix, YouTube, Instagram, Facebook daily
 - Knows how to use apps etc.
- Gains:**
 - He will not develop severe diseases (i.e. cardiovascular etc.)
 - Improves his social life, he becomes more confident
- Frustrations:**
 - Insecure about his body
 - Not very confident
 - Worried if he's able to find a wife and start a family

Made with ❤ by @pixelresearchlab

While getting to know our end users better we also did research on games created for diabetes type 1 and 2 patients and if they have been successful and why. The purpose of both persona and research was to set our target group and explore what has been already done. Then we were able to define our problem statement - **how can we help DT2 patients increase their self-efficacy to cope with the disease and raise their awareness about it?**

2.2. Ideating

In the ideation phase, we used a design fiction method that offers designers an opportunity to look far into the future. We imagined in 15 minutes what would Lars do after 3-5 years if the current design problem has been solved for him. How would he spend his day? Our team came up with a bunch of ideas about how he would live and act, and also what the surrounding environment would look like.

In order to be able to choose the winning ideas, we used voting. Every team member got three votes which she could spend on her favorite idea (either voting for three favorite ideas or spending all three votes on one idea). Our winning ideas were:

1. Pokemon Go - collecting points for healthy food (6 votes)

2. Avatar getting fat when consuming junk food and slimmer while exercising (4 votes)
3. Sending alert notifications to complete the criteria from the app (3 votes)
4. The habit "star" that helps diabetes patients create and keep healthy habits, e.g. waking up early, and daily exercises (3 votes)

The team chose to go further with idea nr 1 - Pokemon Go - collecting points for healthy food.

2.3. Prototyping and Testing I

After the ideation phase, the first paper low-fidelity prototype was drawn (Figure 6).

Figure 6

The first paper low-fidelity prototype

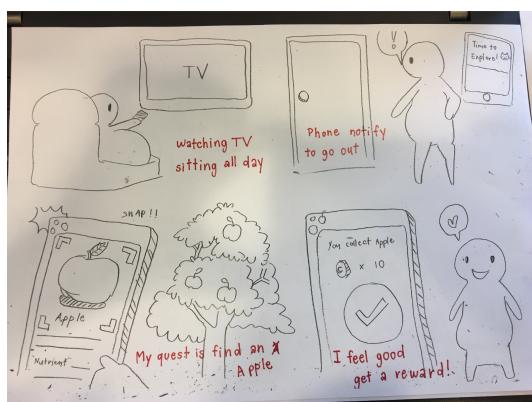


To better describe our game scenarios to users, two user storyboards were drawn to narrate our initial design solutions (Figure 7A and Figure 7B) before implementing our low-fidelity paper prototypes. The goal of the game is to motivate users with diabetes to engage in appropriate outdoor activities and gradually develop healthy habits as they play daily.

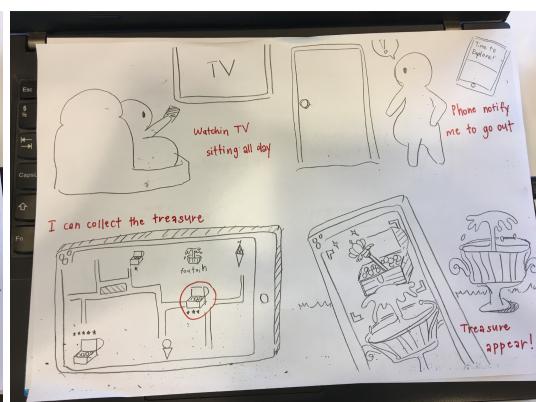
Figure 7

The user storyboard of the design solution

A



B



Note. (A) - Version 1; (B) - Version 2

Version 1: The first version was inspired by Pokémon GO. The aim was to encourage players to go outside by performing daily tasks, as shown in the picture, where the user receives a

task reminder to "go out and find the apple tree and scan an apple". When the user completes the task, he or she gains health knowledge about apples, health recipes and is rewarded with gold coins.

Version 2: The second version is treasure hunting. The user opens the game map, and gets the location of the treasure as well as a photo of the clue. The further the distance, the rarer the treasure. The user reaches the location of the treasure and successfully scans the objects in the photo of the clues to obtain the treasure. The treasure can be a weapon of different force values that the user can collect or use to perform more difficult tasks. such as battles between players, etc.

To evaluate our first paper's low-fidelity prototype, we divided into two small groups and conducted 11 user tests where we observed and interviewed these participants. This test was done at Blåsenhus, where the participants were given the two versions of storyboard. The user was asked to read through two versions of the storyboard and give feedback on our game ideas. The results from the interviews showed that:

- Most participants were interested in our second version idea (treasure hunting), with only two younger participants giving feedback that they would have done the outdoor exercise regardless of whether they used the game or not
- Some interviews said that recipes in different categories can be added in the game
- The icons were too childish for middle-aged users
- Adding more gamification elements, such as leaderboards, levels, and rewards

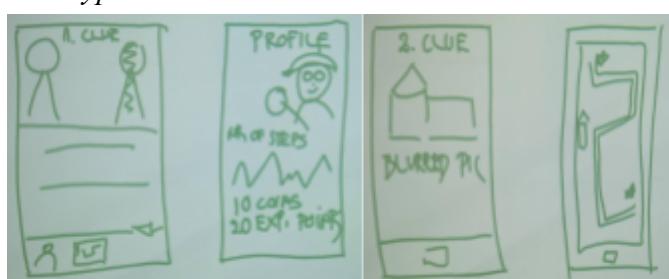
2.4. Prototyping and Testing II

Using the results of the interviews, a brainstorming of the group was performed to generate ideas and improve the prototype (Figure 8). We had two sessions of brainstorming, where in the first session we generated ideas individually and in the second session we voted on what idea we thought was the best idea.

The idea is a detective game that inspires users to go outside and play through a mystery story that leads users to walk to different locations to collect clues and eventually unravel the mystery. In addition, the game requirements include :

- Monitoring of health data from glucose wristband, such as blood sugar, weight, heart rate
- Rich gamification elements such as experience value, levels, daily punch rewards, etc.
- Build awareness of diabetes and increase knowledge of healthy living and healthy eating through mini quiz games
- Easy to use, step-by-step encourage users to build a healthy lifestyle habit of consistent exercise

Figure 8
Prototype II



To improve this prototype, we performed a pilot test by ourselves. We analyze whether the intended user could understand the game and perceive the right actions . All group members did individual tests and feedback of the prototype and then discussed improvements together. The results from the discussion showed that:

- Include diabetes questions as a part of the mini quiz game
- Show an in-game notification to the diabetes people to take medicine on time
- Specify the correct icons in the map to showcase the current location, upcoming tasks, and solved clues
- What can the goal of the coins be?

2.5. Prototyping and Testing III

We develop a high fidelity prototype from the second prototype to see how it looks in the mobile device (Figure 9). These are the primary feedback:

- Daily reward - many don't understand why we immediately give away items, so we change the wording to check-in and design it that there will be a special recipe and clue at the end of the week.
- Coins - Since spending coins to buy in-game items is not so attractive, we replace it with experience and level, which is also more suitable for detective themes.
- Narrative - There is not enough context about the player's role in this game, so we put a story in a daily mission, and a summary after the case is solved.
- UI - Some icons on the map and how to set the notification's time are unclear.
- DIA BEAT IT! - We received positive feedback on this title; even we are concerned that it has no relation to mysterious solving.
- Mini-games (Figure 10) - The quiz and Plate model game is straightforward and enjoyable, but a Healthy food game needs to change to a more challenging version.

Figure 9
Prototype III

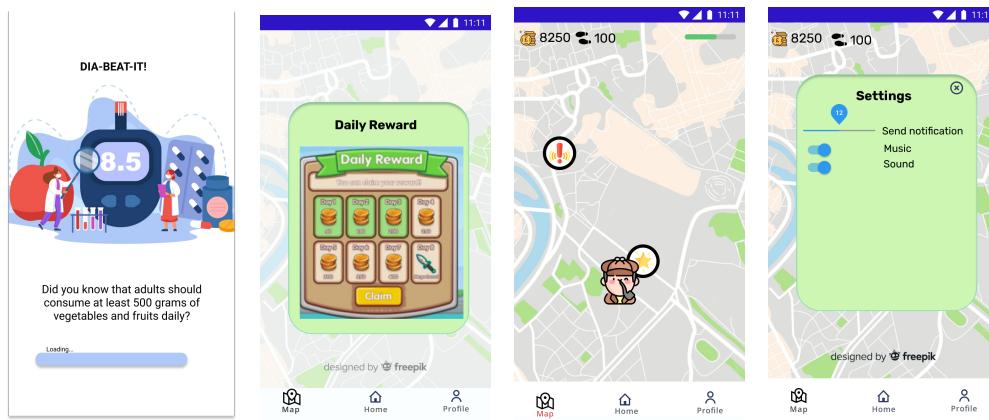
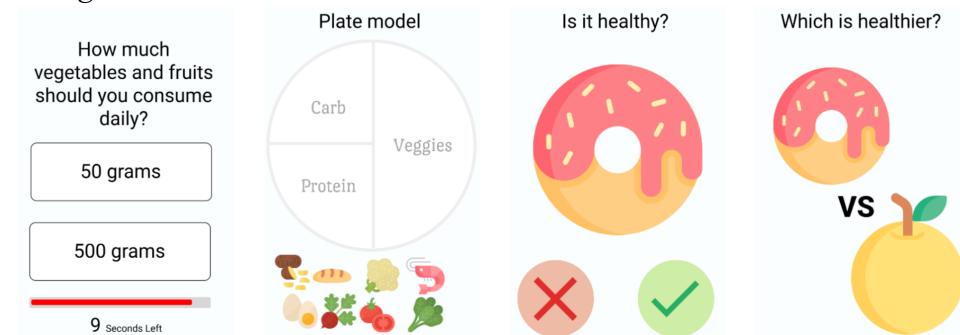


Figure 10
Mini game



3. Final Solution and Business Plan

After a long process of prototyping and testing, we have found a final solution. Dia Beat It! can be defined as an activity app that helps people diagnosed with type 2 diabetes to manage their disease. To prevent the disease from getting worse, it is important to lead a healthy lifestyle. This includes being active and eating a healthy diet. Our app is designed to help patients manage the disease in a fun and engaging way. Through the daily missions, they not only learn more, but also stay active. When they open the app, they see their daily mission. Their task is to follow the map and the clues to get there. To get the clues, they have to answer questions about a healthy lifestyle (e.g. eating habits) correctly. The last clue is a blurred picture of the building or object they need to get to.

In their profile, the user can see their health data. The app is connected to their blood glucose metres so they can see graphs of their blood glucose and how their activity affects it. Another feature of the app is notifications. People with T2D need to take medication regularly, so the app notifies the patient in a timely manner when they choose to take it. There are also other mini-games, such as learning the plate rule and choosing foods that are better for blood sugar. The main goal is to get the children to go outside in a fun way by making them detectives.

The target groups we address and sell our product to are local communities and government institutions (hospitals, medical centers, etc.). The customer segment is a niche market, i.e. the focus is on a specific group of people with unique needs and characteristics. In our case, it is healthcare facilities and people diagnosed with type 2 diabetes. We will interact with our clients by sharing assessment statistics on a quarterly basis. To the end users, we will provide personalized support and communities where users can help each other solve their problems and share their experiences. Our company will reach its customers through direct marketing and word-of-mouth. The app can be downloaded from the App Shop and Play Shop. We will generate revenue from government and non-government grants as well as from monthly subscriptions to the premium version (for non-diabetics only). Therefore, we aim to generate recurring revenue, especially subscription fees.

The main activities that need to be carried out to achieve our business purpose are evaluation and research to convince the client to fund the app. Also, development and maintenance, communication and administrative work, such as writing projects for funding. The main resources for carrying out our main activities are human (design, development, communication and finance staff), financial (funding), intellectual property (patents, copyrights) and physical resources (infrastructure, inventory). Our key partners are healthcare

workers (endocrinologists, diabetes nurses) with whom we have formed a strategic alliance. Then we have a buyer-supplier relationship with a software development company and finally sponsors (e.g. manufacturers of glucometers). All the costs associated with running our business model are services/licenses, salaries, patents, copyrights and maintenance costs. The value proposition of our app is that it helps governments and communities increase the life expectancy of their citizens after the detection of type 2 diabetes by strengthening patient self-efficacy and raising awareness.

The link of the final version of our prototype is:

[https://www.figma.com/proto/Lwmxwl72FaNB3SGIqNqCjT/Dia-beat-it?page-id=1%3A2&n
ode-id=24%3A929&viewport=358%2C102%2C0.11&scaling=min-zoom&starting-point-nod
e-id=24%3A929](https://www.figma.com/proto/Lwmxwl72FaNB3SGIqNqCjT/Dia-beat-it?page-id=1%3A2&node-id=24%3A929&viewport=358%2C102%2C0.11&scaling=min-zoom&starting-point-node-id=24%3A929)

4. Discussion

There are myriad educational and serious games available for people suffering from diabetes type 1 and 2. The target population of the gamification is from different age groups including children, diabetic patients, and healthy people and the games have been designed for medical students and residents, or students of other related medical majors. Most of these games are mobile-based; however, some of them have been designed for game consoles or game boards. The aim of all games is to educate, teach skills and make behavior improvements for diabetics (Asadzandi et al., 2020). The problem is that some of the games do not exist anymore and some of the games function only as a future platform or inspiration for others. There are not any serious games designed for DT2 patients with a specific focus on the 30-50 age group. This is the group who has the most to win because with behavior change and the right treatment they have a possibility to prevent serious complications and even overcome diabetes. Therefore our aim is to increase their self-efficacy with the help of a serious mobile game with a catchy narrative and educational content.

After going through the design thinking process, we identified a number of strengths and weaknesses of our solution. The strengths of the solution are:

- It's for free for diabetes patients;
- It encourages to keep up with regular physical activity outside for at least 30 minutes;
- It syncs a patient's glucose wristband to display blood glucose levels in the app's health statistics and counts steps;
- It allows them to create communities - get support from their families and friends;
- It includes various mysterious missions, so users can be engaged in finding the solution. People often like such mysterious detective stories;
- Besides the main task, it allows users to play mini-games. It is a useful function when a person cannot go outside due to some reasons (extreme weather conditions, long working hours);
- It motivates players to be active - after completing daily missions a user gains experience points as a reward; after completing a weekly streak - people will get a special clue to unlock new missions (after every fourth mission a new mission can be unlocked). They may also get recipes, for example, an extremely great spy pie recipe suitable for diabetic people.
- We will not have “punishment” features in our game, i.e. people will be able to finish their story even after a longer break of more than one day.

The weaknesses are:

- It may not be appealing for individuals who dislike engaging in physical activity through games;
- For those without diabetes, the application can be a bit expensive;
- People might not want to disclose sensitive information like blood sugar levels in the application;
- The business model may not be viable and will need to be adjusted;
- The application is focusing on improving self-efficacy (based on the health belief model), however, it does not include other constraints, for example, perceived barriers or perceived benefits;
- Due to the limitations of the project, we tested the current prototype only with people without diabetes, however, further projects should do testings with real target group;
- The application is mostly suitable only for people who have no motivation to go outside; however, the walking distance might be too easy for those, who exercise regularly; advanced levels should be developed.

Our team managed to successfully pass all five development phases. We had three iterations with prototypes and testings which helped us to improve our product. Our group work was effective because of smooth group dynamics which allowed us to take roles of which we were capable and also challenge ourselves sometimes. As our define and ideation phase took a bit more time than we would have liked we had eventually less time for prototyping and testing though.

As was shown in the previous part of the report, people with diabetes have an increased risk of suffering from health-related problems (damage to the heart, blood vessels, eyes, kidneys, and nerves is highly associated with death). Thus, it is crucial to find suitable solutions to prevent people from it at a young age (30-50 years old). Besides the health-related problems, it has a tremendous negative economic impact (direct medical costs, indirect costs associated with productivity loss, premature mortality, and the negative impact of diabetes on nations' gross domestic product (GDP)). Thus, simple solutions, like our application, could be one of the instruments, lowering medical costs and prolonging the working capacity of people with diabetes.

Ethics may come into question when our app is so addictive that users spend too much time in it and it becomes dangerous to their health. Also, we must conduct informed consent procedures in accordance with privacy and security concerns relating to our app, in order to mitigate potential liability regarding the collection of client-generated data (Edwards-Stewart, A. *et al*, 2018).

We will follow guidelines from "Good research practice" for all scientific research, which are provided by the Swedish Research Council (2017). We will also follow universal ethical principles (The pursuit of human well-being; The respect for human dignity, including fundamental human rights and non-discrimination; The principle of respect for persons, including the imperatives of beneficence and non-maleficence; The principle of respect for individual autonomy). Applications related to ethics will be submitted to the Swedish Ethical Review Authority.

As the current topic is very important and relevant at the moment we would really like to bring this idea to work also in real life. It could be us or some other team, but this has definitely potential for further development.

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Appendix A

The Business Model Canvas

