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Diabetes type I treatment requires daily insulin injections together with a regular diet and frequent blood glucose monitoring. To regulate the insulin intake the patient has to measure the blood glucose level multiple times a day. Patients encounter many barriers while dealing with diabetes self-management in everyday life. Self-monitoring of blood glucose has been shown to be significantly associated with better metabolic control. Diabetes management in adolescence is poorer than in other age groups so they need interventions that suit the target group. Since smartphones are common nowadays they could provide a tool to assist diabetes patients. An application for diabetes patients was designed, implemented and evaluated. The application focuses on daily blood glucose monitoring and data synchronization with medical professionals. This is done by using a virtual coach and reminders that users can set to measure their blood glucose level or synchronize the data with a server. The application was evaluated in a user evaluation with five participants over a period of three months. The results showed no increase in daily blood glucose measurement frequency but the participants indicated some features of the application were useful to them.
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This report will conclude my master Human Media Interaction at the Twente University. A long journey which I will look back at with fondness.
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Abstract

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Chapter 1

Introduction

Diabetes is a chronic disease that involves insulin insufficiency. Diabetes type 1 patients have a total lack of insulin. In type 2 diabetes, the body does not use its insulin properly, because of insulin resistance.

Diabetes type 1, previously called insulin-dependant diabetes or juvenile-onset diabetes, is caused by an absolute deficiency of insulin secretion. The destruction of insulin producing Beta-cells in the pancreas leads to absolute insulin deficiency. In type 2 diabetes the cause is a combination of resistance to insulin action and insufficient insulin secretion. Genetic factors, lifestyle, obesity and lack of physical activity are risk factors for developing this type of diabetes [1].

Type 1 diabetes is treated with multiple daily insulin injections or continues insulin administration by an insulin pump, together with a regular diet, frequent blood glucose monitoring and exercise. Adherence to so many factors is a challenge for all patients, especially children and adolescents. To regulate the insulin intake the patient has to measure the blood glucose level multiple times a day. Patients encounter many barriers while dealing with diabetes self-management in everyday life.

Self-monitoring of blood glucose was shown to be significantly associated with better metabolic control [2]. In this study by Ziegler et al. 26 thousand diabetes patients ranging from 0 to 18 years old have been monitored during eleven years. In all age groups an increase in self-monitoring of blood glucose showed a positive correlation with better glycemic control. The same is shown in a similar study where the researchers interviewed 132 adolescents annually for five years [3]. Diabetes management in adolescence is poorer than in other age groups so they need interventions that suit the target group [4]. Since smartphones are common nowadays they could provide a tool to assist diabetes patients. We have investigated how the patient can be assisted with the adherence
to daily blood glucose monitoring. Smartphones are already used often to send blood glucose data to caregivers. This is helpful for medical professionals so they can check on the patient and provide timely feedback. This project designed, implemented and evaluated an application for diabetes users that focuses on daily blood glucose monitoring and data synchronization. We wanted to know what features of such an application are useful and how the user will behave when given much freedom to set the frequency and times of goals like the amount and time of daily blood glucose measurements and data synchronization.

1.1 Research question

Based on an extensive literature study in the field of persuasive technology for support of self-management systems in health care and based on reviews about existing applications for diabetes patients [5], we designed and implemented a mobile coaching system that can function as a personal coach for young people with diabetes. The focus of the coaching is on adherence to daily blood glucose monitoring and data synchronization between patient and medical professionals.

The coach application, called GlucOnline Coach (GO Coach), has the primary objective to support the users in adherence to a measurement regime that they have chosen themselves. The GO Coach has a number of features. For example, it offers the user to choose his own virtual coach, a male or a female character. The GO Coach is implemented in Android and runs on smartphones.

We have tried to find answers to a number of questions regarding this mobile coaching application. We wanted to know if patients used the GO coach and what reasons there were to use it or not. An important question is: if patients use it, does it have a positive effect on adherence to daily blood glucose measurements and data synchronization of those measurements? After all, this was the main focus of the coaching.

Methods In order to find answers to our questions we set up and executed a user evaluation with young diabetes patients of Gelderse Vallei Hospital in Ede over a period of three months. Questionnaires for surveys were designed and applied to obtain information about the usability, useful features and added value of the coach for patients. The user evaluation was concluded by conducting a focus group.
1.2 Outline

First we will introduce the context and background of this research, such as the barriers that patients face, the role of the virtual coach and some related work in the form of applications for diabetes patients. Then we discuss how the requirements are formed. Chapter 3 will discuss the design of the application. This chapter describes the initial design by a group of students from the Conversation Agents course, the design of the coach and how to deal with the two main problems of adherence to daily glucose monitoring and data synchronization between patient and medical professionals.

Chapter 4 describes the implementation, the infrastructure and the features of the application. To evaluate the application a user evaluation was done, first we discuss the design and set-up of the user evaluation and then the results in chapter 5. The results consist of data generated by the application, pre and post experiment questionnaires and a focus group meeting. This report is then concluded with a general conclusion and discussion, mainly about the results of the user evaluation.
Chapter 2

Background

2.1 Barriers of diabetes patients

Research is done to identify barriers that diabetes patients encounter in everyday life. Most of the barriers involve the environment of the patients, including their parents, peers and social situation.

The barriers are divided into five components: stress and burnout, time pressure and planning, social support, autonomy support and stigma. The prevalence of the barriers is 36% for stress and burnout, 23% for time pressure and planning, 22% for social support, 16% for stigma, and 10% for parental autonomy support. For all components together the prevalence is 16% [6].

Stress and burnout contain barriers that are associated with the negative attitude towards diabetes by the patient, like feeling angry, frustrated, stressed or anxious about diabetes. The time pressure and planning component contains barriers that patients face when having to take time to deal with diabetes while being busy. Having to take time, forgetting or having to carry supplies are some examples. The social support component contains barriers about having social support to share the problems. For example feeling alone and not having anyone to talk to about diabetes. Autonomy support contains barriers about sharing opinions and decision making with the parents. The last component stigma contains barriers about the opinion of the outside world about diabetes. For instance when at parties or restaurants, or dealing with diabetes in front of other people and friends [6].

Another study identified the barriers peer influence, social context, affect and eating disorders [7]. These barriers quite overlap those of the aforementioned study, only eating
disorders is not a component there but it is mentioned as a barrier of the time pressure and planning component.

Barriers that are encountered when trying to comply with diabetes health regimens are also looked at. The factors connected to compliance align with some barriers in the aforementioned studies. For instance, support from parents and physicians, the attitude of the patient, and the feeling of being threatened on multiple levels, like the emotional, physical or social level [8]. The barriers are summarized in table 2.1.

A mobile application could help to overcome some barriers. It could help with the attitude and motivation barriers by making diabetes self-management more engaging and fun. Some barriers concerning time and planning could be addressed by using alerts or reminders so the patient does not forget. By definition, communication is a strong feature of smart-phones, so data sharing and interaction with medical professionals or peers could be facilitated using a mobile application. Some example projects that have features to overcome barriers and try to make diabetes management easier in general are discussed in 2.2.2.

<table>
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<td>• Stress and burnout&lt;br&gt;• time pressure and planning&lt;br&gt;• Social support&lt;br&gt;• Parental autonomy support&lt;br&gt;• Stigma</td>
<td>• Peer influences&lt;br&gt;• Social context&lt;br&gt;• Affect&lt;br&gt;• Disordered eating</td>
<td>• Motivation&lt;br&gt;• Sense of normality&lt;br&gt;• Experience of results&lt;br&gt;• Energy and willpower&lt;br&gt;• Support from parents&lt;br&gt;• Support from physicians&lt;br&gt;• Support from nurses&lt;br&gt;• Attitude&lt;br&gt;• Threat to social well-being&lt;br&gt;• Threat to emotional well-being&lt;br&gt;• Threat to physical well-being</td>
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Table 2.1: Summary of barriers
2.2 Related work

2.2.1 Virtual coach

Virtual coaches or avatars are used in many forms and fields. The definition of a virtual coach in this project is that of anthropomorphic agents and avatars that positively impact motivational and affective outcomes. Such a coach or agent is available at all times and also have the advantage to be customizable to suit a particular target group [9].

An example of an application for diabetes patients is MySugr [10]. This application advertises itself as a diabetes logbook with an array of extra features. The data that users are able to enter is very extensive and varied, including blood sugar, carbohydrates, foods, moods and insulin intake. When users make a data entry, they can set a reminder for the next blood glucose measurement. The application is also able to generate pdf files of the data. It also includes small playful challenges to motivate users in their diabetes self-management.

The application has a companion in the form of a monster that reflects the well-being of the user, based on the data that is entered. The monster also reacts to every data entry, for example by being happy when the values are in a good range.

Schulman and Bickmore present an empirical study on the effect of a computer agent, designed to engage a participant in a persuasive counselling dialogue, on attitudes towards regular exercise. Two variables are used, text or embodied conversation agent (ECA) and with, or without social dialogue. The ECA delivered output as synthesized speech with synchronized non-verbal behaviour. The introductory conversation without social dialogue is only four lines long, social dialogue adds another thirteen lines. Social dialogue consists of small talk and expressions of interest in the user among other things. After the introduction is the persuasive dialogue, which is the same for all versions. Social dialogue and the ECA combined lead to positive perceptions of the message [11].
Mazotta et al. have also studied ECA versus text in persuasion. A persuasive message is conveyed by an ECA called Valentina, or through text only. Participants read the text or listen to Valentina convey the message. A post-test questionnaire was presented, where the following was measured: satisfaction, helpfulness, easiness, persuasiveness, reliability and validity. No significant differences were measured in satisfaction and helpfulness but the textual message is easier to understand (easiness). The message conveyed by the ECA is found to be significantly more persuasive and reliable [12].

Although some of these computer agents are not implemented on a mobile device, the same effect could occur when the medium changes. Based on these findings we concluded that a virtual agent as a coach would be a positive addition.
2.2.2 Mobile diabetes health systems

In this section some related work is discussed, we review the important features that applications for diabetes patients share and how they are used.

Lee et al. designed and implemented a diabetes mobile care system. With the system patients are able to upload physiological data, like blood glucose, blood pressure and ECG data. Patients are also able to receive and reply to alerts, make on-line registrations and look at the history record of the data. The system uses urgency levels when the patient does not upload blood glucose data on schedule. When a deadline is exceeded for the first time, the system automatically sends an alert to the patient. When the patient does not receive this or does not reply to this alert the urgency level is raised and alerts are not only (re)sent to the patient, but also to the medical professional [13].

Another application is Diab-Memory. Users are able to enter diabetes-related data with the numeric keypad of the phone, this data is then synchronized with a remote database. Users are able to view this data in the application but can also use a web portal. The web portal shows more elaborate statistics and trends. When the patients upload less than three data transfers a day, an automated reminder message is sent. The application was also used in a clinical pilot. The application was well accepted and found to be practical for daily usage. Ten patients used the application for 92 days. On 780 out of 920 cumulated monitoring days at least three blood glucose values were sent, this gives an adherence rate of 85%. The clinical outcome gave a statistically significant decrease in HbA1c and a slight, but not statistically significant decrease in average blood glucose level [14].

A similar application is presented by Harris et al. Here a blood glucose meter is used that can transmit the data from the meter to the phone. Users can see the data on their phone or in a web portal. The web portal shows more sophisticated graphical displays in comparison with the data shown on the phone. Both the phone and the web portal are able to show trend graphs over a month, week or day. The application also has an automated and tailored messaging feedback system for self-management support but this feature was received with mixed reactions [15].

Cafazzo et al. designed and tested an application called bant. This application uses a blue-tooth adapter for automated data transfer to iOS devices. The user then gets feedback on the data in real-time. Users also get rewarded with gamelike experience points for adhering to best-practice guidelines for blood glucose testing (goal of three or more tests per day). These points can be redeemed for real money to use in the Apple iTunes and App Store. bant also features a micro-blogging platform, so users can share experiences and gain or provide support. A clinical trial was performed with 20
participants. Daily average frequency of blood glucose measurement increased with 50% from 2.4 readings to 3.6 readings per day. A total of 161 rewards were given to patients. Two participants gathered many points and were highly adherent but never redeemed the points for rewards. This indicates that the form of reward is not the sole motivator for some participants [16].

Some of these applications feature reminders. The alerts or reminders are focused on measuring frequency or deadline. All of them have automated data transfer to a database and most of them also have automated data transfer from blood glucose meter to phone.
Chapter 3

Requirements analysis

At the start of the project we had the opportunity to attend consultation meetings with multiple medical professionals to experience first hand what the patients and medical professionals deal with. Here we noticed the need and advantages of electronic data capture and transfer. Paper-based recording in a paper diabetes diary are susceptible to backfilling, for example filling in all the measurements just before a consultation meeting. When the measurements are transferred digitally before a consultation meeting the medical professional is also able to prepare him/herself better.

In this chapter we will look at the components that make up the infrastructure of a project the hospital Gelderse Vallei has done. This project is called BLink, one of the most important components is an application called GlucoLog Lite. We will also discuss our visit to the makers of GlucoLog Lite and the requirements that followed from that visit. Other requirements based on literature study are also presented in this chapter.

3.1 Current situation

The current available components of the infrastructure consists of the GlucoLog Lite app, GlucoMen LX Plus glucose meter and the GlucOnline web portal created by Netbasics for the Gelderse Vallei Hospital. Figure 3.1 shows that patients and medical professionals can enter data via third party applications or the web portal directly. This data is then stored and can be shown in logs and charts. The environment also keeps track of carbohydrates and insulin intake.
GlucOnline  GlucOnline is a web portal that is able to receive data from GlucoLog Lite and other sources. Users can log in to see statistics and trends based on their data.

GlucoMen LX Plus  The GlucoMen LX Plus is a blood glucose meter that can produce a result within 4 seconds. It can store measurements within its own memory, the measurements can also be sent to GlucoLog Lite when a Bluetooth dongle is connected to the meter.
GlucoLog Lite is a free diabetes diary application with a logbook and charts feature. This application can also send the data by e-mail or to a web server for the health care professional.

We will briefly evaluate the Android version of GlucoLog Lite using work that discusses the evaluation of accessibility, usability and user experience [17]. In this work guidelines for usability are presented. These include Neilsen’s usability heuristics [18] and Shneiderman’s 8 golden principles of good interface design [19].

In the three images below the settings screen is shown, figure 3.4.

It consists of one screen that is scrollable and encompasses many fields. This could be divided in multiple screens for a better overview. The settings screen is the first screen (after the terms of use) the user sees. Below are buttons or tabs, which show if the settings tab is active. When the user tries to access a different tab this is not possible but why it is not possible is not shown. Pressing other tabs simply does nothing as it seems. After the ”measurement unit” fields are filled in, the other tabs become accessible. This is an example of failing to meet the heuristic Visibility of system status by Nielsen. This heuristic says the system should keep the user informed what
is going on, through appropriate feedback within reasonable time. This is not the case when trying to access an other tab without entering the measurement units. A message should be shown that tells the user why the other tabs cannot be accessed. This problem is also in conflict with the principle of **Offer informative feedback** by Shneiderman and Plaisant.

When trying to enter a value manually the screen below is shown, figure 3.5.

![Figure 3.5: Enter a blood glucose value](image)

At the bottom is a confirmation button. When a value is entered using the on-screen keyboard the confirmation button is covered as is seen in the right image and when we press outside the keyboard area, the keyboard is not dismissed, so it is necessary have to press the Android back key. This is an example of failure of the heuristic **Flexibility and efficiency of use** by Nielsen.
The last two images below show the Glycaemia tab below, figure 3.6.

![Glycaemia Tab Images](image)

**Figure 3.6: Glycaemia tabs**

When this tab is accessed the result screen is shown. There are other screens in this tab, like "Diary" which is shown in the upper right corner. By swiping the screen other overviews can be shown, but this is not immediately clear when opening the Glycaemia tab. The overviews of this tab are Results, Diary, Chart and Stats.

The heuristic of **User control and freedom** and the principle of **Permit easy reversal of actions** are applied properly with GlucoLog. The user is able to easily undo, delete or exit a data entry. Although the settings screen is somewhat long the settings can be easily accessed and changed.

Later in the focus group of the user evaluation the participants indicated they did not use other features of GlucoLog Lite than the data synchronization with the server.
3.2 BLink

To provide more effective care by regulating the data transaction and feedback, the hospital Gelderse Vallei did a project called BLink. BLink consisted of four main components: an app called GlucoLog Lite, the GlucoMen LX Plus blood glucose meter, the hospital web portal where the measurements were sent to from the app and a Personal Health Record called Patient1, in which the glucose data were stored, and the medical professional and the patient could send messages to each other. BLink enabled the medical professional to receive the measurements in a uniform way. The measurements could be checked before a patient came in for consultation.

BLink provided a tool to share data messages, which was helpful because the medical professional had a uniform way to receive the data and provide feedback. But there was no stimulation within the system to share the data. Sometimes medical professionals had to contact the patient to ask them if they could send the data. The patients sometimes did not read the Patient1 message board, so this had to happen outside the system when the patient did not respond.

Although GlucoLog Lite was a nice tool to store and send blood glucose measurements it did not provide a way to help the patient to do the blood glucose measurements. It did provide elaborate statistics but to fully use them the patient had to take initiative and put in effort.
3.3 Visiting Zuchetti Centro Sistemini

The company A.Menarini has outsourced their IT work to Zuchetti Centro Sistemini. They are also responsible for the Glucolog Lite app. We went to Florence, Italy where Zuchetti Centro Sistemini is based to discuss how the mobile virtual coach could fit into the existing infrastructure with the Glucolog Lite app and the GlucoMen LX Plus glucose meter.

Before we went there we had formulated the following questions:

1. How does the virtual coach fit into the current infrastructure?
2. Should the virtual coach be integrated in the Glucolog Lite app, or should they be separate apps?
3. Could it be possible for the coach to retrieve blood glucose measurements without the use of the internet?
4. Is it possible for Glucolog Lite to share its data with another app on the same device?
5. If Glucolog Lite could share its data, how could that be realised?

The blood glucose measurements are already available through the GlucOnline server. The Glucolog Lite app sends the measurements to that server. Because the coach needs up-to-date information to be able to perform well this means it has to have internet access at all times, if this option of retrieving data is selected. This could be a hindrance, because internet access is not always available, especially when the user is not at home.

During the meeting the following answers to the questions became apparent:

1. The policy of A.Menarini is to not integrate separate functionality into the Glucolog Lite app, due to hardware limitations of mobile devices, such as storage space.
2. Looking at the previous answer the virtual coach should become a separate app.
3. Yes this could be possible, the data could be retrieved from Glucolog Lite.
4. It is possible to share data on the Android platform. The engineers of Zuchetti Centro Sistemini will see how this could be facilitated.
5. During the meeting the engineers came up with two possible ways to access the data. One is to make the database of GlucoLog Lite accessible to other apps. Another solution could be to write the data to a file and have the virtual coach app access and read that file.

During the trip we found out that the mobile virtual coach should become a separate app that runs next to GlucoLog Lite. Although it is not ideal for the users to use to applications, the solution fits best in the current environment. We already had a way to retrieve the blood glucose measurements through the GlucOnline API that Netbasics is working on. However this would mean that the user should have access to the internet to do so. The engineers of Zuchetti Centro Sistemin would find a way to make the data of GlucoLog Lite available to applications on the same device.

### 3.4 Requirements

Based on the previous sections of this chapter these were the requirements for the application:

#### 3.4.1 User requirements

R1.1: The user should be able to enter their blood glucose measurement.

R1.2: The user should be able to enter diary entries.

R1.3: The user should be able to see an overview of the diary entries.

R1.4: The user should be able to delete a diary entry.

R1.5: The user should be able to see an overview of the available historical glucose level data in logs or graphs.

#### 3.4.2 System requirements

R2.1: The coach should keep the patients involved and interested in self-care.

- Conversation about the patient’s thoughts and feelings.
- Possibility to write this down in a diary/journal.

R2.2: The coach should stimulate patients to measure.

- Achievements, rewards or through interaction.
R2.3: The coach should remind patients to measure the blood glucose level and inject insulin.

- Reminders

R2.4: The coach should provide feedback after certain events, in particular

- after a missed measurement deadline.
- after evaluation of blood glucose level input.
- at the end of certain user selected days.

R2.5: The coach should be able to work without an internet connection.

R2.6: The coach should have up-to-date information about the measurements.

R2.7: The coach should be able to synchronize with a server.

R2.8: The application should work with Android 2.3.3 (API 10) and above.

To meet these requirements the coach should require minimal user input so it does not become a hindrance. The coach should do as much work as possible in the background while being able to provide feedback to the user.
Chapter 4

Application design

4.1 Initial design

The initial design is done by Brilman, Van Herwijnen and Varkevisser for the course Conversational Agents [20]. For that course they created an application called Gluco-Mate as an example but with most features missing. For persuasion the theory of Fogg is used. Computing products can use five types of social cues to motivate and persuade. These are physical, psychological, language, social dynamics and social roles [21]. An eight step design process for persuasive technology is developed. These eight steps are [22]:

1. Choose a simple behaviour to target
2. Choose a receptive audience
3. Find what prevents the target behaviour
4. Choose a familiar technology channel
5. Find relevant examples of persuasive technology
6. Imitate successful examples
7. Test and iterate quickly
8. Expand on success

The working components that we used for the GlucOnline Coach application are the database to store values and some settings, the system to display the coach images, the list view of the measurements and the text used by the coach. For the database of
the GlucOnline coach extra tables were added. With GlucoMate, users are able to set reminders, but these are not implemented. The reminders settings screen was redesigned and the reminder function was implemented for the GlucOnline coach. The list view of the measurements was updated, so it is easy to see at a glance if the measurements are too high or too low. The graph feature to show the measurements was also added. The way to display the coach was used but the appearance of the coach was changed. The new appearance resembled a Mii from Nintendo, a more familiar appearance for most children and adolescents.

The text system for the coach is still used. Text for the coach is stored as pre-made sentences, a sentence is selected, based on the situation and the mood of the coach. If there are multiple alternatives, then one of the appropriate alternatives is selected randomly. Figure 4.1 shows this in practice. New sentences were added for the reminders and the coach moment, since these features were not present in GlucoMate.

Figure 4.1: Text selection from GlucoMate
4.2 System communication

After the initial design we had a few meetings with medical professionals to look at the progress and more additional features. One of the features from a later iteration is that of the achievement stars.

The desired infrastructure is shown in figure 4.2. The GlucoMen LX Plus blood glucose meter sends the measurements to the smartphone. The data is then sent to the GlucOnline server, where patients and medical professionals can view it.

Figure 4.2: Infrastructure
**Interactions** The system interacts with three parties and is a three-way information exchange system. The three parties are the coach, the patient and the doctor or diabetes care team.

![Interacting parties](image)

**Figure 4.3: Interacting parties**

Patient $\rightarrow$ Coach:

- Blood glucose level
- Diary
- Personal details like name and age

Coach $\rightarrow$ Patient:

- Reminders
- Feedback through conversation at the coach moment
- Encouragement and tips if the goal is not met
- Representation of measurements in the form of logs and graphs.
- Log of the diary entries

Coach $\rightarrow$ Doctor:
• Diary entries if shared by patient
• Notable messages sent to patient

4.3 Blood glucose monitoring

Because the focus of this project is on adherence, the giving of reminders is a logical feature. Alerts and reminders are important when the user has to take some action, this could be an action in the past (when the deadline has already exceeded), present or future. The alert and reminder mechanism is used to notify users that it is time to measure the blood glucose level, or take some other action. The most important action here is measuring the blood glucose level.

In this study where the opportunities of using smart-phone applications as a means of delivering behavioural interventions for health were discussed. Four focus groups were conducted with 19 participants that discussed experiences of using smart-phone apps to support a healthy lifestyle, and their interest in-, and feelings about features and capabilities of such apps. One section is about reminders and prompts. Participants indicated that reminders and prompts would be useful but users should have a choice in the frequency and timing. Messages with positivity and praise would also be appreciated. Some participants discussed annoyance caused by alerts, reminders or prompts. They felt their phone was nagging or harassing them, which caused the users to abandon the app [23]. Freedom for the user to choose the frequency and time would hopefully remedy these problems.

Another helpful feature is the glanceable display. Glanceable displays provide information that can be interpreted at a glance, and that is visible almost at all times [24]. An example of a glanceable display is that of a dynamic background of the smartphone as used in a project called Ubifit Garden. The background consists of a number of flowers that will increase or decrease, based on the exercise data of the user [25]. Our application will apply a glanceable display, coupled with a reminder. A countdown bar will be shown in the notification tray of Android. The notification tray is visible most of the time when using the smartphone, although some applications are run in full screen mode.
4.4 Data synchronization

Another big issue is sending the measurements to GlucoLog and then to the medical professional. This is done by connecting a bluetooth dongle to the blood glucose meter and pairing it with the smartphone. The GlucoLog app can then receive the data and send them to the GlucOnline server, where the medical professionals can access and monitor them. This saves valuable time and costs for the medical professional when it happens correctly and on a regular basis.

Users have indicated that they send the data once a week or once in two weeks. In our application users will be able to choose on which week days they will synchronize the data with a minimum of once a week. According to the medical professionals this is a good frequency and it gives the user some degree of freedom.

4.5 The Coach

![Possible avatars for the coach](image)

Different appearances for the coach avatar were considered, a few shown in Figure 4.4. Options were older and more formal or younger and informal. Eventually we chose the young and informal one, because the users in the user evaluation were adolescents and the coach would be a peer then. The avatar most to the right was chosen, it is also familiar because it is based on a Mii from the Nintendo systems. Most children and adolescents would recognize it.

It has been shown that people consider others who resemble them as more persuasive [26]. This also has been shown to work for embodied conversational agents. A study was done where participants rated agents that were created by someone else, and that resembled the participant, higher than those that did not resemble them. In this study participants had to choose an answer to a question. Afterwards a virtual human would recommend them to change the answer. Participants would change answers more often when the agent that resembled them but was created by someone else told them that
Since we were not able to create agents to resemble every user we took the most basic aspect to differentiate users: the gender.

Two coaches were created, one of each gender. The user was able to choose with which one they wished to interact. Multiple moods of the same coach were created, shown in Figure 4.5. These were shown based on the results and whether the user has met the goals or not. Because the coach was displayed as still images the focus was on the facial expression and not on other non-verbal communication like gestures.

![Avatar moods](image-url)

**Figure 4.5:** Avatar moods
Chapter 5

Implementation

5.1 Server

After some testing with the GlucOnline server we discovered it is applicable to receive and store all kinds of measurements but not for other data about how the application is used. Because there was no other server available, a possible solution was to use e-mail to send the data. It was decided to use the GMail SMTP to send the data in a comma-separated values format which can be easily copied and used in a spreadsheet. Only the researcher has access to the GMail account that is used. The blood glucose values and other settings were sent to a GMail account with a key that users have to enter upon first use of the application. Only the hospital has the information which key belongs to which person. The anonymous data were deleted after the user evaluation was completed and the analysis of the data was done. The implemented infrastructure is shown in Figure 5.1. When the data is uploaded from the blood glucose meter to GlucoLog Lite the data is also sent to the GlucOnline server by GlucoLog Lite, so the GO Coach application does not need to do this again.
Figure 5.1: Implemented infrastructure
5.2 Features

In this section we present the features of the GlucOnline Coach application. The home screen is shown in figure 5.3. The four main components are shown below the coach: the stars screen, the diary screen, the list screen and the graph screen. In the upper left and right corners are the settings for the Coach Moment and the reminders.

![Figure 5.2: The GlucOnline Coach icon](image)

![Figure 5.3: Home screen of the GlucOnline Coach application](image)
Reminders  Users are able to set daily reminders. The preferred measurement frequency also determines the number of reminders. When this is lower than 3 the bar will turn red, see Figure 5.4a. When the goal is 3 times per day the bar will turn yellow, see Figure 5.4b. When the goal is set to be 4 times or more the bar will turn green, see Figure 5.4c, to show the user what is desirable, but to also give the user the freedom to choose.

![Insufficient goal](image)

![Adequate goal](image)

![Preferred goal](image)

Figure 5.4: Goal settings

The application also includes settings for different reminder intensities as seen in Figure 5.5a.

With the mildest intensity the reminder goes off once with the corresponding sound and notification. The medium intensity has the reminder repeat 3 times in 5-minute intervals. The most strict intensity keeps repeating in 5-minute intervals until the user taps the notification to imply he/she has measured, then the reminder is stopped. When a reminder goes off, the next reminder will be set after a short time.

A countdown bar is shown in the notification tray. The bar starts completely green and becomes increasingly more red when the next time to measure approaches, as is shown in Figure 5.6. At the time of the reminder the user gets a small notification that looks like a chat message from the coach and the countdown bar will turn completely red, see Figure 5.5b.
Chapter 5. Implementation

Figure 5.5: Reminders

(A) Reminder settings

(b) Reminder notification

Figure 5.5: Reminders
List  The list screen shows the data imported from GlucoLog Lite sorted according to time. Normal values between 4 and 10 are shown in black. Values below 10 are shown in bold red and values above 10 are shown in bold blue as is shown in Figure 5.7a.

Graph  The graph screen shows the measured blood glucose values on the y-axis and the time on the x-axis. In the default view the most recent 7 days are shown but users are able to scroll and zoom in or out as is shown in Figure 5.7b.
Diary  In the diary screen the user is able to make a textual diary entry. The amount of measurements and the goal for each day are also shown here, so users can quickly see how they performed, as is shown in Figure 5.8. This screen also gives a summary of the performance of the user. When the summary is generated at the coach moment, the users are able to comment on their performance. This comment is also sent to the researcher and can be shared with the medical professionals. Users are also able to make a textual entry in their diary of whatever they like, which is only stored locally for their own use. If desired, if desired this information could also be shared with the medical professionals. This gives the medical professionals more insight in the causes of undesirable blood glucose values.

![Figure 5.8: The diary screen](image)

**Figure 5.8:** The diary screen
Stars  Users are able to achieve stars. Stars come in three grades: bronze, silver and gold. Stars are awarded for certain milestones. Figure 5.9 below shows some stars, with the already obtained star filled in and the rest partly transparent. The milestones when stars are awarded are:

- Meet the goal amount for 10 days. (Bronze star)
- Meet the goal amount for 40 days. (Silver star)
- Meet the goal amount for 70 days. (Gold star)
- Measure 4 times or more for 4 days. (Bronze star)
- Measure 4 times or more for 16 days. (Silver star)
- Measure 4 times or more for 40 days. (Gold star)
- Measure a total of 50 times. (Bronze star)
- Measure a total of 100 times. (Silver star)
- Measure a total of 250 times. (Gold star)

![Figure 5.9: The stars screen](image)
**Coach moment** Users can choose a time to evaluate the results, ranging from once a day to a minimum of once a week, see Figure 5.10a. When it is time for the coach moment a notification will be shown with an image of the moon and stars, see Figure 5.10b, designating the end of the day, so all measurements of that day are taken into consideration.

![Coach moment settings](image1)

![Coach moment notification](image2)

(A) Coach moment settings  
(B) Coach moment notification

**Figure 5.10:** Coach Moment settings and notification

When the user taps this notification, the application checks whether there are new blood glucose measurements in Glucolog Lite. If there are no new blood glucose measurements, the coach will prompt the user to upload the measurements from the blood glucose meter to GlucoLog Lite, see Figure 5.11a. When new blood glucose measurements are found in GlucoLog Lite, the GlucOnline Coach application imports them and the coach examines if the goal is met for each day from the previous coach moment until now. The user is also presented with the Smileyometer to measure their subjective opinion on their accomplishments, see Figure 5.11b. The user receives feedback and sees the mood of the coach, based on whether the user did, -or did not meet the goal, see Figure 5.11c.
The Smileyometer is a Likert scale ranging from 1-5 using icons. The original design was for children to judge the experience of using certain technology [28], see Figure 5.12.

Figure 5.12: Smileyometer scale
Chapter 6

User evaluation

6.1 User evaluation design

We wanted to have a long-term evaluation of the application to see what the impact of the application is on everyday life during a longer period of time. The hospital found willing participants to evaluate the application for three months. The user evaluation was started with five participants.

With the user evaluation we wanted to answer the following questions:

- Which alarm intensity will the users use?
- Does the amount of daily blood glucose measurements increase when it is insufficient at the start of the user evaluation?
- What do the users think of the usability of the application?
- Do the users perform the coach moment on the planned days and on a frequent basis?
- Which functions of the applications are useful?
- What do the users think of the presence and appearance of the coach?

At the kick-off meeting the application was introduced to the participants. The participants were presented with the features. They had to sign a consent form, see Appendix A, and fill in a demographic questionnaire that also asked questions about their diabetes history. The pre-experiment questionnaire can be found in Appendix B. The participants also received a manual which can be found in Appendix C and contact information, so errors or problems could be reported.
During the evaluation period we collected data from the application, about the settings, the coach moment and the measurements. The data fields in Table 6.1 are recorded by the GlucOnline Coach application. The key is the GlucOnline API key all participants received from the hospital. This was done for privacy reasons.

**Table 6.1: Collected data by application**

<table>
<thead>
<tr>
<th>Type</th>
<th>Data fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coach (gender) option</td>
<td>• Key</td>
</tr>
<tr>
<td></td>
<td>• Timestamp</td>
</tr>
<tr>
<td></td>
<td>• Gender coach</td>
</tr>
<tr>
<td>Coachmoment settings</td>
<td>• Key</td>
</tr>
<tr>
<td></td>
<td>• Timestamp</td>
</tr>
<tr>
<td></td>
<td>• Selected week days</td>
</tr>
<tr>
<td></td>
<td>• Coach moment time</td>
</tr>
<tr>
<td>Alarm settings</td>
<td>• Key</td>
</tr>
<tr>
<td></td>
<td>• Timestamp</td>
</tr>
<tr>
<td></td>
<td>• Goals (amount of measurements per day)</td>
</tr>
<tr>
<td></td>
<td>• Alarms times</td>
</tr>
<tr>
<td></td>
<td>• Alarm intensity</td>
</tr>
<tr>
<td>Coach moment evaluation</td>
<td>• Key</td>
</tr>
<tr>
<td></td>
<td>• Timestamp</td>
</tr>
<tr>
<td></td>
<td>• Smileyometer rating</td>
</tr>
<tr>
<td></td>
<td>• Amount of measurements for each evaluated day</td>
</tr>
<tr>
<td></td>
<td>• Diary entry</td>
</tr>
<tr>
<td></td>
<td>• Blood glucose measurements</td>
</tr>
</tbody>
</table>

After the evaluation period there was another meeting with the participants. At this meeting the participants had to fill in a post-experiment questionnaire, which can be found in Appendix D. This questionnaire consisted of specific questions about the application, the System-Usability-Scale [29] and some applicable questions from Godspe [30] about the coach.
6.2 Results

The user evaluation was done with five participants between the age of 9 and 16 years. There were three female and two male participants, with an average age of 13.6 years. All participants indicated they sometimes had to be reminded by someone else to measure their blood glucose value. Four participants were using GlucoLog Lite and no other diabetes apps. See Appendix E for all pre-experiment demographical responses to the questionnaire (in Dutch).

While performing the user evaluation, one user encountered an error that none of the other users encountered. We were not able to reproduce the problem. While a fix was implemented, this user did not try again and dropped out. Luckily the hospital could find another suitable participant that joined shortly after, so the number of participants of the user evaluation remained the same, five.

Table 6.2 shows some notable data, collected using the application and the questionnaire. The amount of measurements for the first and last 5 days are shown for each participant and their last used alarm intensity. These data were collected by the application. The table also shows the number of times data synchronization occurred, and whether it was successful or unsuccessful. Unsuccessful means the coach moment took place, but the coach could not find any new measurements since the last coaching moment. The coach asked whether the measurements were indeed in GlucoLog Lite. If the user chose Yes, it assumed the user did 0 measurements on those days. See Figure 5.1 for the interaction between GlucoLog Lite and the GO Coach application.

As we found out in the focus group, the participants indicated that they often had problems getting the measurements in GlucoLog Lite, so they also did not do the coach moment. There was a period we did not receive any data from some participants, we thought those participants had stopped using the application. This was not true. The participants still used the application for the reminders.

User B had some problems linking the smartphone with the GlucoMen LX Plus after two weeks. After some e-mail contact we were told that the problem was fixed, but we received no more data from the coach moment reports. User E only has three successful coach moment data synchronizations, apparently after two synchronizations the same problem with linking the blood glucose meter and GlucoLog occurred. Until the last coach moment, then all the coach moment evaluations of 84 days came in together. User D sent in data 29 times, during the coach moments. This high frequency was caused by the coach moment setting, see Figure 5.10a. This user chose one day in the week initially. But after one month this setting changed to four days in the week, while all the
other users kept using one coach moment day in the week. This explains the relatively high number.

The System Usability Scale (SUS) score is shown and their opinion on whether they would use the application after the user evaluation, see Table 6.2. These answers come from the post-experiment questionnaire.

Table 6.2: Notable collected data

<table>
<thead>
<tr>
<th></th>
<th>User A</th>
<th>User B</th>
<th>User C</th>
<th>User D</th>
<th>User E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period data collected through coach moments</td>
<td>3 months</td>
<td>2 weeks</td>
<td>3 months</td>
<td>3 months</td>
<td>3 months</td>
</tr>
<tr>
<td>Alarm intensity (last used)</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Number of measurements first 5 days</td>
<td>8/7/6/7/7</td>
<td>3/3/3/4/3</td>
<td>2/2/1/1/3</td>
<td>5/4/4/4/3</td>
<td>7/7/6/5/7</td>
</tr>
<tr>
<td>Number of measurements last 5 days</td>
<td>6/4/1/7/6</td>
<td>3/3/3/5/2</td>
<td>2/2/2/3/3</td>
<td>5/4/4/5/5</td>
<td>8/7/7/4/7</td>
</tr>
<tr>
<td>Coach moment days (per week)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>First month: 1</td>
<td>Afterwards: 4</td>
</tr>
<tr>
<td>Successful coach moment data synchronizations</td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td>Unsuccessful coach moment data synchronizations</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SUS score</td>
<td>70</td>
<td>77.5</td>
<td>50</td>
<td>67.5</td>
<td>85</td>
</tr>
<tr>
<td>Would use app after user evaluation?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
6.2.1 Application generated data

All participants chose their own gender as coach avatar, 2 male and 3 female. All participants switched from the alarm intensity setting they chose initially, upon first use of the application. Three participants ended with alarm intensity 1, where the alarm only goes off once. One participant ended with the three times repeating intensity and one ended with an endless repeating intensity (until it is manually turned off). This is shown in Table 6.2. Three participants chose 4 as their measurement goal, one participant chose 3 and one participant chose 6.

6.2.2 Post-test questionnaire

Pre test questionnaire  User B indicated that prior to the user evaluation he/she sometimes used the alarm clock of the smart-phone as a reminder to measure, the other participants did not use reminders. All participants said someone had to remind them to measure on occasion or regularly. None of the participants used any other applications for diabetes management, except for GlucoLog Lite to send the data to the hospital server. See Appendix E for all responses to the post-test questionnaire.

Post-test questionnaire  The Godspeed questionnaire regarding anthropomorphism, likeability and perceived intelligence show rats of 3.5 to 4.25 out of 5 averagely, except for the question whether the coach seemed machinelike(1) or human-like(5) which was rated 2.5. Closer to 5 means a more positive attitude towards the coach. Questions 20 to 28 of Appendix D are taken from the Godspeed questionnaire. For the corresponding responses see Appendix F. Table 6.2 shows that all users said they would use the application after the user evaluation. This shows that the application has some value for all users.

For the System Usability Scale (SUS) part of the questionnaire the application scored 77.5, 67.5, 85, 50 and 70. SUS scores range from 0 to 100. The mean of the scores is 70. Research has been done with 10 years worth of SUS data on numerous products. This resulted in a scale as shown in Figure 6.1. The scale shows three classifications, a quartile range based on the data used in the study. An acceptability range categorized in Not acceptable, Marginal and Acceptable. An adjective ratings categorized in Worst imaginable, Poor, OK, Good, Excellent and Best imaginable. To be at least passable the SUS score should be 70, with better products scoring in the high 70s to upper 80s. [31]. Using this scale the mean SUS score of 70 for the GO Coach falls in the OK category.
6.2.3 Focus group

A focus group session was held after the user evaluation, where all the participants were invited. One participant could not attend, but sent the answers at a later time. The introduction meeting as well as this focus group session was led by the researcher and designer of the application himself.

The session was semi-structured. The following questions were asked:

- What did you think of the app? Which functions worked well and which did not?
- Which functions did you use often and which not at all?
- Did you use the "Lijst", "Grafiek", "Dagboek" or "Sterren" screen?
- What did you think of the coach?
- Did the coach give correct feedback? (For instance) When evaluating your measurements or telling you when to measure.
- Would you have preferred a different appearance of the coach?

Some questions were deliberately in the form of open questions so they could start a small discussion. The questions were separately asked to each of the participants, to give them the opportunity to formulate their own opinion.

All participants indicated that the reminders for their time to measure worked well, although three participants experienced crashes. Overall the reminder function with the countdown bar was well received. It was clear what the countdown bar meant to all participants. Four participants indicated that they sometimes used the list screen and three participants said they used the graph screen with representations of their blood glucose measurements. One participant experienced the list screen especially handy and another mostly used the graph screen of all features of the application. One participant
said that the link between the blood glucose meter and the Glucolog Lite application stopped working after a few weeks, so that participant did not use the list or graph screen much, because the data could not be retrieved.

All but one participant said the feedback of the coach was appropriate and correct when going through the coach moment. The remaining participant indicated that he/she did not pay much attention to whether the goal was met or not so he/she was not sure whether the feedback was correct.

When asked whether they would like to have a different appearance of the coach, one participant answered that it would be nice to be able to choose a custom photo. Another participant thought the cartoon-like appearance suited the application, because realistic coaches would be over-acted and show fake emotions. Some patients said they did not pay much attention to the appearance and text or messages of the coach after a while. When a message of the coach for a reminder was shown, they already knew what it was for without looking at it or reading it.

When asked about improvements one participant indicated that the achievements with stars are like a race with oneself, it would be better to compete with others. So it would be nice to be able to see the results of other users inside the application. Another participant indicated that it would be nice to have a small present when earning a star. This present could be awarded when they come in for consultation for example. He/she also said it would be better to be able to choose a custom sound for the alarms because there is no personalisation in that regard now.
Chapter 7

Conclusion

In this project an Android application called GlucOnline Coach was designed, implemented and evaluated. Most other applications in this field focus on collecting the data and displaying it in a way patients can analyse the data and use it to their advantage. Some applications also use reminders to make certain the data is provided. The focus of GlucOnline Coach is on adherence to daily blood glucose monitoring and data synchronization. Two main feature help the users with adherence to their diabetes intensity are the reminders in the form of chat-like messages from the virtual coach and secondly a glanceable display in the form of a countdown bar. The coaching moment helps with data synchronization.

The user evaluation was done to see whether the application helped on these two points. The user evaluation let five participants use the application for three months. Looking at the results we see that in this user group there is no notable difference in the amount of measurements at the start and at the end of the evaluation period. The users performed the planned coach moment including data synchronization on the planned day, or the next day. The frequency of the data synchronization varied a lot per user.

All participants chose their own gender as coach avatar. The participant with the most data synchronizations used alarm intensity 3. Another participant used alarm intensity 2 and the remaining three participants used alarm intensity 1. The reminder function was well received by the participants. The other features like the list, graph and stars screen were used differently per participant. This depended on the success rate of establishing the link between GlucoLog Lite and the blood glucose meter and the transfer of the data. One participant stated the stars feature should be expanded and improved by adding social networking features and physical or real presents. Others agreed with this.
Chapter 7. Conclusion

The usability was measured using the System Usability Scale. The lowest score is 50, the application scored a mean of 70. This means an OK rating, so it could do much better. We can draw the positive conclusion that the application is valuable for the participants, since all participants indicated that they would keep using it after the user evaluation.

7.1 Discussion

Because the user evaluation was done with a small group it is hard to draw significant conclusions. Considering the adherence to daily blood glucose measuring at the start and at the end of the user evaluation, there was no notable difference. A possible explanation could be that the participants already measured adequately at the start of the user evaluation. Whether stimulation of the data synchronization with the coach moment worked, is also not very clear, because most users did not go through the coach moment when they failed to get the data from the blood glucose meter into GlucoLog Lite. Most users indicated sooner or later they had problems trying to link GlucoLog Lite and the blood glucose meter via Bluetooth. The user with a SUS score of 50, which means a Poor rating on the adjective scale, experienced some crashes with the application and also had problems synchronizing between GlucoMen LX Plus and GlucoLog Lite. These problems and frustrations could explain the low score. To our understanding these problems are caused by both applications.

There was no correlation between the reported wellness by the Smileyometer and the achieved goals, when asked about this at the coach moment. This could be due to the fact that the question is not interpreted correctly. The question asked about measurements since the last time. Users seemed to interpret this as a question about the measured blood glucose values. So sometimes a user would measure many times but the values were too high or too low. In that case the measuring itself went well but the results were not good.

Sometimes the coach moment was not performed once a week like the settings demanded. The notification for the coach moment is not very intrusive, a sound is played and a notification is shown in the left upper corner of the Android operating system and stays there until the coach moment is performed. When the user chooses to go through the coach moment, all the data until that point will be retrieved from GlucoLog Lite, so all new measurements are synchronized with the hospital server as well as our server. The notification for the coach moment could be made more strict, like a repeating reminder, so the synchronized data is more up-to-date. For the user evaluation some participants sometimes performed the coach moment a day to a week later than scheduled.
Because the user has a high degree of freedom to choose the settings. For instance, the coach gender, the goal of measurement frequency, the alarm intensity and the reminder times, we had no concrete expectations beforehand what users would choose. The observation that all participants chose their own gender as the coach avatar could be explained by reports in the literature that embodied conversational agents may be considered more persuasive when they resemble the user[27].

This project focused on daily blood glucose monitoring and data synchronization, so it was beyond the scope of this study to look at other important factors that influence diabetes management, such as exercise and foods. We recommend to add the virtual coach to diabetes applications where one of the goals of the application is to stimulate users in repetitive actions. The attitude towards the coach is positive and it gives the user a recognizable entity that can be used to convey messages. The freedom of choice in the type of the coach and the settings provides a touch of personalization. GlucoLog Lite could be such an application, if the creators want to expand the existing functionality. GlucoLog Lite now focuses exclusively on data tracking and sharing through synchronization with a web server or e-mail.

**Lessons learned** We’ve learned that it is hard to test an application thoroughly without actual users participating actively in reporting problems and suggestions for improvement when it is still in development. During the user evaluation some problems occurred and although the contact information of the developer was in the manual, we had to find out ourselves there was a problem and contact the users.

During the evaluation of the application problems occurred that were not directly related to the GO Coach application itself, such as difficulties in retrieving the glucose data from the meter. As long as this cannot be done smoothly, the testing becomes biassed. We could have put in more effort to eliminate such problems or prevent them from occurring.

Working with the target group of adolescents brings many challenges in itself. Although we knew this beforehand it did not make it easier. Sometimes expectations of the participants were too high with regards to responsibility and independence. This will be taken into account in future projects.

### 7.2 Future work

With our application we tried to make the daily blood glucose measurements and data synchronization between the patient and medical professionals easier. We tried to do as much work as possible in the background without disturbing the user. This was not
as successful as we had hoped due to crashes and problems linking the blood glucose meter with GlucoLog lite. The coach must have reliable information about the data, the measurement times and other relevant actions taken by the user, in order to provide useful feedback. This requires reliable communication between the user and the system and also between all parts of the system. In our opinion it is necessary to reduce the number of actions that are needed to transfer the glucose data from the blood glucose meter to the smartphone. For example by integrating the blood glucose meter in the smartphone.

Also user evaluations must be done with a larger group to get more representative results. A user of the potential target group should be involved and consulted in the early stages of development. Such a user could provide feedback or scenarios that medical professionals or developers could oversee.

Some features that make the coach more lively could also be implemented. For example animating the coach or text-to-speech. We tried to implement text-to-speech for GlucoOnline Coach but were not able to get it to work easily on all Android versions from 2.3 and up. Other features that could be added are those that focus on other aspects of diabetes management like exercise and diet.
Bibliography


Appendix A

Consent Form
Toestemmingsverklaring GlucOnline Coach Diabetes 1

UNIVERSITY OF TWENTE.

De Universiteit Twente en de afdeling EWI voeren een actief beleid ter bescherming van de rechten van individuele personen die meedoan aan onderzoek dat onder (mede)verantwoordelijkheid van de afdeling wordt uitgevoerd. In overeenstemming met dit beleid is dit project geëvalueerd en goedgekeurd door de Ethische Commissie van de afdeling. De informatie over het project in deze toestemmingsverklaring wordt u verstrekt zodat u een beslissing kunt nemen of u wel of niet aan dit onderzoek mee doet of dat uw (pleeg-)zoon of (pleeg-)dochter aan dit onderzoek mee doet. Voor deelnemers tot en met 18 jaar dient de ouder of voogd deze toestemmingsverklaring te ondertekenen. Meedoan aan het onderzoek is vrijwillig, dit betekent dat u kunt stoppen wanneer u wilt zonder dat u een reden daarvoor hoeft op te geven.

Het doel van dit onderzoek is te kijken of de GlucOnline Coach app (dat is een computerprogramma dat geinstalleerd wordt op de smartphone) kan helpen met het op tijd en vaak genoeg meten van de bloedglucosewaarden.

Gedurende het onderzoek meet de gebruiker de bloedglucosewaarden zoals gebruikelijk met de meter. Op door de gebruiker ingestelde tijden herinnert de coach de gebruiker eraan dat het tijd is om te meten. De gebruiker stuurt regelmatig de gemeten waarden naar de coach app. De coach kan een overzicht geven van de meettijden en de gemeten glucosewaarden.

Aan het begin en aan het eind van het onderzoek zal de deelnemer gevraagd worden een vragenlijst in te vullen over de ervaringen met het gebruik van de Coach app. De gegevens die verzameld worden gedurende de duur van dit onderzoek zullen door andere partijen niet naar de gebruiker te herleiden zijn. Tijdens de introductiebijeenkomst is een handleiding uitgedeeld waarin meer informatie staat over de Coach app.

Als u nog vragen heeft over dit onderzoek dan kunt u terecht bij de onderzoekers of bij het kinderdiabetesteam van De Gelderse Vallei.

1. Ik doe mee met dit onderzoek.
2. Ik heb bovenstaande informatie gelezen. Ik weet dat meedoan helemaal vrijwillig is. Ik weet dat ik op ieder moment kan beslissen om niet (verder) mee te doen (zonder opgave van reden).
3. Ik heb aanvullende vragen kunnen stellen. Ik had genoeg tijd om te beslissen of ik meedo.
4. Ik geef toestemming om data die tijdens het gebruik van de app is verzameld te laten gebruiken voor onderzoek.

Teken hieronder als u akkoord gaat met de bovenstaande punten.

__________________________________________  __________________________
Naam deelnemer                                           Datum

__________________________________________  __________________________
Naam en handtekening ouder/voogd                          Datum

Handtekening onderzoeker:
Appendix B

Pre test questionnaire
Vragenlijst GlucOnline Coach

Deze vragen gaan over de persoon die meedoet met het onderzoek. Vul alstublieft het gehele formulier in. De antwoorden zullen anoniem behandeld worden.

1. API key:

________________

2. Hoe oud ben je?

_______ jaar

3. Wat is je geslacht?

○ Man
○ Vrouw

4. Hoe lang heb je al diabetes?

_______ maanden / jaren (doorhalen wat niet van toepassing is)

5. Hoe vaak meet je nu je bloedglucosewaarde per dag?

_______ keer

6. Gebruik je de app GlucoLog?

○ Nee
○ Ja

7. Als je de GlucoLog app gebruikt, op welk toestel doe je dat?

(Bijvoorbeeld Samsung Galaxy S of iPhone)

________________

8. Als je de GlucoLog app gebruikt, hoe vaak download je de waarden uit je meter?

_______ keer per dag / week / maand (doorhalen wat niet van toepassing is)
9. Meet je nu op min of meer vaste tijden?
   ○ Nee
   ○ Ja. Op welke tijden?
   __________________________________________

10. Vergeet je weleens te meten?
    ○ Nee
    ○ Ja

11. Gebruik je een hulpmiddel om te onthouden wanneer je moet meten?
    ○ Nee
    ○ Ja. Wat gebruik je daarvoor?
    __________________________________________

12. Gebruik je een diabetesdagboek?
    ○ Nee
    ○ Ja

13. Gebruik je apps voor diabetes?
    ○ Nee
    ○ Ja. Welke?
    __________________________________________

Bedankt!
Appendix C

Go Coach manual

De GlucOnline Coach app kan je glucosewaarden van de GlucoLog Lite app inlezen, bij alle nieuwere versies van GlucoLog Lite is dit mogelijk. Zo weet de coach wanneer je hebt gemeten en kan hij je waarschuwen wanneer het tijd is om te meten als je vergeet om te meten. Je kunt zelf instellen hoe vaak per dag en wanneer je wilt meten en je gegevens wilt doorsturen.

De coach kan de data doorsturen aan een centrale server zodat het medische team je glucosewaarden kan zien. Verder worden gegevens voor onderzoek bekeken. We willen graag weten hoe vaak je meet en hoe je de coach hebt ingesteld. Zo kunnen we zien of je echt iets aan de coach hebt.
Intro

Figuur 1 (links):
Vul hier je naam en geboortedatum in. Vul hier ook je API key van GlucOnline in.

Figuur 2 (links):
Kies de gewenste coach met de knoppen naast de coach.

Figuur 3 (rechts):
Coachmoment.
Kies de dagen van week waarop jij de metingen van je meter naar Gucolog Lite gaat sturen.
Kies het tijdstip wanneer jij deze metingen wilt doornemen, dit is het coachmoment. De metingen moeten daarvoor wel van de meter naar GlucoLog Lite gestuurd zijn.
Figuur 4 (links):
Kies het aantal keer dat je per dag wilt meten, dit is het meetdoel. Op de ingestelde meettijden krijg je een bericht van de coach. Kies daar onder het aantal keren dat je er aan herinnerd wilt worden wanneer een meettijd aangebroken is.
Home screen

Op het home scherm zijn de volgende knoppen:

сте: Ga naar het scherm om de dagen en het tijdstip voor het coachmoment in te stellen.

.loads: Ga naar het scherm om het aantal keren meten per dag; het meetdoel, in te stellen. Hier kun je ook de meettijden en het aantal keer herinneren instellen.

Metingen ophalen: Met deze knop worden de metingen van GlucoLog Lite opgehaald. De coach zal kijken of er nieuwe metingen zijn, deze worden opgeslagen.

Ga naar het scherm met sterren. Hier zie je welke sterren wel en nog niet gehaald zijn.

Ga naar het scherm met een overzicht van het aantal metingen per dag en eventueel je commentaar. Het commentaar kan gaan over hoe het ging, wat je er van vond of wat jij maar kwijt wilt.

Ga naar het scherm met een lijst van de metingen.

Ga naar het scherm met een grafiek van de metingen. Standaard zie je de laatste 7 dagen in de grafiek maar het is mogelijk om uit of in te zoomen.
Meettijden

Op dit scherm kun je het meetdoel, het aantal keren per dag dat je wilt meten, instellen. De meettijden kun je instellen door op de knop van een tijd te drukken. Wanneer een meettijd ingesteld is gaat er linksbovenin de Gluco Meet Timer (GMT) lopen. Dit balkje telt af vanaf wanneer een meettijd is ingesteld tot de volgende meettijd.

Eerst is het balkje helemaal groen:

![Groene balkje]

Naarmate de meettijd dichterbij komt zal het steeds meer rood worden:

![Rode balkje]

Totdat het tijd is om te meten, dan is het helemaal rood:

![Rode balkje]

Snooze

Op dit scherm is het ook mogelijk om het oproepssignaal te laten herhalen wanneer het tijd is om te meten. Moet de coach 1 keer een signaal geven, 3 keer of moet deze je blijven oproepen totdat je de metingen hebt doorgegeven. Dat kun je hier zelf instellen. Dit zal er gebeuren wanneer je een van deze opties kiest:

1 keer: Het is tijd om te meten, je ziet een bericht van de coach en de telefoon trilt en maakt geluid (mits het geluid aan staat). Het balkje wordt helemaal rood. Na een aantal minuten zal het volgende alarm ingesteld worden, het bericht gaat weg en het balkje wordt weer helemaal groen.


Tot het wegedrukt wordt: Het is tijd om te meten, je ziet een bericht van de coach en de telefoon trilt en maakt geluid (mits het geluid aan staat). Het balkje wordt helemaal rood. Het geluid en het trillen zal na een aantal minuten herhalen, dit blijft zich herhalen totdat er op het bericht van de coach gedrukt wordt of wanneer er een nieuwe meting in GlucoLog Lite komt. Op het bericht drukken betekent dat er gemeten is maar dat het nog niet verzonden is naar GlucoLog Lite. Het is ook mogelijk om handmatig een meting in te voeren, dan stopt dit bericht ook.
Coachmoment

Op dit scherm kun je de dagen aanvinken waarop jij de metingen naar GlucoLog Lite gaat sturen. Op die dagen zal de coach op het tijdstip daar onder het aantal metingen met jou doornemen.

Je krijgt een bericht met dit plaatje wanneer het zo ver is: 🌋. Als je op dit bericht drukt zal de coach je een aantal dingen vragen en samen met jou het aantal metingen die je gedaan hebt bekijken.

Voordat de coach de metingen kan bekijken moeten ze wel naar GlucoLog Lite gestuurd zijn, dit zal de coach ook controleren en indien de metingen nog niet in GlucoLog Lite staan zal de coach je vragen het door te sturen.

Veel succes met de GlucOnline Coach app!
Contactinformatie voor hulp en vragen

E-mail: x.h.ye@student.utwente.nl
Telefoonnummer: 0627068224 (ook voor WhatsApp)
Appendix D

Post test questionnaire
GlucOnline Coach vragenlijst
Vul de vragen in door het antwoord aan te kruisen of in te kleuren.

API Key:

1. Was het balkje hierboven op je mobiel links bovenin altijd zichtbaar?
   - Ja
   - Nee

2. Was het duidelijk wat het balkje betekende?
   - Ja
   - Nee

3. Viel het balkje op wanneer je je mobiel gebruikte voor iets anders dan de GlucOnline coach app?
   Bijvoorbeeld bellen, whatsappen of spelletjes.
   - Ja
   - Nee

4. Deed je het coachmoment altijd op de dag dat je het had ingesteld?
   Het coachmoment is wanneer je de resultaten samen met de coach doorneemt en de coach kijkt hoe vaak je de afgelopen tijd hebt gemeten.
   - Ja
   - Soms
   - Nee

5. Gebruikte je het Sterren scherm?
   - Ja
   - Soms
   - Nee
6. Gebruikte je het Dagboek scherm?
- Ja
- Soms
- Nee

7. Gebruikte je het Lijst scherm?
- Ja
- Soms
- Nee

8. Gebruikte je het Grafiek scherm?
- Ja
- Soms
- Nee

9. Ga je de app na dit project ook gebruiken?
- Ja
- Nee

Gebruiksgemak
De volgende vragen gaan over hoe makkelijk jij de app vond in gebruik.

10. Ik denk dat ik de app graag regelmatig wil gebruiken
    1 2 3 4 5
    Sterk mee oneens Sterk mee eens

11. Ik vond de app onnodig ingewikkeld
**Appendix D. Post test questionnaire**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**12. Ik vond de app makkelijk te gebruiken**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**13. Ik denk dat ik hulp nodig heb van een technisch persoon om de app te kunnen gebruiken**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**14. Ik vond dat de verschillende functies in de app erg goed samengevoegd zijn**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**15. Ik vond dat er teveel tegenstrijdigheden in de app zaten**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**16. Volgens mij leren de meeste mensen zeer snel leren om de app te gebruiken**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**17. Ik vond de app erg onhandig in gebruik**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**18. Ik was snel gewend aan de app**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterk mee oneens</td>
<td>Sterk mee eens</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix D. *Post test questionnaire*

19. Ik moest erg veel leren voordat ik aan de gang kon gaan met de app

   1 2 3 4 5

   Sterk mee oneens ○ ○ ○ ○ ○ Sterk mee eens

**De coach**

De volgende vragen gaan over de coach.

20. De coach is...

   1 2 3 4 5

   Onecht ○ ○ ○ ○ ○ Natuurlijk

21. De coach...

   1 2 3 4 5

   Lijkt op een machine ○ ○ ○ ○ ○ Lijkt op een mens

22. De coach is...

   1 2 3 4 5

   Kunstmatig ○ ○ ○ ○ ○ Levensecht

23. De coach is...

   1 2 3 4 5

   Onvriendelijk ○ ○ ○ ○ ○ Vriendelijk

24. De coach is...

   1 2 3 4 5

   Niet lief ○ ○ ○ ○ ○ Lief

25. De coach is...

   1 2 3 4 5

   Onplezierig ○ ○ ○ ○ ○ Plezierig

26. De coach is...
### Appendix D. Post test questionnaire

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onbekwaam</td>
<td>Bekwaam</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

**27. De coach is...**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onwetend</td>
<td>Veel wetend</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**28. De coach is...**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onintelligent</td>
<td>Intelligent</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Never submit passwords through Google Forms.*
Appendix E

Pre test questionnaire responses
Appendix E. Pre-test questionnaire responses

User 2. Hoe oud ben je? 3. Wat is je geslacht?
A 16 Man
B 13 Vrouw
E 16 Man
D 9 Vrouw
C 14 Vrouw

4. Hoe lang heb je al diabetes?
3,5 jaren
~4 jaren
6 jaren
1 jaar
6 (niet ingevuld of het maand of jaar is)

5. Hoe vaak meet je nu je bloedglucosewaarde per dag?
6 3,5 jaren
~4 jaren
6 jaren
1 jaar
6 (niet ingevuld of het maand of jaar is)

6. Gebruik je de app Glucolog?
Ja

7. Als je de GlucoLog app gebruikt, op welk toestel doe je dat?
Samsung S4 mini
Samsung Galaxy Core 18260
Samsung Galaxy Core
Samsung Galaxy trend lite

8. Als je de GlucoLog app gebruikt, hoe vaak download je de waarden uit je meter?
1 keer per week
1 keer per week
1 keer per week
1 keer per week

9. Meet je nu op min of meer vaste tijden?
Ja

10. Vergeet je weleens te meten?
Ja
Nee
Nee

11. Gebruik je een hulpmiddel –bijvoorbeeld een signaal of berichtje op je mobiel of smartphone dat je vertelt dat het tijd is om te meten of je waarden door te geven?
Ja
Nee

12. Wijst iemand anders –bijvoorbeeld je vader of moeder –je er wel eens op dat je moet meten?
Ja
Nee

13. Gebruik je een diabetessedagboek?
Ja
Nee

14. Gebruik je apps voor diabetes?
Ja, Glucolog
Ja, Glucolog
Ja, Glucolog/Gluconline
Ja, Glucolog/Gluconline

Nee
Nee, schriftelijk
Ja
Nee
Nee
Nee
Appendix F

Post test questionnaire responses
**Appendix E. Post-test questionnaire responses**

<table>
<thead>
<tr>
<th>User</th>
<th>1. Was het balkje hierboven op je mobiel links bovenin altijd zichtbaar?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Ja</td>
</tr>
<tr>
<td>D</td>
<td>Nee</td>
</tr>
<tr>
<td>E</td>
<td>Ja</td>
</tr>
<tr>
<td>C</td>
<td>Ja</td>
</tr>
<tr>
<td>A</td>
<td>Ja</td>
</tr>
</tbody>
</table>

| 2. Was het duidelijk wat het balkje betekende? |
|------|------------------------------------------------------------------------|
| Ja   |Ja                                                                       |
| Ja   |Ja                                                                       |
| Ja   |Ja                                                                       |
| Ja   |Ja                                                                       |
| Ja   |Ja                                                                       |

| 3. Viel het balkje op wanneer je je mobiel gebruikte voor iets anders dan de GlucOnline coach app? |
|------|------------------------------------------------------------------------|
| Ja   |Ja                                                                       |
| Ja   |Ja                                                                       |
| Nee  |Ja                                                                       |
| Nee  |Ja                                                                       |

| 4. Deed je het coachmoment altijd op de dag dat je het had ingesteld? |
|------|------------------------------------------------------------------------|
| Ja   |Soms                                                                    |
| Soms |Soms                                                                    |
| Soms |Soms                                                                    |

| 5. Gebruikte je het Sterren scherm? |
|------|------------------------------------------------------------------------|
| Nee  |Ja                                                                       |
| Soms |Nee                                                                      |
| Soms |Ja                                                                       |

| 6. Gebruikte je het Dagboek scherm? |
|------|------------------------------------------------------------------------|
| Soms |Ja                                                                       |
| Soms |Nee                                                                      |
| Soms |Ja                                                                       |

| 7. Gebruikte je het Lijst scherm? |
|------|------------------------------------------------------------------------|
| Soms |Nee                                                                      |
| Soms |Soms                                                                     |
| Soms |Soms                                                                     |

| 8. Gebruikte je het Grafiek scherm? |
|------|------------------------------------------------------------------------|
| Ja   |Nee                                                                      |
| Nee  |Ja                                                                       |
| Soms |Ja                                                                       |
| Nee  |Soms                                                                     |

| 9. Ga je de app na dit project ook gebruiken? |
|------|------------------------------------------------------------------------|
| Ja   |Ja                                                                       |
| Ja   |Ja                                                                       |
| Ja   |Ja                                                                       |

| 10. Ik denk dat ik de app graag regelmatig wil gebruiken |
|------|------------------------------------------------------------------------|
| 3    |3                                                                         |
| 3    |5                                                                         |

| 11. Ik vond de app onnodig ingewikkeld |
|------|------------------------------------------------------------------------|
| 1    |2                                                                         |
| 2    |1                                                                         |
12. Ik vond de app makkelijk te gebruiken
13. Ik denk dat ik hulp nodig heb van een technisch persoon om de app te kunnen gebruiken
14. Ik vond dat de verschillende functies in de app erg goed samengevoegd zijn
15. Ik vond dat er teveel tegenstrijdigheden in de app zaten
16. Volgens mij leren de meeste mensen zeer snel leren om de app te gebruiken
17. Ik vond de app erg onhandig in gebruik
18. Ik was snel gewend aan de app
19. Ik moest erg veel leren voordat ik aan de gang kon gaan met de app
20. De coach is...
21. De coach...
<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. De coach is...</td>
<td>3 3 3 3 2</td>
</tr>
<tr>
<td>23. De coach is...</td>
<td>5 5 4 3 4</td>
</tr>
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<td>24. De coach is...</td>
<td>5 5 3 3 4</td>
</tr>
<tr>
<td>25. De coach is...</td>
<td>4 4 4 3 4</td>
</tr>
<tr>
<td>26. De coach is...</td>
<td>5 3 3 3 4</td>
</tr>
<tr>
<td>27. De coach is...</td>
<td>3 4 4 3 4</td>
</tr>
<tr>
<td>28. De coach is...</td>
<td>3 4 4 3 4</td>
</tr>
<tr>
<td>SUS score oneven vragen</td>
<td>16 15 15 9 13</td>
</tr>
<tr>
<td>SUS score even vragen</td>
<td>12 19 11 15 15</td>
</tr>
<tr>
<td>SUS score totaal</td>
<td>77.5 67.5 85 50 70</td>
</tr>
</tbody>
</table>