Mobile Application Design to Improve Self-Management in Type 1 Diabetes

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Abstract

Diabetes Mellitus Type 1 (T1DM) is a chronic disease that besides medication, requires establishing and preserving a healthy lifestyle. The majority of those who receive the diagnosis are young and need to learn quickly about the condition and its management. In their age they are also fond of mobile technology, which could work to their advantage since they are looking at a life long task of managing their health.

The Design Science research methodology was used throughout the project to develop a self-management tool for people with T1DM. This development spanned four design iterations and produced a high-fidelity prototype named *DiaLog* that encompasses user needs. Through user and expert evaluations the prototype can be seen as user friendly, meaningful, and useful.

The DiaLog application consists of five main sections; *Glucose measuring, My data, Diabetes information, Forum*, and *diet*. The application focuses on support, behavioural change, and disease education for young people with T1DM.

During the four design iterations data from people with T1DM, medical professionals, and IT experts were collected. Based on their feedback the prototype was developed and improved upon.

Additional functionalities could be incorporating more nutritional information, summary graphs showing eating habits and other desired functionalities. A gamification aspect could also improve motivation through challenges, competitions, and rewards based on personalised goals. Continuous Glucose Monitoring (CGM) technologies could potentially be integrated into the DiaLog application to streamline the monitoring process.

Abbreviations

T1DM - Diabetes Mellitus Type 1

T2DM - Diabetes Mellitus Type 2

SUS - System Usability Scale

NSD - Norsk senter for forskningsdata

UCD - User-Centered Design

CW - Cognitive walkthrough

UI - User Interface

RQ - Research Question

HCI - Human Computer Interaction

CGM - Continuous Glucose Monitoring

HbA1c - Glycated hemoglobin

WHO - The World Health Organization

GOe - Global Observatory for eHealth

GP - General practitioner

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Chapter 1

Introduction

Type 1 Diabetes Mellitus (T1DM) is a chronic autoimmune disease that is characterised by a dependency on insulin and hyperglycemia [6][7]. T1DM usually affects young people and it is estimated that 86.000 children under the age of 15 get this illness every year [8]. Although it typically occurs in younger people the disease can occur at any age [7]. It does not have a definite cause, but it is believed that there is a genetic predisposition and that it could be triggered by a virus infection or environmental factors [9] [6] [7]. Symptoms such as, frequent urination, thirst, hunger and fatigue, weight loss and impaired vision is characteristic for T1DM. It is diagnosed by a doctor measuring glycated hemoglobin (HbA1c) [10].

It can be difficult for many to receive the diagnosis of T1DM regardless of age. However, especially in young persons it can feel alienating and some hide their diagnosis [4]. It forces a lifestyle change, people with this disease need daily insulin replacement therapy [11], to lead a healthy lifestyle, and practise good self-management to achieve euglycemia. It is therefore important to provide support and education on the disease. As young people tend to have more experience and be more comfortable with mobile technologies, a mobile application to support self-management is promising.

This research project explores how a mobile application can be designed to improve self-management in T1DM in young people. This is done by developing a prototype using the Design Science framework which provides useful methods towards development and evaluation. Through data gathering and evaluations done with users, the needs and preferences of young people with T1DM have been identified. The development of this prototype was done in collaboration with another master student, Natasha Najafi who has researched self-management in Type 2 Diabetes Mellitus (T2DM); *En Mobilapplikasjon Designet for Selvhåndtering av Diabetes Mellitus Type 2*. This means that the artifact was developed in collaboration, however different aspects of the prototype are tied to the different illnesses and had to be developed individually.

1.1 Research Questions

These are the Research Questions (RQ) that will be answered during this research project:

RQ1: What needs and lifestyle preferences, identified in Diabetes Mellitus Type 1, can

be met by a mobile application to support young people?

RQ2: How can a mobile application be designed to improve self-management in Diabetes Mellitus Type 1?

1.2 Motivation

The rationale for this research project was both personal motivation and an interest in medical informatics. Through the initial research into this topic it was revealed that digital tools can make monitoring of glucose levels easier, more efficient, and help reduce some of the stress associated with diabetes. The prototype developed in this project was done in collaboration with Natasha Najafi. Creating two separate applications for diabetes type 1 and 2 were considered unnecessary since the two types have many similarities in terms of self-management. A good approach would be making one application where the user specifies which type of diabetes he or she has and the user interface is personalised based on user input.

1.3 Outline of Research Project

The following is an outline of the research project:

Chapter 2: Medical Theory presents what T1DM is, who might get it, treatment and management, and complications.

Chapter 3: Literature Review presents relevant literature and related work.

Chapter 4: Requirements presents ethical considerations, target group, research participants, and the different requirements established.

Chapter 5: Methods and Methodologies explains the different methods and methodologies used in this research project.

Chapter 6: Prototype Development presents the tools used in development as well as the different design iterations.

Chapter 7: Features of DiaLog presents the different features of the application and how the application can be used as a self-management tool.

Chapter 8: Evaluation presents the evaluation results from the various design iterations.

Chapter 9: Discussion goes through the methods, methodologies and prototype development. It also presents limitations in the research and answers the research questions.

Chapter 10: Conclusion summarizes the project and presents possibilities of future work.

Chapter 2

Medical Theory

This chapter presents what Type 1 Diabetes Mellitus (T1DM) is, who it may affect and why, how the disease is managed and treated, and possible complications.

2.1 What is Diabetes Mellitus Type 1

T1DM is a chronic autoimmune disease and is characterised by a dependency on insulin and hyperglycemia [6][7]. The body is attacking the insulin producing cells in the pancreas over months or years, resulting in the body no longer being capable of producing enough insulin [9]. Insulin is an essential hormone that regulates the amount of glucose in the bloodstream however, it also effects the metabolism of carbohydrates, fats, and protein. People with T1DM require insulin replacement therapy for the rest of their lives. Insulin must be taken as injections with either a syringe, often called pens, or with an insulin pump.

2.2 Who gets Diabetes Mellitus Type 1

T1DM usually affects young people and it is estimated that 86.000 children under the age of 15 get this illness every year [8]. Although it typically occurs in younger people the disease can occur at any age and in adults it is sometimes misdiagnosed as T2DM [7]. It does not have a definite cause, but it is believed that there is a genetic predisposition and that it could be triggered by a virus infection or environmental factors [9] [6] [7]. With no family history of T1DM a person has an approximate 0.4% risk of developing the disease, whilst someone with an affected mother has 1 to 4% risk. The chances of developing this illness is greater if the father is the one affected, approximately 3 to 8%, and if both parents are affected the risk is approximately 30% [11]. Symptoms such as, frequent urination, thirst, hunger and fatigue, weight loss and impaired vision is characteristic for T1DM. It is diagnosed by a doctor measuring HbA1c [10].

2.3 Treatment/Management

People with T1DM need insulin replacement therapy and daily injections of insulin is necessary [11]. The dosages are calculated based on the persons weight however the dosage is adjusted based on diet, physical activity, and if it is taken before or after meals. There is short-acting insulin which is taken with meals and long-acting insulin which is usually taken one to two times a day. People with this disease are also educated on carbohydrates and encouraged to aim for a low carbohydrate diet as this helps regulate glucose levels. Exercise is also encouraged as this lowers the need for insulin [11]. Insulin need is also dependant on age where an individual going through puberty, or with the development of obesity need larger doses of insulin. People with T1DM should monitor their glucose levels throughout the day, especially before meals and a few hours after [11].

Relatively recent technology such as Continuous Glucose Monitors (CGM) are becoming useful tools that may reduce some of the anxiety and stress related to hypoglycemia. Lucier et al. describes CGM as a tool with sensors that are "inserted into the subcutaneous tissue" where it measures glucose levels continuously and displays glucose readings in real-time [11]. This makes it possible to examine trends and this tool can alarm the user if the readings are too high or too low. They also state that a CGM can communicate with insulin pumps, and that there are a few different types that have a varied range of functionalities.

Research is currently being conducted on islet-cell transplantation which is a procedure where islets are taken from the pancreas of an organ donor and transferred into another person. These islets contain beta cells that begin to make and release insulin [12]. This is a promising future therapy, that gives hope for a life without the daily injections and perhaps a cure for this disease [11].

Euglycemia is the condition of having a good glycemic control, meaning a normal concentration of glucose in the blood. Achieving and maintaining this condition can cause severe anxiety and depression, and for a lot of people with T1DM the quality of life can be severely affected [11]. Majority of people living with T1DM will be able to live a relatively normal life. However, it is important to be aware of the effects this disease can have on the body. Many complications can be prevented by having good control over ones glucose levels with a healthy lifestyle and good self-management [9]. However this can, as mentioned cause great stress and a solid support system from both family and health care professionals is essential [11].

2.4 Complications

The complications associated with T1DM are varied in severity and T1DM has a high morbidity and mortality rate. Approximately 50% of people with this disease will throughout their lifetime develop a serious complication [11]. This disease is also a financial and psychological burden despite the advancements in treatment. Hypoglycemia and hyperglycemia are serious complications and can be fatal. There are also microvascular and macrovascular complications.

2.4.1 Hypoglycemia and Hyperglycemia

The state of having too much insulin is called hypoglycemia, and too little insulin is called hyperglycemia. The extreme state of hyperglycaemia is called diabetic ketoacidosis, which occurs when someone with diabetes has dangerously high glucose levels. This can, among other symptoms cause fatigue, anxiety, and confusion. Hypoglycemia, meaning too low glucose levels can among other symptoms cause, a very dry mouth, fatigue, and increased thirst. Severe cases of both states can lead to loss of consciousness which in turn can lead to a diabetic coma. If left untreated, a diabetic coma can be fatal [13]. Hyperglycemia results from having too little insulin and causes the body to break down fat for energy. By doing this the body accumulates acids called ketones which can cause brain swelling and shock [14]. Hypoglycemia can require treatment assistance as it can lead to unconsciousness or seizures. Increased hypoglycemic events can lead to less awareness towards the symptoms, which in turn increases the chances of these events recurring. Having recurring hypoglycemic events can make it increasingly difficult to achieve euglycemia as the counter-regulatory response becomes less effective by a reduction of glucose concentration [7].

2.4.2 Microvascular Complications

Microvascular complications relate to neuropathy, nephropathy, and retinopathy however T1DM can also affect cognitive function and the heart. According to Linda et al. hyperglycemia serves as the main risk factor when it comes to microvascular complications [7]. Further development of these complications can lead to kidney failure, blindness, and sensory and autonomic function [15].

2.4.3 Macrovascular Complications

Macrovascular complications relate to coronary artery disease, cerebrovascular disease and peripheral artery disease. These complications can cause stroke, heart attack and leg pain, which may lead to amputation [16]. Cardiovascular diseases, which the aforementioned diseases are, are according to Huang et al. the most common cause of mortality in T1DM by 44% [17].

Chapter 3

Literature Review

The background of this literature review is to gain an understanding of why self-management of T1DM can be difficult, and which tools and methods can help improve this. In addition, this review will give a perspective of the different needs that a person with T1DM has, both physical and psychological, thus aiding the development of an artifact to suit these needs. It will also look at already existing solutions to get an understanding of the market and which solutions were well received. The articles will be summarized, and the most relevant findings will be presented.

3.1 Relevant Literature

3.1.1 Experiences with Type 1 Diabetes Mellitus

Ida Marie

Ida Marie (14) has had T1DM for six years. Usually it is unproblematic, and she is not very worried for her health. However, she would have liked to not have to plan everything [18]. The main ways that T1DM has impacted her life is that routines surrounding meals and how carefully choosing foods became crucial. She describes her diabetes as tiresome, having to prepare every time she wants to go out and do something. She explains how she found it unpleasant to have it talked about in school, but that she has gotten used to people asking questions.

A hospital visit is necessary every three months, where she has appointments talking about her insulin and how she is doing. In general, she describes her experience with the public health care services as pleasant, but when she was young her experience was not as good. She thinks this might have to do with them not being considerate of her age. Despite her now pleasant experience, she still finds the hospital visits tedious.

Karoline Thorbjørnsen

Karoline Thorbjørnsen writes in the online Norwegian newspaper *bt.no* that T1DM is an unpaid full-time job, with a working day that never ends. She says that some people have an easier time managing their diabetes than others. Diabetes is different for everyone. She answers her own question on why diabetes is so difficult. Her answer is "To have an organs job in your own hands, for the rest of your life" [19]. She also

talks about how her diabetes correlates to her mental health, and if one of them suffers the other does to.

3.1.2 Psychological Aspects

Specialist in psychology Jon Haug writes in *NHI.no*: "There are particular psychological challenges for type 1 diabetes. They must be taken seriously and treated properly, in order to achieve the best quality of life possible." [20]. He explains how calculating dosages of insulin can get very complicated. When glucose levels and the need for insulin is affected by your emotions it is even more complicated.

Further in the article he discusses the prevalence of eating disorders among those with T1DM. Young girls seem to be most at risk of developing an eating disorder, 3-4 times more likely than girls without T1DM. They may inject too little insulin, which is effective for weight loss. However, this can have some very serious consequences, such as kidney failure and loss of vision [20].

T1DM is a job with no time off. Threats of complications can do more harm than good, making the person with this illness anxious and scared. Haug states that in the doctor appointments, too little time is spent on how the patient is doing psychologically [20].

3.1.3 Factors Affecting the Ability to Practice Self-Management

A study carried out to identify factors affecting self-care performance shows that management of T1DM in adolescence is a challenge not only for the patient but also parents and the people who help treat this illness [4]. The main take back of this study is the evidence that supports the importance of education for all the actors involved. This involves not only the cause of the illness, considering the "Why me?" questions, but also the treatment. Depending on cultural and religious beliefs, the spiritual aspect can also be very important in how one educates about this illness. Spirituality can serve as a motivator to improve self-management. The participants express that doctors do not take this into consideration [4].

Some participants noted that they hid their diabetes from their friends, fearing that their connections to them might be affected. In addition, the stigma around this illness was also a contributor to hiding it. Lack of self-efficacy was also considered by all the participants to be the main reason for weak self-management. Table 3.1 from the study shows the categorized responses of the participants.

Application of PEN-3: Diabetes Self-Care Needs Assessment Results

Domains	Positive	Existential	Negative
Perceptions	Awareness of self-care behaviors; Attitude of patients towards disease; Attitude of patients, parents and physicians towards the effects of spirituality on self-care	Awareness about the complications of the disease	Lack of knowledge of patients, parents and community members about the disease and its causes; Attitude of patients and parents towards reasons for becoming sick (Why me?); Hiding the disease; Stigma; Low self-efficacy
Enablers	Easy access to needed medical services (insulin, blood glucose test strips, …)	Use of traditional medicine	Limited education; Fear of diabetes complications; High cost of blood glucose test strips; Lack of educational therapeutic curricula based on spirituality; Ignoring the role of spirituality in treatment and self-care by physicians, patients and their families
Nurturers	Influence of maternal support	Appreciating their health and fitness by seeing our sufferings	Conflict between parents and patients; Family lifestyle; Poor interaction and communication of patients with each other and with their family members

Table 3.1: Categorization of responses [4]

Polonsky writes that effective self-care requires effort and caution. The daily routines are important and if someone does not adhere to these routines, they may be labelled as unmotivated or in denial. These labels are often wrong, and the main issue lies in personal obstacles. Many people with diabetes in general find that self-management is simply not worth the effort [21].

Depression is a common complication among those with diabetes, they are 1.5 to 2 times as likely to suffer from depression as those without diabetes. This can be a major obstacle in self-management. Proactive treatment of depression and guidance to manage the diabetes can help people with self-management. A survey done in 2005 shows that more than 40 percent felt they had poor mental health, where many felt that the standards set by doctors and nutritionists were unrealistic. Self-management can be improved by allowing people with diabetes to openly vent about their hardships and struggles with this illness. A positive relation to health professionals is also important, this also includes realistic goals for the individual in terms of their treatment and self-management [21].

3.1.4 Self-Management in Type 1 Diabetes

A survey that was done in 2017 set out to investigate the effect of diabetes applications on diabetes self-management. Glucose monitoring and dietary logs were most commonly used functions, and they found that one in three participants who had T1DM would "first consult Facebook groups, diabetes smartphone applications or the inter-

net whenever they have concerns regarding their diabetes self-management." [22]. The main results from this survey was that they found that self-management improved when using applications. These applications would improve the participants behaviour regarding self-care.

A study carried out in 2019 by Park and Jeon, evaluated an application for self-management for people with diabetes [5]. They measured the before and after effects of using this application. Table 3.2 shows the comments from the participants.

Application of PEN-3: Diabetes Self-Care Needs Assessment Results

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Nurturers	Influence of maternal support	Appreciating their health and fitness by seeing our sufferings	Conflict between parents and patients; Family lifestyle; Poor interaction and communication of patients with each other and with their family members

Table 3.2: Comments from participants [5]

The main difference found in the before and after of the intervention of the study were social motivation in self-care, as well as the self-care behaviour. The application significantly improved both aspects. The social motivation was improved by the ability to communicate with other users about struggles, and the self-care behaviour was improved by the glucose monitor that did not need manual input. However, this study did not find any significant improvement in personal motivation or behavioural skills [5].

3.2 Human-Computer Interaction

Human-Computer Interaction (HCI) is a discipline studying the communication between computers and humans using interactive interfaces. It focuses on the design, evaluation and implementation of computer technology. It is a multidisciplinary field that covers aspects such as computer science, human factors engineering, and cognitive science. Beginning as a field focusing on computer science it has now broadened and

diversified its focus by taking into account accessibility, collaboration systems, social computing, games, health applications and much more [23]. The principles and practises found within this field will be applicable to this research by guiding the design process.

3.3 mHealth

The World Health Organization (WHO) Global Observatory for eHealth (GOe) defines mHealth as medical and public health practice supported by mobile devices [24]. mHealth applications can serve as tools to promote behaviour change, treatment, and adherence to routines by personalising goals, notifications, and gamification. These applications can help with forgetfulness and they can be educational. By providing disease and treatment related education it may provide value to the patient when communicating with healthcare providers during shared decision making [25].

In *What is the clinical value of mHealth for patients?* Rowland et al. divides mHealth applications into four categories as follows [25]:

- support clinical diagnosis and/or decision making;
- improve clinical outcomes from established treatment pathways through behavior change and enhancement of patient adherence and compliance with treatment;
- act as standalone digital therapeutics; and
- primarily to deliver disease related education.

The authors predicts that mHealth technologies can serve as tools in patients managing their own health integrated into digital care plans constructed by their healthcare provider [25].

Many people use digital tools to check for symptoms when suspecting an illness. The accuracy of these applications vary depending on emergency status and the area of emerging symptoms, such as knees and hands. Emergency cases have a higher accuracy compared to non-emergency cases and these symptom checker applications may lead to an increase in unnecessary non-emergency consultations [25].

Applications made with behavioural change in mind have shown to improve glycemic control in people with diabetes, improve weight loss when used optimally, and improve treatment of chronic illnesses after long-term non-adherence. Functionalities such as reminders, customisable medication regimes and logs have been given positive feedback [25].

Applications functioning as digital therapeutics supports self-management in treatments such as cognitive behavioural therapy. Functionalities that might support this are mood- and symptom tracking. Although these applications might improve self-management they currently do not replace face-to-face therapy [25].

Education aimed applications can provide patients with better disease understanding, which in turn can improve decision making and communication with health care

providers. Patients can better express worries and concerns, and also feel more empowered in the patient - health care provider relationship.

In T1DM self-management strategies are important in improving quality of life through euglycemia. Mobile applications are becoming increasingly popular in people with diabetes when managing their condition and mHealth technology can improve quality of life [6]. This is particularly evident in T2DM, however in T1DM the results are more varied. Factors such as age and intervention time has been linked to the effectiveness of mHealth self management tools. Wang et al. explains that there is a significant change in HbA1c in adults, but not in the youth group that they analyzed. In addition, an intervention time longer than six month showed a significant decrease in HbA1c, whilst shorter intervention time did not. Wang et al. also concludes that longer intervention time produced better glycemic control [6].

In a study conducted by Conway et al. the user preference in mHealth applications for diabetes was explored [26]. They found that the majority of users thought that patient education would be useful and that this feature was scarcely implemented. In addition they found that younger people were more enthusiastic towards social media integration compared to older users. Conway et al. also expressed how mHealth applications can aid in web-based interventions when it comes to accessibility and that many users prefer mHealth applications to manage their diabetes. However, age, gender, and diabetes type were factors that affected whether or not a person with diabetes would prefer the use of an mHealth application or not. They found that women over 56 years were significantly less likely to show a preference for a diabetes management application. With this in mind it would still be important to not alienate sub-groups in the population. The study is concluded with a note that the potential of mHealth systems is vast and that they could "empower patients, increase patient choice, improve outcomes and provide service in a different and sustainable way." [26].

3.4 Existing Solutions

Looking at existing solutions and how they have been received gives an understanding of what functionalities work well and which do not. There are countless applications that vary in complexity, ranging from only manual input of glucose levels without any other functionalities, to input via Bluetooth, with functionalities such as food tracking, bolus calculator, and activity tracking. Reviews and rankings of applications that vary in complexity in the Play Store were explored to see which solutions were well received. The applications downloaded and tested were *Contour, mySugr, Diabetes:M* and *diasend*. The ratings, reviews and main functionalities are taken from the Play store.

mySugr

- **Rating:** 4.7
- **Negative reviews:** Must upgrade to premium to properly test it. Wish it could be paired with activity trackers. Sounds are annoying, and the monster is childish.
- **Positive reviews:** Well organized and it is easy to keep track of food. The bolus calculator is very useful.
- **Main functionalities:** Can log medications, carbohydrates, activity, moods, emotions, and more. Shows estimated HbA1c and glucose trends. Has a bolus calculator. Can create a report that can be shared.
- **Limitations:** Some features require a premium account.
- **Unique functionalities:** Feedback based on trends and tracks mood and emotions. Has achievements and a bolus calculator.

Figure 3.1: Glucose measuring page on the mySugr application

Diabetes:M

- **Rating:** 4.5
- **Negative reviews:** Not in Norwegian and does not save log in data if the phone runs out of battery.
- **Positive reviews:** Reliable and precise.
- **Main functionalities:** Can create reports that can be shared, shows trends, food intake and activity logs, and supports automatic input.
- **Limitations:** Many useful functionalities require a premium account. Cannot choose your own safe glucose levels.
- **Unique functionalities:** Bolus advisor and a vast food database for food logs.

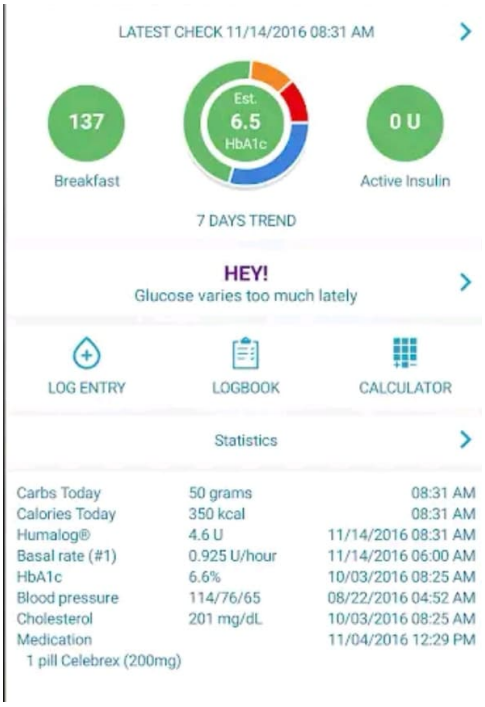


Figure 3.2: Glucose measuring page on the Diabetes:M application

Diasend

- **Rating:** 2.8
- **Negative reviews:** No option to upload CSV files
- **Positive reviews:** N/A
- **Main functionalities:** Can share data with a clinic, has graphs to show trends, compatible with glucose devices that support automatic input, can choose your own safe levels of glucose.
- **Limitations:** Lacks documentation which makes it somewhat difficult to use
- **Unique functionalities:** -

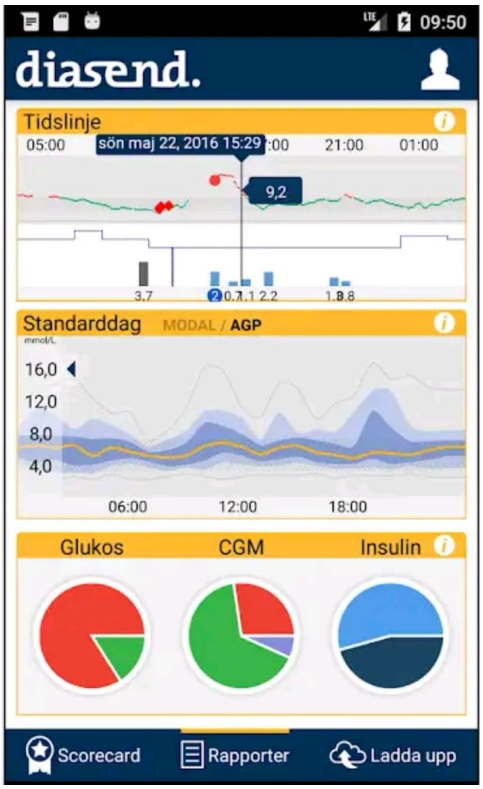


Figure 3.3: Report page on the Diasend application

Contour

- **Rating:** 2.8
- **Negative reviews:** Unstable and crashes a lot, cannot delete logs, unorganized, and issues with Bluetooth device connecting to the app.
- **Positive reviews:** A good tool which gives good control.
- **Main functionalities:** Shows daily logs which include activity, food, medication and notes. Shows weekly and monthly averages. Automatic input via Bluetooth. Shows trends through graphs with advice. Can create a report that can be shared.
- **Limitations:** Plain design and difficult to navigate.
- **Unique functionalities:** Has its own Bluetooth device and gives advice based on trends.

Figure 3.4: Trend view on the Contour application

Based on the reviewed applications, there is no single applicationthat fully encompass all the functionalities that the literature review points to as being wanted by people with T1DM, nor by the reviewers in the Play store. However, this has given insight into some functionalities that could be incorporated and evaluated. Functionalities such as a bolus calculator and estimating HbA1c seems to be well received. The importance of usability is also showcased through this, where stability, navigation and language were something that was pointed out by the reviewers as not being optimal.

Chapter 4

Requirements

This chapter presents the ethical considerations made in this research, as well as the approval from the Norwegian Centre for Research Data. The target group, users, IT experts and medical professionals are also presented. Lastly, the requirements established based on the literature review and initial interviews are presented.

4.1 Research Ethics

Ethical considerations have been made where this research has been approved by the Norwegian Centre for Research Data (Norsk senter for forkningsdata - NSD). In addition, all participants have been informed of their rights to anonymity, confidentiality and ability to withdraw from the research by signing an informed consent form. The NSD approval can be found in Appendix A, the informed consent forms in Appendix B, and the interview guides are in Appendix C.

4.2 Target Group

The target group for this research has been young adults between 18 - 30 living with T1DM in Norway. This is presented in Table 4.1. This age group was chosen to explore which functionalities a somewhat newly diagnosed person would find useful. In addition, since T1DM is usually diagnosed from early childhood until the age of 30 this age group made sense for the research. People younger than 18 were not included in the research since data gathering form minors would require parental consent. There is a higher number of female representatives in this research, although both female and males were required. Since most participants were recruited through personal connections it was difficult to get an equal distribution. All participants also had to be comfortable with, and have experience with mobile applications.

Gender	Male/Female
Age	18-30
Diagnosis Established	3 - 5 years
IT Experience	Uses a smartphone and has knowledge about mobile applications and social media

Table 4.1: The application's target group

It is necessary to mention that although the intended target group was 18-30 the current restrictions with Covid-19 made it very difficult to recruit participants. Therefore, the initial interviews have also been conducted with people above the intended age group. These participants were still able to give useful feedback on which functionalities would have been useful when they first got the diagnosis.

4.3 Research Participants

4.3.1 Users

The users for this research were recruited through social media and personal connections. This resulted in a total of ten users. The initial interviews were conducted with five participants, two male and three female. Usability testing was done with one male and four female participants, and two of the female participants were part of a case study.

4.3.2 IT Experts

Eight IT experts contributed in different iterations to the evaluation of the prototypes. Two experts evaluated using a cognitive walkthrough in the first iteration, whilst three experts evaluated using System Usability Scale (SUS) in the second iteration. The last three experts evaluated using SUS and Nielsen's heuristics in the fourth iteration. Four female master students and two male bachelor students were all studying Information Science, whilst one male and one female participants were studying Information and Communications Technology.

4.3.3 Medical Professionals

The medical professionals were a nurse from Stavanger University Hospital and a general practitioner from Oslo. These participants were recruited through personal connections and took part in semi-structured interviews in the second iteration.

4.4 Establishing Requirements

Requirements are established by getting to know the users and by identifying their needs. The two different sets of requirements are *functional* and *non-functional* requirements. The functional requirements are concerned with what the product itself will do whilst the non-functional requirements captures the characteristics and/or constraints of the product [27].

The requirements were established through the literature review and the initial semi-structured interviews with users and medical professionals. The exploration of existing applications and their reviews, as well as the articles revolving self-management, gave insight in which functionalities were useful and which were viewed as superfluous by the users. Participants in the semi-structured interviews deepened this insight by stating which functionalities they would actually use, and the medical professionals gave a better understanding of which functionalities could be beneficial from a treatment perspective.

4.4.1 Functional Requirements

The application needs to:

1. Store necessary data the user needs to remember
2. Provide a platform for support and discussion
3. Show an overview of trends
4. Provide simple recipes based on user input
5. Provide important information about diabetes
6. Provide access to system settings based on user needs

4.4.2 Non-functional Requirements

The application must:

1. Be user-friendly (easy to use)
2. Be satisfying to use/look at
3. Be designed for both iOS and Android
4. Have no bugs or faults
5. Have a response time no longer than two seconds
6. Give feedback in the form of popups and alert messages
7. Structure and sort elements within the forum based on time of posting

Chapter 5

Methods and Methodologies

This chapter contains methodologies and methods used to gather data and evaluate the artifact that this research project has produced. Steps in prototype development are explained, persona and evaluation methods are presented in detail.

5.1 Design Science Research

Design science research aims to solve real problems that are present in the real world with satisfactory results through man-made artifact design [1]. The implication of this is that an optimal solution to a problem in a simplified version of the world, will not necessarily be the optimal solution in the real world. Thus, a satisfactory solution that will work well in the real world is the aim. By designing an artifact that can aid in this problem solving, and validating it to ensure that the solution actually will solve the intended problem, this can contribute to improve theories and better the human performance [1]. The resulting artifact of this research will not be a finished solution to the problem space presented, but will serve as a proof of concept. The main goal of this research is to contribute to the medical informatics field by highlighting the needs of people affected by T1DM and proposing a solution to improve self-management. Thus, hopefully be able to improve human performance in self-management and solve some of the problems associated with this issue.

In design science relevance and rigor are two essential factors. Their relationship is shown in Figure 5.1. Relevance provide organizations with research that are of value to them. Thus, the professionals in these organizations may use this in problem solving. Rigor is an essential factor in all research as it determines its validity and reliability and can help generate knowledge [1].

Figure 5.1 also shows the knowledge base and the environment. The knowledge base, which can be seen as the environment where accumulated theories and artifacts that have been discovered, developed or used by the researchers. These elements are considered the raw material to be used in the research/development. The knowledge base is not always sufficient, and researchers may rely on trial and error or their own experience. The environment, or problem area, is where the problem is observed and where the idea of research stems from. Within this environment we find the people that it affects or contains, organizations, and the technology that it uses. This environment can help strengthen the knowledge base and supports the development of artifacts [1].

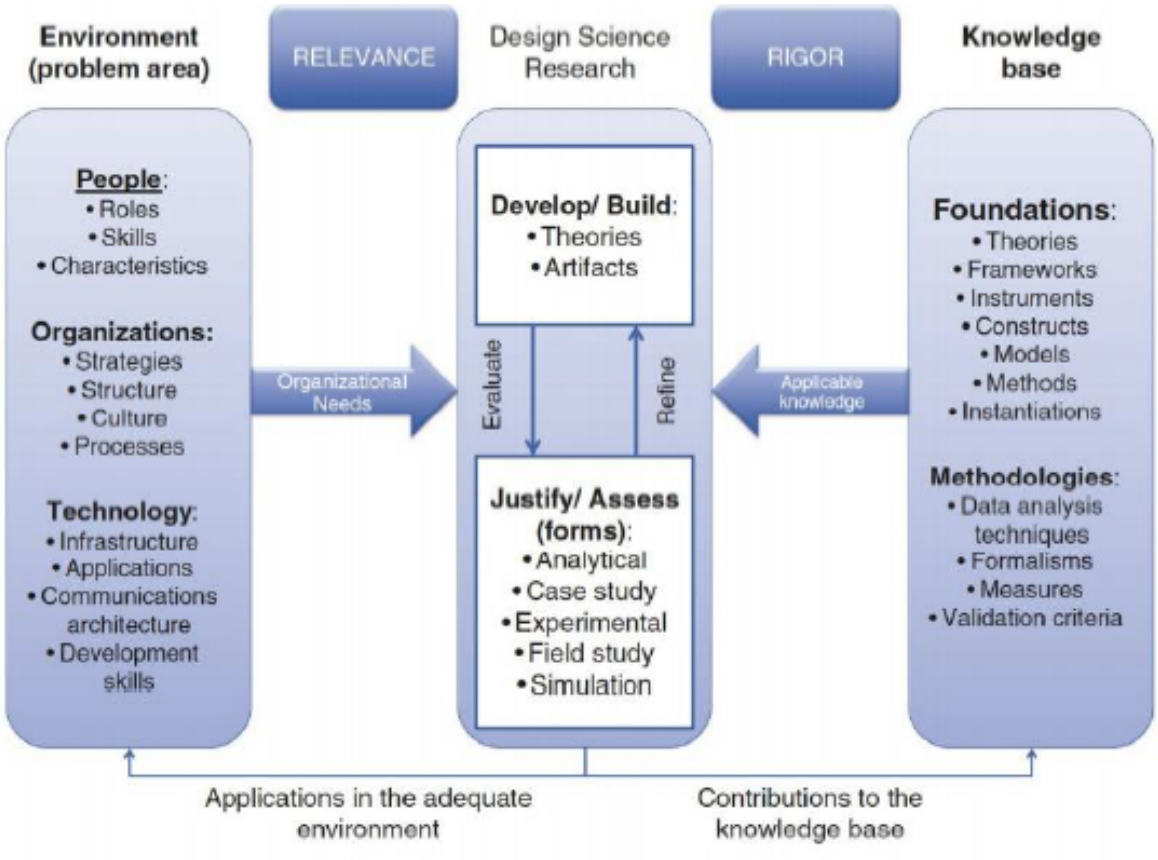


Figure 5.1: Design Science Research Cycles [1]

Seven essential criteria have been defined by Hevner et al. to assist in design science research. The essentiality of these criteria are based on the demand of this field; the development of a new artifact with the intention to solve a specific problem [1]. These criteria are [28]:

1. Design as an artifact
2. Problem relevance
3. Design evaluation
4. Research contributions
5. Research rigor
6. Design as a search process
7. Communication of research

These criteria all relate to each other, where the first criterion simply states that there must be a creation of a new artefact and the second criterion demands that this artefact tries to solve a specific problem. This artefact then needs to be evaluated, which is criterion three. The fourth criterion is concerned with increasing knowledge within the specific field and to clarify for professionals how this artefact can be used to solve the intended problem. Within the fifth criterion the research rigor is evaluated to determine its validity and to ensure that the artefact has been developed according to its criteria. The sixth criterion is concerned with that the researchers involved, research the problem

area and previously used methods to thoroughly understand the problem to be able to make use of existing solutions. Finally, the seventh criterion relates to the research results that should be shared with similar fields or other interested parties [1].

Hevner et al. proposed a checklist that would be more specific by providing eight questions (Table 5.1) to ensure that the key aspects of design science research are covered [28].

	Questions
1	What is the research question (design requirements)?
2	What is the artifact? How is the artifact presented?
3	What design processes (search heuristics) will be used to build the artifact?
4	How are the artifact and the design processes grounded by the knowledge base? What, if any, theories support the artifact design and the design process?
5	Which evaluations are performed during the internal design cycles? Which design improvements are identified during each design cycle?
6	How is the artifact introduced into the application environment and how is it field tested? What metrics are used to demonstrate artifact utility and improvement over previous artifacts?
7	What new knowledge is added to the knowledge base and in what form (e.g., peer-reviewed literature, meta-artifacts, new theory, new method)?
8	Has the research question been satisfactorily addressed?

Table 5.1: Checklist for Design Science Research

5.2 Interaction Design

The main motive in interaction design is to enhance the user experience by reducing the negative factors that affect the experience, such as frustration and annoyance, and amplifying the positive factors, such as enjoyment. Preece et al. reduce, in *Interaction Design: Beyond Human-Computer Interaction*, the field of interaction design into one key concept; being the development of interactive artefacts that from the users perspec-

tive will be easy, effective and enjoyable to use [27]. Therefore, usability is a crucial aspect in design development. Incorporating the user in the design process makes this a more achievable task. Some issues may be overlooked by the developers or other key features can be discovered when involving the intended users in the development.

5.2.1 User-Centered Design

User-centered design (UCD) is developing with the user and their needs in mind, and involving the user in the development process. Gould and Lewis presented in *Designing for usability: Key principles and what designers think.*, three main principles in regard to UCD that would ensure improved usability. These principles are as follows [29]:

1. Early Focus on Users and Tasks:
   By studying the users behaviour, attitude, anthropometric and cognitive characteristics the designers get a deep understanding of their users and who they are.
2. Empirical Measurement:
   Prototypes or simulations should be developed in order for real work to be carried out. The users should use these prototype or simulations, and their interactions, reactions and performance should be recorded and analysed.
3. Iterative design:
   Issues found during user testing must be fixed and changes must be made to continue the user testing. This means that this process will be iterative and will be repeated as many times as necessary.

UCD is an iterative design process with four phases, as shown in Figure 5.2. By understanding the context of which the design will be used it will become easier to define which requirements that the design must fulfil, both functional and non-functional. Part of understanding the context is also knowing the intended target group for the product. The requirements that are set supports the further development of the product, as they stay unchanged during the process. The understanding of context is established through data gathering and analysis. After the requirements have been set it is necessary to produce some design solutions to evaluate if these solutions satisfy the users needs and the established requirements. These design solutions are usually either conceptual or concrete designs in the first iterations and are further developed into low- and high-fidelity prototypes. The evaluation of these solutions measures the usability of the design to see if further iterations are necessary. Since this is an iterative process, the design solutions can be polished until the result is satisfactory. By involving the users in this iterative process, the final solution should be highly usable and accessible to the user group [2].

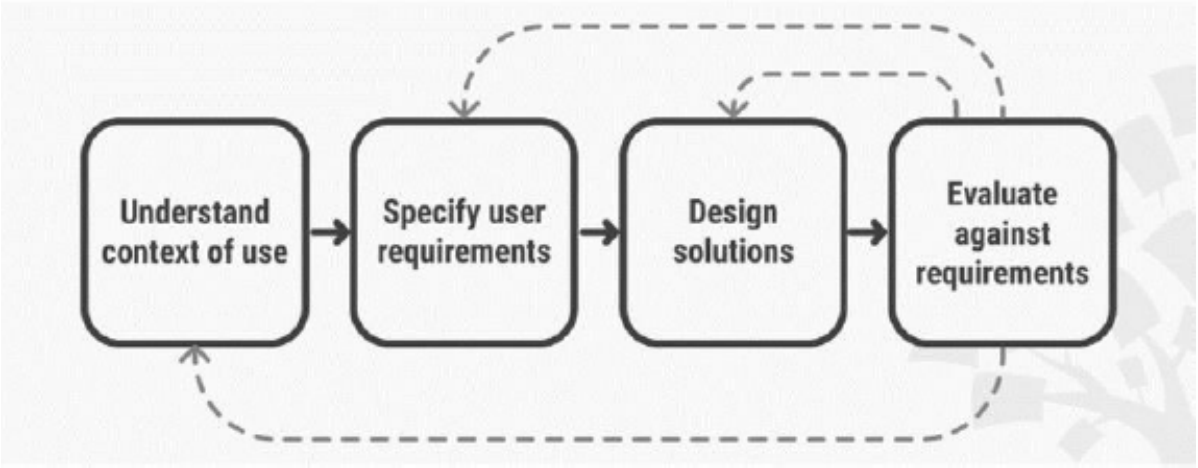


Figure 5.2: The four phases of user-centered design [2]

5.2.2 Conceptual Design

Conceptualizing a design is transforming established requirements into a conceptual model of the application. This type of model shows functionalities, appearance and how the user can interact with the application [27]. Such models can, among other ways, be represented by simple sketches or low-fidelity prototypes, making them useful in early stages of development. This research will use a low-fidelity prototype to present the conceptual model for the application, and personas to represent realistic users. Thus, the initial requirements and constraints will be set, making further development smoother and more efficient.

5.2.3 Persona

Personas serve as a representation of a typical user based on a realistic image of people. They are a part of UCD as they help the developers make design decisions and help visualise that there are real people that will be using their product. The persona should not describe real people, but have realistic characteristics. Such characteristics could be hobbies, skills, goals, and frustrations. They should also have background information such as age, name, family, education, etc. By creating a persona the developer can keep the user and their needs in mind, by imagining what the persona would do in various situations with the developed product [27].

5.2.4 Design Principles

Design principles are used in the development process of the design and aid interaction designers during this process to ensure a good user experience. These principles are abstractions that promote thinking about different perspectives and uses regarding the design, which in turn can improve the interactions by limiting frustration and confusion. The following principles were presented by Preece et al. in *Interaction Design: Beyond Human-Computer Interaction* [27].

Visibility

Visibility in a design is of high importance and the way different functions are laid out and displayed in a design will highly affect its usability. Increased visibility will make it clear to the user what actions are available and what they can do to move along in the design.

Feedback

Feedback in a design is crucial for the user to realize that an action has been successfully accomplished. It also tells the user which action has been done and allows the user to continue their activity. Feedback comes in many forms and can be combined if needed. In addition, it can also aid as visibility in user interaction and can be important for accessibility. The various forms of feedback are audio, tactile, verbal, and visual.

Constraints

Constraints in a design manages the available interactions that a user has. The aims with such constraints are, among others, to prevent and minimize mistakes, specify usage and show relation between information. Constraints can be physical, graphical or textual.

Consistency

Consistency in a design affects the aesthetic of the interface as well as the intuitiveness of the design. Keeping a design consistent, refers to using similar elements for similar tasks and similar operations should be carried out in the same fashion. This avoids confusion and frustration and makes the design easier to learn and use. Consistency can be distinguished between internal or external applications, meaning that a design can have consistent features within the same design (similar elements), or that one design is consistent with another design (use established symbols or metaphors to represent the same function).

Affordance

Affordance in a design refers to the design attributes or objects that let a user understand its functionality. Such attributes can be buttons, scroll bars or links. Just by looking at these attributes or objects the user will have a clue about how to use them without further instructions.

5.2.5 Usability Goals

Since usability plays an important role in the development of interactive artefacts, testing the artefact with specific usability goals can be very beneficial in the development.

Preece et al. break usability down into the following six goals [27]:

1. Effectiveness refers to the products performance in doing what it is supposed to do. Meaning that the product functions in a way that allows the user to interact with it in an efficient manner, such as accessing available information and being able to do their work efficiently.

2. Efficiency refers to the products capability of supporting the user in their tasks. Having minimal number of steps to perform a common action increases the efficiency of the interaction.

3. Safety refers to how the product minimizes the risks of errors and ways of recovery should a mistake occur.

4. Utility refers to the products functionalities. High utility would in this case mean that the product offers functions that coincides with the intended use of the product in a way that helps the user reach their goal.

5. Learnability refers to how complex the product is. A system should be easy to learn how to use, meaning that a user should have to spend a minimum amount of time figuring out the different functionalities.

6. Memorability refers to how easy it is for the user to remember how to use the product and its functionalities after some time once they have learned it.

By using such usability goals, the interaction designer has a tool to assess the usability of different aspects of the artefact through various evaluation methods. Some of these methods are covered in Section 5.5. Through the exploration of such usability goals it becomes easier to weed out the obvious errors or shortcomings of the artefact before it is released to the public.

5.2.6 Prototype

A prototype can be many things and take many forms, from a hand-drawn concept to a complex system. They are made to be tested, evaluated and interacted with to explore if the proposed solution would be usable. However, there are limitations to prototypes, all functionalities are usually not implemented and some characteristics are more emphasised than others [27]. They are useful when exploring different design ideas and can be divided based on levels of fidelity, from low- to high-fidelity. This research project will go through three different levels of fidelity during prototype development.

Low-Fidelity

Low-fidelity prototypes do not resemble the final product and are very limited in functionality, which makes them not suitable for discovering usability issues. They are useful for exploring layout options and are quick to make, which also means that they are easy to modify. Usually the initial ideas are sketched out and further developed into wireframes or mockups.

Mid-Fidelity

Mid-fidelity prototypes are a in between of low- to high-fidelity prototypes meaning that they have mostly the correct content and layout. However, they still lack some elements and do not have full functionality. These prototypes can be useful in evaluation as the design and functionalities are not "set in stone".

High-Fidelity

High-fidelity prototypes are very close to the final product and they provide higher functionality and are easy to evaluate when looking for usability issues.

5.3 System Development Method

Considering how this research was going to follow a UCD approach an agile development method seems the most fitting. By dividing the development into timestamped iterations that end with evaluations, backtracking can be minimized, and the workflow should be consistent. Each iteration will include data gathering, some work on a prototype, followed by an evaluation of the work. To keep an overview of the backlog and the finished iterations, the tool Trello was used [30]. This is a tool that represents a board with different "tabs" that can be specified as "to do", "in progress", "finished", etc. By using Trello this research followed the Kanban development method. This is a system development method that is comprised of cards that are divided into lists depending on their status in the workflow. This workflow system limits the amount of cards that can be processed at a time, which ensures a steady workflow [31].

5.4 Data Gathering

This section will present which data gathering methods that were used during the different stages in the prototype development. Since data gathering is a crucial part in establishing requirements and in evaluation, the type of data gathering method becomes important. For establishing stable requirements interviews and a literature review were conducted. In the evaluation of the prototype data gathering were done using usability testing, system usability scale, and by carrying out a heuristic evaluation. Both quantitative and qualitative data were collected in order to get a general overview of the various issues and needs that people with T1DM have.

5.4.1 Literature Review

A literature review acts as a summary of current knowledge and relevant information such as data, methods, and research approach. Conducting a literature review involves gathering and analyzing relevant published articles, books, reports, and other information relevant to the specific research topic.

5.4.2 Interviews

Interviews can be useful in gathering data from specific groups of people. The type of interviews used in this research were semi-structured interviews. Semi-structured interviews allow both open and closed questions and is a combination of both structured and unstructured interviews [27]. Thus, the interviews are rather flexible but will still have some structure in order to get answers to specific questions. The type of data gathered from such interviews are both qualitative and quantitative. This method was the most fitting for the intended target group of this research, as health can be a sensitive issue. By having some predefined questions, answers can be more specific on questions concerning the applications functionalities. The more open questions leave room for the participants to expand on topics they believe to be important, that may have been neglected. This provides an overall picture of what they would want in a self-management application. The people interviewed were people with T1DM and medical personnel involved in T1DM treatment.

5.4.3 Case Study

A case study has an aim to study an individual or a community on a deeper level. It is considered to be an intensive method that gathers qualitative data [32]. Multiple-case studies were used to gather stronger and more reliable data within the intended user group. This multiple-case study included two participants with T1DM, where the data gathered were analysed and compared.

5.5 Evaluation

This section presents the evaluation methods that were chosen for this research. Evaluation is a crucial step when assessing the usability of a product and whether it has satisfied the goals and requirements that were set. It is also useful in evaluating the user experience of the product in terms of how enjoyable and motivating the interaction is. By carrying out such an evaluation the interaction designers can improve the design where it is needed and make changes if necessary. The cognitive walkthrough were carried out by IT experts on the low-fidelity prototype, as usability testing on a non-interactive prototype can be challenging. The usability testings that were conducted were carried out by people with T1DM. The System Usability Scale (SUS) was conducted with both people with T1DM and a few IT experts, who also carried out a heuristic evaluation. This provided enough feedback and information to develop a usable high-fidelity prototype.

5.5.1 Cognitive Walkthrough

A cognitive walkthrough is an evaluation method used to assess the usability of a system or product. It simulates a problem-solving process from the user's perspective by going through tasks step-by-step in human-computer-interaction [27]. It is an evaluation method that is both fast and cost effective, and can be done early in the design

process. Only the pre-defined tasks are used in the usability evaluation, and any other possible tasks and functionalities are not evaluated during the walkthrough [33].

5.5.2 Usability Testing

Usability testing aims to uncover problems and obstacles related to how usable a product is. Such testing is often done in a controlled setting with predefined tasks which allows the evaluators to control what users do, and the environment around them, to optimize the users' performance. It is important to note that it is not the user that is being tested, but the usability of the product. The usability test does not only test how usable the product in itself is, but also if it has achieved the tasks that it was designed for [27]. The testing sessions are usually recorded and followed by an interview or questionnaire to find out how users truly feel about the product.

5.5.3 System Usability Scale

The System Usability Scale (SUS) was developed as a measure for effectiveness, efficiency, and satisfaction of a product. It is a ten-item scale which gives an overall view of the subjective usability. SUS is a Likert scale, 1 being strongly disagree and 5 being strongly agree, where the ten items are questions with corresponding boxes [34]. Figure 5.3 shows the SUS scores and their associated adjective and grade. SUS is usually used after the participants have tested the system that is under evaluation. The interpretation of the scoring can be complex, where anything above 68 is considered above average. John Brooke explains the calculations of the scoring like this [34]:

> *To calculate the SUS score, first sum the score contributions from each item. Each item's score contribution will range from 0 to 4. For items 1,3,5,7, and 9 the score contribution is the scale position minus 1. For items 2,4,6,8 and 10, the contribution is 5 minus the scale position. Multiply the sum of the scores by 2.5 to obtain the overall value of SUS. SUS scores have a range of 0 to 100.*

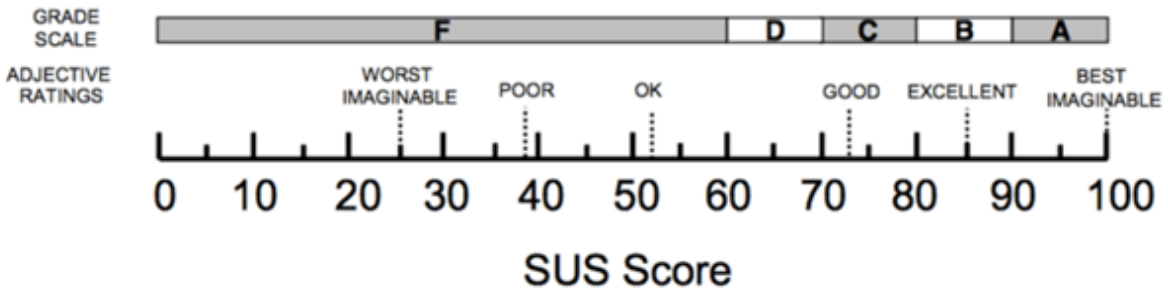


Figure 5.3: SUS scale

5.5.4 Nielsens Heuristic Evaluation

A systems usability can also be evaluated using different heuristics. It is a method that was developed by Jakob Nielsen and his colleagues and was further modified to fit different systems. This type of evaluation uses experts guided by heuristics to evaluate user interfaces against various tried and true principles. These revised heuristics are cited from Preece et al. as follows [27]:

Visibility of system status

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

Match between system and the real world

The system should speak the users language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

User control and freedom

Users often choose system functions by mistake and will need a clearly marked emergency exit to leave the unwanted state without having to go through an extended dialog. Support undo and redo.

Consistency and standards

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

Error prevention

Even better than good error messages, is a careful design that prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

Recognition rather than recall

Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialog to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

Flexibility and efficiency of use

Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

Aesthetic and minimalist design

Dialogues should not contain information that is irrelevant or rarely needed. Every extra unit of information in a dialog competes with the relevant units of information and diminishes their relative visibility.

Help users recognize, diagnose, and recover from errors

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

Help and documentation

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

Chapter 6

Prototype development

This chapter presents the tools used in the development process of the prototype, as well as an in depth presentation of the various iterations.

6.1 Development Tools

6.1.1 Trello

Trello follows a Kanban style as a web based application. It allows the creation of boards that can be shared with multiple people. These boards contain cards that can be put into named lists. Each card can be assigned to different members on the board and the cards can be given colors to define priority [30].

6.1.2 Hubspot - Make My Persona

Hubspot provides the persona tool "Make My Persona" that is aimed at companies to help illustrate a buyer persona [35]. It has a selection of avatars and a few pre-made traits that can be changed to fit your needs. It generates a persona card based on your chosen traits and information.

6.1.3 Balsamiq

Balsamiq is an online wireframing tool for web and mobile wireframe creations. It makes it possible to reproduce the experience of sketching on a whiteboard, but with a computer [36].

6.1.4 Figma

Figma is a collaborative browser-based prototyping tool for interface design. It has both Web, Android, and iOS presets and allows the user to upload images to be used as backgrounds and icons [37].

6.1.5 AdobeXD

AdobeXD is a vector-based User Interface (UI) tool used for prototyping. It also has a mobile application where you can preview your design, which is useful in usability-testing [38].

6.2 Iteration Overview

Table 6.1 shows a summary of all the iterations during the research in terms of stages, method and outcome. Each iteration follows the UCD process.

Iteration	1	2	3	4
Define/Redefine	Define Literature review	Redefine after experts	Redefine after usability-testing and SUS	Redefine after case study, usability testing and SUS
Fidelity	Low-Fidelity	Mid-Fidelity	High-fidelity	High-fidelity
Method	Interviews with people with T1D	Interviews with medical professionals	Case study	
Evaluate	Evaluated with CW by experts	Usability-testing with users and SUS with experts	Usability testing and SUS with users	SUS with users SUS and Nielsens heuristics with experts

Table 6.1: Iteration overview of the four design iterations

6.3 Collaboration

The prototypes developed in this research were created in collaboration with Najafi from low- to high-fidelity. The system development process has therefore followed the method Kanban. We used the tool Trello in our collaboration which is seen in Figure 6.1. The Trello board covers all the design iteration for both projects and the contribution from each of us is shown as members on each card. It is divided into three categories of what needed to be done, what was in process, and what had been finished. The different tasks were divided based on the needs of the different user groups, some tasks would be used by both user groups and were therefore done together. The different colors highlight the priority of the various tasks, red being highest priority, orange second highest, yellow medium priority, and green being the lowest priority.

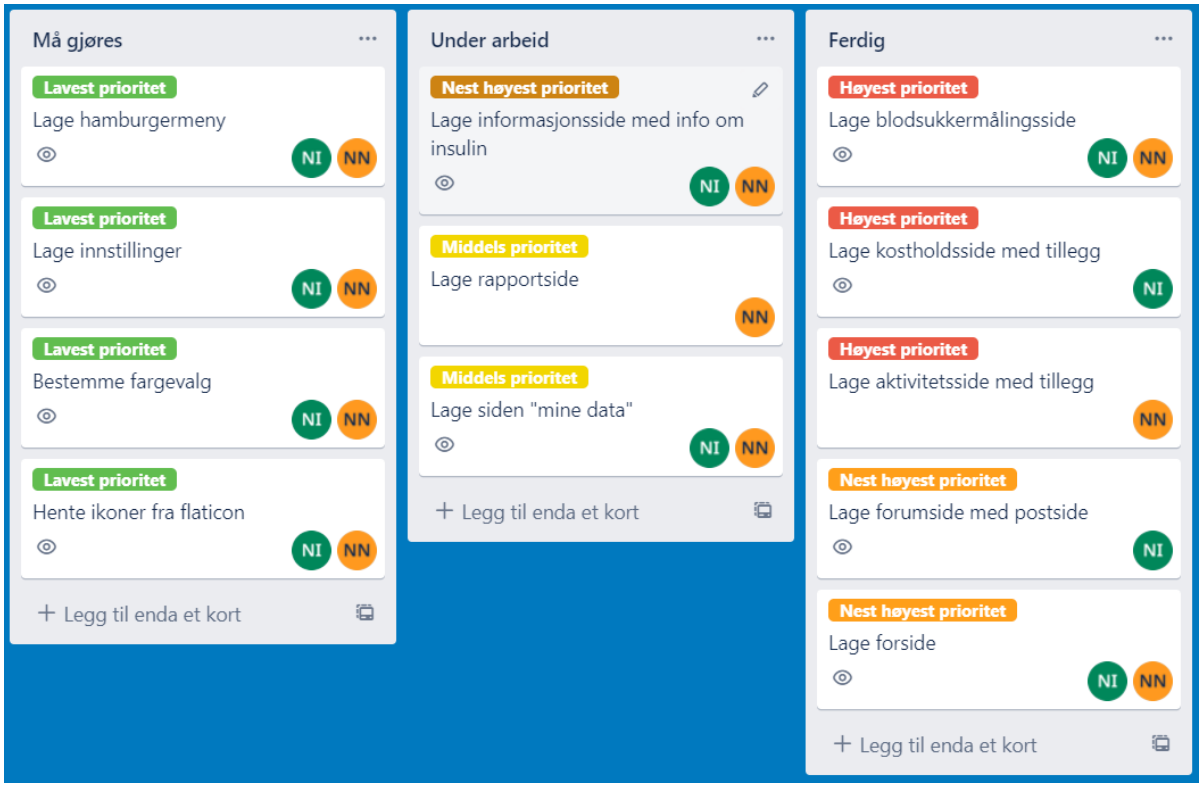


Figure 6.1: Trello board

6.4 First Design Iteration

In order to determine which functionalities would benefit self-management in T1DM a literature review was first conducted. Investigating the experiences of people with T1DM gave an insight as to what is important for them in a treatment perspective, but also on a psychological level. Within this literature review there was also an exploration of existing solutions to see which functionalities were implemented and to see what reviews these applications got (Section 3.4). The literature review gave an idea of which functionalities to suggest during the first interviews. These interviews provided answers in terms of what aspects of T1DM is neglected in health care and also a concrete answer to whether or not the suggested functionalities would be useful and beneficial.

Based on the findings from both the literature review and the interviews a list of requirements were set (Section 4.4). Following these requirements a low-fidelity prototype was created that was evaluated by IT experts using the cognitive walkthrough method.

6.4.1 Persona

As a part of a user-centered design approach two personas were created on the basis of the five interviews conducted. The personas were created to keep the potential users in mind during the prototype development, see Figure 6.2 and 6.3 for the personas. This was useful to identify the needs and characteristics and helped keep the focus on

the users. The personas also made visualising the use of the prototype easier, as two potential users had been established.

Figure 6.2: Persona 1: Lisa Hansen

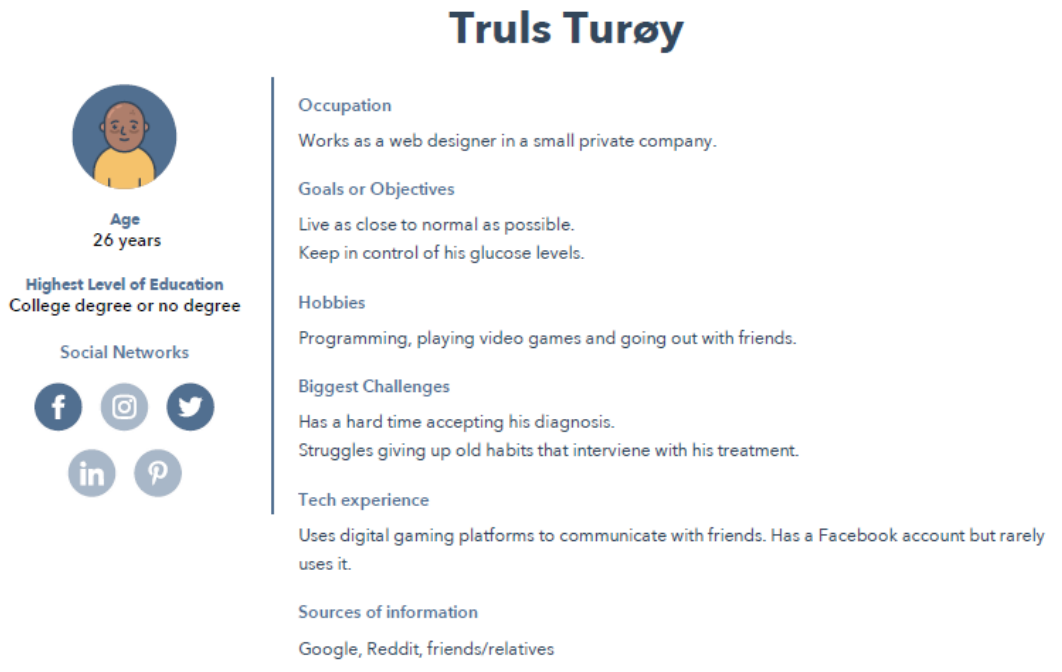


Figure 6.3: Persona 2: Truls Turøy

6.4.2 Interviews with Users

Five people with T1DM participated in a semi-structured interview. The goal of the interviews were to get a better understanding of how people with T1DM self-manage their diabetes and some of the challenges that accompany this illness. The research project was first presented before the interview process began. The questions for the interviews were pre-defined and can be found in Appendix C.1. The interview was divided into three sections regarding *personal information*, *lifestyle*, and their thoughts on *potential functionalities*. At the end of the interview process the participants could come with input on other functionalities that they would find useful.

The participants found the proposed idea interesting and useful as some of them did use an application for some aspects of self-management. However, they found that they would use multiple applications and that having these functionalities in one place would make it less tedious. Some of the proposed functionalities were of less interest depending on how long it had been since the diagnosis was established. People who had gotten diagnosed at a younger age found the report and activity section unnecessary as they had already established healthy habits that rendered these functionalities superfluous to them. Some felt that they had a good grasp on the treatment aspect of the illness however, the mental strain that accompanied it was more challenging. Feeling alone despite having support from family was a prominent finding and majority of the participants mentioned that they had used social media such as Facebook and Reddit. Therefore most of the participants stated that the forum functionality would be very beneficial. One of the older participants mentioned that the physical activity function would be useful however, with the opinions of the other participants and the literature review this was found to be not as relevant for the target group. This functionality would however be found in the complete application which would include the functionalities desired for people with T2DM, which would mean that any user regardless of type would be able to use all the applications functionalities. Based on these findings the *Report* and *Activity* functionalities was regarded as superfluous for the T1DM side of the application.

6.4.3 Low-Fidelity Prototype

The first version of the application was created in the wireframing tool Balsamiq. The main functionalities wanted by people with T1DM based on the literature review and interviews were: an *information page*, a *glucose measuring page*, a *profile page*, *diet-logging* and a *forum page*. The settings page was made so that the user could easily turn on and off notifications, and some functions that they might deem superfluous. It also gives the user the option to change some settings on their personal account. Various layouts were tested until the final option stuck. The main functionalities for people with T1DM can be seen in Chapter 7.

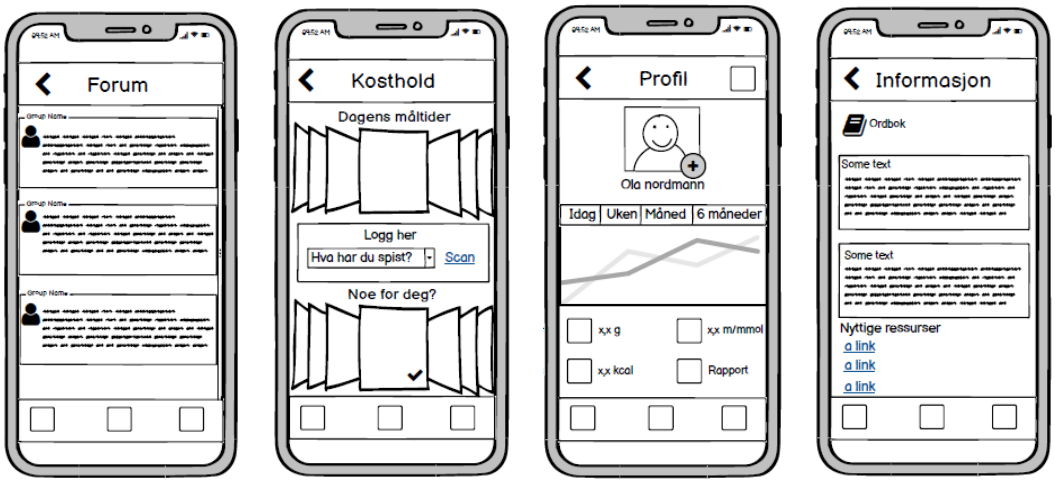
The *Glucose measuring* section represents how a user could manually input measured glucose levels and time of measuring. It also includes a graph showing trends in glucose levels.

The *Information* section (Figure 6.4d) is intended to give the user some easily accessible resources, that have reliable sources. This would hopefully give a newly diagnosed user an easier time when looking for information.

The *Diet* section (Figure 6.4b) makes it possible for the user to add what they have eaten. It also offers suggestions on recipes that might be suitable for the user. These suggestions could be based on ingredients and meals that the user has already logged.

The *Profile* section (Figure 6.4c) gives a more thorough visual overview of past trends in glucose levels where the user can choose the time span. This section also gives an overview of how many carbohydrates and calories have been consumed, as well as the average glucose level for the day.

The *Forum* section (Figure 6.4a) gives the user an overview of different discussion threads created by the community. They can read different threads and respond to them and other commenters.



(a) Forum *(b) Diet* *(c) Profile* *(d) Information*

Figure 6.4: The main sections for T1DM as a low-fidelity prototype

6.4.4 Evaluation with Cognitive Walkthrough

A cognitive walkthrough was conducted by two IT experts as the low-fidelity prototype made in Balsamiq was rather simple and non-interactive, which would make usability testing with users somewhat difficult. Some of the elements were difficult to understand such as how to register time of measuring in the glucose measuring section. Some actions would become tedious over time. The full cognitive walkthrough with tasks and results can be seen in Section 8.2.

6.5 Second Design Iteration

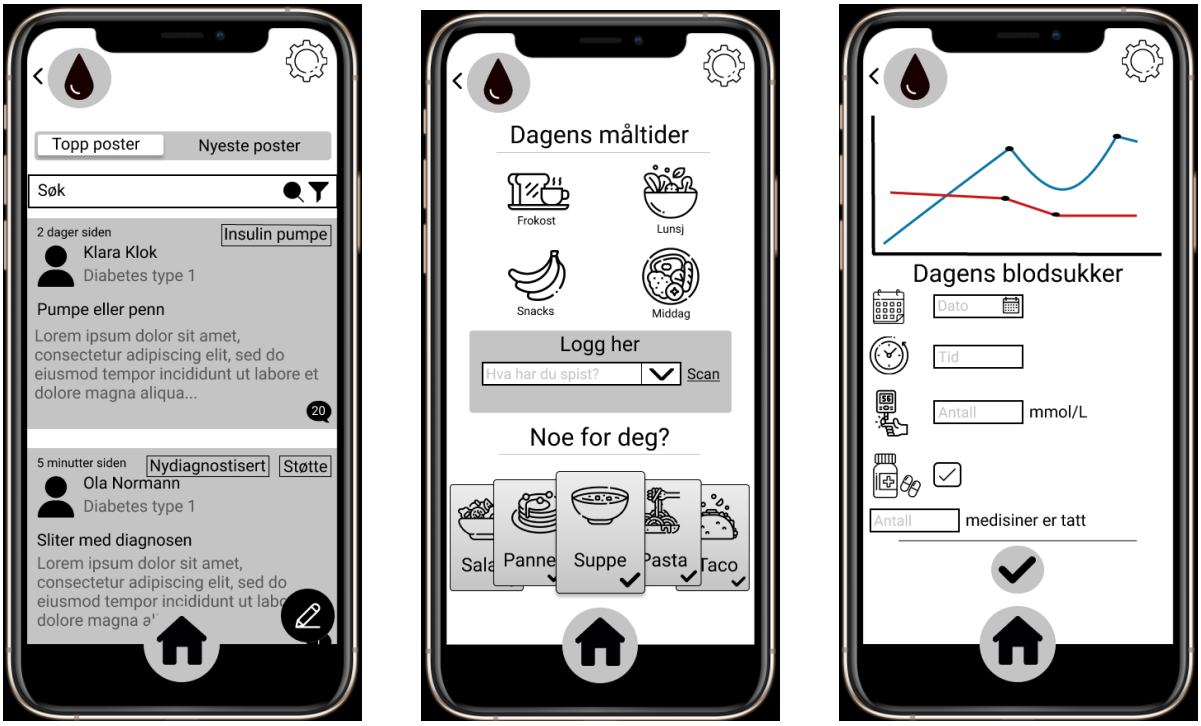
The second design iteration was concerned with interviewing medical professionals and developing a mid-fidelity prototype in Figma. The requirements were redefined and the prototype was developed based on the feedback from both the experts and the medical professionals. Lastly, the prototype was evaluated with usability testing by T1DM participants.

6.5.1 Redefining after Feedback from Users

After all the interviews had been conducted and the cognitive walkthrough carried out, some changes to the prototype were made. The changes consisted mostly of layout rearrangements, incorporating the *Profile* and *Forum* functionalities on the main page and removing them from the navigation bar. A few buttons were added so that the application would save essential data added by the user. The activity and report functionality was dropped as core functionalities for people with T1DM based on the interviews, and was instead worked on as a part of functionalities supporting people with T2DM by Najafi. The new prototype was made in the tool Figma, making usability testing with users more viable. This prototype was made interactive to make it ready for user testing.

6.5.2 Mid-Fidelity Prototype

The new prototype was made in Figma, focusing on making the design more realistic. Colours would be incorporated in the next design iteration however, appropriate icons were chosen although these would not be definite, but used to see if they seemed intuitive to the users. Further changes made from the initial design were added settings to all pages, a search function on the forum and on the information page. The forum pages also got a few additions, a tag that would visualize what category each post belonged to, with the idea that this could be filtered (Figure 6.5a). A like function was also added. The biggest change can be seen on the diet page where instead of a carousel there now are four different categories for each meal group, where the user can see what they have eaten today (Figure 6.5b). A confirmation button was added to the glucose measuring section and on the settings page to make it clear to the user that the data would be saved (Figure 6.5c).



(a) Forum *(b) Diet* *(c) Profile*

Figure 6.5: The main sections for T1DM as a mid-fidelity prototype

6.5.3 SUS with Experts

A SUS evaluation was carried out by three IT experts. They were presented with the application on a computer which may have affected the results however, it was with the Figma iPhone 11 browser window. After giving a brief presentation of the prototype the experts were free to explore the prototype on their own. The SUS scores were 72.5, 75, and 75 which corresponds to the grade "C". This means that the usability is deemed "good", however there is room for improvements. The main feedback was on the layout of the diet page where some of the design was considered ambiguous. This is explored in more detail in Chapter 8.

6.5.4 Usability Test with Users

The mid-fidelity prototype was evaluated using a usability test with five participants, all with T1DM. The tasks can be found in Section 8.3.1. These usability tests were conducted to see if the design was intuitive, and was carried out over video call. The participants were first given a brief description of the research project and the prototype before they were sent a link to the prototype. They shared their screen as they made it through the usability tasks. The time taken on each task was noted, as well as any difficulties or comments. When the usability testing was done the participants were encouraged to give comments and feedback on the prototype. Results of this usability testing is elaborated in Chapter 8.

6.5.5 Interviews with Medical Professionals

Two medical professionals were interviewed, a general practitioner (GP) and a nurse working at Stavanger University Hospital. The goal of the interviews were to get a better understanding of the treatment perspective of self-management in T1DM and which functionalities could aid in this cause. Additionally, based on the responses from people with T1DM explaining that there was a lack of focus on mental health, this was also explored in the interviews with the medical professionals. There was a brief presentation of the project before the interview process started. The interview was divided into two sections, *diabetes treatment* and *existing solutions and desired functions*. The diabetes treatment section explored what kind of information is given to patients and in what form. The second section had the goal of seeing if the proposed functionalities would be beneficial from a treatment perspective. These questions can be found in Appendix C.2. When all the questions had been asked the participants were encouraged to suggest other functionalities that might be useful in a self-management application.

Overall both medical professionals answered similarly and found that the proposed application could be beneficial for self-management. The resources given to people diagnosed with T1DM were usually verbally however, if needed they were provided with printouts/brochures or useful links. Digital resources were not usually given and the GP meant that younger people usually find digital resources such as mobile applications themselves. Since T1DM can affect anyone regardless of lifestyle [6] [7] diet was more in focus compared to physical activity, since most people are diagnosed when they are relatively young, many are already somewhat active. The main goal for people with T1DM in treatment was to live as normal as possible, however individual goals were set based on the patients situation.

The proposed functionalities were well received, however some of them were deemed not as crucial for people with T1DM. They mostly agreed on all of the functionalities. The GP thought that the forum functionality might not be used much however, the nurse thought this would be very useful as he had noted that some people used Facebook groups and online forums to find people in similar situations. However, he also noted that people need to be wary of the information they consume, as not all advice is applicable to each individual. The ability to view trends of various input were deemed as very useful from both participants, since this could make it possible for the patient to take conscious action on their own when they notice a negative trend. The activity logging functionality would perhaps be somewhat unnecessary as many people use smartwatches and might find it tedious to log. The GP found the report functionality to be useful in theory, but that in practise it would be tedious for doctors to go through these reports as they already are short on time. He proposed a different solution where these reports instead could be sent to the patients medical record on HelseNorge. The nurse was positive to the report functionality, but was also of the same conviction.

6.5.6 Proof of Concept

The literature review and the the interviews showed that there is a market for a mobile application promoting self-management of T1DM. The people participating in the user interviews were positive to the concept of such an application and thought that it could be useful for people who are newly diagnosed. The medical professionals were also positive however, the benefit of such an application would depend greatly on how the individual user approaches the application. Although there already exist a variety of mobile applications with this concept, there does not seem to be an application combining the treatment aspect with support from people in similar situations.

6.6 Third Design Iteration

In the third design iteration the prototype was developed further based on the feedback from the usability testing and SUS evaluation with experts, however this time in Adobe XD. A case study with two people with T1DM was conducted where they did usability testing, SUS and a general walkthrough of the prototype.

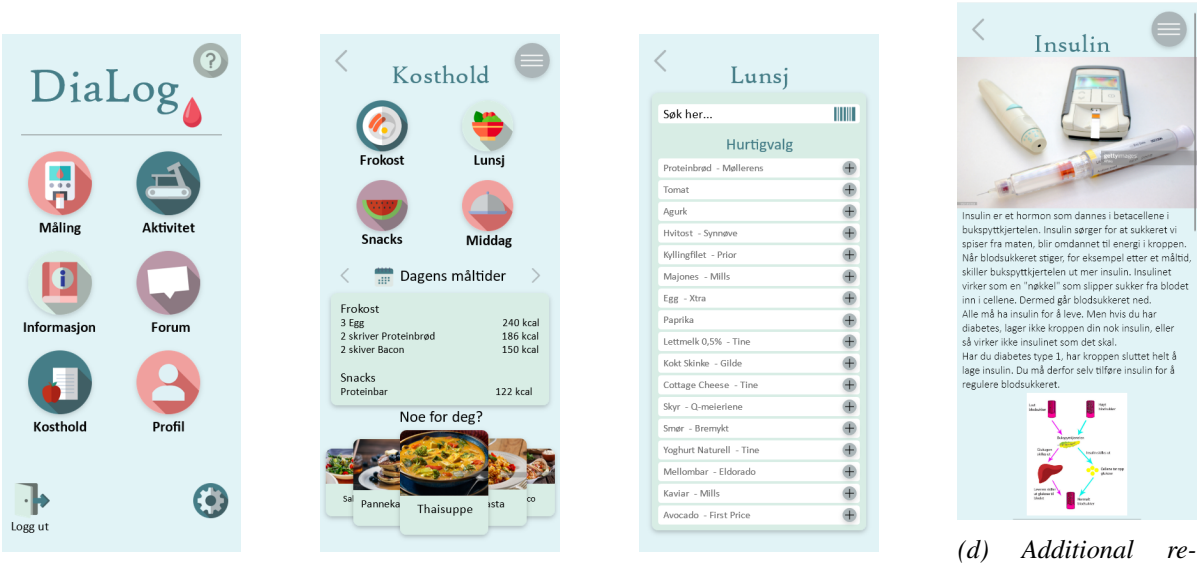
6.6.1 Redefining after Feedback from Users

Based on the feedback from the usability tests and SUS evaluation with experts the first major change was to redesign the diet page. The intention behind the layout was not clear nor intuitive, and was changed to make the affordances obvious. Text explaining each icon on the homepage was also added to ensure the users' understanding of the various sections. The *dictionary* function was removed from the information page, as the medical professionals thought that this would be better incorporated into the sections explaining various topics within the diabetes field in the *information section*. The glucose measuring page had also some minor adjustments, adding the ability to change days and view the glucose levels measured at specific times for the current day. Calculations were removed from the settings and replaced by account settings, as users found the ability to turn of calculations unnecessary. In addition, new pages were added to give the prototype more depth and make it easier for the testers to envision the final product. Lastly a hamburger menu was added.

6.6.2 First High-Fidelity Prototype

In addition to explanatory text added beneath the icons, the settings button was also moved and the logout button was added to the homepage, as some participants spent a lot of time looking for this functionality (Figure 6.6a). A question mark icon serving as a help function was added with the intention of it working as a walkthrough mode of the application that would initiate the first time the user starts the application. This function could also be aborted if the user wants to. In the diet section the meals that the user has added is now presented as a scrollable list and the icons serve as a way to add various foods into each specific meal group (Figure 6.6b). One of the newly added pages is shown in Figure 6.6c. This page shows how the user would add various food into one of the meal groups, in this instance it is in lunch. A hamburger menu was added with

the intention of making navigation more seamless through the application. Although each section within the application is not deep in terms of steps, the participants in the usability tests found it to be somewhat tedious to always having to return to the main page if they wanted to access a different section. The dictionary on the information page was integrated within each topic explaining some of the more difficult words used (Figure 6.6d).



(a) Main page *(b) Diet section* *(c) Lunch page* *(d) Additional resources*

Figure 6.6: The main sections for T1DM as the first high-fidelity prototype

6.6.3 Reviewing Conforming to Design Principles

The design principles were reviewed to ensure that they were well integrated in the current prototype design. This was done to evaluate if the design would give the user a good user experience by quickly finding desired elements and functions, and by making it clear which actions are available.

The first principle, visibility, was followed by having all of the main functionalities presented on the landing page, making the possible actions and potential next step clear for the user. Each icon representing each section of the prototype has text which makes it explicit to the user what each icon means.

The principle of feedback was followed by having titles to each main section, which enables the user to see where they are in the prototype.

The principle of constraints was implemented by using a breadcrumb menu on the forum- and profile page. Additional constraints would be implemented through popups and alert messages to ensure that the user knows the outcome of a possible unwanted action. However, these were not incorporated in this prototype and would need to be revisited.

Consistency was accomplished by using well established metaphors for functionalities such as an arrow to return to the previous page, a check mark for saving data, and well

known icons. In additions to metaphors, the same fonts, colors and buttons were used throughout the design.

The principle of affordance was followed by using recognizable layouts matching industry standards, such as a carousel menu and by highlighting the current tab on the breadcrumb menu. By using well established and recognizable icons the affordance is made clear to the user as they recognize the functionality behind the icon.

6.6.4 Case Study and SUS with Users

The case study span over the third and fourth iteration with usability testing and a SUS evaluation being conducted in the third iteration. In the fourth iteration only a SUS evaluation was conducted. This was done in order to compare the SUS results. During the case study the participants used a smartphone to evaluate the application using the Adobe XD applications which allows an interactive preview of the prototype. The results of the usability tests and the SUS evaluations are explored in more detail in Chapter 8.

A total of two participants took part in the case study, who had also been a part of the usability testing from the previous iteration. The participants were 24 (U2) and 57 (U4), and both were female. They were familiar with mobile applications and were comfortable with smartphones. The case study consisted of a usability test were they were given the same tasks as the ones that were used in the previous usability testing however, they were slightly altered to fit the new prototype. In addition, the participants also filled out a SUS form and were encouraged to give additional comments. A second SUS form was filled out in the fourth iteration on the redefined prototype. Approximately four weeks had passed between each SUS evaluation.

First they were given the different tasks for the usability test and asked to make comments as they navigated through the prototype. After each tasks they were asked questions regarding the navigation and what their thoughts were of the layout and icons. Afterwards they were asked to interact freely with the application and encouraged to think aloud. The participants were observed and any comments were noted. U4 had a slower pace compared to U2 and took their time exploring the application, reading the various mock-up texts. U2 was more "chaotic" and jumped from page to page stopping to read on the more intricate pages. Overall the participants found the prototype to be intuitive however, some elements needed clarifications.

During the SUS evaluation the participants gave additional comments on the design and the overall user experience. Both participants found the application easy to learn and mostly recognized to commonly used symbols and metaphors.

6.6.5 Finishing Design Elements

Product Name

The product name DiaLog was established before the first design iteration during the ideation process together with Najafi. The name is comprised of two words; the abbreviation of the word diabetes, "dia", and the word "log". The intention is that this name

gives an indication of what the application entails; logging diabetes information. It also encompasses the social aspect of the application by sounding like the word "dialogue". This name got a lot of positive reactions from friends, users, IT experts, and medical professionals.

Color Scheme

The color scheme of the prototype was established during the third design iteration. Similar applications were explored and majority used soft colors and many appealed to the color blue as this is the color used on the main symbol for diabetes awareness [39]. This also affected the color decision in the design for this research. The main color palette for the final prototype is shown in Figure 6.7. The prototype has a light blue background with grouped elements presented on a light green background. The text is a variety of black, creating enough contrast between the lighter backgrounds and the textual elements. White was used on the landing page as well as the different search- and input fields. A darker shade of blue as well as another light green/blue shade was used to creative diversity and to highlight and differentiate elements from background to foreground.

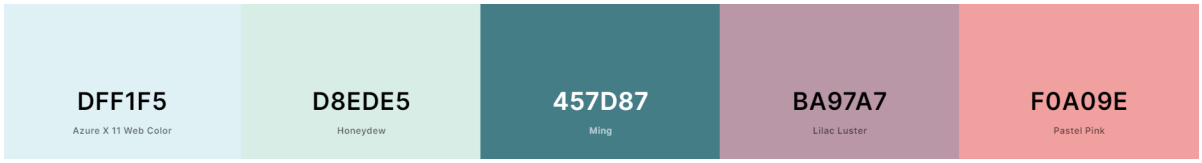


Figure 6.7: Color scheme for the final design of DiaLog

In addition, the colors of some icons required shadows and thus darker shades of the already established color palette was chosen for this purpose as shown in Figure 6.8.

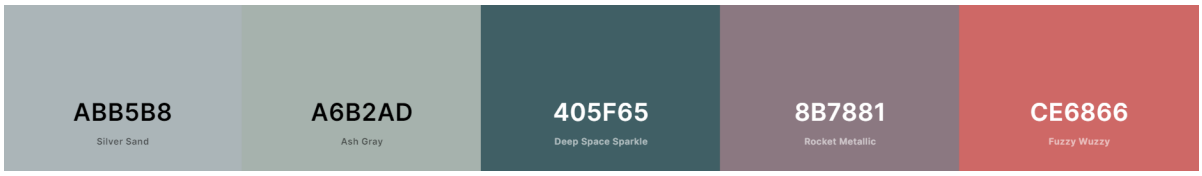
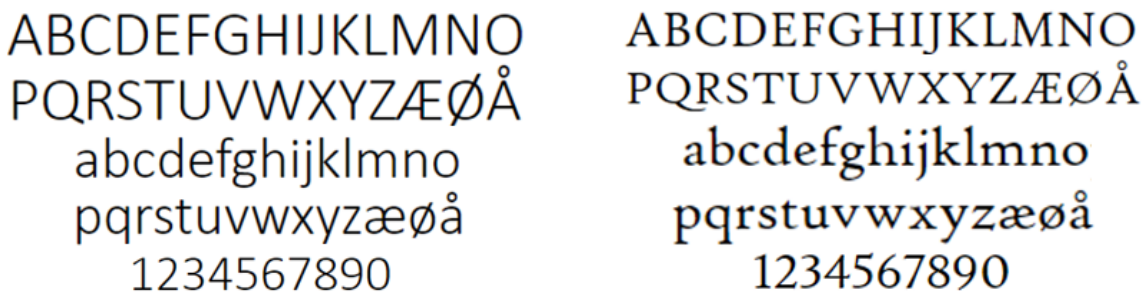


Figure 6.8: Color scheme for the icon shadows for the final design of DiaLog

Font

The fonts used in the final design of the prototype are called *Calibri* and *Hightower Text*, these can be seen in Figure 6.9. Calibri is a sans-serif type whilst Hightower Text is a serif type font. Hightower is used for the titles on the pages whilst Calibri is used on paragraphs and other information. These were both found within the prototyping tool Adobe XD and were used in light, regular and bold versions depending on the context.



(a) Calibri *(b) Hightower Text*

Figure 6.9: Fonts used in regular

Icons and Illustrations

Illustrations, such as the ones form the carousel menu on the activity page were retrieved from *Pexels* [40] and the images from the diet page were retrieved from *GettyImages* [41]. Both of these websites provide licence free images. The graphs in the prototype were made in Adobe XD. All the icons used in the design process are from *Flaticon* [3]. Flaticon is a platform that provide both free and licensed icons. The various icons can also be edited to fit a specific color scheme. Figure 6.10 shows a selection of some of the unedited icons used in the prototype. By using icons that have a well established meaning the affordance and visibility is improved, such as the glucose measuring icon and the question mark icon. The icons were edited to fit the color scheme of the prototype.

Figure 6.10: A selection of free icons used from Flaticon.com [3]

6.7 Fourth Design Iteration

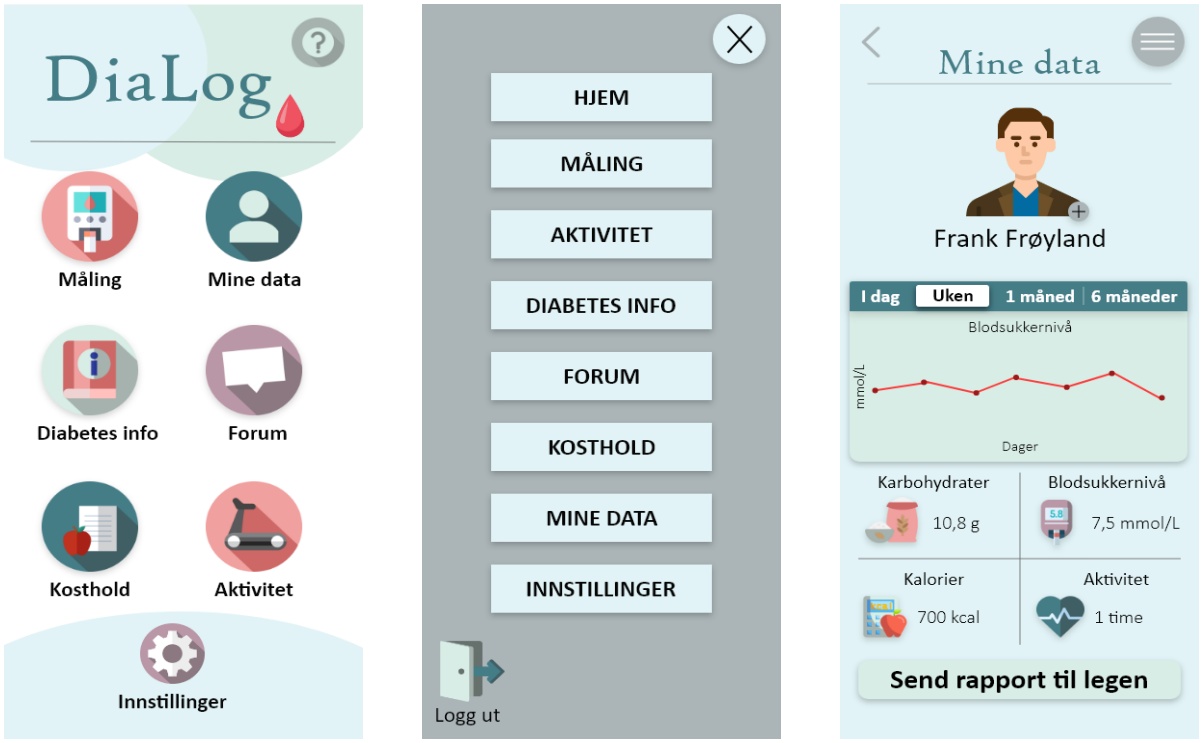
The fourth design iteration was concerned with further developing the prototype in Adobe XD based on user feedback from the case studies. After the final high-fidelity prototype was finalized it was evaluated by IT experts using SUS evaluation and Nielsen's heuristics.

6.7.1 Redefining after Feedback from Case Study

The participants from the case study were quite positive to the new design of the prototype and they only had minor desired changes. This is further established by their SUS scores. Some of these changes were more details on the graphs, slight changes to some icon names, and a more interesting landing page.

6.7.2 Final High-Fidelity Prototype

The main changes were made to the landing page where the design was made more interesting by using the color palette creating overlapping circles. These would help group the icons and highlighting the main functionalities that should be the focus of the page as shown in Figure 6.11a. Log out was moved to the hamburger menu as this gave the landing page better structure and it is a functionality that is usually more hidden (Figure 6.11b). The icon text for information and profile was changed to convey the content of these pages better and increase the visibility. The graph in the glucose measuring page was deemed redundant as it is also shown in the now called *"Mine data"* page with more functionality which can be seen in Figure 6.11c.



(a) Main page *(b) Hamburger menu* *(c) My data*

Figure 6.11: The improved sections of the final high-fidelity prototype

6.7.3 SUS and Nielsen's Heuristics with Experts

Three IT experts conducted a SUS evaluation and a heuristic evaluation using Nielsen's heuristics. A link to the Adobe XD prototype was sent, which allowed them to navigate the application on their computer in a mobile window. After they had explored the

application they filled out the SUS and heuristic forms. No major issues were found however, some wanted more feedback and constraints in the form of popups and alerts, as well as some greyed elements turning green when clicked. The order of the elements inside the hamburger menu no longer corresponded to the order on the landing page and would need to be rearranged. Overall the experts found the prototype to be quite intuitive and easy to navigate.

6.7.4 Future Design Iterations

After the final evaluations of the finalized prototype there were a lot of functionalities that could and should be implemented. One of these functionalities would be a walkthrough-mode that would start the first time the application is initialized giving the user an explanation of the various functionalities. The question mark that has been implemented would be a way for the user to start this walkthrough-mode again after the first initialisation. Popups, alerts, and more feedback would also need to be implemented. All of these functionalities would have to be implemented and evaluated in possible future iterations.

Chapter 7

Features of DiaLog

This chapter shows an overview of the main functionalities of the final high-fidelity prototype *DiaLog*. It presents the final product as a result of the various iterations following methodology and evaluations. It is divided into six main sections where the activity page is covered by Najafi in *En Mobilapplikasjon Designet for Selvhåndtering av Diabetes Mellitus Type 2*.

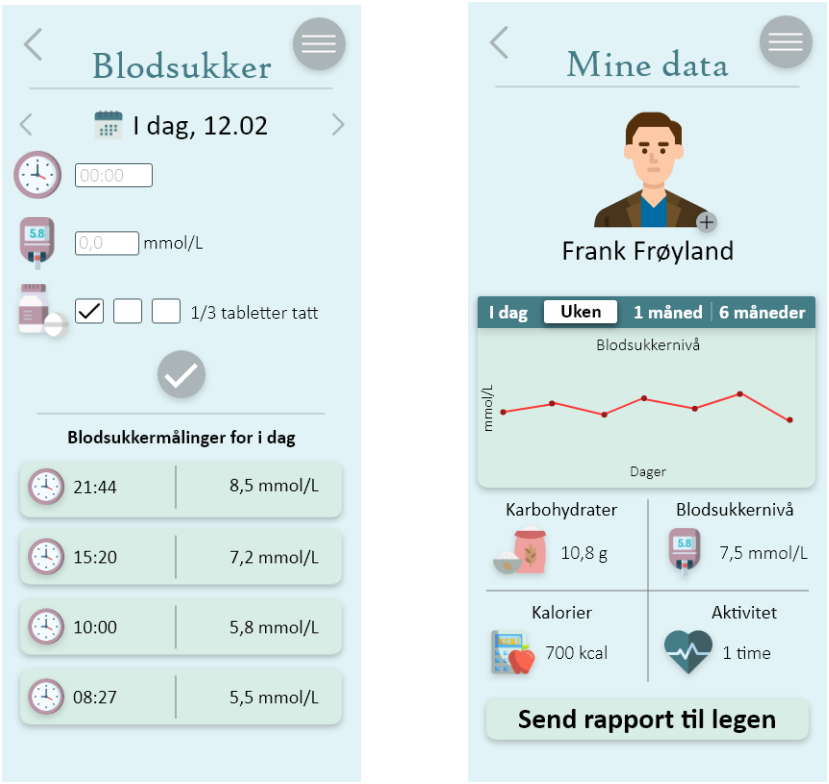
7.1 Glucose Measuring

The functionality that is first presented on the main page is the *Glucose measuring* section (Figure 7.1a). This page allows users to register the time, level of glucose, as well as ticking of medications. The idea is that medications can be adjusted and personalised in the settings to show the appropriate medication. Using the arrows next to the current date, the user can browse through different days to see the exact time and the glucose level measurement appearing in the list below the "blood sugar measurements for today" text. The user saves the data by tapping the check mark and the registered reading and time is added to the list below. This data will be compiled and presented in the *My data* section (Figure 7.1b).

7.2 My Data

The *My data* section (Figure 7.1b) presents the user with their collected data based on what the user has input. The users are then presented with a profile picture and their name. They also get an overview of their glucose levels shown in a dynamic graph for either the current day, one week, one month, or six months in a breadcrumb menu. This makes it possible for the users to see the trends in their glucose levels. In addition, today's carbohydrates, calories, activity, and the average glucose level for the current day are shown divided into four sections to summarize the whole day.

The "send a report to the doctor" is a functionality covered by Najafi in the thesis *En Mobilapplikasjon Designet for Selvhåndtering av Diabetes Mellitus Type 2*.



(a) Glucose measuring section *(b) My data section*

Figure 7.1: Glucose measuring- and My data section

7.3 Diabetes Information

The *Diabetes info* page (Figure 7.2a) provides the user with general information about topics related to diabetes giving them an easier way of learning about this topic. They can search for specific topics and filter their results. Each topic is presented with a short text and a "read more" option. After tapping on a topic, such as insulin the user is taken to the page giving information about what insulin is and how it works, as illustrated in Figure 7.2b. Using pictures and tables the information becomes easier to understand. At the bottom of the page there is an explanation of words that might be unknown to the users as well as some useful links that can be a resource if they want to read more about the topic (Figure 7.2c).

(a) Information page *(b) Insulin page* *(c) Additional resources*

Figure 7.2: Information section

7.4 Forum

The *Forum* page (Figure 7.3a) is a way for users to connect and discuss topics related to their illness. It provides a safe space that can make users feel understood and less alone. It has multiple ways of filtering the various forum posts. The users can either sort by "top posts" or "newest posts", or they can use the search field to search for a specific topic and filter the results based on their needs. Next to the breadcrumb menu there is a pencil icon that the user can click on to create a new forum post. Below the search field there is a list of posts created by users of the application which has various tags based on the topic of the post. The user can also see how old the post is, the profile picture of the user who created it, and how many comments it has. Each post has a title and some of the text to give the user an idea of what the post is about.

By tapping on the "easy recipes" post the user is taken to Figure 7.3b, which shows how a specific forum post is presented. The post takes up the width of the screen with comments being indented to show that they are responses to the original poster. Each response comment has a heart that represents a "like" given by users of the application. A filled heart means that the current user has liked the comment and the number within the heart represents the number of likes the comment has. The comments also have an answer button where the user can respond to a specific comment, or the user can respond to the original poster by writing in the footer element of the page. It is also possible to upload photos in response to posts and comments.

(a) Forum page *(b) Recipe post*

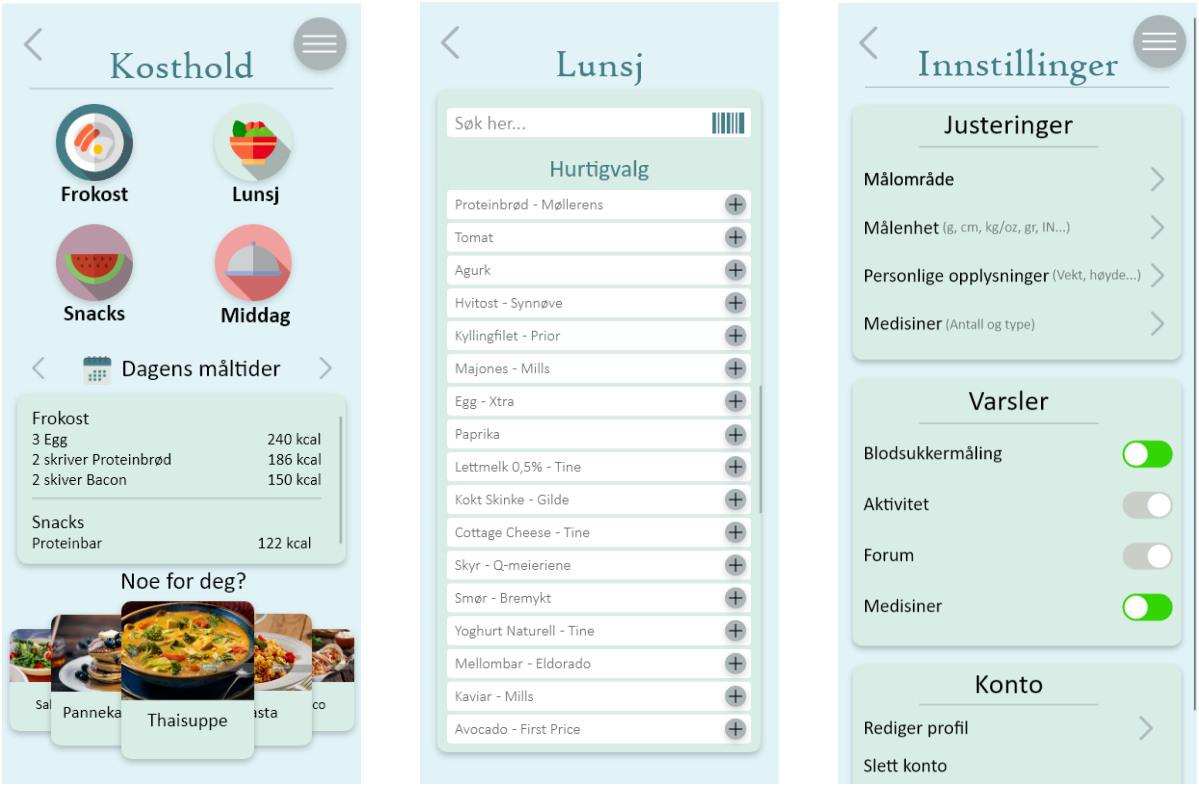
Figure 7.3: Forum section

7.5 Diet

The *Diet* page (Figure 7.4a) is divided into three section and is implemented to make it easier for users to make healthy decisions and get an overview of their food habits. The first section is how the user logs food into the second section, named today's meals. This section is again divided into four sections representing the four main meal groups, breakfast, lunch, snacks, and dinner. By tapping on the lunch icon the user is sent to the page which allows them to add food into this specific meal group as shown in Figure 7.4b. Here the user can search for specific foods or scan their bar code to input them quicker. Below the search field the user has the option for "quick add" where often used foods are listed making it easier to add foods that the user eats regularly.

In today's meals the users gets an overview of what they have eaten during the day and for each food its caloric value. This list is scrollable and is again divided into meal groups based on the foods that the user added in the previous section.

In the last section of the diet page the users gets suggestions for meals based on the foods they have entered so that the suggestions cater to their liking. These suggestions are presented in a carousel menu that can be scrolled through. By tapping one of the options the user would get the recipe and ingredients list for the meal, as well as the nutritional value.



(a) Information section *(b) Lunch page* *(c) Additional resources*

Figure 7.4: Diet section and the settings section

7.6 DiaLog as a Self-Management Tool

The application is a self-management tool for people with diabetes whose needs are central to this research. The aim through this development and the resulting application is to make it easier for users to monitor their illness, identify good and bad habits. This could help them see the bigger picture of how to handle their diagnosis. By providing a platform for people in similar situations, the user might feel more understood, and less alone which helps them deal with the the illness also from a psychological perspective. This could in turn give the users more motivation to improve their lifestyle and thus see an improved relationship with their diabetes. The *My data* section makes it easier for the user to see possible negative trends and assist them in taking action to improve.

The *information* section of the application also serves as a resource to family members who might have a difficulty to fully understand the implications of the illness. The main idea behind this section is to make information from various sources more manageable and to complement the information that can be found online by providing links.

In the *settings* section (Figure 7.4c) of the application the user can set reminders and specify their personal target area in terms of glucose measurements. This makes it easier for the users to remember to take medications if necessary and measure their glucose at specific times, which in turn provides the users with data that can serve as a reflection of how they are handling their illness. This data can also be used during doctors visits to supplement the treatment plan given to the user. This could help paint a broader picture and analyse how patients are managing in between doctors visits.

Chapter 8

Evaluation

This chapter presents the evaluation results of the four design iterations. The extensive work was carried out to evaluate different aspects, since feedback is essential for improving the design throughout iterations. The results are gathered from the cognitive walkthrough, usability tests, SUS and Nielsen's Heuristics.

8.1 Participants

The participants in the different evaluations are comprised of two different groups, intended users diagnosed with T1DM and IT experts. The intended users, shown in Table 8.1, participated in usability testing, SUS evaluation and a case study. All the participants in this group has T1DM and fit the requirements set to participate in this research. The IT experts participated in a cognitive walkthrough, SUS and Nielsen's Heuristics. All the IT experts have experience with human-computer interaction and are briefly presented in Table 8.2.

Users	U1	U2*	U3	U4*	U5
Age	24	25	20	57	64
Gender	Male	Female	Male	Female	Female

*Table 8.1: Users | *Case study participants*

Experts	E1	E2	E3	E4	E5	E6	E7	E8
Age	23	24	27	30	24	26	24	29
Gender	Female	Female	Male	Male	Female	Female	Female	Male

Table 8.2: IT experts

8.2 Cognitive Walkthrough

During the first iteration after the low-fidelity prototype was made, a cognitive walkthrough was conducted by IT experts E1 and E2. Most of the pages required adjustments, as some of the element's layout were not intuitive and navigating the pages would be tedious. The information page and forum page lacked a search option, which would make finding relevant information much quicker. Both the forum- and the profile page were quite hidden in the navigation bar and the registration of glucose measurement was difficult to understand. The tasks and results can be seen in Table 8.3.

8.3 Usability Testing

The usability tests conducted in the second iteration were done online via the video call tool Zoom. The participants were sent a link to the prototype that they could open in their browser, which would simulate a smartphone screen. During the video call the participants shared their screen. The time taken on each task was noted as well as any hesitations and remarks. During the case study the usability testing could be done on a smartphone using the Adobe XD mobile application, which also made it easier to observe the interaction between the users and the prototype. The seconds spent on each task have been rounded off.

Main tasks	Steps	Negative	Positive
Comment on a forum post	1. Open the forum page 2. Open a forum post 3. Write in the comment field 4. Click the send button	(1) Spends time looking for the forum icon (2) Tedious and time consuming to scroll through posts to find one that is relevant for the user (3) Limited options in responding to a thread	(2) Intuitive, and follows forum standards (4) Intuitive
Open the dictionary	1. Open the information page 2. Tap the dictionary icon		(1) Easy to spot (2) Symbol follows standards
Turn off notification for glucose measuring	1. Open settings 2. Tap the toggle button for glucose measuring		(1) Intuitive and follows standard placements for settings (2) Uses toggle button for on/off which is industry standard
Log out of the appliacation	1. Open settings 2. Log out	(2) Uncertainty if log out button actually is log out	(1) Intuitive and follows standard placements for settings (2) Log out symbol is often used on other applications
Add what you have eaten today	1. Open the diet page 2. Tap the “what have you eaten” menu	(2) Uncertanty on how this will present options	(1) Easy to spot
View overview of glucose trends	1. Open the profile page 2. Tap the six-month tab in the breadcrumb menu	(1) Spends time looking for the profile icon (2) No way of knowing which tab is currently active	
Measure your glucose	1. Open the glucose measuring page 2. Add the date 3. Add the time of measuring 4. Add the mmol/L measured	(3) Confusing as to where to add time of measuring. Box lacks text	(1) Easy to spot (2) Uses intuitive symbol

Table 8.3: Results of the cognitive Walkthrough in iteration 1

8.3.1 Tasks for Evaluation

A set of specific tasks were given to the participants to evaluate the prototype. These tasks made it easier for the participants to get familiar with the prototype and its functionalities. It also made it possible to see how the intended user interacts with the application and identify usability issues. The participants were not given an explanation on how to complete the various tasks, but were advised to ask for help if needed.

Usability test tasks were as following:

1. Log your glucose level
2. Find information about insulin
3. Find a forum thread about recipes
4. Turn off notifications for glucose measuring
5. Locate the graph that shows an overview of registered data
6. Log what you have eaten today
7. Log out

8.3.2 Usability Testing with Users

Five users participated in the usability test on the mid-fidelity prototype in iteration two. Each participant got the seven tasks listed above and were observed and timed as they went through each task. They did not get any information on how to complete the tasks and were not allowed to explore the application before the usability test started. None of the participants had seen the prototype beforehand.

All users completed the tasks however, task 6 - *Log what you have eaten today* required some guidance which is visualised in Figure 8.1. This graph shows the amount of time each participant spent to complete the given task. This task of logging what the user had eaten was not intuitive and the layout was confusing. U2 thought that the check marks on the suggestion carousel (Figure 6.5b) meant that they had added these suggestions. U1 and U3 spent a lot of time on this page trying to figure out what the four categories really meant. U2 was hesitating on task 3 (*Find a forum thread about recipes*) and said that they thought the icon was for a chatting functionality, U1 and U5 also showed hesitation and spent some time scanning the homepage. They located the settings page rather swiftly however, the participants found that the log out option not prominent enough. Overall the main issues seemed to be lack of visibility and affordance, which could be improved by adding icon text and changing some of the layout.

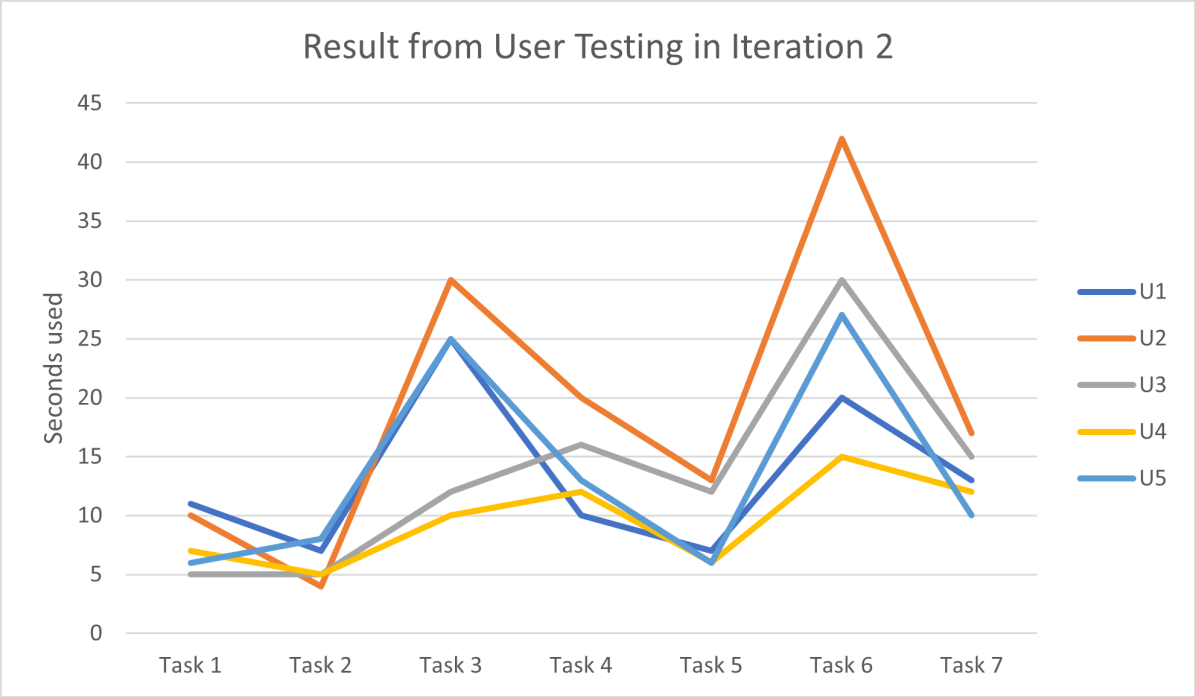


Figure 8.1: Results from usability testing in iteration 2

8.3.3 Usability Testing in Case Study

Two users participated in the usability test on the first high-fidelity prototype during the case study in iteration three. Using the Adobe XD mobile application the usability testing could be conducted on a smartphone, giving the users a more real experience of the prototype. This also helped minimize errors of use that could occur when evaluating using a desktop evaluation. The users in the case study were amongst the five users that participated during the usability testing in iteration two, and were therefore somewhat accustomed to the functionalities of the application. However, approximately four weeks had passed since the last usability test and both users commented that they did not really remember much about the prototype.

The overall results show an improvement from the previous usability test. The participants found this prototype to be much more intuitive. For example performing task 6 - *Log what you have eaten today*, which in the previous prototype was difficult to accomplish, they succeeded quicker. This was due to improving the previous solution, which was confusing, since it presented four different sections and a separate logging functionality. This made it unclear what the four sections meant, but by removing the additional logging section and adding the lunch page (Figure 7.4b) this confusion was eliminated and the user could quickly decide what to do. U2 tried to scroll on the food list and the carousel menu which shows that the intended functionality was understood. U4 mentioned that although they recognized the settings symbol they found it odd that this icon did not have any explanatory text when all the other icons had it.

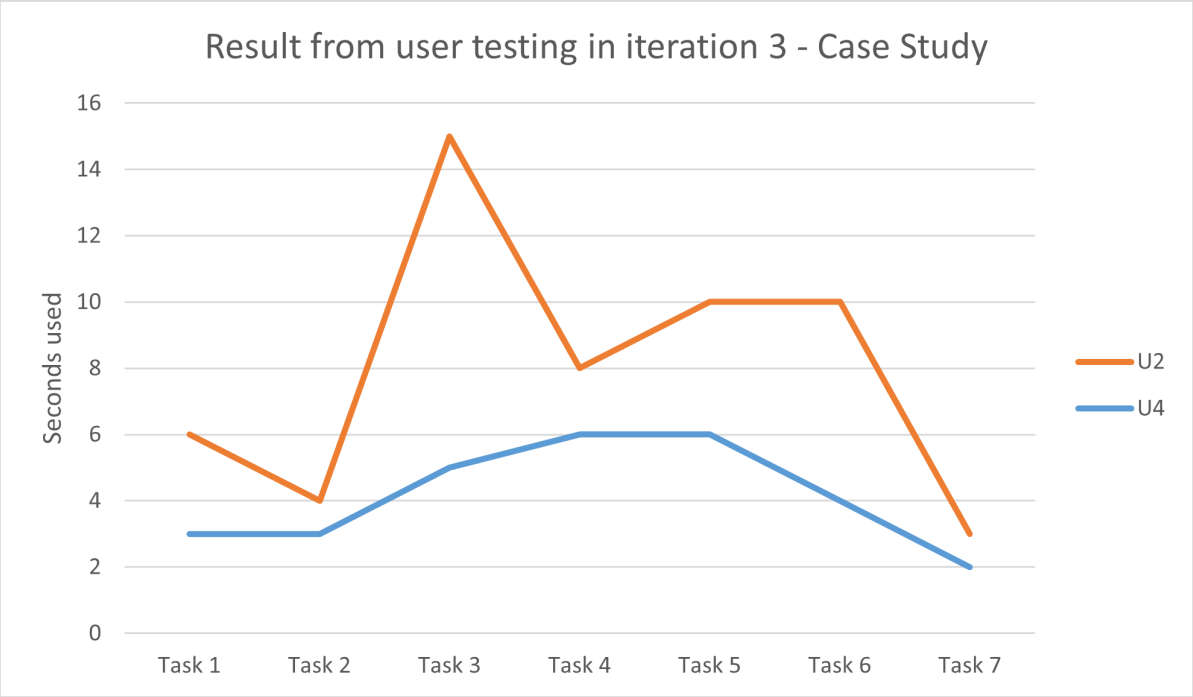


Figure 8.2: Results from usability testing in iteration 3

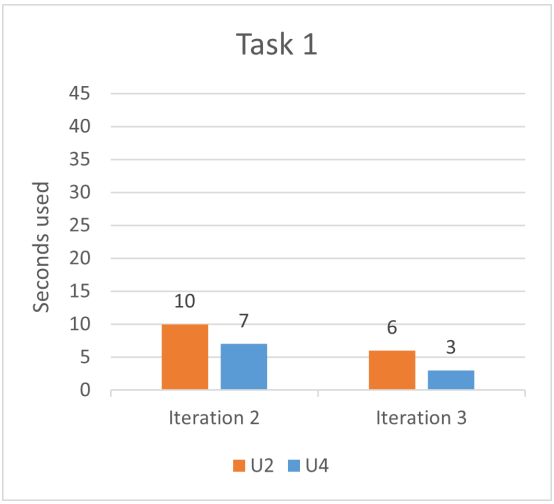
After the usability test the participants were asked some questions about the design itself regarding font, color and layout. These questions were open ended and the participants were encouraged to elaborate on their answers. Follow-up questions were also asked. On the question regarding the font, they both found the font size easy to read and the contrast between the font color and the light background made the text "pop". U2 said on the question of colors that they were pleasant to look at and she liked how the icons matched the color theme. However, she thought that the main page was a bit boring. U4 had similar views however she mentioned that the log out and information icon was not very distinguished from the background color and that the edge of the icons blended in with the background. They both liked the icons and U2 mentioned that the shadows within the icons made them more interesting to look at. Overall they were pleased with the layout and did not have any comments regarding it.

8.3.4 Comparing Usability Test Results

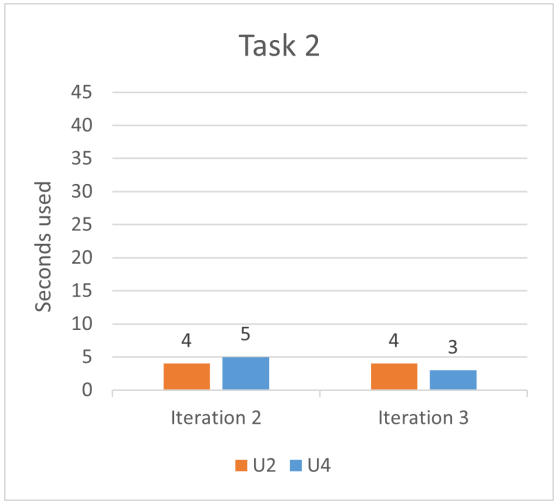
When comparing the two usability tests it is clear that there is an improvement based on task completion time. This is particularly evident on task 3 and 6, see Figures 8.4a and 8.5b. On all tasks both users used the same amount of time as during the previous usability test, or less. The improvement of the overall results may also be affected by the fact that that participants had seen the prototype before although, it had gone through many changes since the previous testing.

Task one (Figure 8.3a) was to *log your glucose level* starting from the main page. U2 spent a few seconds more than U4 as she talked whilst scanning the main page looking for the correct icon. On the glucose measuring page both were quick to identify where they could log their glucose levels. The less time spent in iteration 3 is suspected to be from the prototype now having icon text and the glucose measuring icon being

presented first when scanning the page from left to right. Task two (Figure 8.3b) was *find information about insulin* and the results were similar between U2 and U4 in both iterations.



(a) Log your glucose level

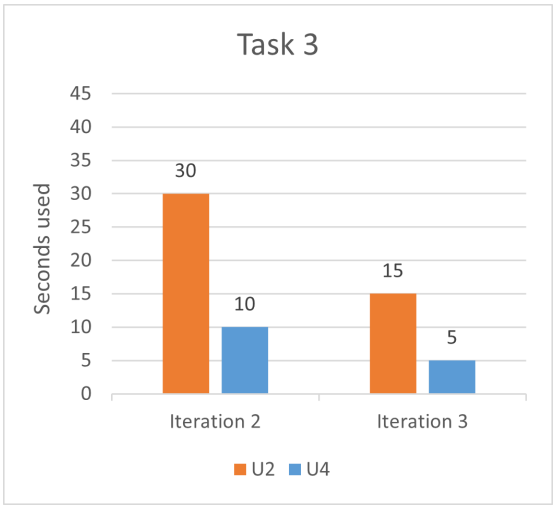


(b) Find information about insulin

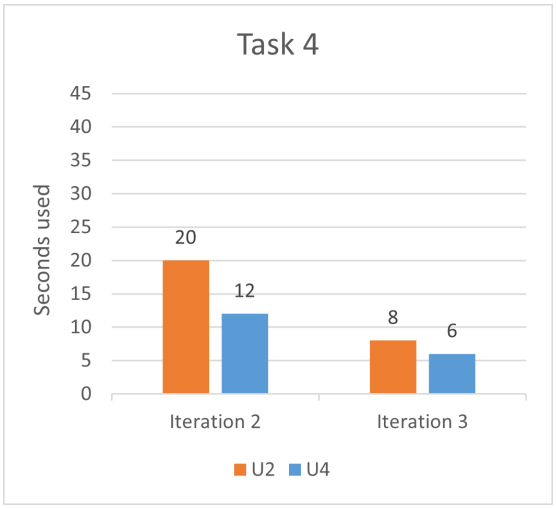
Figure 8.3: Task 1 and 2

Task three (Figure 8.4a) was *find a forum thread about recipes* also starting from the main page. On this task there is a distinct difference between the participants, with U4 using 20 seconds less on this task in iteration 2 compared with U2. As mentioned in Section 6.6.4 participant U2 had a more eager approach and clicked instinctively instead of reading the various texts and therefore made a few mistakes when navigating the prototype. This is something that she herself mentioned and it is noticeable when comparing the results of the two case study participants in Figure 8.2. This is particularly evident on this task where U2 first clicked on the profile icon as she associated the person icon to be a user on a forum and assumed that the speech bubbles represented a chatting function. After returning to the main page she took her time reading the icon text and found the correct path to complete the task. U2 also explained that she felt stressed from being tested and timed. The improvement in iteration three is suspected to be from the added icon text and change of icon from two speech bubbles to one only. Both participants halved their time spent on this task. Although, the design of the forum page of the first high-fidelity prototype (Figure 6.4a) compared to the same page on the mid-fidelity prototype (Figure 6.5a) is almost identical in terms of layout and path, the added icon text is presumed to be the reason for the reduced task completion time.

Task four (Figure 8.4b) was to *turn off notifications for glucose measuring*. On this task U4 located the cog wheel representing *settings* quicker than U2 however they both commented that the icon was not easily distinguishable from the background and appeared too "hidden". U2 clicked on the profile icon before returning to the main page and locating the settings icon. She spent a few seconds reading and locating the glucose measuring option however, she spent about the same amount of time on this in both iterations. In iteration three the participants used approximately the same amount of time and almost halved the amount of time spent on the task. This is most likely due to the icon being made darker and more prominent.



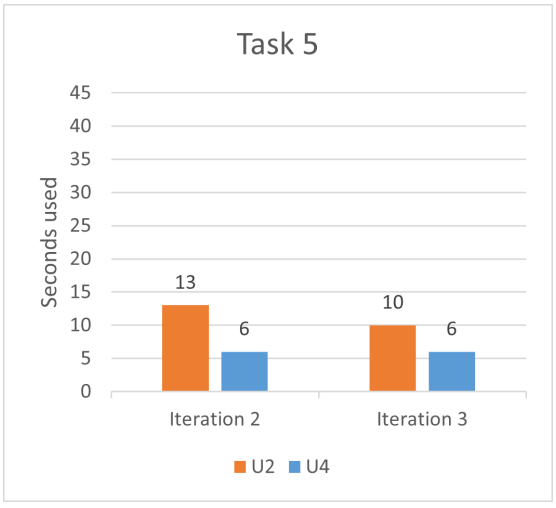
(a) Find a forum thread about recipes



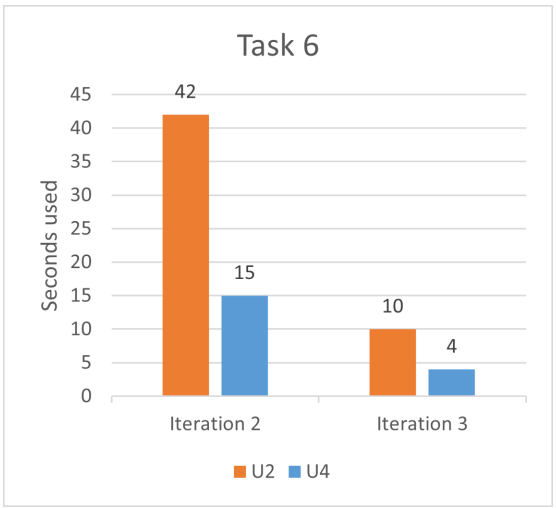
(b) Turn off notifications for glucose measuring

Figure 8.4: Task 3 and 4

Task five (Figure 8.5a) was to *locate the graph that shows an overview of registered data*. The results in both iteration two and three are similar with U4 using the exact same amount of time. Task six (Figure 8.5b) was to *log what you have eaten today*. U2 used a significant amount of time on this task. They both clicked the diet icon rather quickly, both participants expressed confusion and some frustration as to what the different meal group sections on the page meant and how they were supposed to log food. U2 spent more time scanning the page and guessing what they could do and asking for guidance. There is a vast improvement in time spent on this task mainly on U2's results, but U4 also improved by 11 seconds. This page was redesigned and the intentions of the various functionalities were made clearer, increasing the affordance. U2 talked aloud as she scanned the page explaining the various sections of the page as she completed the task.



(a) Locate the graph that shows an overview of registered data



(b) Log what you have eaten today

Figure 8.5: Task 5 and 6

Task seven can be seen in Figure 8.6 and were to *log out*. The participants spent about the same amount of time in iteration two however there is a significant decrease in time spent on this task when comparing the two iterations. During the second iteration testing both participants clicked on the profile icon assuming that they could log out from that section. U2 returned to the main page to find the settings icon and U4 found the icon on the profile page. Within the settings page both participants spent time scanning the page looking for the log out option. They both commented that it was somewhat hidden and would benefit from adding icon text explicitly saying "log out". During the testing in iteration three the amount of time spent on this task dropped. The reason for this is that the log out icon was moved to the main page and the added icon text making the intention of the icon clear to the user.

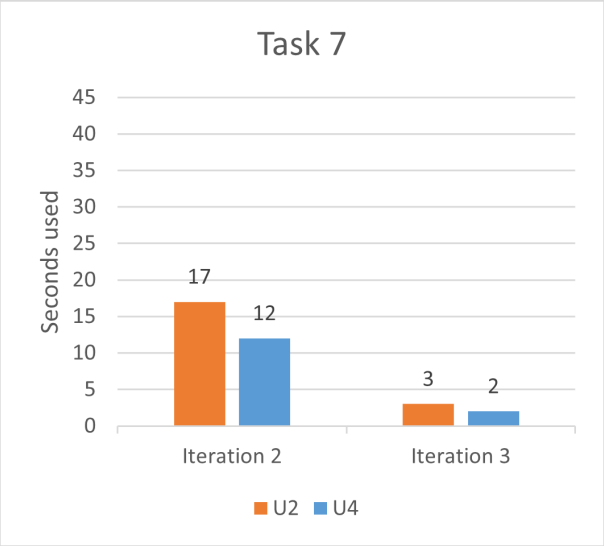


Figure 8.6: Log out

8.4 System Usability Scale

A SUS evaluation was conducted on the two groups, users and experts, in multiple iterations with the goal of providing comparable data. This would make it possible to measure the improvements and ensure an increasing quality between the different prototypes.

8.4.1 SUS with Experts

A SUS evaluation was conducted by a total of six IT experts. Three of them evaluated the mid-fidelity prototype in iteration two, whilst the other three evaluated the final high-fidelity prototype in iteration four. All of the IT experts evaluated on a desktop but were sent an Adobe XD link that would simulate a mobile screen. They were all encouraged to write down any additional comments and questions they had about the prototype.

Iteration 2

The SUS scores from the experts ranged from 72.5 to 75. The individual scores can be seen in Figure 8.7. The mean score of this SUS evaluating came to be 74, which equates to the adjective "good" or the grade C. The experts also wrote down several comments. All of the experts commented on the need for icon text on the main page that tells the user which functionalities can be expected when clicking on an icon. They all also expressed confusion regarding the diet page over how the logging functionality was intended to work. E3 commented on the check marks on the carousel menu on Figure 6.5b similarly to U2 in the usability testing, stating that it was not clear what these check marks meant. On the profile page E3 commented that it was not clear what the four sections actually meant and what they represented.

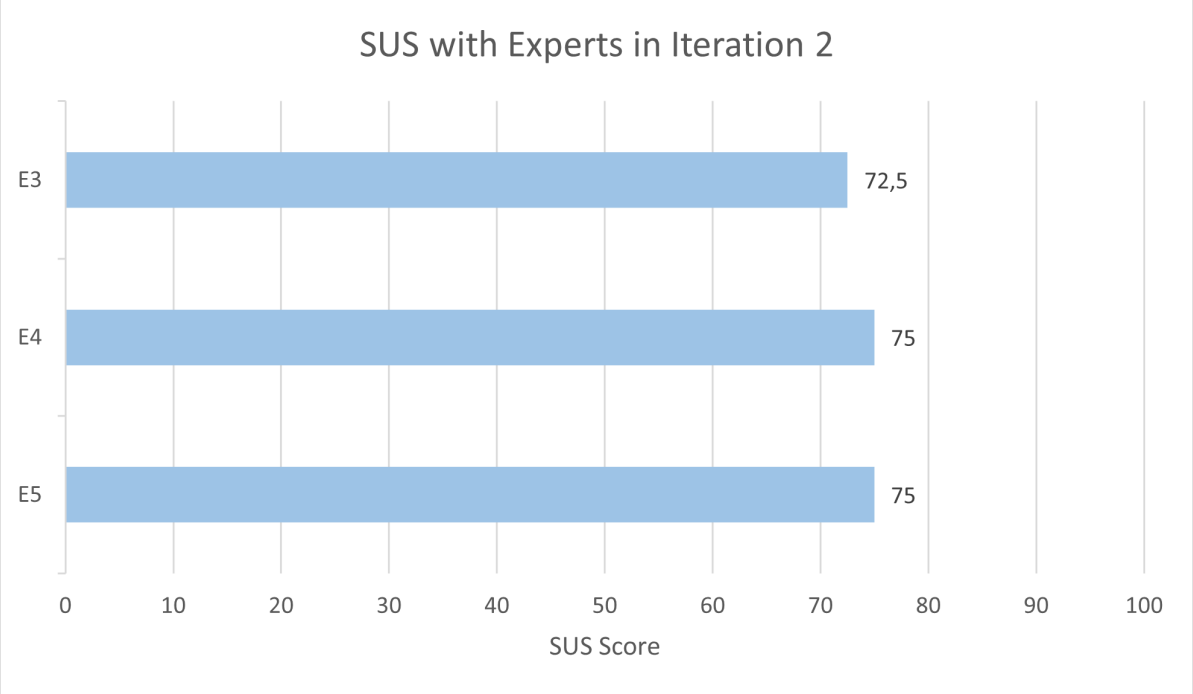


Figure 8.7: System Usability Scale score for experts - iteration 2

Iteration 4

In iteration 4 the three experts gave a SUS score from 85 to 92.5 with a mean SUS score of 89. This mean score equates to the adjective "best imaginable" or the grade A. Figure 8.8 shows the individual scores for each expert. The experts did not have many comments however, E8 commented that it would be useful to have more nutritional information when the user logs food as well as the total amount of calories on the diet page, as navigating to the *my data* page would become tedious. E6 commented that the list over the various sections in the hamburger menu was not consistent with the presentation of the same sections on the main page.

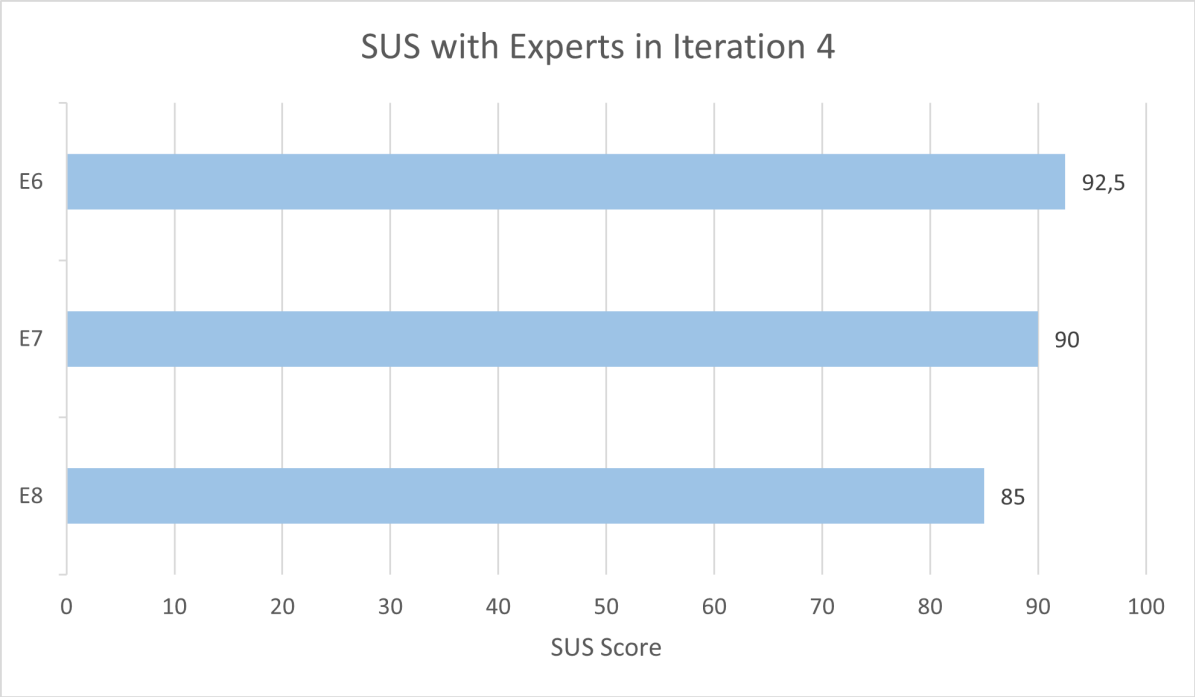


Figure 8.8: System Usability Scale scores for experts - iteration 4

Comparing Expert SUS Scores

With the mean SUS score of 74 in iteration 2 and the mean SUS score of 89 in iteration 4 there is a significant increase of 15 points. This takes the prototype from a grade C to A and from the adjective "good" to "best imaginable". Considering how the experts in the two iterations were three different people, their perception of the prototype is less likely to be affected by bias. Overall there is not too much of a difference between the SUS scores of the experts and the users in iteration 4, with the mean scores of 89 and 93.5 respectively. The experts got a slightly lower scores which is most likely due to their knowledge of usability and their ability to see potential issues that the average user would not detect.

8.4.2 SUS in Case Study

After the users had completed the usability test in iteration three they were presented with the SUS form. The questions were briefly explained and the participants were encouraged to write down any additional comments. In iteration four the users did not conduct another usability test as there were no major changes however, they were again instructed to fill out a SUS form after exploring the prototype. To get further comments not captured by the tasks, a discussion was conducted about the design itself and the changes that were made through the iterations. Having a limited set of real users this was seen as a valuable step to inquire all relevant input.

Iteration 3

Both users got a SUS score of 80 and above as seen in Figure 8.9. A mean score of 81 is referred to as "Excellent" or grade B as mentioned in Section 5.5.3. The users took the evaluation separately with the same prototype.

U2 thought that she would use the application frequently as she measures her glucose levels multiple times a day and likes to keep things organized. U4 mentioned that she usually does not track her glucose and was therefore not sure if she would remember to use the application as frequently. Both users found the prototype simple and straightforward, which made it easy to use. U2 mentioned that she would like some instructions as it would take her a little while to get familiar and fully accustomed to the application.

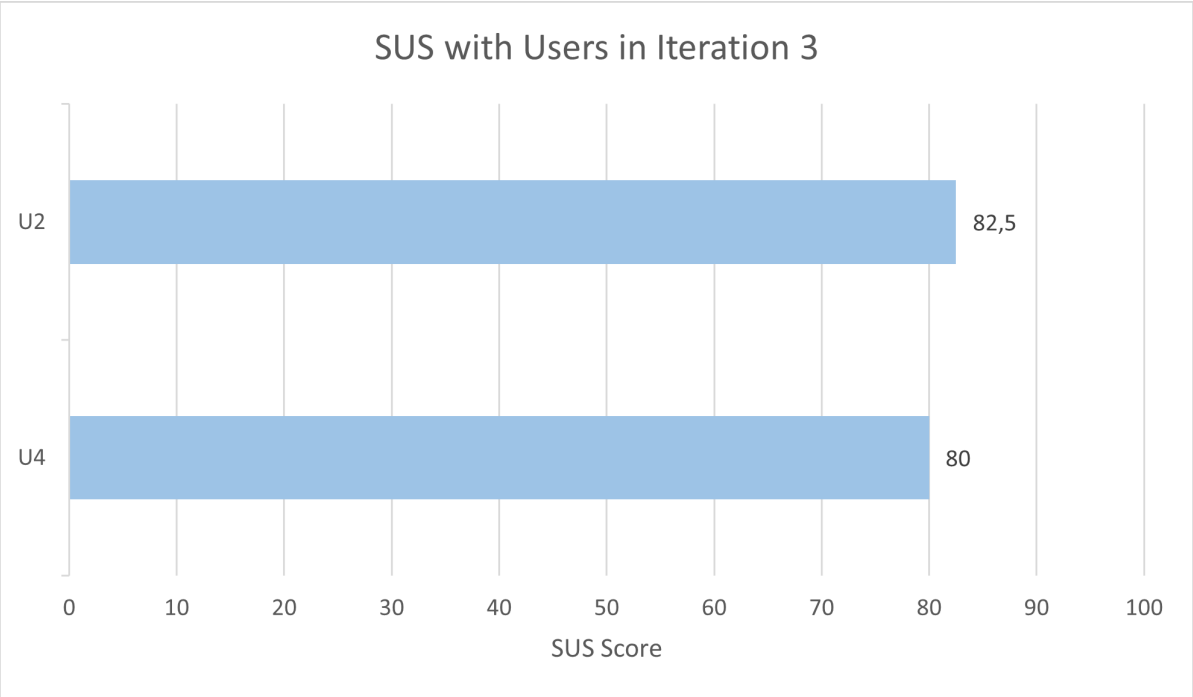


Figure 8.9: System Usability Scale scores for users - iteration 3

Iteration 4

In the fourth iteration the users completed a SUS evaluation of the final high-fidelity prototype. Both users got a SUS score above 90 and a mean score of 93.5 which equates to the grade A or the adjective "best imaginable". Their individual scores can be seen in Figure 8.10.

Both users had the same opinions regarding frequency as the previous SUS evaluation. U2 made a comment on how it was easy to learn the structure of the prototype and how the new icon text made it more obvious what information was behind the icons.

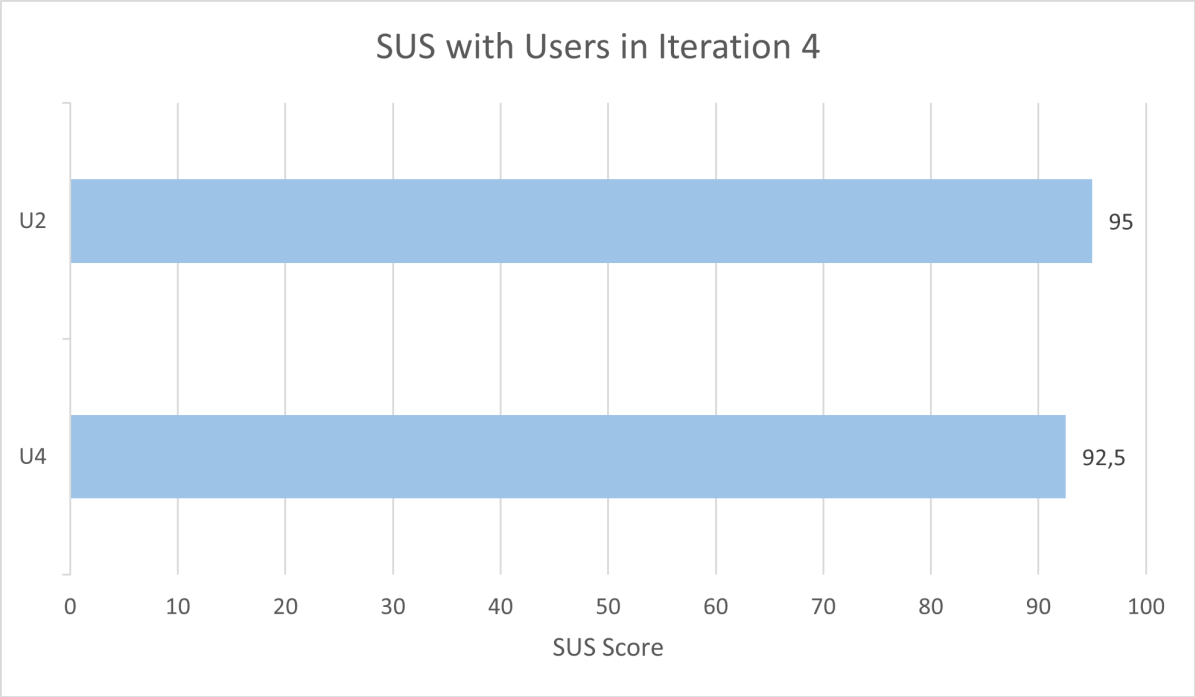


Figure 8.10: System Usability Scale scores for users - iteration 4

Comparing SUS Scores from Users

Both participants increased their SUS scores by 12.5 points as shown in Figure 8.11, which shows a great increase in usability from the users' point of view. This takes the prototype from the grade B to A or from the adjective "excellent" to "best imaginable". The scores could have been affected by the fact that the participants had already seen the prototype, however this could not have affected the SUS scores to such a degree since they have also declared that they have forgotten the previous version. The prototype can therefore be considered usable and user friendly.

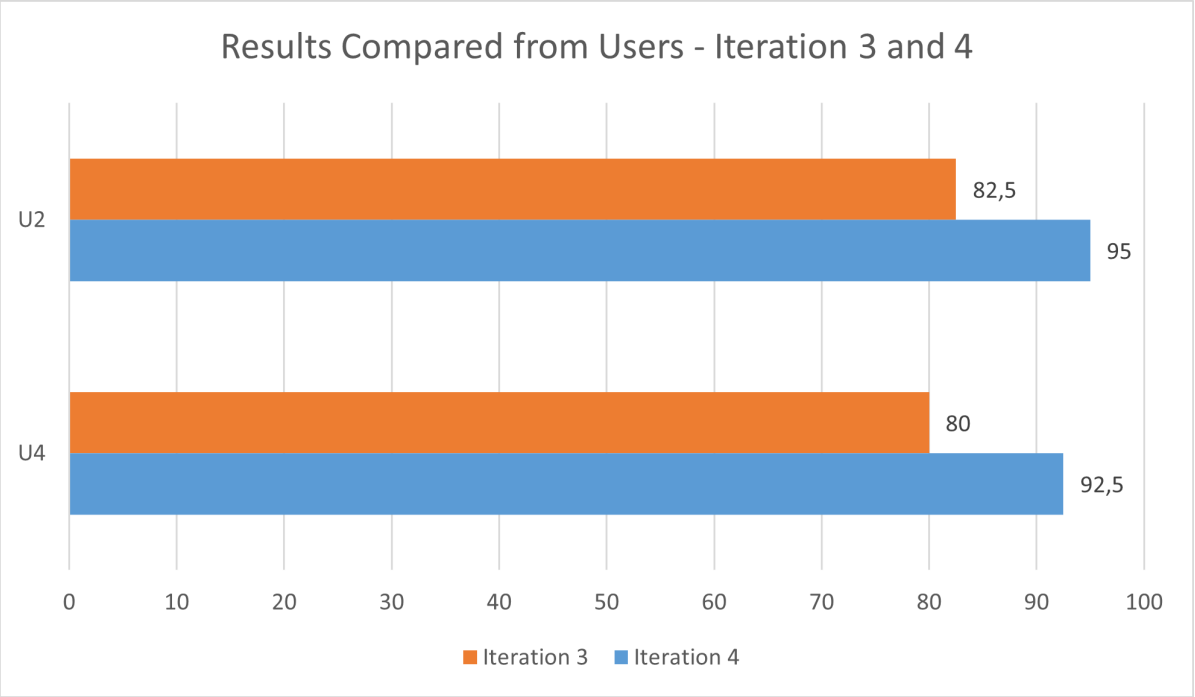


Figure 8.11: System Usability Scale scores from users obtained in iteration 3 and 4

8.5 Nielsen's Heuristics with Experts

The last step in the fourth design iteration was expert evaluation using Nielsen's heuristics. The same three experts, who did the SUS evaluation in iteration four, conducted the heuristic evaluation. They were sent a link to the final prototype, the ten heuristics that would be evaluated, as well as instructions. The experts conducted the evaluation separately on their own desktops. They were also asked to rate the heuristics from 1 to 10, 1 being the worst and 10 the best. Figure 8.12 shows the overall results of the evaluation and highlights that heuristic three, five, nine and ten should be improved.

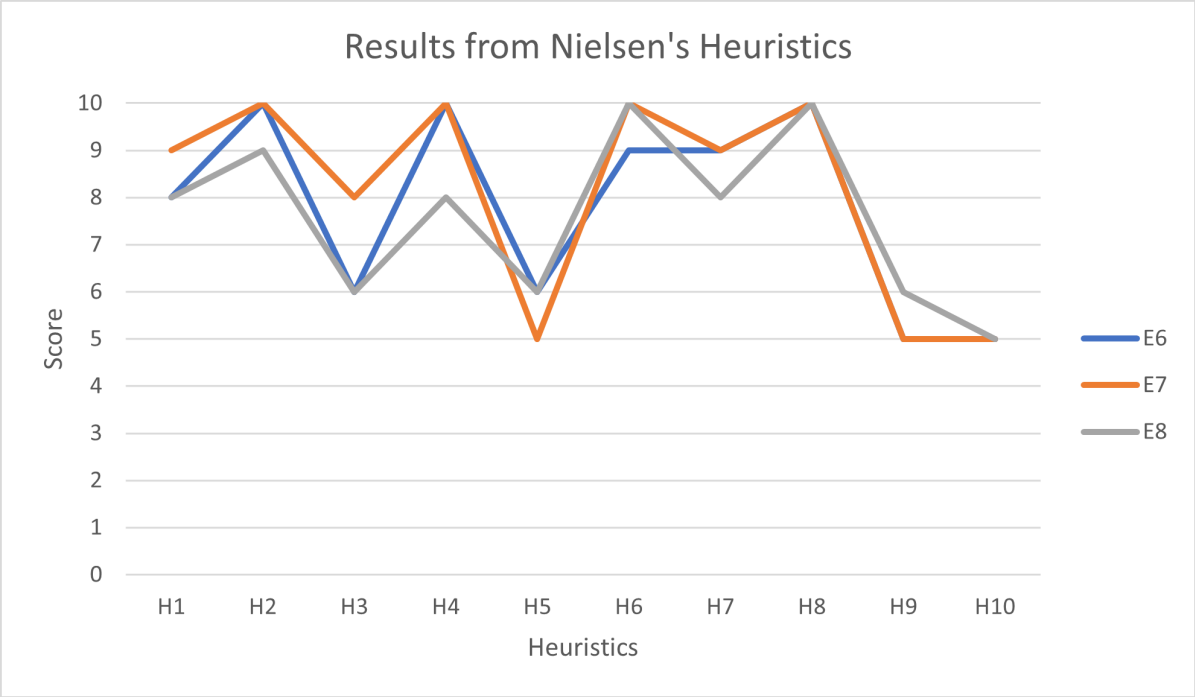


Figure 8.12: Results form Nielsen's Heuristics

The overall results can be regarded as good however, there is room for improvement and the experts have given some suggestions. The result of the evaluation is further elaborated below:

(1) *Visibility of system status* - The experts meant that there was sufficient information about where the user was in the system however, some commented that the prototype lacked feedback on actions.

(2) *Match between system and the real world* - The experts had no issues or comments on this heuristic.

(3) *User control and freedom* - One expert commented that the prototype supports undo but not redo. They also commented that there were not enough ways to get to *My data*, as this would be a page the user visited often.

(4) *Consistency and standards* - The experts commented that the settings on the main page seemed less important since it was not grouped together with the other sections. They also commented that the section listings in the hamburger menu did not correspond to the listings on the main page.

(5) *Error prevention* - The experts meant that it was difficult to check for this heuristic considering the prototype's level of fidelity.

(6) *Recognition rather than recall* - None of the experts had any remarks on this heuristic. They meant that it would be easy to remember the different functionalities and their use even after some time away.

(7) *Flexibility and efficiency of use* - The experts commented that the prototype was easy to navigate however, there was a lack of shortcuts for more proficient users. One expert also mentioned that there would need to be a way for users to delete data that

has been added by accident.

(8) *Aesthetic and minimalist design* - The experts all agreed that the prototype followed this heuristic and that it was pleasant to look at and easy to get an overview of the different elements.

(9) *Help users recognize, diagnose, and recover from errors* - The experts had no particular comments on this heuristic and they mentioned that this heuristic was difficult to check, as the prototype lacked full functionality.

(10) *Help and documentation* - The experts commented that a walkthrough mode would be necessary especially for users unfamiliar with these types of applications.

Chapter 9

Discussion

This chapter discusses the methods used, the design iterations that developed the final prototype, and limitations. It also addresses and reflects on the design science framework and answers the research questions

9.1 Design Science Research

During the research project the design science research methodology was used. The eight questions, serving as a checklist presented in Chapter 5 Table 5.1, were used to ensure that the key elements of design science were covered. Here is how the questions were answered:

1. What is the research question (design requirements)?

The research questions (Section 1.1) and requirements (Section 4.4) were established in the early stages of the project. These research questions were formulated to fit the target group and the problem space with the intention of making a solution that would make life with T1DM easier. By establishing the system requirements early it was easier to design appropriate solutions when moving from one iteration cycle to the next.

2. What is the artifact? How is the artifact represented?

The artifact produced in this research was a high-fidelity prototype of a mobile application named *DiaLog* (Chapter 7). It was developed through four design iterations following design principles and requirements (Chapter 6). It is an interactive prototype made in Adobe XD that contains medical knowledge for educational purposes, social media aspects serving as a supportive environment, and features promoting behavioural change and adherence.

3. What design processes were used to build the artifact?

Adhering to the design principle presented in Section 5.2.4 was important, however Nielsen's heuristic (Section 5.5.4) were also utilized as well as pursuing the usability goals (Section 5.2.5). In addition, implementing a user-centered approach was crucial as establishing user needs were imperative to achieve the desired effectiveness of the artifact (Section 5.2.1).

4. How are the artifact and the design processes grounded by the knowledge base? What, if any, theories support the artifact design and the design process?

To establish a solid knowledge base medical theory related to T1DM was researched and a literature review was conducted (Chapter 3), which gave an insight into people's experience with T1DM (Section 3.1.1), existing solutions (Section 3.4), and the current status of mHealth (Section 3.3). Medical professionals were also interviewed to gain a better understanding of current practises and the potential treatment prospects of such an artifact (Section 6.5.5).

5. What evaluations are performed during the internal design cycles? What design improvements are identified during each design cycle?

The various evaluation methods were based on gaining feedback for design improvements, but also for the intent of comparison to ensure an increase in usability and user experience. The main evaluation methods used were usability testing (Section 6.5.4), System Usability Scale (SUS), and Nielsen's heuristics (Section 6.5.3 and 6.7.3). The improvement made in each design iteration is presented in Chapter 6, whilst evaluation results and comparisons that show improvement are presented in Chapter 8.

6. How is the artifact introduced into the application environment and how is it field tested? What metrics are used to demonstrate artifact utility and improvement over previous artifacts?

Changes and improvements made to the prototype were rooted in user- and expert feedback from interviews (Section 6.4.2 and 6.5.5), usability testing (Section 8.3.2), case study (Section 8.3.3), and SUS (Section 8.4). The metrics were specific to the methods where SUS gave a number, grade and adjective, and Nielsen's heuristics were calculated as a score ranging from 1-10. Usability testing was based on task completion time expressed in seconds.

7. What new knowledge is added to the knowledge base and in what form (e.g., peer-reviewed literature, meta-artifacts, new theory, new method)?

The research and artifact developed documented in the form of a master thesis contributes to the knowledge base of medical informatics. The interactive high-fidelity prototype DiaLog is developed based on user needs from both users themselves and medical professionals. In addition the literature review of the medical field and the technology was conducted to formulate requirements.

8. Has the research question been satisfactorily addressed?

The research questions are answered at the end of this chapter in Section 9.9 and give a full overview of the research by cross referencing different chapters and sections.

9.2 Interaction Design

9.2.1 User-Centered Design

The four phases (Figure 5.2) of User-Centered Design (UCD) were implemented in the design process. Following a UCD approach allowed the prototype to be improved based on user feedback and evaluation throughout the development process. This ensured that the final product would be satisfying to the user based on their needs and preferences.

9.2.2 Prototyping

Prototyping is a time-consuming activity but gives valuable feedback. By having the user interact with prototypes they get a better feel for the product as they get to know the functionalities and the design. The feedback given by both users and experts after they had interacted with the various prototypes drove the changes and improvements made from a low- to a high-fidelity version.

9.2.3 Conceptual Design

Considering how conceptual design focuses on transforming requirements, two personas were created (Section 6.4.1). The personas were established in the first design iteration based on user interviews. By doing this the requirements and interactions between user and application became clearer, which made the prototyping process more efficient. A low-fidelity prototype were created which captured the requirements and displayed the main functionalities.

9.3 Design Principles

The design principles were used in the development of the prototype to ensure the usability of the application. These were reviewed in iteration three (Section 6.6.3) which revealed that constraints had not been sufficiently implemented. In addition, through expert evaluation in the fourth iteration (Section 6.7.3) it was also discovered that the consistency and visibility could be improved upon. Thus, the design principles proved themselves crucial in ensuring a user friendly and intuitive design.

9.4 Usability goals

Effectiveness and Efficiency

The effectiveness of the application is demonstrated in the evaluation (Section 8.3.4) where the task completion time reflects the efficiency for users. Considering the task completion time and the final SUS scores from both users and experts (Section 8.4) it can be concluded that the application is effective and efficient.

Safety

The overall safety of the application is deemed as good however, this is mostly due to the inability to properly test the application due to the current fidelity. Further testing at a higher implementation level would be necessary.

Utility

The application provides enough utility for the basic needs of the user however, further implementation would be beneficial. The functionalities are based on user wants and needs as well as literature research based on mHealth and applications for self-management.

Learnability

The learnability of the application is reflected in some of the questions from the system usability scale. The scores from both users and experts, as well as task completion time in the case study suggests that a high level of learnability has been achieved. However, as one of the experts mentioned, a walkthrough-mode would be beneficial for first time users.

Memorability

The case study conducted shows that the memorability of the application is good, and with the high level of learnability one can infer that the user would have little problem returning to the application after an extended break.

9.5 Data Gathering

9.5.1 Literature Review

During the first design iteration a literature review (Chapter 3) was conducted with the aim of gaining an understanding of self-management in T1DM (Section 3.1.3 and 3.1.4), how mHealth could play a role in treatment (Section 3.3), and exploring existing solutions to see what the current market looks like (Section 3.4). The literature review showed that various aspects of self-management had been researched, including how digital tools such as mobile applications could make this process easier. However, through the exploration of mHealth and the current applications available it became clear that user needs were not met. Considering that T1DM is a chronic disease with not only physical stressors, but also a tremendous psychological impact, current applications do not meet the need for young people trying to incorporate an effective self-management regime. The literature review served as the foundation for the research project.

9.5.2 Semi-structured interviews

The interviews with persons with T1DM (Section 6.4.2) and medical professionals (Section 6.5.5) were semi-structured which allowed the conversation to flow freely, but

still being able to revert back to the pre-defined questions when needed. The interviews gave useful qualitative data which helped assess the needs of users and their experience with the healthcare system. They also gave an insight into which aspects of an application would be useful for both people with T1DM and their healthcare provider. It would have been beneficial to have additional medical professionals involved in the research, such as dietitians and endocrinologists, to get a deeper understanding of the treatment perspective. However, this was not possible at this time and could be revisited for future iterations.

An interesting note from the interviews is that the healthcare professionals stated that when a person is diagnosed with T1DM they are given adequate information and that many patients do not experience a lot of psychological stress. However, the user participants stated otherwise. Two participants mentioned that they felt they were given very generic information and were "left on their own" to find additional information and that mental health was not adequately discussed. These experiences could however be in the minority as the sample size for this research were limited and additional research with a larger sample size could give a different perspective. Although time-consuming the semi-structured interviews were highly beneficial and relevant for the design solutions.

9.5.3 Case Study

The case study was conducted with two participants that spanned over the third and fourth iteration (Section 6.6.4). They used a smartphone to evaluate the prototype to achieve as realistic as possible experience while navigating through predefined tasks. This made it possible to observe the user in a natural setting and get feedback on usability, design, preferences and functionality having it discussed in detail (Section 8.3.3).

9.6 Evaluation of Prototypes

Usability Testing

Usability testing throughout the development process proved very useful in establishing whether the prototype design was intuitive. It highlighted challenges in the functionality and unclear elements. The participants were given seven tasks and were timed from start to completion on each task to establish if the improvements made through the iterations had been sufficient. Task completion time also gave a good indicator regarding hesitation and confusion and showed that the user interface in iteration two was not intuitive. The time differences in task completion (Section 8.3.4) carried out in the second and third iteration was favorable for the third iteration, indicating that the design changes were efficient.

Usability testing in iteration two was done in a browser over video call, and usability testing in iteration three was done face-to-face on a smartphone. This could have been also a factor in the improvements seen between the two iterations as using the smartphone to navigate may have been quicker and felt more natural than a desktop view. In addition, the participants from the case study had also participated in the usability test in iteration two and this could have affected the results. The time in between these two

tests were approximately four weeks and neither participants mentioned recognizing the functionalities of the application however, they might have been biased.

System Usability Scale

SUS is a suitable evaluation method for most systems and artifacts as it is quick and easy to perform. The evaluation was conducted with a total of six experts (Section 8.4.1), three in iteration two, and three in iteration four, and by the users in the case study in iteration three (Section 8.4.2). The results of the evaluations were compared and the scores were quite good, but there is still room for improvement. SUS evaluation helps highlight some usability issues, but it is useful to supplement it with usability tasks.

Nielsen's Heuristics

The same three experts that did the SUS evaluation in iteration four conducted a heuristic evaluation using Nielsen's heuristics (Section 8.5). This evaluation gave useful feedback for possible future iteration however, it could have been more beneficial to have this evaluation in earlier iterations as well. The experts thought the application would be easy to use for someone with experience with mobile application however, someone with less technical experience would need more guidance.

9.7 Prototype

9.7.1 Prototype Development

The prototype went through four main design iteration through low-, mid-, and high-fidelity prototypes. This was very useful during evaluation and testing to see which layouts and designs worked and which did not. The prototypes were created using Balsamiq, Figma, and Adobe XD [36][37][38]. Although these tool allowed for fast development and efficient adjustments, it also restricted the level of fidelity in terms of available functionalities. Additional design iteration implementing a database and proper programming would bring the application to life. Despite the somewhat limited functionalities the prototypes gave valuable feedback which lead to continuous improvements.

9.8 Limitations

The main limitation that caused a cascade of challenges was the ongoing Covid-19 pandemic. Initially this caused a delay in the data gathering as recruitment of interview participants was difficult and had to be organized through social media, which was slow. This meant that the project recruitment was limited to personal connections and left out some potential users that were not reachable.

People with T1DM are in the high risk group which also meant that interviews and the usability testing in iteration two had to be conducted over video calls. This meant that the user had somewhat limited interaction with the prototype and some observational

data may have been lost during the usability testing. Direct contact in a natural setting would allow observation and more spontaneous dialogue, which could have been beneficial and easier on all involved in the evaluation.

9.9 Research Questions

RQ1: What needs and lifestyle preferences, identified in Diabetes Mellitus type 1, can be met by a mobile application to support young people?

Through the initial data gathering with the literature review, interviews with users, and medical professional it has become clear that there is a market potential for an application for self-management of T1DM focusing on education and support (Section 3.4).

The literature review created the foundation of this research project and thus inspired the design and functionalities developed. It pointed out that an application with an educational aspect would be beneficial for people in communication with healthcare providers during shared decision making sessions. In addition applications promoting behavioural change were considered effective (Section 3.3). These aspects were explored during the user interviews and the users confirmed that they could utilize these functionalities (Section 6.4.2).

Having a place to vent about their hardships and struggles surrounding the illness could improve self-management [21]. This could also improve social motivation in self-care by communicating with others who understand the users situation [5]. Young people are more receptive to social media integration in comparison to older users [26]. Majority of the interview participants commented that they had used or regularly used social media to gain information about their illness, whether this was them taking the initiative or just observing the discussions happening on these platforms (Section 6.4.2).

The participants in the user interview were also asked if they would consider a diet and activity section beneficial for their self-management. Majority of participants commented that they would not care to log physical activity however, a diet section could be useful (Section 6.4.2). Having to be vary of carbohydrates can be time consuming and stressful, therefore having a database with nutritional information was seen as beneficial by interviewed participants, who felt they could easily log in and obtain useful information. In short, two major preferred areas were identified by Norwegians that participated in the study; education and diet, both of which could be supported by mobile technologies.

RQ2: How can a mobile application be designed to improve self-management in Diabetes Mellitus type 1?

Based on the findings on education and behavioural changes to improve self-management two crucial sections were implemented (Chapter 7). A diabetes information section was developed that would increase disease understanding by providing the users with general information on diabetes related topics with word explanations and links to additional resources (Section 7.3). The behavioural change aspect were incorporated through notifications, logs and a graph showing trends in glucose levels (Section 7.1

and 7.2). By logging measured glucose levels the user would get an overview over daily logs. In addition they would also get an overview of their glucose level trend in a dynamic graph that would show the trend for the current day, a week, and over a few months (Section 7.2). The literature review uncovered that self-management is made increasingly difficult by a lack of self-efficacy (Section 3.1.3) and this could potentially be improved by a dynamic graph showing progress over time.

The participants experiences with social media for T1DM motivated the development of a social aspect which would give the user a sense of community with other people in similar situations. The ability to search and sort forum posts makes navigation easier and efficient, and the ability to like posts may give users motivation to participate in discussions (Section 7.4).

The diet section contains an overview of daily food intake, which makes the user more aware of their eating habits (Section 7.5). This could help them recognize patterns and bad habits that affect their glucose levels. By providing the user with meal suggestions the user may find it easier to make decisions regarding what to eat, knowing that the suggestions fit their needs (Section 7.5). The suggestions would be low in carbohydrates and fit their preferences based on previous food logs. These functionalities would need further development, but the basis is already provided by the thesis.

This work has followed closely the needs of the interviewed group and the literature, but more extensive evaluation of the prototype could give additional ideas and feedback for further development. Within the time frame of the project we have succeeded to present a functional prototype that could be introduced to healthcare personnel. Their more extensive evaluation and approval of the DiaLog application would help users see it as credible and consider it as a personal self-management tool.

Chapter 10

Conclusion

The Design Science research methodology was used throughout the project to develop a self-management tool for people with T1DM. This development spanned four design iterations and produced a high-fidelity prototype named DiaLog that encompasses user needs. Through user and expert evaluations the prototype can be seen as user friendly, meaningful, and useful.

In order to gather this data and to ensure ethical practice, an approval from the Norwegian Centre for Research Data was obtained. The data gathering during the literature review served as the foundation of the initial requirements and functionalities proposed to the interview participants. Personas were then created on the basis of the interviews and established requirements to keep the user in mind throughout the development process. Prototyping was then used to create design solutions that could be tested by potential users, starting with a low-fidelity prototype and ending with an interactive high-fidelity prototype developed in Adobe XD.

The DiaLog application consists of five main sections; *Glucose measuring, My data, Diabetes information, Forum*, and *Diet*. The application focuses on support, behavioural change, and disease education for young people with T1DM. During the four design iterations data from people with T1DM, medical professionals, and IT experts were collected. Based on their feedback the prototype was developed and improved upon.

This research project has shown that there is a need and a market for integrating mobile technologies to improve self-management in T1DM. An application such as DiaLog has the potential to increase disease understanding, improve adherence, and lessen some of the psychological strain accompanying this illness. In addition, the medical professionals both agreed that an application for self-management could be useful in a patient - physician setting with patient entered data. This would be a way to gather a broader picture of the patients' management of the disease and overall well-being.

10.1 Future Work

Future work would be concerned with technical implementation to achieve a realistic fully functioning system. In addition, the remaining usability issues found through the final evaluations would need to be solved, as well as implementation of additional

functionalities. This would entail improving feedback, visibility, implementing constraints, and a walkthrough-mode. Additional functionalities could be incorporating more nutritional information, additional graphs showing eating habits and other desired functionalities not uncovered in this research. A gamification aspect could also be beneficial, giving users increased motivation through challenges, competitions, and rewards based on personalised goals regarding glucose levels, or through logging. Continuous Glucose Monitoring (CGM) technologies could potentially be integrated into the DiaLog application to streamline the monitoring process.

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Appendix A

A.1 NSD Approval

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Mobile Application Design to Improve Self-Management in Type 1 Diabetes

Referansenummer

965164

Registrert

14.09.2020 av Nanfrid Idsø - Nanfrid.Idso@student.uib.no

Behandlingsansvarlig institusjon

Universitetet i Bergen / Det samfunnsvitenskapelige fakultet / Institutt for informasjons- og medievitenskap

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Ankica Babic, Ankica.Babic@uib.no, tlf: 55589139

Type prosjekt

Studentprosjekt, masterstudium

Kontaktinformasjon, student

Nanfrid Idsø, nanfrid.idso@student.uib.no, tlf: [redacted]

Prosjektperiode

12.10.2020 - 01.07.2021

Status

06.10.2020 - Vurdert

Vurdering (1)

06.10.2020 - Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet den 06.10.2020 med vedlegg, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde:
https://nsd.no/personvernombud/meld_prosjekt/meld_endringer.html
Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet behandler særlige kategorier av personopplysninger om helseforhold og alminnelige kategorier av personopplysninger frem til 01.07.2021.

LOVLIG GRUNNLAG – UTVALG 1
Utvalg 1 består av personer med diabetes type 1. Prosjektet vil innhente samtykke fra de registrerte i utvalg 1 til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 nr. 11 og art. 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse, som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen av alminnelige kategorier og særlige kategorier av personopplysninger om helseforhold er dermed den registrertes uttrykkelige samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a, jf. art. 9 nr. 2 bokstav a, jf. personopplysningsloven § 10, jf. § 9 (2).

LOVLIG GRUNNLAG – UTVALG 2 og 3
Prosjektet vil innhente samtykke fra de registrerte i utvalg 2 og 3 (helsepersonell og IT-eksperter) til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen av alminnelige kategorier av personopplysninger vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

TAUSHETSPLIKT
Vi minner om at helsepersonell har taushetsplikt og at det er svært viktig at intervjuene gjennomføres på en slik måte at taushetsplikten overholdes. Intervjuer og informanter har sammen ansvar for dette, og bør innledningsvis i intervjuene drøfte hvordan dette skal håndteres. Vi minner om at informantene ikke kan gi opplysninger som kan identifisere en enkelt pasient eller pårørende, direkte eller indirekte. Vi anbefaler at dere spesielt oppmerksomme på at identifiserende bakgrunnsopplysninger må utelates og at dere er forsiktige ved å bruke eksempler under intervjuene.

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Zoom vil benyttes til å gjennomføre intervjuer digitalt og vil være databehandler i prosjektet. NSD legger til grunn at behandlingen oppfyller kravene til bruk av databehandler, jf. art 28 og 29.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Kontaktperson hos NSD: Eva J. B. Payne
Tlf. Personvernтjenester: 55 58 21 17 (tast 1)

Appendix B

B.1 Informed Consent Form - Users

Informasjonsskriv for deltakelse i masterprosjektet

Mobile Application Design to Improve Self-Management in Type 1 Diabetes

Med dette ønsker vi å invitere deg til å være deltaker i masterprosjektet om selvhåndtering av diabetes type 1. Du har blitt invitert til å delta ettersom at du passer den tiltenkte målgruppens alder og har diabetes type 1. Prosjektets hovedmål er å finne ut om en mobil applikasjon kan være med å hjelpe diabetikere med selvhåndtering av sykdommen. Dette skrivet skal informere deg, som deltaker, om dine rettigheter, din rolle, samt hva målet med prosjektet er.

Om prosjektet
Dette prosjektet er en del av en masteroppgave ved instituttet for informasjons- og medievitenskap ved Universitetet i Bergen. Prosjektet skal finne personer som har diabetes type 1, og se om en slik applikasjon kunne hjulpet dem på en bedre måte med å håndtere sykdommen. Fokuset vil ligge på å samle informasjon om hva de allerede vet om sykdommen, støtte man allerede mottar fra helsepersonell, hvordan den støtten kan forbedres og hvordan en slik applikasjon kan hjelpe potensielle brukere på best mulig måte. Det endelige produktet av prosjektet vil være en høyt fungerende prototype.

Din rolle og oppbevaring av data
Med din deltakelse i dette prosjektet kan du være med på å tilpasse applikasjonen etter ønsket behov. Dette vil bli gjennomført gjennom personlige intervjuer. Det vil ikke ta mer enn maksimalt 1 time. Under alle intervjuer vil det bli tatt notater og eventuelt lydopptak om det er nødvendig, men det vil du få beskjed om på forhånd.

Personopplysninger som vil bli samlet under intervjuene er navn, epostadresse, eventuelt lydopptak, helseopplysninger og alder. I tillegg vil intervjuene ta for seg tema som omhandler hvordan du håndterer diabetesen. Dette vil være tanker og følelser knyttet til sykdommen, utfordringer, vaner og uvaner, og hvordan du utøver selvhåndtering for øyeblikket. All personlig data som blir samlet fra deg vil bare være tilgjengelig for masterstudenten, veilederen, og UiB som er behandlingsansvarlig. Informasjonen som blir samlet, vil bli behandlet konfidensielt. Dine personopplysninger vil ikke bli publisert i oppgaven med navn, men med et pseudonym. Det skal ikke være mulig å identifisere deltakerne til prosjektet gjennom informasjon som gis i oppgaven.

Masterprosjektet avsluttes, etter planen, sommeren 2021. Etter avsluttet prosjekt vil alle personopplysninger bli slettet og makulert. Dette inkluderer referansenummer og pseudonymer som var koblet opp mot spesifikke navn, lydopptak og samtykkeerklæring med underskrift.

Covid-19
Dette prosjektet vil ta hensyn til smittevernregler, og derfor vil du ha muligheten til å velge fritt om personlige intervjuer skal foregå fysisk eller digitalt.

Fysiske personlige intervjuer vil følge reglene for smittevern ved å tilby antibac og hansker, samtidig som 1-metersregelen blir opprettholdt.

Dine rettigheter
Deltakelse i dette prosjektet er frivillig, og du kan når som helst trekke ditt samtykke uten å måtte begrunne for valget.

Dine rettigheter om dine personopplysninger:

- Innsyn i hvilke personopplysninger som er registrert,
- Å få rettet på personopplysninger,
- Å få slettet personopplysninger,
- Å få utlevert en kopi av dine personopplysninger,
- Å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger

Når du signerer samtykkeerklæringen, gir du oss rett til å behandle personopplysninger om deg. Prosjektet er også meldt inn til Norsk senter for forskningsdata for å få tillatelse til å behandle dine personopplysninger.

Oppstår det spørsmål om prosjektet kan du ta kontakt med:

Masterstudent	Nanfrid Idsø	**xxxxxxxx**	nanfrid.idso@student.uib.no
Veileder	Ankica Babic	55589139	ankica.babic@uib.no
Personvernombudet	Norsk senter for forskningsdata	55582117	nsd@nsd.no
Janecke Helene Veim	UiB personvernombud	55 58 20 29	Janecke.Veim@uib.no

Samtykkeerklæring

Jeg har mottatt og forstått all nødvendig informasjon om prosjektet, og fått anledning til å trekke meg når som helst om ønskelig. Jeg samtykker til:

- ☐ Å delta i intervju.
- ☐ At mine opplysninger blir publisert i oppgaven under et pseudonym.
- ☐ At mine opplysninger blir behandlet frem til prosjektavslutning, sommeren 2021.

_____ _____

SIGNATUR FRA DELTAKER DATO

B.2 Informed Consent Form - Experts

Informasjonsskriv for deltakelse i masterprosjektet

Mobile Application Design to Improve Self-Management in Type 1 Diabetes

Med dette ønsker vi å invitere deg til å være deltaker i masterprosjektet om selvhåndtering av diabetes type 1. Du har blitt invitert til å delta ettersom at du har kompetanse til å teste prototypen av den tiltenkte applikasjonen. Prosjektets hovedmål er å finne ut om en mobil applikasjon kan være med å hjelpe diabetikere med selvhåndtering av sykdommen. Dette skrivet skal informere deg, som deltaker, om dine rettigheter, din rolle, samt hva målet med prosjektet er.

Om prosjektet
Dette prosjektet er en del av en masteroppgave ved instituttet for informasjons- og medievitenskap ved Universitetet i Bergen. Prosjektet skal finne personer som har diabetes, og se om en slik applikasjon kunne hjulpet dem på en bedre måte med å håndtere sykdommen. Fokuset vil ligge på å samle informasjon om hva de allerede vet om sykdommen, støtte man allerede mottar fra helsepersonell, hvordan den støtten kan forbedres og hvordan en slik applikasjon kan hjelpe potensielle brukere på best mulig måte.

Din rolle og oppbevaring av data
Med din deltakelse i dette prosjektet vil du være med på å forbedre brukeropplevelsen til prototypen. Dette vil bli gjennomført gjennom personlige intervjuer. Det vil ikke ta mer enn maksimalt 1 time. Under alle intervjuer vil det bli tatt notater og eventuelt lydopptak om det er nødvendig, men det vil du få beskjed om på forhånd.

Personopplysninger som vil bli samlet under intervjuene er navn, epostadresse, og eventuelt lydopptak. Intervjuene vil gå ut på brukertesting av prototypen, samt utfylling av et System Usability Score skjema. All personlig data som blir samlet fra deg vil bare være tilgjengelig for masterstudenten, veilederen, og UiB som er behandlingsansvarlig. Informasjonen som blir samlet, vil bli behandlet konfidensielt. Dine personopplysninger og vurderinger av prototypen vil ikke bli publisert i oppgaven med navn, men med fagfelt. Det skal ikke være mulig å identifisere deltakerne til prosjektet gjennom informasjon som gis i oppgaven.

Masterprosjektet avsluttes, etter planen, sommeren 2021. Etter avsluttet prosjekt vil alle personopplysninger bli slettet og makulert. Dette inkluderer referansenummer og fagfelt som var koblet opp mot spesifikke navn, lydopptak og samtykkeerklæring med underskrift

Covid-19
Dette prosjektet vil ta hensyn til smittevernregler, og derfor vil du ha muligheten til å velge fritt om personlige intervjuer skal foregå fysisk eller digitalt.

Fysiske personlige intervjuer vil følge reglene for smittevern ved å tilby antibac og hansker, samtidig som 1-metersregelen blir opprettholdt.

Dine rettigheter

Deltakelse i dette prosjektet er frivillig, og du kan når som helst trekke ditt samtykke uten å måtte begrunne for valget.

Dine rettigheter om dine personopplysninger:

- Innsyn i hvilke personopplysninger som er registrert,
- Å få rettet på personopplysninger,
- Å få slettet personopplysninger,
- Å få utlevert en kopi av dine personopplysninger,
- Å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger

Når du signerer samtykkeerklæringen, gir du oss rett til å behandle personopplysninger om deg. Prosjektet er også meldt inn til Norsk senter for forskningsdata for å få tillatelse til å behandle dine personopplysninger.

Oppstår det spørsmål om prosjektet kan du ta kontakt med:

Masterstudent	Nanfrid Idsø	**xxxxxxxx**	nanfrid.idso@student.uib.no
Veileder	Ankica Babic	55589139	ankica.babic@uib.no
Personvernombudet	Norsk senter for forskningsdata	55582117	nsd@nsd.no
Janecke Helene Veim	UiB personvernombud	55 58 20 29	Janecke.Veim@uib.no

Samtykkeerklæring

Jeg har mottatt og forstått all nødvendig informasjon om prosjektet, og fått anledning til å trekke meg når som helst om ønskelig. Jeg samtykker til:

- ☐ Å delta i intervju.
- ☐ At mine opplysninger blir publisert i oppgaven under fagfeltet som jeg tilhører.
- ☐ At mine opplysninger blir behandlet frem til prosjektavslutning, sommeren 2021.

_____ _____

SIGNATUR FRA DELTAKER DATO

B.3 Informed Consent Form - Medical Professionals

Informasjonsskriv for deltakelse i masterprosjektet

Mobile Application Design to Improve Self-Management in Type 1 Diabetes

Med dette ønsker vi å invitere deg til å være deltaker i masterprosjektet om selvhåndtering av diabetes type 1. Du har blitt invitert til å delta ettersom at du spiller en viktig rolle i behandlingen til personer med diabetes type 1. Prosjektets hovedmål er å finne ut om en mobil applikasjon kan være med å hjelpe diabetikere med selvhåndtering av sykdommen. Dette skrivet skal informere deg, som deltaker, om dine rettigheter, din rolle, samt hva målet med prosjektet er.

Om prosjektet
Dette prosjektet er en del av en masteroppgave ved instituttet for informasjons- og medievitenskap ved Universitetet i Bergen. Prosjektet skal finne personer som har diabetes, og se om en slik applikasjon kunne hjulpet dem på en bedre måte med å håndtere sykdommen. Fokuset vil ligge på å samle informasjon om hva de allerede vet om sykdommen, støtte man allerede mottar fra helsepersonell, hvordan den støtten kan forbedres og hvordan en slik applikasjon kan hjelpe potensielle brukere på best mulig måte.

Din rolle og oppbevaring av data
Med din deltakelse i dette prosjektet kan du være med på å tilpasse applikasjonen etter det behovet som personer med diabetes type 1 har. Dette vil bli gjennomført gjennom personlige intervjuer. Det vil ikke ta mer enn maksimalt 1 time. Under alle intervjuer vil det bli tatt notater og eventuelt lydopptak om det er nødvendig, men det vil du få beskjed om på forhånd.

Personopplysninger som vil bli samlet under intervjuene er navn, epostadresse, og eventuelt lydopptak. I tillegg vil intervjuene ta for seg tema som omhandler din rolle i behandlingen av diabetes type 1. Dette vil være informasjon som gis til pasienter, hva slags informasjon du ønsker av pasienten, oppfølging, oppfordringer og mål som gis, og ressurser som pasienter blir henvist til. All personlig data som blir samlet fra deg vil bare være tilgjengelig for masterstudenten, veilederen, og UiB som er behandlingsansvarlig. Informasjonen som blir samlet, vil bli behandlet konfidensielt. Dine personopplysninger vil ikke bli publisert i oppgaven med navn, men med stillingsnavnet ditt. Det skal ikke være mulig å identifisere deltakerne til prosjektet gjennom informasjon som gis i oppgaven.

Masterprosjektet avsluttes, etter planen, sommeren 2021. Etter avsluttet prosjekt vil alle personopplysninger bli slettet og makulert. Dette inkluderer referansenummer og stillingsnavn som var koblet opp mot spesifikke navn, lydopptak og samtykkeerklæring med underskrift.

Covid-19
Dette prosjektet vil ta hensyn til smittevernregler, og derfor vil du ha muligheten til å velge fritt om personlige intervjuer skal foregå fysisk eller digitalt.

Fysiske personlige intervjuer vil følge reglene for smittevern ved å tilby antibac og hansker, samtidig som 1-metersregelen blir opprettholdt.

Dine rettigheter
Deltakelse i dette prosjektet er frivillig, og du kan når som helst trekke ditt samtykke uten å måtte begrunne for valget.

Dine rettigheter om dine personopplysninger:

- Innsyn i hvilke personopplysninger som er registrert,
- Å få rettet på personopplysninger,
- Å få slettet personopplysninger,
- Å få utlevert en kopi av dine personopplysninger,
- Å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger

Når du signerer samtykkeerklæringen, gir du oss rett til å behandle personopplysninger om deg. Prosjektet er også meldt inn til Norsk senter for forskningsdata for å få tillatelse til å behandle dine personopplysninger.

Oppstår det spørsmål om prosjektet kan du ta kontakt med:

Masterstudent	Nanfrid Idsø	**xxxxxxxx**	nanfrid.idso@student.uib.no
Veileder	Ankica Babic	55589139	ankica.babic@uib.no
Personvernombudet	Norsk senter for forskningsdata	55582117	nsd@nsd.no
Janecke Helene Veim	UiB personvernombud	55 58 20 29	Janecke.Veim@uib.no

Samtykkeerklæring

Jeg har mottatt og forstått all nødvendig informasjon om prosjektet, og fått anledning til å trekke meg når som helst om ønskelig. Jeg samtykker til:

- ☐ Å delta i intervju.
- ☐ At mine opplysninger blir publisert i oppgaven under stillingsnavnet mitt
- ☐ At mine opplysninger blir behandlet frem til prosjektavslutning, sommeren 2021.

_____ _____

SIGNATUR FRA DELTAKER DATO

Appendix C

C.1 Interview Guide - Users

Intervjuguide til masterprosjektet Unge med Diabetes Type 1

Mobile Application Design to Improve Self-Management in Type 1 Diabetes

Dette skrivet tar for seg hvordan intervjuet vil foregå for masterprosjektet som omhandler livsstil og diabetes type 2. Det vil være fokus på hva slags informasjon som blir gitt til de med diabetes type 2 og om den er forståelig. I tillegg vil kunnskap om eksisterende løsninger for selvhåndtering av diabetes utforskes.

Intervjuguiden er et enkelt og simplifisert eksempel på hvordan et intervju vil foregå. All informasjon samlet under disse intervjuene vil være anonymiserte med mindre deltakeren har et annet ønske. Dersom det blir nødvendig vil intervjuet bli tatt opp.

Personopplysninger (ca. 10 min)
Denne delen vil ta for seg spørsmål som alder, når diagnosen ble stilt, okkupasjon, problemer knyttet til diabetes.

Livsstil (ca. 15 min)
Denne delen vil ta for seg spørsmål angående vaner og uvaner, kosthold og aktivitet, og støtte fra utenforstående.

Eksisterende løsninger og ønskede funksjoner (ca. 25 min)
Denne delen vil ta for seg mer utdypende spørsmål om bruk av eksisterende løsninger for selvhåndtering, og ønskede funksjoner i en mobilapplikasjon for selvhåndtering av diabetes type 1.

Del 1 - personopplysninger
Hvor gammel er du:
Når ble du diagnostisert:
Hvordan har diabetes påvirket deg fysisk:
Hvordan har diabetes påvirket deg psykisk:
Hva følte du da du fikk diagnosen:
Hvor fikk du informasjon om diabetes:
Var informasjonen du fikk forståelig og tilstrekkelig:
Hva vet du nå som du ønsker du visste når du fikk diagnosen:

Del 2 - Livsstil
Hvor ofte er du aktiv:
Hva jobber du som:
Hvordan vil du beskrive kostholdet ditt:
Hva slags informasjon fikk du angående fysisk aktivitet:
Hva slags informasjon fikk du angående matvaner:
Benytter du deg av alkoholholdige drikker:
Føler du at de rundt deg forstår deg og sykdommen:
Føler du deg forstått av helsepersonell:
Føler du helsepersonell setter oppnåelige mål for deg mtp sykdommen:
Hvilke følelser har du knyttet til sykdommen:

Del 3 - Eksisterende løsninger og ønskede funksjoner
Bruker du apper knyttet til diabetes:

Kunne du brukt en app knyttet til diabetes:
Bruker du sosiale medier til å finne informasjon om diabetes:
Kommunisere du med andre på forum for diabetes:
Ville du brukt en app til å:

- Loggføre blodsukkermålinger
- Få personiliserte tips og råd om kosthold og fysisk aktivitet
- Registrere matvaner
- Registrere aktivitet
- Registrere psykiske faktorer
- Kommunisere med legen din - rapport
- Forum for å kommunisere med andre
- Finne informasjon om diabetes
- Finne betydningen til ord som blir brukt innen diabetesfeltet
- Overvåke grafer for målinger

Hva ønsker du fra en app som skal hjelpe med selvhåndering for de med diabetes type 1:

C.2 Interview Guide - Medical Professionals

Intervjuguide til Helsepersonell knyttet til diabetesbehandling

Mobile Application Design to Improve Self-Management in Type 1 Diabetes

Denne intervjuguiden tilhører masterprosjektet som omhandler livsstil og diabetes type 1. Det vil være fokus på hva slags informasjon som blir gitt til de med diabetes type 1 og om den er forståelig. I tillegg vil kunnskap om eksisterende løsninger for selvhåndtering av diabetes utforskers.

Intervjuguiden er et enkelt og simplifisert eksempel på hvordan et intervju vil foregå. All informasjon samlet under disse intervjuene vil være anonymiserte med mindre deltakeren har et annet ønske. Dersom det blir nødvendig vil intervjuet bli tatt opp.

Diabetesbehandling (ca. 10 min)
Denne delen vil ta for seg spørsmål som okkupasjon, støtte og behandling som gis til pasienten samt informasjon om livsstilsråd.

Eksisterende løsninger og ønskede funksjoner (ca. 20 min)
Denne delen vil ta for seg mer utdypende spørsmål om bruk av eksisterende løsninger for pasienten samt helsepersonellet, informasjon og tips som blir gitt og ønskede funksjoner i en mobilapplikasjon for å tilby selvhåndtering til pasienter med diabetes type 1.

Del 1 - Diabetesbehandling
Hva jobber du som:
Hva slags informasjon blir gitt ut til nydiagnostiserte pasienter:
Hvordan blir informasjon gitt til pasienter:
Hvordan hjelper dere pasienter med psykiske påkjenninger:
Hvor ofte får diabetikere oppfølging:
Hva slags oppfordringer får pasientene mtp fysisk aktivitet:
Hva slags oppfordringer får pasientene mtp kosthold:
Hva slags mål blir satt for pasientene mtp mestring:

Del 2 - Eksisterende løsninger og ønskede funksjoner
Hvilke digitale ressurser blir presentert for pasientene:
Blir apper eller lignende benyttet i behandlingen:

Ville en app med disse funksjonene vært nyttig for pasienten og deg som helsepersonell:

- Loggføre blodsukkermålinger
- Registrere matvaner
- Registrere aktivitet
- Registrere psykiske faktorer
- Kommunisere med legen din
- Forum for å kommunisere med andre
- Finne informasjon om diabetes
- Finne betydningen til ord som blir brukt innen diabetesfeltet
- Overvåke blodsukkertrender

Om du skulle tilby en passende app som skal hjelpe med selvhåndtering til en diabetiker, hvilke andre funksjoner ville vært nyttige:

Appendix D

D.1 System Usability Scale Form

Participant ID: _____ Device: _____ Date: __/__/__

System Usability Scale

Instructions: For each of the following statements, mark **one** box that best describes your reactions to the app *today*.

	Strongly disagree				Strongly agree
1. I think that I would like to use the app frequently					
2. I found the app unnecessarily complex					
3. I thought the app was easy to use					
4. I think I would need assistance to be able to use this app					
5. I found the various functions on the app well integrated					
6. I thought there was too much inconsistency on the app					
7. I would imagine that most people would learn to use the app very quickly					
8. I found the app very cumbersome/awkward to use					
9. I felt very confident using the app					
10. I need to learn to learn a lot of things before i could start using the app					

Please provide more comments about the app:

D.2 Nielsen's Heuristic Form

Participant ID: _____ Device: _____ Date: __/__/__

Nielsen's Heuristic

Please rate each heuristic from 1-10, 1 being the worst and 10 the best.

Severity:

1 – Cosmetic problem only: need not be fixed unless extra time is available

2 – Minor usability problem: fixing this should be given low priority

3 – Major usability problem: important to fix, should be given high priority

4 – Usability catastrophe: imperative to fix this before product can be released

Heuristic	Severity	Issues	Recommendation	Rating
Visibility of system status The system should always keep users informed about what is going on, through appropriate feedback within reasonable time				
Match between system and the real world The system should speak the users' language, with words, phrases, and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.				
User control and freedom Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.				
Consistency and standards Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.				
Error prevention Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.				

Recognition rather than recall Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.				
Flexibility and efficiency of use Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.				
Aesthetic and minimalist design Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.				
Help users recognize, diagnose, and recover from errors Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.				
Help and documentation Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.				