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Emotion-oriented Game-based Fitness App for Diabetes Patients

Master's Thesis (30 ECTS)

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Abstract:
Diabetes is a growing health concern globally, and managing the condition requires regular monitoring of glucose levels and physical activity. Conventional methods of monitoring and exercise often lack the motivation required to keep patients engaged and committed. This thesis proposes the development of an emotion-oriented game-based fitness application - DiaBeatIt, specifically designed for diabetes patients to support them in maintaining a healthy lifestyle despite their disease through the use of exercise such as running or walking. DiaBeatIt combines elements of gamification to provide a fun and interactive way of physical activity which includes walking on real-world maps and solving diabetes-related quizzes.

In this research, the goal model is used to develop DiaBeatIt. The created application is subsequently tested on a variety of diabetes patients to see if the emotional goals of the patients are found to match the emotional goals obtained before and after the application trial.

Keywords: emotion-oriented, gamification, goal model

CERCS: P170 Computer science, numerical analysis, systems, control

Emotsioonidele-orienteeritud mängupõhine treeningrakendus diabeedihaigetele

Lühikokkuvõte: Diabeet on maailmas kasvav terviseprobleem ja selle eest hoole kandmine nõuab glükoositaseme ja kehalise aktiivsuse regulaarset jälgimist. Tavapärastel jälgimise ja treenimise meetoditel puudub sageli motiveeriv osa, mis on vajalik patsientide kaasamiseks. See lõputöö pakub välja emotsioonidele orienteeritud mängupõhise fitness-rakenduse - DiaBeatIt, mis on spetsiaalselt loodud diabeedihaigete toetamiseks tervislike eluviiside säilitamisel, hoolimata haigusest, kasutades selleks harjutusi nagu jooksmine või kõndimine. DiaBeatIt ühendab mängulisuse elemendid, et pakkuda lõbusaid ja interaktiivseid kehalise tegevuse viise, mis hõlmavad endas kõndimist pärismaailma kaartidel ja diabeediga seotud viktoriinide lahendamist.

Selles uuringus kasutatakse DiaBeatIt väljatöötamiseks eesmärgimudelit. Loodud rakendust testitakse erinevate diabeedihaigete peal, et näha, kas patsiendi emotsionaalsed eesmärgid on võrreldavad enne ja pärast rakenduse katsetamist.

Võtmesõnad: emotsioonidele orienteeritud, mängulisus, eesmärgimudel

CERCS: P170 Arvutiteadus, arvutusmeetodid, süsteemid, juhtimine (automaatjuhtimisteooria)

Contents

1 Introduction

Many products do not succeed in their target market because they were created without considering the emotional needs of the target audience [1]. According to researchers [2, 3], software engineers often overlook the emotional needs of their users when designing systems, which can lead to dissatisfaction. Conversely, studies [2, 4] show that user emotions play a critical role in the acceptance of technology, particularly in regard to domestic and social systems. To improve the user experience, it is essential to understand the emotional goals of stakeholders.

Software engineers typically design systems with both functional and non-functional properties in mind. However, the design of these systems can sometimes be lacking in terms of engagement, and adoption which negatively impacts the user experience. According to Cooper [5], this can lead to a situation where "the inmates are running the asylum," where software engineers gather requirements from users and design the product to meet those requirements as they envision it, resulting in software that does not meet the needs of its intended users. This issue is exacerbated by the prevalent belief that issues with the interaction design can be resolved after development by simply fixing the user interface.

The field of digital health has seen rapid growth in recent years, with fitness apps being a particularly popular tool for promoting physical health and wellness. However, the success of these apps depends not only on their functional capabilities but also on how well they meet the emotional needs and desires of users. Diabetes patients, in particular, face unique challenges in maintaining their health and wellness and thus require specialized attention in the design of fitness apps.

This thesis focuses on the application of emotional modelling in the context of type 2 diabetes, a chronic disease that affects millions of people worldwide. It is a condition where the body generates insulin but has problems using insulin properly which leads to high blood glucose levels [6]. According to the World Health Organization (WHO), the common causes of type 2 diabetes are overweight, not getting enough exercise and genetics [7]. Another resource [8] also shows that obesity and an inactive lifestyle are the two major causes of type 2 diabetes. There are four stages of type 2 diabetes:

- Stage 1: Insulin Resistance
- Stage 2: Prediabetes
- Stage 3: Type 2 Diabetes
- Stage 4: Type 2 Diabetes With Vascular Complications

Following table 1 shows an overview of the stages of type 2 diabetes [6, 9]:

Table 1. Stages of type 2 diabetes [6, 9]

Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
The ability of muscle, fat, and liver to react to insulin starts to diminish	Blood glucose levels rise over normal but are not yet high enough to be classified as diabetes	Blood glucose levels have risen and are now regarded as being in the type 2 diabetes range i.e. 126 milligrams of sugar per deciliters of blood or higher	Type 2 diabetes continues to worsen and complications occur including vascular damage
In this case, the pancreas exerts greater effort to make up for this by producing extra insulin	Pre-diabetes diagnosis criteria: • A1C of 5.7-6.4%, • Fasting Plasma Glucose 100-125 mg/dl, • Oral Glucose Tolerance Test 140-199 mg/dl	Type 2 diabetes diagnosis criteria: • A1C > 6.5%, • Fasting Plasma Glucose > 126mg/dl, • Oral Glucose Tolerance Test > 200 mg/dl	Examples of complications: • neuropathy, • nephropathy, • retinopathy, • increased risk for stroke and cardiac events

According to WHO, in 2019, around 463 million people had diabetes, and 90-95% of these cases were type 2 diabetes (WHO, 2020) [10]. In the European Union, around 32.3 million adults were diagnosed with diabetes in 2019, up from an estimated 16.8 million individuals in 2000 [11]. According to the World Bank collection of development indicators, diabetes prevalence in Estonia was reported at 6.5% within the % of the population aged between 20 and 79 years in 2021 [12] which is presented in Figure 2. Type 2 diabetes is characterized by high levels of glucose in the blood due to the body's insulin resistance or reduced insulin production (American Diabetes Association, 2020) [13].

The number of diabetics worldwide in 2021 is shown in Figure 1, broken down by

region. With 206 million people aged 20 to 79 suffering from diabetes, the Western Pacific is the region with the highest number of diabetics worldwide [14].

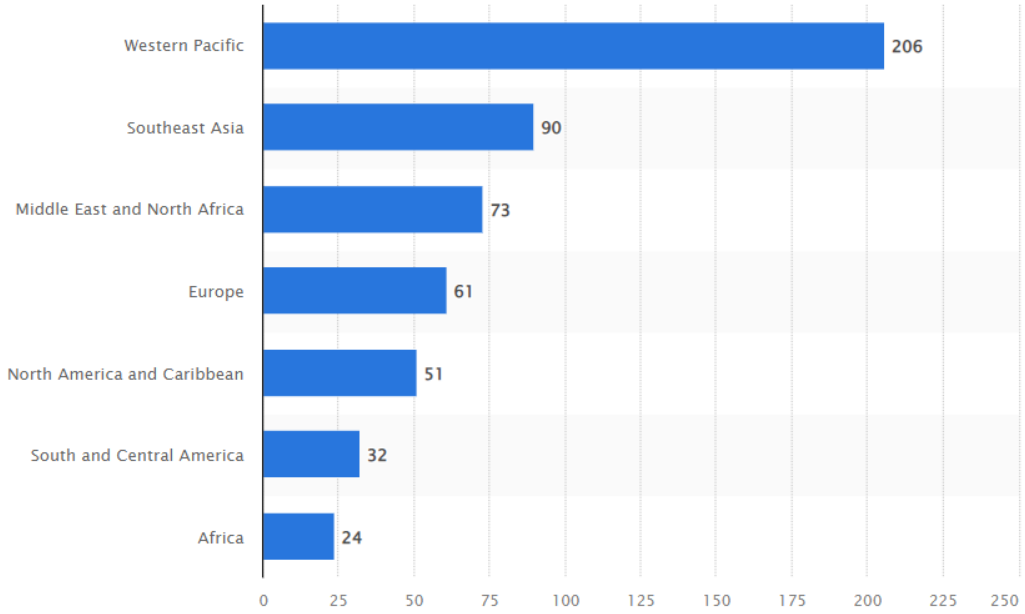

Figure 1. Number of diabetics worldwide in 2021, by region(in millions)[14]

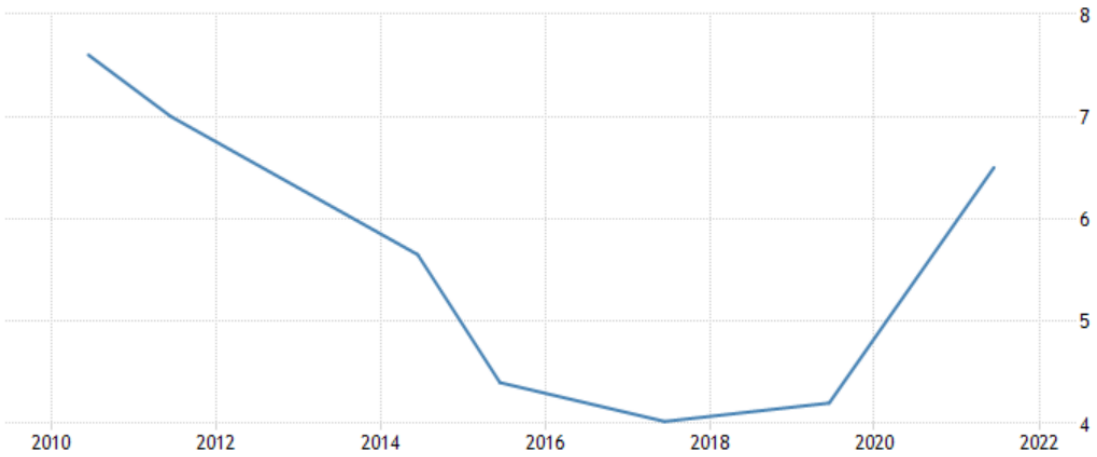

Figure 2. Number of diabetics worldwide in 2021, by region(in millions)[12]

Diabetes self-management is complex and demanding, and emotional factors play a significant role in patient's ability to adhere to treatment plans and maintain healthy

lifestyles. The study "Barriers to Self-Management of Type 2 Diabetes During COVID-19 Medical Isolation: A Qualitative Study" conducted by Diabetes Metab Syndr Obes [15] found that the main obstacles to diabetes self-management during isolation was a lack of resources, having health issues, experiencing negative emotions, and not having support. For this reason, telephone interviews with 12 diabetic patients were conducted as part of a qualitative study. A series of open-ended questions on several facets of self-management were asked throughout the interviews. Figure 8 in Appendix A contains the collection of questions. Following the collection of the responses, a list of themes was created based on the diabetes patients' responses. Figure 9 in Appendix A indicates the complete table. The findings of this study demonstrated that a major impediment to managing diabetes on one's own was a lack of understanding of the disease. To determine the obstacles to type 2 diabetes self-management among African American adults living in rural communities, the Center for Health Research, School of Public Health conducted a further study on a similar case [16]. Twenty-two African American people with type 2 diabetes were chosen for this study from three churches in small Kentucky towns. Three focus groups were held to find out what made managing diabetes more challenging. A 15-item survey was utilized to gather information on the participants' personal, social, and medical histories in relation to type 2 diabetes. Figure 10 in Appendix A contains a list of the questionnaires that were created. After gathering the data, it was examined with Statistical Package for Social Sciences (SPSS) software, and its frequencies were assessed. Researchers have created a list of themes to define the barriers of type 2 diabetes, which demonstrates that the ones identified are the ones that relate to the lack of self-control with regard to food and diet, confusion and forgetfulness, inconvenience, and self-perception. If not properly treated, this can result in a number of health issues.

As a result, we can use the following self-management to enhance patients' health:

- Regular encouragement for education and motivation of patients may receive in-depth information about the illness and stay motivated to alter/mitigate its trajectory.
- Making use of mobile technologies like glucose monitors and smartphone applications could improve diabetes self-management [15]. By offering individualized and entertaining tools that cater to patients' emotional needs and objectives, it has the ability to enhance diabetic self-management. This may lead to reduced HbA1c (glycated haemoglobin) levels and blood pressure measurements, all of which are quantifiable signs of better health.

Improved self-management can benefit patients' health in the following ways:

- Lowers the need for hospitalization: If self-management is practised early on, patients are more likely to identify the health issues they are experiencing and seek medical attention, which helps to improve the patient's health.

- Improve disease control: When a person with a disease takes self-management seriously, it helps them to control their health issues by checking their blood sugar levels, taking their medications on time, engaging in regular physical activity, and adhering to a nutritious diet.

In this research, we introduce a fitness application called DiaBeatIt, designed specifically for diabetes patients. Fitness apps have become a popular way for individuals of all ages to manage their health and fitness, including those who are unable to leave their homes. However, even with the widespread use of fitness apps, it remains a challenge for people to use them to stay fit consistently.

1.1 Problem Statement and Research Goal

Diabetes is a chronic condition that requires ongoing management, and regular exercise is important in managing the disease. However, exercise adherence can be a challenge for many people, including those with diabetes. Some people with diabetes may not have access to traditional fitness equipment or may not be comfortable using it. The role of emotions in the acceptance and use of technology is an area of ongoing research.

Our goal is to improve health outcomes, address adherence challenges, and overcome technology barriers in diabetes people which led us to bring the research question "**How can the identified emotional objectives be translated into app design?**" in this research.

The utilization of emotional modelling in game-based diabetes applications for diabetes patients. By taking into account the emotional needs of patients, game-based diabetes apps could help improve adherence to regular exercise and ultimately improve health outcomes for those with diabetes. A game-based diabetes app that is accessible and easy to use could help overcome the barriers of traditional fitness equipment and allow more people with diabetes to engage in regular exercise. A study of a game-based fitness app that is designed to address the emotional needs of diabetes patients could contribute to the advancement of knowledge in the area of emotions in the acceptance and use of technology.

1.2 Research Contribution

The research described in this thesis includes the design, development and evaluation of a game-based app for diabetes patients' self-management that incorporates emotional modelling techniques to boost adherence to regular exercise to better health outcomes with the application of technology.

The first contribution of this research is the development of a game-based app that is focused on diabetes patients. The app includes features such as diabetes tips, real-time geolocation-based physical activity, and a steps counter. The additional features that

are set to be developed in the next version include goal-setting, medication time with notifications, blood glucose and weight measurement. The app addresses barriers to exercise such as lack of access to equipment, by providing an exercise option to walk on a real-world map.

The second contribution of this research is the incorporation of emotional modelling methods into the app design. By taking into account the emotional needs of diabetes patients, the app offers adherence to exercise and lets the users solve diabetes-related quizzes while playing the game. The emotional modelling techniques used in the app were developed through a research process which included taking surveys, writing functional and non-functional requirements based on the survey results, and testing with diabetes patients.

The third contribution of this research is the evaluation of the game-based app for diabetes patients. The findings show that the app is effective in enhancing the diabetes patients' exercise and is knowledgeable in helping the patients in gaining diabetes-related education.

Overall, this research offers insights into how game-based technology and emotional modelling techniques can be used to improve diabetes self-management. The development and evaluation of the game-based app for diabetes show how technology has the ability to enhance health and meet the particular needs of diabetes patients. The findings of this research have significance for current and future work on the self-management of diabetes and the use of technology in health.

1.3 Thesis Outline

The following outline (Figure 3) provides a detailed overview of the thesis structure:

1. Chapter 2 presents the background and context of the research.
2. Chapter 3 outlines the methodology and approach taken in the study.
3. Chapter 4 delves into the implementation details of the application.
4. Chapter 5 provides the approach to the evaluation plans for application testing and an evaluation of the results.
5. Chapter 6 addresses the potential threats to the validity and limitations of the research.
6. Finally, Chapter 7 concludes the thesis with a summary of the thesis and recommendations for future work.

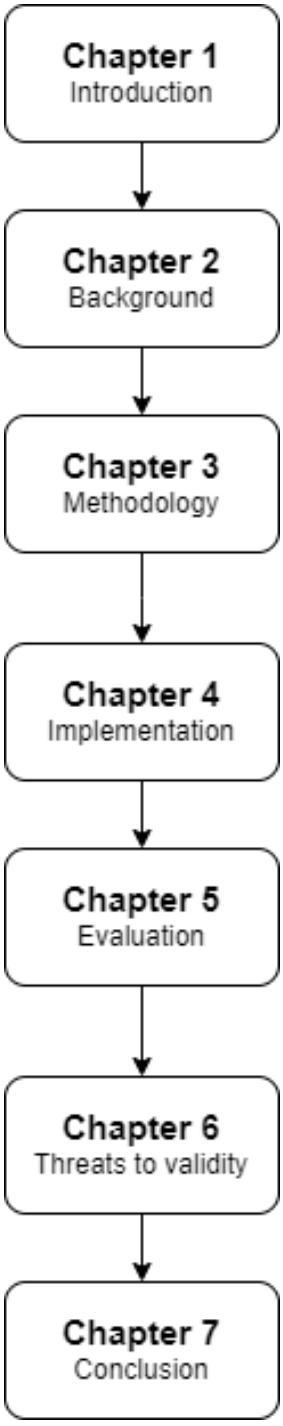

Figure 3. Thesis outline

2 Background

2.1 Fitness Apps

Fitness apps are mobile or web-based applications designed to help individuals track their physical activity, exercise routines, and nutrition [17]. They are widely used by people of all ages and fitness levels, ranging from casual users to professional athletes. These apps have become increasingly sophisticated, offering features such as personalized workout plans, goal setting, and progress tracking [18]. The use of fitness apps has been shown to have a positive impact on physical health and overall well-being, making them an important tool for individuals looking to improve their health and manage chronic conditions such as diabetes. A good amount of exercise is essential for long-term health, weight management, prognosis of chronic conditions, including a 33% reduction in all-cause mortality, and a 35% decrease in cardiovascular mortality[19, 18].

2.2 Diabetes (Risks, Symptoms and Management)

Risk factors for type 2 diabetes include factors such as genetics, age, obesity, physical inactivity, following an unhealthy diet, having high blood pressure or high cholesterol levels and a family history of diabetes. In particular, people of South Asian, African, and Middle Eastern descent are at higher risk of developing type 2 diabetes [20, 21]. Symptoms of type 2 diabetes can include increased thirst, frequent urination, fatigue, blurred vision, and slow wound healing. Over time, uncontrolled type 2 diabetes can lead to serious health problems such as heart disease, nerve damage, and kidney disease [13, 22, 23].

Effective management of type 2 diabetes involves a combination of lifestyle changes, such as healthy eating and physical activity, as well as the use of medications as prescribed by a healthcare provider [24]. Regular monitoring of blood glucose levels, as well as regular check-ups with a healthcare provider, can help people with type 2 diabetes manage their condition and reduce the risk of complications [22, 10, 25, 23]. Screening for prediabetes and early detection of diabetes can help prevent the development of complications. In particular, lifestyle interventions in people with prediabetes have been shown to significantly reduce the risk of developing diabetes [26]. Common medications include metformin, sulfonylureas, and insulin [24]. In some cases, bariatric surgery may also be recommended for people with severe obesity and uncontrolled diabetes [27].

In 2021, diabetes was linked to 6.7 million deaths, with one death occurring every 5 seconds [28]. The 2016 Global Report on Diabetes highlights the significant economic impact of diabetes, encompassing direct medical expenses, indirect costs from lost productivity, premature mortality, and the detrimental effect on a nation's Gross Domestic Product (GDP) [29].

In conclusion, type 2 diabetes is a common and complex health condition that requires

careful management to reduce the risk of complications. Effective management can involve a combination of lifestyle changes and medical treatments, as well as regular monitoring and check-ups with a healthcare provider.

2.3 Emotion-oriented Requirements Engineering

The field of emotion-oriented software engineering encompasses emotional objectives and proposes additions to existing goal models, scenarios that elicit motivation, and models for representing the roles of individuals and agents in a system. These enhancements aim to provide a versatile approach for modelling the emotions of individuals and agents involved in a system [30].

Emotion-oriented requirements engineering is an approach to software development that takes into account the emotional needs and goals of users. It involves identifying, modelling, and evaluating emotional goals in order to design software that meets those goals. This approach can help create software that is not only functional but also emotionally satisfying for users [31].

The idea of emotion-oriented software engineering involves integrating emotional objectives into the design of software systems. The aim is to develop software systems that not only meet users' functional and quality requirements but also have a positive impact on their emotional state. Emotions are personal experiences that define an individual's mental state, such as happiness, fear, security, empowerment, or a sense of normality. Emotional objectives, in contrast to functional or quality objectives, focus on how users feel and are, therefore, the concern of people rather than the system or a goal.

2.4 Emotional Goals

In requirements engineering, emotional goals are essential to ensure that software systems are designed to meet both the functional and emotional needs of users. These objectives are non-functional and define the desired level of emotional expression for a given role [30].

Emotional goals come in two different varieties. Positive emotions, such as joy, trust, interest, calmness, surprise, and motivation, are examples of feelings that users hope to experience while interacting with the application [32]. Emotional goals are integrated with a goal model, which demonstrates how functional objectives can satisfy user demands. Conversely, an emotional threat refers to a negative feeling that a user wants to avoid or suppress in an application, such as fear, annoyance, or distraction [32].

An example that demonstrates the concept of emotional goals is provided in [33]. This approach involves two roles: the gift giver and the gift recipient. In this scenario, the gift giver's primary objective is not to simply give a gift but to select the ideal gift that makes the recipient feel special. The giver aims to choose a thoughtful gift that will make the recipient feel appreciated, while the recipient's objective is to acknowledge

receiving the gift and express gratitude for the emotions the giver is attempting to convey [33, 30].

3 Methodology

The origin of this thesis topic stems from a course [1] taken at Uppsala University entitled "Serious Game Design in Health Care and Education." This course provided insight into innovative processes and a creative mindset to address needs-based problems and promote behaviour changes in the healthcare sector. As a part of the Women's and Children's Health Department, students were tasked with selecting a topic that addressed the needs of women and children. A team of five students, including the Author, chose to focus on type 2 diabetes, which is a major health concern both in Sweden and globally. The course was supervised by a PhD student who was also working with diabetes patients.

Over the course of two weeks, we underwent a design thinking process that involved the steps of empathizing, defining, ideating, prototyping, and testing. Our final product was a mock-up of an application[2].

Inspired by the work done in the course, the Author wanted to explore further the application of the emotion-oriented requirements engineering model in developing a game-based fitness app for diabetes patients. This research aims to understand the emotional goals of these patients better and to fulfil their needs through the creation of an effective and meaningful application.

In the following sections, we will discuss the research approach for achieving the research goal, requirements gathering, and the creation of a goal model for the development of the application.

The Use of Text-generating Language Model

To make the text easier to read and to comprehend the overall idea of research papers, we employed the text-generating language model as indicated in Appendix B.

3.1 Research Approach

We conducted a literature review from online repositories such as the Institute of Electrical and Electronics Engineers (IEEE), Science Direct, Association for Computing Machinery (ACM), and Scopus in order to understand and study the related literature. We browsed through the repositories to gain a better understanding of emotion modelling and its applications in various systems while also learning more about the existing systems that are currently in use. We needed to learn more about emotion-oriented applied systems since we want to utilize a similar modelling strategy to create an application. To locate the relevant papers we required for our research, we used a variety of search strings.

[1] https://www.uu.se/en/admissions/freestanding-courses/course/?kKod=3HI001&typ=1

[2] https://www.figma.com/proto/Lwmxwl72FaNB3SGIqNqCjT/Dia-beat-it?page-id=1%3A2&node-id=24%3A929&viewport=1652%2C296%2C0.67&scaling=scale-down&starting-point-node-id=24%3A929

The information connected to the search string and the essential information about the extracted research papers[3] is included in the excel file. The content analysis helped us identify patterns and topics in the research papers concerning the existing systems, their validations, limitations, and future work.

Additionally, we also wanted to know if there have been any previous studies on diabetes patients that used the emotion-modelling approach to create a system, but after going through the literature review, we encountered a lack of studies and applications related to diabetes patients. As a result, we needed additional information about the disease and its patients. Therefore, we conducted research using reports from reputable organizations such as WHO and Mayo Clinic to gain a better understanding of the risk factors, preventive measures, and symptoms associated with type 2 diabetes. More information about the articles, blogs, and reports can be found on 'extra resources findings'[4] tab. In our investigation, it was found that type 2 diabetes is commonly seen among people who are middle-aged and older, although it can also impact teenagers [25, 23, 22]. The research [22] showed that the age group of 10-15 years old had the least chance of being affected by diabetes, whereas those between 16-79 years old were at the greatest risk. This information is crucial because it can help us better understand the target audience for our application and guide our emotion-oriented and goal-based analysis towards the specific needs and concerns of those most likely to be affected by the disease.

The symptoms of the disease include obesity as the main symptom and being overweight as the second. These findings emphasize the need for individuals with type 2 diabetes to engage in physical activity as a means of mitigating their symptoms and reducing the impact of the disease [22, 23, 13, 10].

The risk factors associated with type 2 diabetes include ageing, being overweight, a lack of physical activity, inefficient insulin, and genetics [13, 23].

In terms of preventive measures, healthcare organizations and physicians generally recommend engaging in physical activity as the top way to prevent type 2 diabetes, followed by taking a prescription medication and eating a healthy diet. This highlights the crucial role that physical activity plays in mitigating the risks associated with type 2 diabetes [22, 10].

Therefore, it is evident that physical activity is an essential aspect in the management and treatment of type 2 diabetes, which is why our proposed application focuses on incorporating physical activity as a means of mitigating the disease.

After conducting the content analysis, we moved forward to the next phase of our research, which was the development of the use cases for our proposed application. Use cases are an integral part of software development as they help to clearly outline the

[3]https://docs.google.com/spreadsheets/d/1QAQpEMpK6lcEbnUtwUwIhjDpudIMPWy3xBZvqzPtoLE/edit?usp=sharing

[4]https://docs.google.com/spreadsheets/d/1QAQpEMpK6lcEbnUtwUwIhjDpudIMPWy3xBZvqzPtoLE/edit?usp=sharing

expected behaviour of a system. Our approach in this phase was to carefully consider each feature of the application and craft a use case for it, effectively encapsulating all the necessary details for that particular feature. This helped us to have a clear and concise understanding of how the system should operate, and we were able to ensure that we covered all the necessary requirements for the application.

3.2 User Personas

User personas are fictional characters that show the various user types who might use the product, service, or brand in a similar way [34]. Personas are designed to better understand users' needs, experiences, behaviours, and goals. They are tailored to the desires and needs of the target audience [35, 36]. Some of the alternatives to user personas are as follows [37]:

- Task-flows
- Mental models
- User/customer journeys
- Jobs-to-be-done
- Asset-maps
- Triptech
- User clocks

We chose to use user personas because of the following reasons:

- They give a human-centred approach to the design process and facilitate the development of empathy for the target audience [38]
- They offer a framework for comparing design choices to the objectives and wants of the key audience, reducing the possibility of creating solutions that do not satisfy their requirements [39]

The following table 2 shows a list of combinations we performed to write the 7 personas. In the table below, the two different genders: Male and Female are represented as M and F, respectively. Male (M), Female (F).

We chose to focus on seven different personas that have been picked using a variety of criteria. These factors include the person's gender, age group, diabetes diagnosis, the year they have had the condition, and a wide range of perspectives, including a variety of symptoms and experiences. The chosen personas assist in representing the experiences of

a larger range of people who may be more prone to having the condition by incorporating high-risk individuals, such as those with a family history of diabetes. The selection procedure aimed to create a broad and representative sample of people with diabetes, allowing us to have a deeper knowledge of the difficulties and problems that these people confront.

Table 2. Type 2 diabetes personas

Gender	**Age (years)**	**Diagnosis**
M	45	New diagnosis
F	40	5 years
M	50	A high risk
F	35	Recently diagnosed
M	25	2 years
F	70	50 years
M	17	1 year

The following outlines the use case scenarios for the capabilities of the system:

Consumers Persona 1: Michael
A 45-year-old man who had always been in good health and lived an active lifestyle. Michael enjoyed playing sports, hiking, and spending time outdoors with his family. However, despite his healthy habits, he started to experience unusual symptoms such as increased thirst, frequent urination, and fatigue. He initially dismissed these symptoms as signs of ageing or overexertion. Over time, his symptoms worsened, and he found himself struggling to keep up with his daily activities [5]. He also started experiencing vision problems and difficulty healing from cuts and bruises. Concerned, he decided to visit his doctor to get checked out. During his appointment, he was diagnosed with type 2 diabetes, a condition he knew little about. He was shocked to learn that his family history, combined with his age and sedentary job, had put him at risk for this disease. After his diagnosis, he became more educated about his diabetes and began to take control of his health. He learned about the importance of a healthy diet, regular exercise, and proper medication management. He struggled with the changes in his diet and the need for regular blood sugar monitoring. He discovered new recipes that were healthy and delicious and found ways to incorporate physical activity into his daily routine. Today,

[5]References to AI(Artificial Intelligence)
The answer comes from a combined effort of the author and ChatGPT(15.04.2023), i.e. a language model whose training is based on a large number of different text sources. ChatGPT is developed by OpenAI. For more information about ChatGPT and OpenAI: https://openai.com. Prompt: “Rephrase in good words a user persona story who is suffering from type 2 diabetes with its symptoms where Michael suffered more from diabetes and it got worsened” (example)

he continues to lead an active lifestyle and manages his diabetes with ease, knowing that he is taking control of his health and future.

Consumers Persona 2: Sarah

A 40-year-old woman was diagnosed with type 2 diabetes five years ago. Despite being aware of the disease and its potential risks, Sarah struggled to take the necessary steps to manage her diabetes. She often indulged in unhealthy foods and didn't make time for regular physical activity. She also skipped her medication and didn't monitor her blood sugar levels regularly, leading to complications such as neuropathy in her feet and vision problems. However, after a scary incident where she experienced a hypoglycemic episode, she realized she needed to take her diagnosis seriously and started making changes to her lifestyle and diet to better manage her diabetes.

Consumers Persona 3: Juhan

A 50-year-old construction worker who has a family history of type 2 diabetes. Juhan grew up in a household where healthy eating habits were not a priority, and his job requires him to be on his feet all day and perform physically demanding tasks. He often skips breakfast and relies on fast food and sugary drinks for sustenance throughout the day. His doctor recently informed him that his blood sugar levels are higher than normal and that he is at high risk of developing type 2 diabetes. This news came as a shock to him, who had never given much thought to his health and well-being. However, he is determined to make changes to his lifestyle to prevent the onset of the disease. After the diagnosis, he began to educate himself on healthy eating habits and started to pack his own lunch and snacks for work, incorporating more fresh fruits and vegetables into his meals. He also started to make an effort to drink more water and limit his intake of sugary drinks. Although he still has a family history of type 2 diabetes, he feels empowered knowing that he can take control of his health and prevent the onset of the disease. He continues to prioritize his health by maintaining a healthy diet and making small but impactful changes to his daily routine.

Consumers Persona 4: Emily

A 35-year-old marketing manager, who was recently diagnosed with type 2 diabetes. Emily had always considered herself to be healthy and active, but her busy work schedule and stressful lifestyle led her to develop unhealthy habits, such as skipping meals and relying on processed foods and sugary snacks for energy. Since her diagnosis, Emily has been working with her healthcare team to manage her condition through medication and lifestyle changes. She has been monitoring her blood sugar levels regularly and has been working to make healthier food choices, such as incorporating more whole foods and lean proteins into her diet. She has also been prioritizing regular exercise, such as going for walks or attending yoga classes and has found it to be a helpful way to manage her stress levels and keep her blood sugar levels stable. Although she found the initial diagnosis to be overwhelming, she has been taking proactive steps to manage her condition and improve her overall health. She has also been connecting with other

individuals who have type 2 diabetes through support groups and online forums, which has helped her to feel less alone in her journey.

Consumers Persona 5: Sam

A 25-year-old who has been struggling with type 2 diabetes for the past two years. Sam's love for chocolates started at an early age, and he indulged himself in eating them excessively, leading to his diagnosis of diabetes. He has found it challenging to control his sweet cravings, leading to uncontrolled blood sugar levels and constant monitoring of his diet. He has a hard time finding food that he enjoys, that fits his dietary restrictions and often feels left out when socializing with his friends who don't have dietary restrictions. Despite the challenges, he is determined to manage his diabetes, lives a healthy life and enjoys doing outdoor activities like hiking and jogging.

Consumers Persona 6: Renata

A 70-year-old who has been living with type 2 diabetes for over 50 years. Renata was diagnosed with diabetes during her teenage years and has been managing it ever since. Despite her long-standing experience with the disease, she still struggles to maintain her blood sugar levels and often feels overwhelmed by the constant monitoring of her diet and insulin injections. She has had to make significant lifestyle changes, including a strict diet and exercise regimen, and often feels isolated from her peers who don't have to worry about their health in the same way. Despite the challenges, she remains determined to live a fulfilling life and enjoys reading, gardening, and spending time with her grandchildren.

Consumers Persona 7: David

A 17-year-old was diagnosed with type 2 diabetes a year ago. David inherited the disease from his dad, who has been living with diabetes for many years. He has found it challenging to come to terms with his diagnosis and often feels frustrated by the restrictions on his diet and lifestyle. He worries about his future and how diabetes will impact his life. He is determined to manage his diabetes and is starting to take control of his health by monitoring his blood sugar levels, taking his medication, and making healthy food choices. He enjoys playing soccer and spending time with his friends and family.

3.3 Data Gathering Techniques

For data gathering, we sent out our survey questions to a list of organizations mentioned on the 'Diabetes organizations' [6] tab.

We also translated our English survey into Estonian so that people who do not know English can participate, but we did not get any feedback on it. After that, we contacted the ACM group, who advised us to post our survey questions on the Facebook groups

[6] https://docs.google.com/spreadsheets/d/1QAQpEMpK6lcEbnUtwUwIhjDpudIMPWy3xBZvqzPtoLE/edit?usp=sharing

for diabetes. We used a list of Facebook groups which we used is mentioned on the 'Facebook group'[7] tab. A collection of Facebook groups dedicated to diabetes was discovered using the search term "diabetes groups". Because of the groups' concerns about privacy, we only chose those particular groups.

However, after posting the text in open groups, we only got 2 responses. We think the reason we only managed to gather a small number of responses is that the Facebook groups gave us permission, and the organizations didn't give the unknown research group much of a priority. We also believe that the length of the survey questionnaire may have contributed to participants' feelings of boredom while completing the survey questions.

Because we believed the questionnaire with the features on it was too lengthy for individuals to complete, we sent out a second survey question with a few changes. Consequently, the updated version of our survey questionnaire can be found in Appendix C. There were two additional responses from this area.

The survey questions posted to the participants in the Facebook group aimed to gather insights regarding their level of knowledge about the disease, their emotions and worries concerning the features of DiaBeatIt, and how the application could potentially aid them. Overall, we were able to gather a total of 4 responses.

3.4 Capturing and Modelling User Emotional Expectations

In this section, we will explain how we utilized emotion-informed elicitation techniques and emotion-oriented models to identify and illustrate the emotional, functional, and quality goals for DiaBeatIt. Prior to this, we had already prepared a requirements document(described below) and created wireframes for each screen to showcase the features that the DiaBeatIt app should possess.

Functional requirements

1. As a user, I should be able to see the notification for medication so that I don't forget when to take medications.

2. As a user, I should see varieties of dietary for diabetes so that I can follow a healthy dietary schedule.

3. As a user, I want to select and modify the notification time for taking diabetes medicine so that I can time myself for taking medicine.

4. As a user, I want to track my physical health so that I know how to maintain my health.

[7] https://docs.google.com/spreadsheets/d/1QAQpEMpK6lcEbnUtwUwIhjDpudIMPWy3xBZvqzPtoLE/edit?usp=sharing

5. As a user, I should be able to see tips to control diabetes so that I can gain information about diabetes.
6. As a user, I should be able to see the steps counted on my walk so that I can monitor my everyday streak.
7. As a user, I want to check my heart beat rate and blood glucose statistics so that I can train myself according to my need.
8. As a user, I want to see a list of collected recipes with a description of them on the recipe menu so that I can cook them to balance my diabetes and stay healthy.
9. As a user, I want to select my own notification time for taking a walk so that I do not miss the mission and plan my schedule beforehand. As a user, I should be able to see check-in rewards every day with different items (Recipe) so that I can use the rewards in the game and recipes for preparing new dishes.
10. As a user, I want to be able to solve quizzes at different locations so that it helps me keep track of different destinations and learn about diabetes along the way.
11. As a user, I want to see a question mark on the map when I go close to the destination so that I can see the guidance and clues of the mission.

Non-functional requirements

1. As a user, I want the application to be available 98% of the time so that I can track my health.
2. As a user, I should be able to see the notification for medication synced with my selected timing so that I don't miss the medication.
3. As a user, I should see varieties of diets loaded in the app so that I don't have to refresh the app and load it again to see the diets.
4. As a user, I want the modified notification time for taking diabetes medicine to be automatically modified at the time of creation so that I can confirm the medication timing is created.
5. As a user, I want to check my heart beat rate and blood glucose statistics within seconds of loading the app so that I don't get frustrated and check the statistics instantly.
6. As a user, I want to see a list of recipes being loaded in the app so that I don't need to wait a long time to prepare the recipe and cook.

The following section outlines the methods used for elicitation processes to extract important objectives for the DiaBeatIt app, as well as how these objectives were portrayed using emotion-based models and personas.

3.5 Elicitation Technique with no Stakeholders

The elicitation strategies we used to determine the emotional, functional, and quality goals for the DiaBeatIt are described in this subsection. Emotion-informed requirements elicitation technique without a direct user is used and discussed in the subsection as follows:

Elicitation-informed Requirements Elicitation Technique with no Direct User Interaction

For this process, we created requirements for the DiaBeatIt app from a survey taken by diabetes people. Since there was no direct interaction with people, requirements were generated through the survey answers. The elicitation method used to identify the users' emotional goals, was an adaption of existing techniques namely content analysis, and Affinity Diagram.

3.6 Applying the Content Analysis to the Elicitation Process

We used the content analysis technique and incorporated the affinity diagram to extract emotional, functional, and quality goals. The method we employed is illustrated in Figure 4.

The process involves identifying the content that is related to the diabetes survey, which is then divided into smaller parts to complete a series of tasks as outlined below:

- highlight content which is relevant to the study, for example, words such as "I want to be comfortable while checking heart beat rate and blood glucose statistics"
- find content relating to the emotional expectations and concerns of the user, for example, "I feel motivated to keep walking/running to solve quizzes"
- find content relating to the quality goals, for example, "It is unsafe to use current location"
- find content relating to the functional goals
- use an affinity diagram for arranging recognized patterns or content into four primary groups: emotional goals, emotional concerns, quality goals, and functional goals
- group similar patterns together
- create the corresponding goals for every emotional concern that has been identified

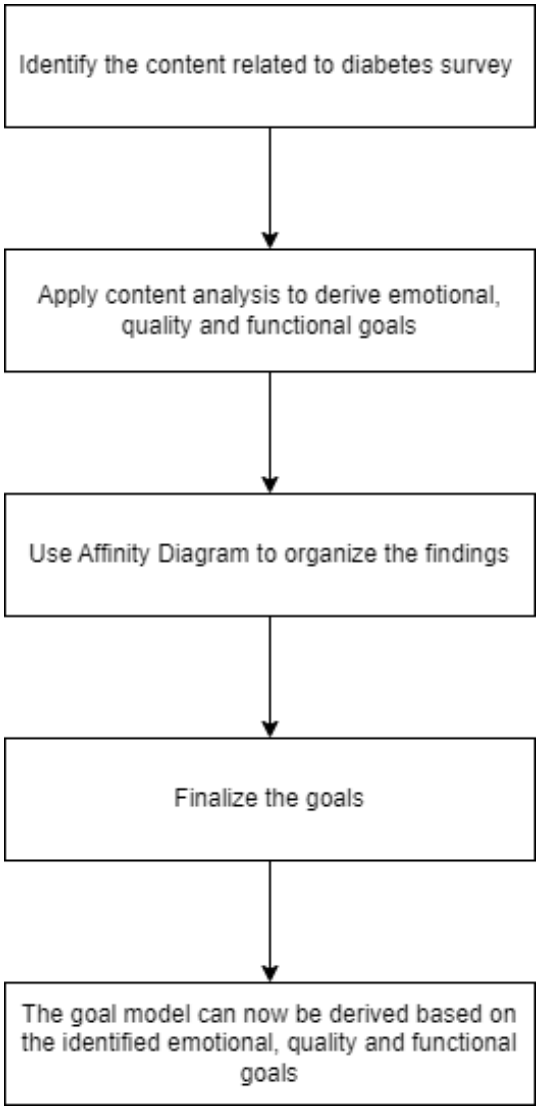

Figure 4. Elicitation technique with no direct user interaction [40]

- Write a title for each group that reflects whether it denotes an emotional, quality, or functional goal of the system that is being created

Once the goals are identified, an affinity diagram is used to organise all the goals identified whereby similar goals are grouped together and each group is named. Once the goals are finalised, the goal model can now be derived. The process to convert the identified goals into a goal model is described in subsection 3.6.

We prepared the survey questions using words such as 'feel' by giving some the examples such as happy, sad, angry, comfortable, insecure, etc. in the questions to elicit

emotional goals from the survey participants. For instance, one of the questions was "How does this feature make you feel"? We then applied the content analysis technique to the data from the survey answers with the objective to identify the key functional, quality, and emotional goals. The results of content analysis are given in Appendix D Table 18.

During our analysis, we figured out that most negative emotions were used in the survey answers to explain what they want to feel when using the application. for instance, one answer was "negative", or "angry" which is why, we have written a list of negative emotions which we refer to as emotional threats, along with any positive emotion which we termed as an emotional goal. We then came up with corresponding emotional goals for each emotional threat [40]. The heart and the spade were represented as emotional goals and emotional threats [40] as shown in Figure 5.

The functional goals are represented with parallelograms, quality goals are represented with cloud symbols and emotional goals are with heart shape. The emotional goals linked to the consumers are comfortable, happy, easy, updated, motivated, and decisive. the emotional threats linked to the consumers are uninterested, it won't help, negative, I don't care, and angry. The way these goals were included in the system is discussed in Section 4.5.

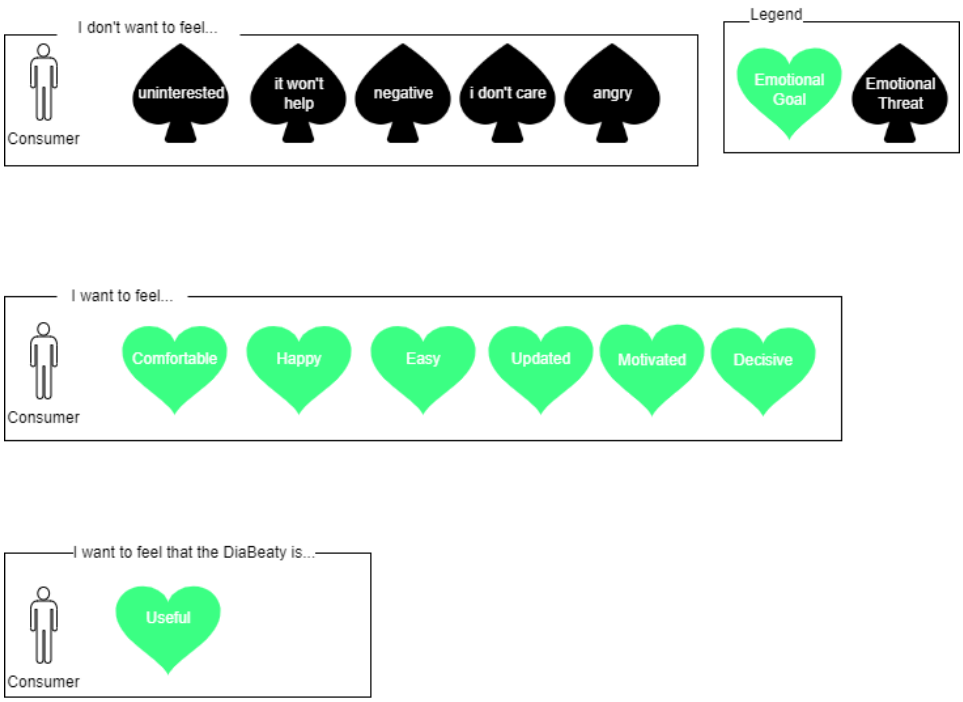

Figure 5. DiaBeatIt app emotional goals and emotional threats

3.7 The DiaBeatIt App

This section includes the app's features as well as an explanation of how each emotional goal was reflected in these features. The primary target audience of the application is people with diabetes. The app offers gamified material that encourages people with diabetes to leave their homes and engage in physical activity like walking or jogging. It also emphasizes inspiring people with diabetes to follow diabetes diets and lead healthy lives by offering them various motivational ideas.

The DiaBeatIt app's features are listed in the following part, along with how the design of the app takes into account the user's emotional goals.

- As a user, I should be able to see tips to control diabetes so that I can gain information about diabetes.
- As a user, I should see the latest/updated XP with levels in the game so that I can keep track of my progress.
- As a user, I want to see the daily mission so that I can solve the mystery mission every day.
- As a user, I want to be asked to allow for location permission so that my current location be used in the game.
- As a user, I want to see my current location on the map so that I know where to begin the game from.
- As a user, I want to see the alert location sign of the next destination and an exclamation sign for other locations where the clues are hidden on the map so that I can distinguish my next destination from the other locations.
- As a user, I want to see a question mark on the map when I go close to the destination so that I can see the guidance and clues of the mission.
- As a user, I want to see a green check mark on the map when I identify the clue so that I can remember my completed tasks.
- As a user, I want to gain 20 XP per correct answer so that I can unlock the character's costume.
- As a user, I want to see the number of clues collected and steps taken after the accomplished mission so that I can collect the clues for the next mission and check my walking steps per day.
- As a user, I want to check my heart beat rate and blood glucose statistics so that I can train myself according to my need.

Realisation of Emotional Goals in the DiaBeatIt App

In this section, we describe how each emotional goal was addressed. The functional and emotional goals expressed by consumers are displayed in the table below.

Table 3. Design Considerations of Consumer's Functional Goals

Functional Goals	**Design Considerations**
Shows a real-world map	This should show the live location map of the world
Levels and experience points	This happens when the user starts playing the game and collecting experience points and thus increases the levels
Gain points	The points are gained when a player solves certain quiz questions in the game
Current location	The map shows the current location of the player
Alert locations	The map shows the alert locations of the next closer destinations
Solves quizzes	The game allows the user to solve quizzes in different locations
Number of clues and steps taken	The clues and steps taken are collected and shown when a player finishes a game
Tips for Diabetes	Tips for diabetes are shown at the very beginning of the application
Check-in rewards	Rewards are collected every single day by a participant to motivate them to play the game every single day
Daily missions	Daily missions with a different story are given to a person to solve a different case every single day
Statistical information on health	Measuring the heartbeat rate, blood glucose level and weight are the three statistical information that is shown in the profile section of the application
Recipes description	Recipes description are shown in the recipes section where a list of diabetes recipes is collected by the player while playing the game
Notification time	The player can modify the notification time to take their medication

Table 4. Design Considerations of Consumer's Emotional Goals

Emotional Goals	**Design Considerations**
Comfortable	This should come through when the number of clues and steps taken in the walk is counted; when the heart beat rate and blood glucose statistics are checked; notification time for taking a walk and taking medicine is created and modified; check-in rewards every day with different items (recipe, experience points)
Happy	This feeling of being happy is conveyed when a question mark is seen on the map when the user goes close to the destination; when a user solves quizzes and puzzles at different locations; when a list of recipes with a description is shown in the app
Easy	This emotion is reflected when a user sees a list of recipes with a description in the app
Updated	The user can check heart beat rate, and blood glucose statistics and sees its updates in the app
Motivated	The user gets motivated to go outside when the application shows a real-world map where a user needs to walk/run to solve quizzes on diabetes; Check-in rewards can motivate the users to play the game every day; When a user sees a question mark on the map when the user goes close to the destination, they tend to be more curious about the next step and makes them more motivated to play the game
Decisive	The application helps the users to decide on various ingredients which are healthy for them and which need to be avoided by showing tips for controlling diabetes hence, the user can make a good decision based on that

3.8 Goal-modelling

The goal model shown in Figure 6 was produced using the results and emotion model (which includes functional, quality, and emotional goals) from the aforementioned process.

Goal model

A goal model is used to identify and represent the different types of goals that a system should achieve to meet the emotional requirements of its users. These goals can be functional, quality-related, or emotional in nature. A goal model provides a structured way to represent the different goals and their dependencies and relationships, allowing designers and developers to make informed decisions about how to prioritize and address emotional goals in the system. By using a goal model, emotional requirements can be linked to specific system goals and features, ensuring that the final product meets the emotional needs of its users. [41]

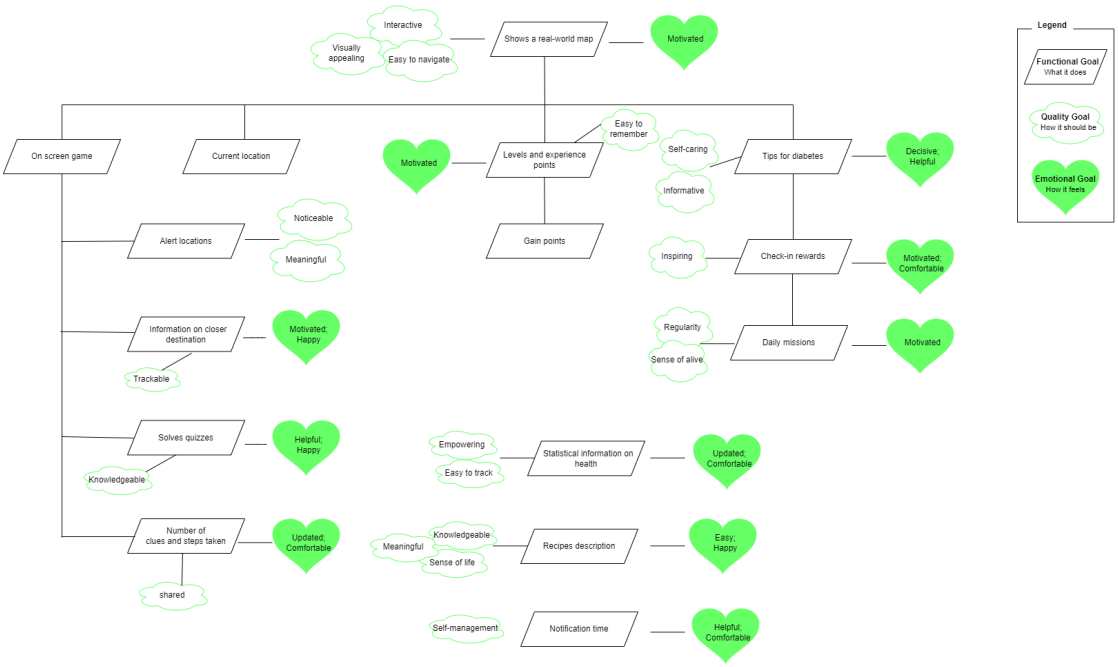

Figure 6. DiaBeatIt Goal Model

4 Implementation

In this section, we defined how we have implemented our DiaBeatIt application using Android Studio. The GitHub repository[8] containing the implementation and the .apk file[9]of DiaBeatIt are made publicly available.

4.1 The Map

Regarding the map implementation, we utilized the Google Maps Application Programming Interface (API) to display nearby places of interest based on the user's current location. The app uses LocationManager and SensorManager APIs to track the user's location and steps taken, respectively. The app also makes use of Retrofit to handle API requests to the Google Places API [10].

The app starts by requesting permission to access the user's Global Positioning System (GPS) location. If permission is granted, the app obtains the user's current location and displays it on the map. The app then sends a request to the Google Places API to obtain a list of nearby places of interest. The app adds alerts to the map for each location in the list and sets the bounds of the map view to include all the alerts.

The app implements functionality to track the user's steps without the use of a device sensor because of not having the testing feature in our physical device. Therefore, we decided to calculate the distance between coordinates from GPS with the previous and current data, and then we divided it by 2 as we walk a meter on two steps. It is used to track the number of steps taken by the user. The app displays the number of steps taken in a text view and also adds the number of steps taken to the alert for the user's current location on the map.

4.2 Profile Screen

For the profile screen implementation, we made use of the Android framework's Fragment class to create a reusable User Interface(UI) component that can be added to an Activity. The layout file contains a ViewPager and a TabLayout, which are used to display two different Fragments inside the ProfileFragment. The GlucoseFrag and WeightFrag are implemented as separate classes that extend the Fragment class. These Fragments are responsible for displaying UI elements related to glucose and weight, respectively.

[8]https://github.com/MsAkiNom/DiabeteApp

[9]https://github.com/MsAkiNom/DiabeteApp/tree/master/app/release

[10]References to AI(Artificial Intelligence)
The answer comes from a combined effort of the author and ChatGPT(04.05.2023), i.e. a language model whose training is based on a large number of different text sources. ChatGPT is developed by OpenAI. For more information about ChatGPT and OpenAI: https://openai.com. Prompt: "Rephrase in good words the use of Retrofit which handles API requests to Google API"

4.3 Technologies

Kotlin was chosen as the programming language for the development of the DiaBeatIt application because of its compatibility with existing libraries and frameworks. Android Studio was used as the Integrated Development Environment (IDE) due to its ability to provide essential tools, APIs, and libraries that aid in creating robust Android applications. Moreover, Google's free map API was integrated into the application to provide a map user interface that enhances the user's experience. The combination of these technologies enabled us to build a functional and efficient application that met the emotional goals of the users.

Figure 7 contains images taken from the application:

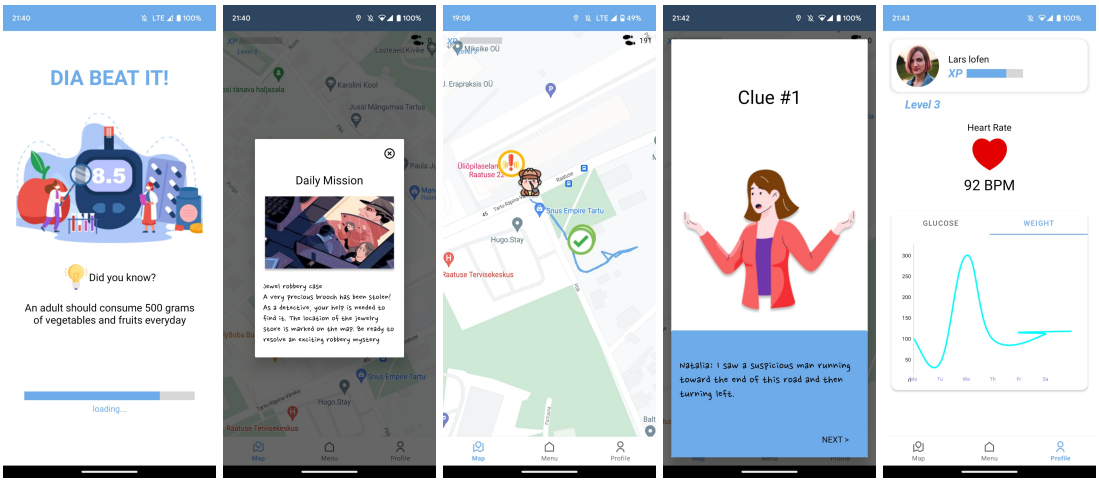

Figure 7. Screenshots from DiaBeatIt

5 Evaluation

This section outlines our evaluation strategy and the findings obtained after diabetic patients tested the developed application - DiaBeatIt.

5.1 Evaluation Plan

Our evaluation plan was to reach out to a large number of diabetes patients and provide them with the trial application to gather significant feedback. However, due to time constraints, we were only able to distribute the application to 2 diabetes patients who used it consistently for four days. The trial group were a recently diagnosed diabetes: two females between 21-30 years. Feedback was collected via a questionnaire[11], which included questions about various features of the DiaBeatIt application, and their ratings on them. Although the sample size was limited, we believe the feedback received is valuable for further development and improvements of the application.

5.2 Evaluation Result

The results from the feedback form indicated that the majority of participants exhibited a positive inclination towards utilizing the application. Nonetheless, there were some who expressed their aversion to the concept of walking as a means of physical activity. One of the underlying reasons cited was their lack of motivation to engage in outdoor activities. The feedback results from the participants are as follows:

Participant 1 & Participant 2:
Age: 21-30 years
Gender: Female

Feature 1: The application shows a real-world map where a user needs to walk/run to solve quizzes on diabetes
Feature 2: The application shows tips for controlling diabetes
Feature 3: The application shows levels and experience points depending on the gained points in the game
Feature 4: Daily missions are visible to the users
Feature 5: A user's current location is seen on the map
Feature 6: Alert locations are shown on the map of the next destination, and an exclamation mark for other locations where quizzes/clues on diabetes tips are hidden
Feature 7: A user can gain 20 XP per correct answer about diabetes
Feature 8: A question mark is seen on the map when the user goes close to the destination

[11] https://7pm9aejx2ku.typeform.com/to/SpY5mxXb

Feature 9: A user solves quizzes and puzzles at different locations
Feature 10: The number of clues and steps taken in the walk is counted
Feature 11: Check heart beat rate, and blood glucose statistics
Rate your overall experience using the application on a scale of 1 to 5 (1 = worst, 5 = excellent)

Table 5. Feature 1

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	4	gelocation is interesting	positive
2	5	It helped me go out of my house and stay active	positive, motivated

Table 6. Feature 2

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	5	useful	positive
2	5	gain knowledge	positive

Table 7. Feature 3

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	1	not useful	negative
2	4	i don't care about the xp	negative

Table 8. Feature 4

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	5	inspiring	positive
2	5	this is good	positive

Table 9. Feature 5

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	1	useful for this game	positive
2	5	this is needed in this game it seems	okay

Table 10. Feature 6

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	4	helpful to go to final destination	positive, inspired to move to next step
2	5	interesting	okay

Table 11. Feature 7

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	1	not important	negative
2	1	i don't care about points	negative

Table 12. Feature 8

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	5	important to finish the game	positive
2	4	seems important to find the destination	positive

Table 13. Feature 9

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	5	increase knowledge on my understanding	positive
2	5	knowledgeable	positive, inspired

Table 14. Feature 10

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	5	they are cool	positive
2	5	steps counting is good	positive, helped me keep track

Table 15. Feature 11

Participant	**Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)**	**How do you think it helped you, and in what aspects?**	**What are your concerns about using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?**
1	2	don't know how it works	okay
2	3	doesn't seem to be working	negative, but the feature is cool

Table 16. Overall all DiaBeatIt ratings

Participant	**Rating**
1	3
2	4

Upon collecting the evaluation results, it was found that the diabetes patients responded more positively to the application after its implementation compared to before.

Feature 1 was initially regarded with negative concerns by participants before the trial, but after testing, the response became positive and motivated.

For Feature 2, participants' interest and feelings towards the feature remained the same, which was considered a positive outcome.

However, for Feature 3, the feelings towards the feature remained negative both before and after the trial.

Feature 4 led participants to change their neutral thoughts to positive feelings after using the application.

Regarding Feature 5, location sharing was not considered helpful by participants before the trial, but after the trial, positive responses were received.

For Feature 6, participants initially showed feelings of anger and disinterest towards seeing alert locations on the map. However, after the trial process, their attitude changed to be more positive and inspired.

Feature 7 generated neutral feelings towards gaining experience points in the game both before and after the trial.

Feature 8 showed positive and motivated results in both the pre-evaluation and post-evaluation surveys.

For Feature 9, solving the quizzes was preferred both before and after the trial, with positive and happy responses.

Feature 10, which tracked the number of steps taken, was considered positive and comfortable both before and after the trial.

However, Feature 11, which involved the calculation of blood glucose and weight measurement, received positive and comfortable responses but also generated negative emotions due to its unfinished development.

In general, the trial outcomes were satisfactory and some of the participants' emotional responses towards the features appeared to have fluctuated after experiencing the application.

6 Threats to Validity

In this section, we evaluate the validity of the study by using two tests:

6.1 Internal Validity

During the development of the DiaBeatIt, we acknowledged the impact of factors such as user motivation and technological background on the internal validity of our research. Despite the careful consideration given to emotional goals, these factors could significantly affect the user's acceptance of the technology and, in turn, the application's effectiveness. Therefore, we recognize the need for further investigation into these factors and their potential impact on user behaviour.

6.2 External Validity

In terms of external validity, it should be noted that this research was conducted with a limited sample size of only 4 individuals with diabetes. However, we strongly believe that the findings and outcomes of this study could be further extended to a larger population of diabetic patients. In fact, we anticipate that similar results could be observed if the research were replicated with a more diverse and extensive sample size.

7 Conclusion

7.1 Summary

In this research, we developed a mobile application, named DiaBeatIt, specifically for people with diabetes, utilizing emotion-oriented goal models. Our primary focus was to design and implement a functional prototype of the application, which could help people with diabetes to stay active in their everyday life. To achieve this, we employed the emotion-oriented requirements modelling strategy, which ensured that the emotional needs of users were integrated into the application design process. The emotion and goal models that we created were carefully crafted to address the unique challenges faced by people with diabetes.

In order to ensure that our application met the needs of its intended users, we tested it on 2 individuals with diabetes, who provided invaluable feedback that we then used to refine and improve the application's design. Our evaluation process enabled us to measure the effectiveness of the DiaBeatIt application in meeting the emotional goals of its users, which was a critical component of our research.

7.2 Future Work

Our future work holds immense potential for refining and enhancing the application's functionality to better serve its users. Our foremost priority is to implement the remaining features of the application in a seamless and intuitive manner, ensuring that users have access to all the tools they need to manage their diabetes effectively. Additionally, we plan to conduct extensive user testing in collaboration with a diverse range of organizations and user groups. This approach will provide us with invaluable insights into the emotional and practical needs of our users, allowing us to tailor the application to meet their specific requirements. By doing so, we hope to create an application that truly resonates with users and helps them improve their diabetes management in a meaningful way.

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Appendices

Appendix A

The Authors: Chunhong Shi, Haili Zhu, Jun Liu, Jian Zhou, and Weihong Tang conducted a series of questionnaires that interviewed diabetes patients is displayed in Figure 8. This interview question is associated with Chapter 1 which helps us assess the final results we get from the questionnaire and have a better understanding of patients' health self-management.

Dimensions	Open-Ended Questions
A. Dietary modifications	
	(1) How was your diet managed during the isolation period?
	(2) What kind of diet did you expect to get at an isolation site?
B. Physical activity	
	(1) How was your physical activity during the isolation period?
	(2) What forms did your physical exercise take?
C. Medication compliance	
	(1) How did you take your hypoglycemic medicines during the isolation period?
	(2) How did you obtain your hypoglycemic medicines?
D. Blood glucose monitoring	
	(1) How did you perform blood glucose monitoring during the isolation period?
	(2) How were your blood sugar levels during the isolation period?
E. Social support	
	(1) What did your family and friends provide you to facilitate your glycemic control?
	(2) What services did you hope to get from the isolation site to assist with the management of your diabetes?
F. Psychological state	
	(1) What were the psychological and emotional changes that you experienced at the isolation site?
	(2) How did these emotional changes influence your self-management of diabetes?

Figure 8. Interview Guide Used to Facilitate Conversation in Telephonic Interviews [15]

The Authors: Chunhong Shi, Haili Zhu, Jun Liu, Jian Zhou, and Weihong Tang received the response shown in Figure 9 from the questionnaire shown in Figure 8. This response data is related to Chapter 1 and is used to identify the most significant and minor barriers to managing diabetes.

Themes	Sub-Themes	No. of Responses (N = 12)
Inadequate knowledge and behavioral beliefs	Limited diabetes knowledge	11
	Confusion about taking medications	7
	Low adherence to self-monitoring of blood glucose	4
Shortage of resources	Limited space for physical exercise	12
	Unavailability of blood glucose monitoring	11
	Absence of a diabetic diet	5
	Undersupply of hypoglycemic medications	5
Suffering from health problems	Hyperglycemia	8
	Physical discomfort	6
	Insomnia	5
Negative emotions	Stigma	6
	Dissatisfaction	4
	Anxiety	4
Lack of support	Lack of professional guidance	6
	Lack of family support	5

Figure 9. Barriers to Diabetes Self-Management [15]

The Authors: Dina Byers, Katy Garth, Dana Manley conducted a questionnaire to gather information on diabetes management is shown in Figure 10. This questionnaire is related to Chapter 1 and it is useful in examining the type 2 diabetes barriers.

Briefly introduce yourself. Tell us a little bit about your diabetes (e.g., how long you've had it and how it is treated).

Does anyone regularly help you with your diabetes management? If so, explain the role of this person in helping you manage your diabetes.

What has been most helpful to you in managing your diabetes?

What has been most difficult for you in managing your diabetes?

What parts of your diabetes management have been the easiest for you? Tell us why.

What parts of your diabetes management have been most difficult for you? Tell us why.

.

Can you remember a specific time when it was difficult for you to manage your diabetes? What made this situation so difficult?

If you could go back to the day you were diagnosed with type 2 diabetes, would you now do anything different in managing your diabetes?

Chlebowy et al. (2010)

Figure 10. Focus Group Session Questions [16]

Appendix B

Table 17 describes the tools used for the text-generating language model in this research. This table is related to Chapter 3.

Table 17. Articifical Intelligence (AI) tools

Tools	**Description**
QuillBot	We paraphrased some technical phrases in order to better understand the notion and to rephrase our ideas in a more conventional way
Phind	We used this tool to quickly locate references from the internet and reformulate the idea of the findings presented in a structured manner
ChatGPT	To make the text more readable, to gain an overview of the paraphrasing from the research article, and to separate the paragraphs into certain categories, such as risk factors, symptoms, and prevention of diabetes

Appendix C

The following is the survey questionnaire that was put in the Facebook group to learn more about people's knowledge about diabetes, their emotions toward it, and their concerns about the design and the features of DiaBeatIt. In this research, this survey data is related to Chapter 3, and Subsection 3.3.

1. Please choose your age group
    - < 20
    - 21-30
    - 31-50
    - 51-65
    - > 65
2. Please choose your gender
    - Female
    - Male
    - Non-binary
3. Have you ever forgotten to take your medications?
    - Yes
    - No
4. If yes, why do you think you forgot?
    - Too busy to remember everything
    - Didn't turn on my alarm
    - Other
5. How are you currently managing your medications?
    - I use an application
    - I remember my medications time
    - I get taken care of by a nurse
    - I don't manage
6. How often do you visit the clinic to check your glucose and blood pressure?

- Daily
- At 3 times a week
- When needed only

7. What is your usual wake-up and sleep times?
    - 6:00 am - 8:00 pm
    - 7:00 am - 10:00 pm
    - 8:00 am - 11:00 pm
    - Other
8. How are you controlling your diabetes?
    - Eating healthy foods
    - Getting active
    - Losing weight
    - Medications
    - Other
9. Rate your knowledge with diabetes foods on a scale of 1 to 5 (1 = worst, 5 = excellent)
10. My diets/healthy foods consist of:
    - Eating fresh fruits and vegetables
    - Less-sugary food
    - Low-fatty products
    - Other
11. How do you keep track of your physical health?
    - I use an application
    - I take notes
    - I don't track at all
12. Do you use any physical activity apps such as Pokemon Go?
    - Yes
    - No

13. If yes, when was the last time you used that application?

    - Just today
    - This month
    - More than a month ago
    - I don't use any

14. How was the experience with it?

    - I loved it, and would love to play
    - I am not a fan of it

15. What kind of physical activity do you prefer?

    - Gym
    - Run/Walk
    - Other

16. How often do you work out/go out for a walk/run in a week?

    - Almost everyday
    - At least 3 times
    - Whenever I feel like it
    - I don't do any

    "We would like to know how you think and feel about the following features in a gaming application to manage diabetes

17. Feature 1 : The application shows a real-world map where a user needs to walk/run to solve quizzes on diabetes

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?
    For example: It will help me lose my weight and stay healthy with the knowledge that I gain through walking and playing diabetes related quizzes

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?
    For example: I will be very inspired and comfortable to use this feature because it makes me feel upbeat and content.

18. Feature 2 : The application shows tips for controlling diabetes

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

19. Feature 3: The application allows for check-in rewards every day with different items (recipe, experience points)

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

20. Feature 4 : The application shows levels and experience points depending on the gained points in the game

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

21. Feature 5: Daily missions are visible to the users

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

22. Feature 6: A user's current location is seen on the map

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

23. Feature 7 : Alert locations are shown on the map of the next destination, and an exclamation mark for other locations where quizzes/clues on diabetes tips are hidden

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

24. Feature 8: A user can gain 20 XP per correct answer about diabetes

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

25. Feature 9: A question mark is seen on the map when the user goes close to the destination

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

26. Feature 10: A user solves quizzes and puzzles at different locations

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

27. Feature 11: The number of clues and steps taken in the walk is counted

    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)

    b How do you think it will help you, and in what aspects?

    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

28. Feature 12: Check heart beat rate, and blood glucose statistics
    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)
    b How do you think it will help you, and in what aspects?
    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?
29. Feature 13: A list of recipes with a description is shown in the app
    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)
    b How do you think it will help you, and in what aspects?
    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?
30. Feature 14: Notification time for taking a walk and taking medicine can be created and modified
    a Rate this feature on a scale of 1 to 5 (1 = worst, 5 = excellent)
    b How do you think it will help you, and in what aspects?
    c What are your concerns of using this feature (positive, negative, etc.)? How does it make you feel (happy, sad, angry, comfortable, insecure, etc.)?

Appendix D

The requirements survey results for diabetes patients are analyzed in Table 18, which is related to Chapter 3 and Subsection 3.6.

Table 18. Analysis of survey results

Functional Goals	**Emotional Goals**	**Quality Goals**	**Status**
Shows a real-world map	Motivated	Interactive; Visually appealing; Easy to navigate	
Levels and experience points	Motivated	Easy to remember	
Alert locations	-	Noticeable; Meaningful	
Information on closer destination	Motivated; Happy	Trackable	
Solves quizzes	Helpful; Happy	Knowledgeable	
Number of clues and steps taken	Updated; Comfortable	Shared	
Tips for diabetes	Decisive; Helpful	Self-caring; Informative	
Check-in rewards	Motivated; Comfortable	Inspiring	Not yet developed feature
Daily missions	Motivated	Regularity; Sense of alive	
Statistical information on health	Updated; Comfortable	Empowering; Easy to track	
Recipes description	Easy; Happy	Knowledgeable; Meaningful; Sense of life	Not yet developed feature
Notification time	Helpful; Comfortable	Self-management	Not yet developed feature
Gain points	-	-	
Current location	-	-	

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