Diabetic Self-Management Mobile Application

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Acknowledgements

- Thank you to my family and girlfriend, who gave only support and also went through this experience with me.
- I'm proud of my lecturers and peers, who without each other, would not have gotten this far.

I, Daniel Sabau, declare that this proposal titled, "Diabetic Self-Management Mobile Application' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this proposal has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.

Signed: Daniel Sabau

Date: 02/05/2021

Abstract

The main topics of this thesis is mobile software development and medical software. The thesis outlines how the diabetic self-management application improves on the shortcomings of applications already available on the respective app stores and has ease of use as a priority since application inception. My research will include a blend of both medical and software development fields and how their combination has brought benefits to its patients and users.

Throughout the thesis, the main topic of research is if the users of such applications saw a positive increase in their self management of their diabetes.

As the thesis progresses, topics of how the diabetic self-management application was planned, programmed and finally shipped is explained in detail.

Contents

Chapter 1

Introduction

1.1 General

This thesis discusses how a diabetic self management application was created, backed by research in fields such as how diabetic self management applications positively affects the care habits of patients living with type 1 and 2 diabetes. The thesis begins with the introduction chapter you are reading now, continuing on to a background concepts and terminology chapter that explains more technical and less-known concepts and terminology about the technologies and concepts utilised throughout the thesis and project.

Subsequently, the thesis will progress onto the literature review where most of the research was completed, where all sources of literature are reviewed in detail for the purpose of background research for the completion of the application and thesis.

Continuing through the thesis the next chapters includes the methodology and system requirements and specification chapters, where the thesis explains the methodology used throughout the creation of the application and discusses topics such as system scope, requirements analysis.

After, the project prototypes are listed and explained, showing the natural evolution between prototype versions.

Lastly, the thesis ends with its conclusion chapter, where final ideas and experiences of the thesis and project are discussed and analysed.

1.2 Aims and Objectives

The aims and objectives is to use the research collected and analysed throughout the thesis and project to help create a better and more suited application for diabetic self management. Some of the questions posed throughout the research phases were questions like: *"Do diabetic self-management applications provide a positive affect to the care habits of type 1 and type 2 diabetics?"* and *"How feasible is it to create your own diabetic self-management application using currently available technologies on today's market?"*

1.3 Main Research Topics

The main research topics are as follows:

1. *What are the most common struggles in mobile application development?*
2. *How has mobile software advancements helped in the treatment and management of diabetes?*
3. *How has wearable technology changed how people view their health?*

With each research topic explained and discussed in more detail in the Literature Review chapter.

Chapter 2

Background concepts and terminology

2.1 Background Concepts and Terminologies

The function of this chapter is to give the reader the required knowledge to understand and interpret the many deeper topics discussed throughout the thesis. To expect every reader to have the same base knowledge and information on the many different topics discussed would be unrealistic, so this section will prove very useful to engage with the thesis topic on a deeper level. Terminology wise, this section would also explain any uncommon terminology used throughout the thesis to ensure the reader fully interprets and understands the material discussed.

2.2 Technologies and Concepts

2.2.1 React

React Native is an open source framework for building both Android and IOS applications using React. It achieves this using the app platform's native capabilities. This would be the main programming framework for the diabetic self management application.

2.2.2 Native Base Library

A user interface library used in the diabetic self management application that helps with rendering components of the application. Changes the "look-and-feel" of the application.

This was used to achieve a cohesive and professional look throughout the application. Native base is cross-platform, with the "mantra" of the library being a native look-and-feel. (Having components that look native to the device and look like they belong to the operating system)

2.2.3 React Native Chart Kit

A graph and chart library which was the basis of all graph work in the application. Supports many different types, including, line, bezier line, pie, progress rings, stacked bars, and contribution graphs.

2.2.4 React Navigation Library

Gesture and navigation library used throughout the application. The golden standard for all gesture and navigation work when working with the react framework. Cross-platform, completely customizable and modular.

2.2.5 Components

React Native is like React, but it uses native components instead of web components as building blocks. So to understand the basic structure of a React Native app, you need to understand some of the basic React concepts, like components, state, and props and JSX.

2.2.6 Props

Most components can be customized when they are created, with different parameters. These creation parameters are called props.

2.2.7 State

Unlike props that are read-only and should not be modified, the state allows React components to change their output over time in response to user actions, network responses and anything else.

2.2.8 JSX

React and React Native use JSX, a syntax that lets you write elements inside JavaScript

2.2.9 Screens

A screen when in the context of a react native application refers to the view a user would see when opening the specific application. An example of such would be a home screen in an application, where it hosts the basic components and navigation options.

Chapter 3

Literature Review

Introduction

This literature reviews delves into the research, ideas and conclusion of papers, journals and other material on several topics that will aid and influence the creation of my diabetic self-management android application. Each of these materials offer great insight into different aspects of my future development, each focusing on a different topic of discussion throughout my review. The four papers I have used as sources of research in my review are as follows: "Real Challenges in Mobile App Development" by Mona Erfani Joorabchi, Ali Mesbah and Philippe Kruchten. "Mobile technology to empower people with Diabetes Mellitus: Design and development of a mobile application" by Stavroula G. Mougiakakou, Ioannis Kouris, Dimitra Iliopoulou, Andriani Vazeou and Dimitrios Koutsouris. "Health at hand: A systematic review of smart watch uses for health and wellness" by Blaine Reeder and Alexandria David. Lastly, "Mobile Applications for Diabetes Self-Management: Status and Potential" by Omar El-Gayar, Prem Timsina, Nevine Nawar and Wael Eid. The literature review will also focus on my personal discussions and views on each of the materials found throughout the document.

3.1 Relevance to Research

All these articles were carefully chosen to undertake the issues of my research questions which includes:

1. *What are the most common struggles in mobile application development?*

2. *How has mobile software advancements helped in the treatment and management of diabetes?*

3. *How has wearable technology changed how people view their health?*

My analysis of these papers had the goal of answering my research questions through the papers composed arguments and ideas. All of this provides valuable information on these topics through both written ideas and visual evidence presented throughout the material. These research questions act as a guide to my research and help give an overview on the topics needed in order to achieve the final goal of the application being created.

"Real Challenges in Mobile App Development" is included in my choice of papers due to the fact that it gives a great general oversight of the issues most developers face when creating their applications. This paper was chosen to its relation of my first research question and acted as a basis to my planning of my application before I begin development. These questions also pose to display possible problem areas in the development process of my application. This early insight into common problematic areas also is a great aid to improving my application and give me the edge of spotting and correcting these issues before they even possibly occur.

"Mobile technology to empower people with Diabetes Mellitus: Design and development of a mobile application" and **"Mobile Applications for Diabetes Self-Management: Status and Potential"** were also both chosen and proved vital for the focus of my project and application that attempts to create an android application to aid in the management of type 1 and type 2 diabetes. These articles all provided information on the idea of the effectiveness of diabetic self-management applications already available on the respective mobile application stores. This was a great tool to see what is currently deployed and expected of this genre of application, and helped me decide the feature set of my application.

"Health at hand: A systematic review of smart watch uses for health and wellness" was the last chosen paper as it focuses on the wearable technology aspect of my project. Wear OS (Wear Operating System) provided by google for smart watches running a specialised android operating is something I've been using myself and I've personally seen the benefits it's provided to my health and productivity. I will use this paper to gain more knowledge in the health aspects of smart watch use and how it's changed how people view their health. This will also provide some insight into how people will interact with the wearable technology features my application will include.

3.2 Strengths of Sources

In relation to my first research question, the chosen paper was a direct answer to my question. It provided a great synopsis of the main challenges during mobile application development. It concluded these results using a scientific approach, adopting data collection and analysis techniques. It accomplished this using an interview and survey approach, gathering the opinions of experts through thirty minute interviews. The general workforce was also asked questions through a survey that was available on linkedin and other work-related social media platforms for the period of 2 months. These results were then processed and the best were chosen for review throughout the paper. It became clear reading this material that there were several issues throughout the field. Fortunately for my research, these problems were widely accepted and the results followed a trend in challenges.

One of the main challenges seen throughout the source is that the fragmentation of mobile development as a platform is an inherent problem, creating different development environments depending on the platform (IOS vs Android) and even within the platform as seen with the multitude of different device configurations and operating system versions deprecating and changing SDK (Software Development Kit) environment on the Android platform. *"guidelines are quite different across platforms, since no standards exist for the mobile world"* Joorabchi et al. [2013], This fragmentation of the field also leads to increased development costs entailed with hiring the skilled workforce needed to port an application to another platform. This clearly presented the feasibility of having my application on multiple platforms, leaving me to focus on only one platform, from which I've chosen the android platform as this is where I am most skilled and has been an area of study.

Another issue correlated with the vast amount of device configurations is the ability to keep up with the frequent and every changing updates to these platforms. This has shown that my application will most likely have to only support the most recent android versions as supporting legacy systems proves every challenging with each deprecation of features between SDK versions. Keeping up with changes will also be a challenge, as this field is ever evolving.

Further, testing for these devices increases in challenge as each device has separate hardware, sensors and motors et cetera. *"changing requirements means changing UI/-logic, so GUI and integration tests must be constantly rewritten"* Joorabchi et al. [2013]. Each configuration has to be specifically programmed and tested for leading to massive multiplication of the time, effort and budget needed to provide quality applications.

In relation to my second research question, the two chosen papers have many similarities discussing very similar topics. This was helpful to solidify the expected feature-set of my diabetic self-management application as both papers specify the expected features in applications and what was lacking in the current market, allowing me to add additional features I didn't expect or think about. Both papers used the metric of HbA1c's (Blood test done to obtain average blood glucose level over the period of 3 months) when describing the benefits of using this genre of application, showing a clear increase in both cases after continual use of these applications.*"reported a 1.7 percent improvement in HbA1c","Applications proved particularly useful for patients with very high blood sugar or for those having difficulty controlling it"* El-Gayar et al. [2013]

When discussing features in both papers, they included the basic requirements of self-management applications, some of these features included: Logging of insulin dosage, medication type, physical exercise amount and diet. Secondary features also included notification and alert support, graphing of data and integration with social media. Depending on the feasibility at application development these all seem like viable and possible features to include. Features lacking in most of the applications discussed topics such as education, fitness tracking and data feedback.*"diabetes education is the ongoing procedure of supporting patients by enhancing their knowledge, skill, and ability necessary to self-manage diabetes"* El-Gayar et al. [2013] When discussing fitness tracking, part of my project includes wearable technology the fitness tracking is something that would perfectly integrate with my diabetic self-management application as there are means to pull fitness data from Wear OS smart watches using google API's.

When pertaining to education, this is something I have noticed also lacking throughout my use of these applications, and after my research concluded it was something I decided I definitely want to include in the application as the means to linking to some official health organisations throughout the application proved a small task. Data feedback with dynamic suggestions is something that will have to be included in the application depending on the feasibility at development time as this area is more complex and provides some challenges. *"For example, RapidCalc Diabetes Manager provides insulin dosage suggestion based on blood glucose reading"* El-Gayar et al. [2013]

As the current situation with the corona virus pandemic worsens the demand to export your data to a healthcare professional safely and reliably greatly increases. I myself did this electronically for months as all healthcare appointments slowed to a crawl. Adding this feature to my application not only benefits the patient but also the healthcare specialists as they can study your data from a remote location and provide feedback way more frequently

than by per visit basis. *"The review also seems to point out that diabetes self-management applications are useful to patients as well as providers"* Mougiakakou et al. [2009].

Lastly, my final research question is probed in the paper on wearable technology and its use for health and wellness. Smart watch use has evolved from simple notification and time-keeping devices to having an array of health related sensors. These sensors can be used to self-monitor personal activity, allowing the watch to provide feedback on these measurements, and highlight and identify patterns of behaviour. Some of these measurements include *"activity monitoring, heart rate monitoring, speech therapy adherence, diabetes self-management and detection of seizures, tremors, scratching, eating and medication taking behaviours"* Reeder and David [2016]. The paper also examined the use case of my application as they did several studies on the different usages of smart watches with different medical conditions, one of which included six type 1 diabetic patients. The use case study focused on these patients and they're recording of their data on their smartwatches, similar to a diary. (This aspect of diabetic care used to be done by writing log books manually by hand). The patients recorded things such as blood glucose measurements, insulin injections, physical activity and dietary information for a period of two weeks. After recording their activities on the smart watches this was transferred to an Android based smart phone. This is a similar use case to how I plan the integration of smart watch use in my android application. *"Participants reported positively on smart watch features and provided recommendations for future design iterations"* Reeder and David [2016]. This paper also gave me the required knowledge of how smart watches would enhance the user experience while using my diabetic self-management application.

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3.3 Summary of Research

While researching the material of **"Real challenges in mobile app development"** it became clear that this paper had a clear and scientific way to gather the most common challenges that mobile developers face. The paper used a scientific approach, adopting data collection and analysis techniques to achieve its goals. It accomplished this using an interview and survey approach, gathering the opinions of experts through thirty minute interviews. The reviewers also collaborated to create a survey that was posted online for a period of 2 months, gathering a broader array of issues from the developer community. One of the most apparent challenges developers confronted included the vast amount of different device configurations, operating systems and their included platforms varying vastly, this

proved frustrating, expensive and time consuming for teams as it was impossible to account for every user. It became very clear that the field was very fragmented and no standard was created for the various devices. The rest of the challenges faced all stemmed from this idea of too many devices to continue supporting, delving into topics such as testing, keeping up with frequent SDK changes and supporting legacy and deprecated systems.

Approaching the second research question I had chosen two papers as this was the main focus of my application. Both **"Mobile Applications for Diabetes Self-Management: Status and Potential"** and **"Mobile technology to empower people with Diabetes Mellitus: Design and development of a mobile application"** covered similar material, highlighting the current features present in diabetic self-management applications on the respective application stores and delved into some of their short comings. Through reading these sources it became apparent that there was an expectation of a feature-set, which included logging of daily data. Things such as social media integration was also discussed. Lastly, components such as fitness tracking, data feedback and education where all common missing features. I also mentioned how educational material would be an easy addition to my application, data feedback would have to wait until development feasibility was considered and that fitness tracking was already part of my idea for my wearable technology segment of the project.

Finally, my last research question was explored in the paper **"Health at hand: a systematic review of smart watch uses for health and wellness"** where this source discussed how smart watches could help enhance a users medical experience. It discussed how smart watches have evolved from time-keeping and notification devices to complex devices filled with medical sensors. These sensors support the measurements of an array of health statistics including things such as blood glucose measurements, insulin injections, physical activity and dietary information. In the case of a study, the paper discussed how six type 1 diabetics for a period of two weeks logged their blood glucose measurements and dietary information similar to a diary, they all commented positively on its use. This paper gave me a good idea of how people may use smart watches to improve their health and lives, giving me a focus on their user experience and satisfaction.

Chapter 4

Methodology and Testing

4.1 Agile Scrum Method

The development model chosen for the project is the agile scrum model. This provides the advantage of having the shortest time schedule as the mobile application development environment is filled with quick changes and iterations. The work methodology will follow the scrum "sprints" model, where work will be quickly divided into a backlog. This will allow the developer the best opportunity to make necessary changes fast and effectively and provide the developer with the most creative freedom and work flexibility.

4.2 Testing

Throughout the creation of the diabetic self management application a log of exercise and blood sugar values began to be recorded in order gather some scenarios of the application being used and to test the graph features available in the application.

Here is the log below:

Everyday at around 4pm the subject took a blood sugar reading and then went for a 30 minute running exercise. When returning after the 30 minutes, another blood sugar reading was taken. These blood sugar values were then compared. This data would then be able to be used in recreating the scenarios a user would experience using the application.

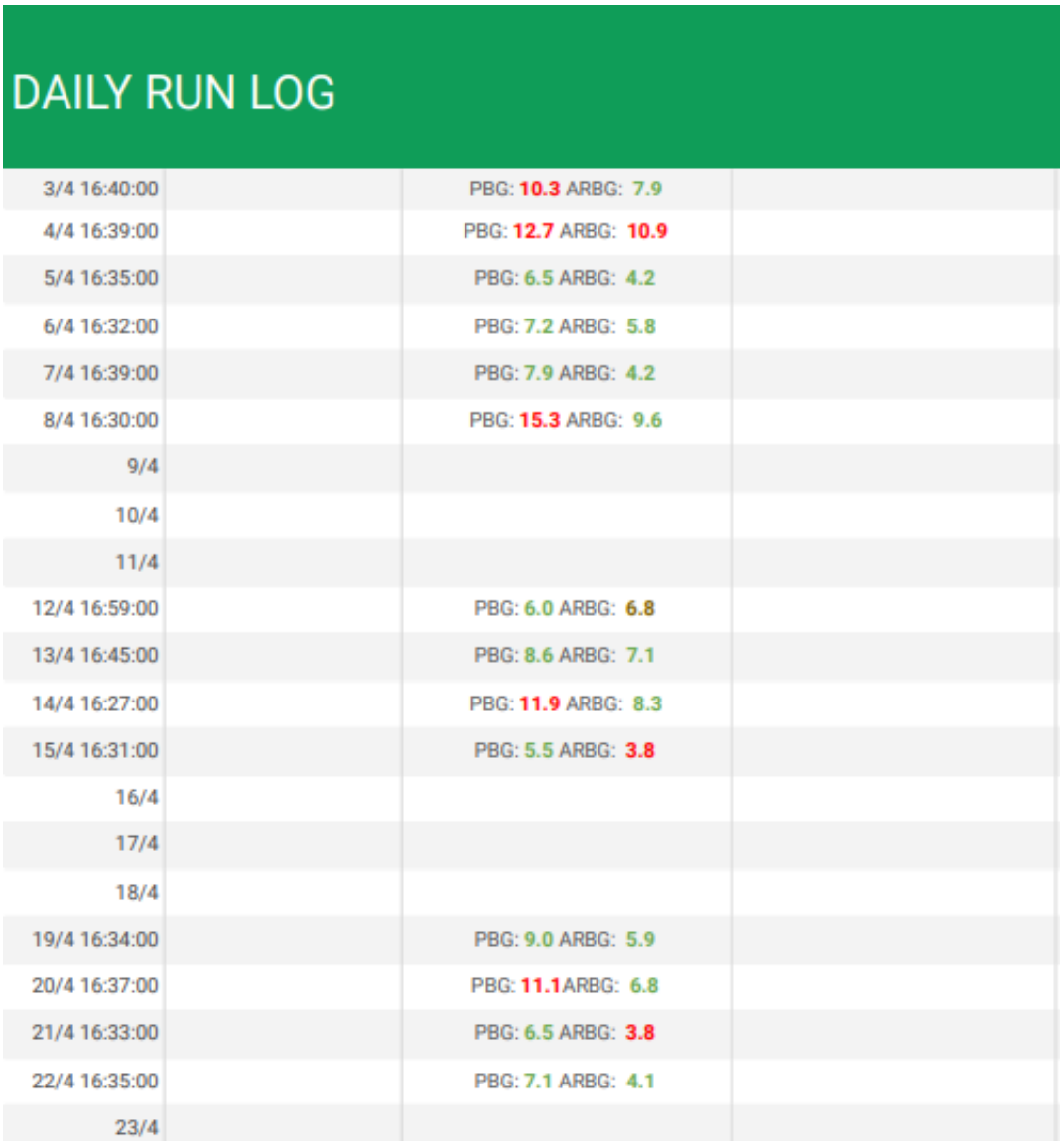


Figure 4.1: Running Scenario Log

Chapter 5

System Requirements and Specifications

5.1 System Scope

The system scope of the project included an Android and IOS build of the diabetic self-management application. The application feature set was to have multiple application screens with many differing components. The home screen was planned to have a fully dynamic graph from which the user could input different habit data, view such data and finally plan their care from such. The the user could spot apparent patterns in their blood glucose levels from viewing the graph and see the time of day that they needed to improve their care for. Educational information was also planned for the project. Wear OS smart watch integration was planned to be integrated for fitness data for the application.

5.2 Requirements Analysis

User functionality was split up depending on application screen. The user can expect to access several different screens, of which includes:

1. *Home Screen*
2. *Reports Screen*
3. *Educational Information Screen*
4. *Account Screen*

5. *About Screen*

5.3 Home Screen

The user was planned to be able to quickly input data into the graph for logging using the floating action buttons. The user would also be able to navigate the application using the navigation drawer available on a left gesture swipe. The user also has access to buttons, header and footer tabs for various application logic and navigation.

5.4 Reports Screen

Here the user would be able to go back in time and see their data up to present time. The user will be able to analyse and examine trends in their blood sugar logs, with ability to see details such as exercise and diet intake for that given log.

5.5 Educational Information Screen

This screen would include some essential educational information on type 1 and type 2 diabetic care. Here entries for things such as how to perform a blood sugar measurement, how to calculate your insulin dosage ratios and how often to take your blood sugar reading are explained.

5.6 Account Screen

The user was planned to be able to register, login and manage their accounts from this screen. Users would be able to input data in text form fields and sign up to the application. After register the user would be able to input their account information and login into their accounts, being able to have their application data carry from device to device through the account system.

5.7 About Screen

The user was planned to be able to see application information and a short informational section on myself and the GitHub repository of this project.

Chapter 6

Project Prototypes

6.1 General

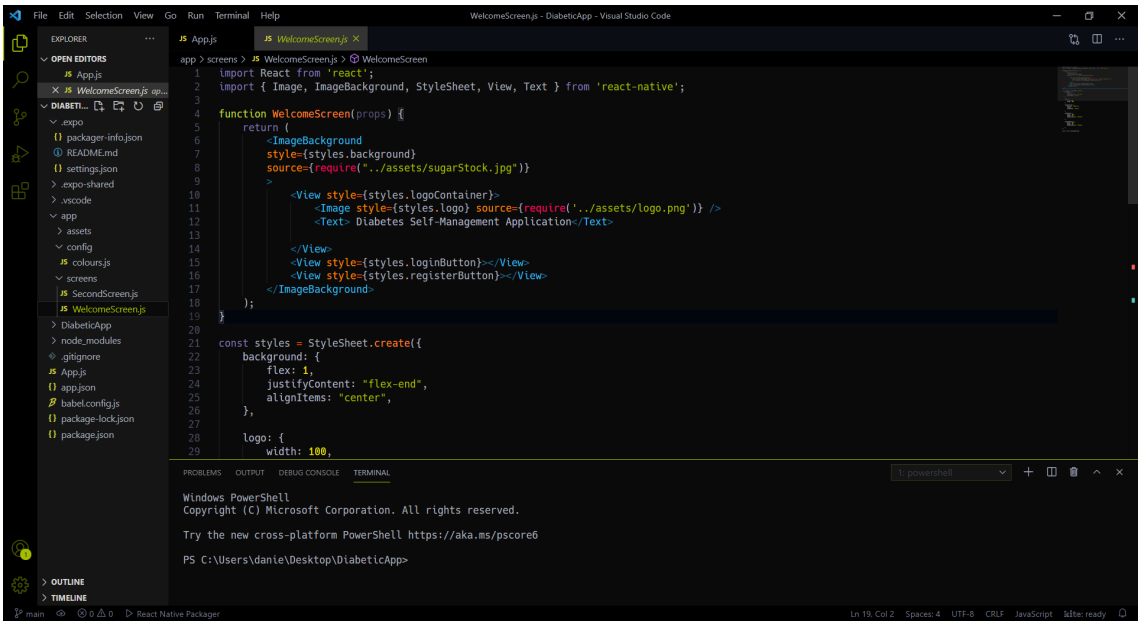
The diabetic self management application underwent several prototype versions and revisions before the final build was conceived. This allowed a natural evolution between prototypes and helped catalog and see the progress between versions for further analysis and discussions.

6.2 First Prototype

The first prototype of the application was a basic colour scheme and look-and-feel test. The prototype began as an experiment with different colour schemes for the application and to get a general idea of how the application was going to look and behave.

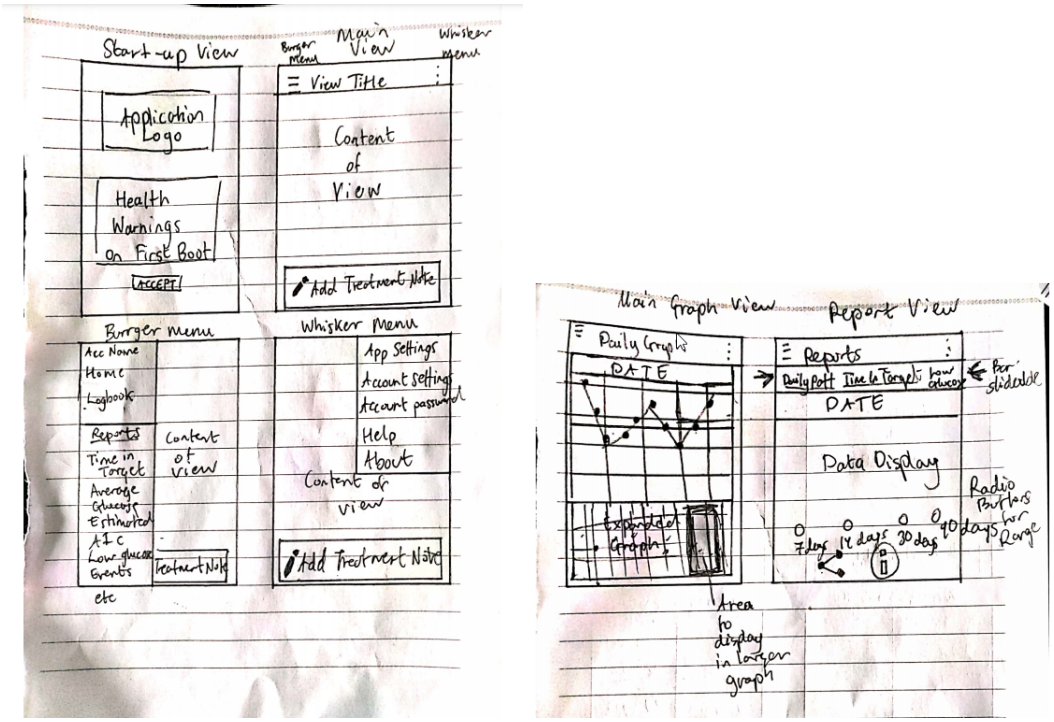
Figure 6.1: First Prototype - Login Screen Test

Figure 6.2: First Prototype - WelcomeScreen.js



In this prototype, programming wise, it served as a test bed for working with react native components (the building blocks of react) and stylesheets. After finishing the work on the first prototype the next plan was to begin sketching out a plan for the general user interface.

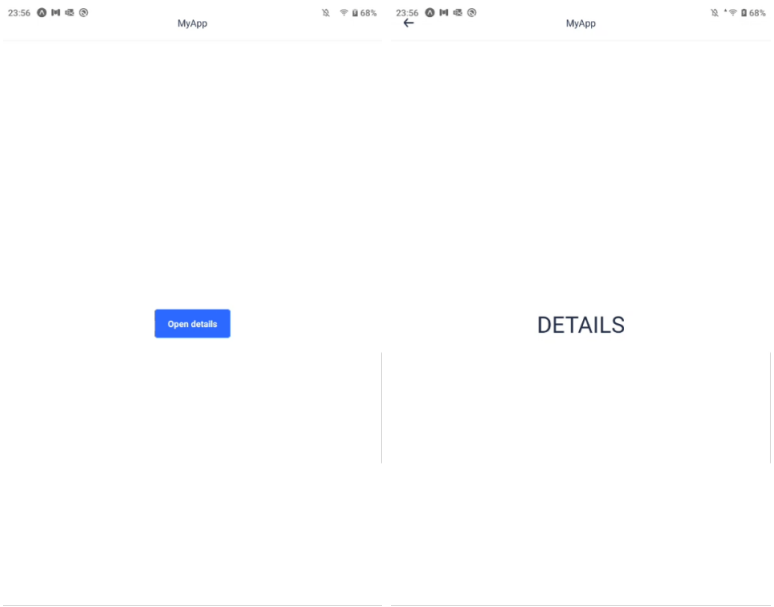
Figure 6.3: User Interface - Sketches



6.3 Second Prototype

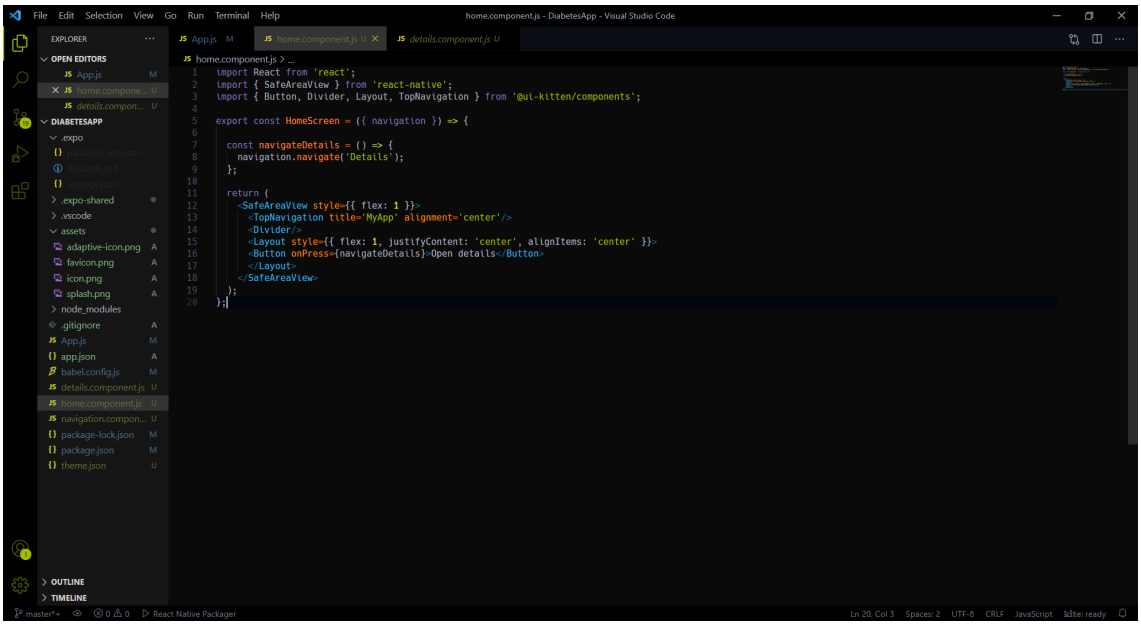
After completing the first prototype, work would continue by experimenting and tinkering with the **React Navigation Library**, which began the basis for the second prototype. These experiments gave the understanding and a grasp of how the application would handle it's gestures and navigation from application screen to screen. **createStackNavigator** is a function that returns an object containing two properties: Screen and Navigator. Both are React components used for configuring the navigator. The Navigator should contain screen elements as its children to define the configuration for routes. **NavigationContainer** is a component which manages our navigation tree and contains the navigation state. This is usually rendered in the root of the application. The paradigm for navigation throughout react entails a pop and stack queue model.

Figure 6.4: Image of Native Base Library Work



Navigation from application screen to application screen.

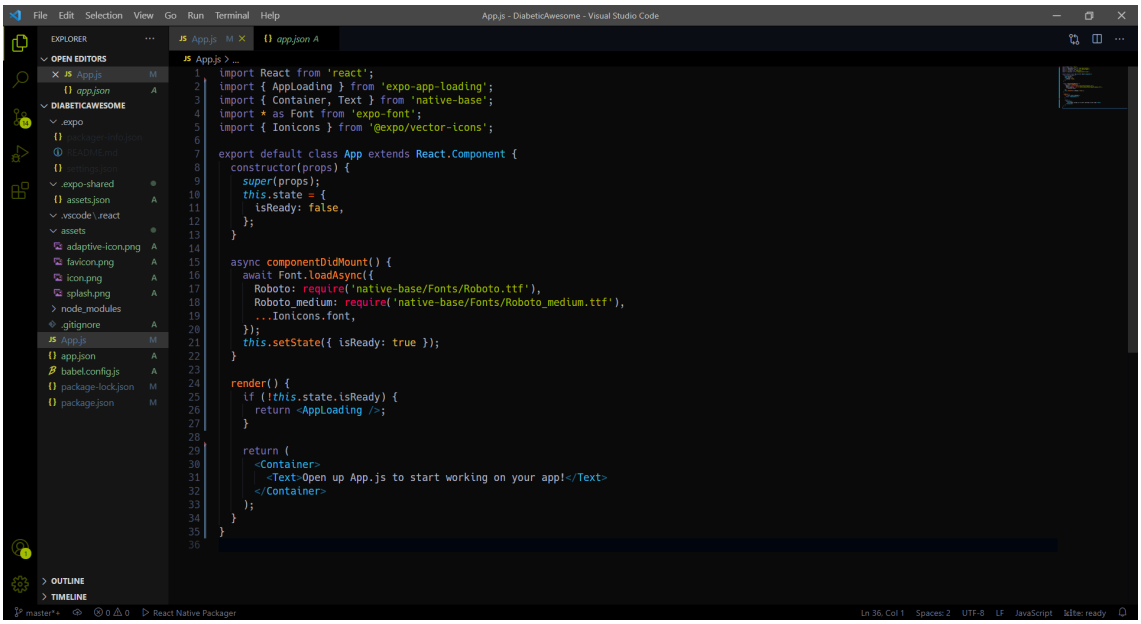
Figure 6.5: Image of Native Base Library Work



6.4 Native Base Library Experimentation

Native base provides some unconfigured but feature-full boiler plate components for react user interfaces. When experimenting with Native Base a start was made with the libraries components called "*Container*" and "*Text*" components.

Figure 6.6: Image of Native Base Library Work



The *Container* tag houses all the user interface components to be rendered on the screen while the *Text* tag contains all the renderable text to be displayed in the component.

6.5 Application Home Screen Prototype

As the work on the prototypes progressed work began on putting a prototype with how the main screen of the application would look. This would act as a basis for all future screens and gave a template for future work on the project.

Components such as screen header tabs and buttons, contents of the home screen, floating action buttons and footer tabs were all added and tested in this prototype. These components are all reusable and would act as a basis for all the static and dynamic components of the application that would be used throughout most of the screens in the application.

Figure 6.7: Home Screen with Components

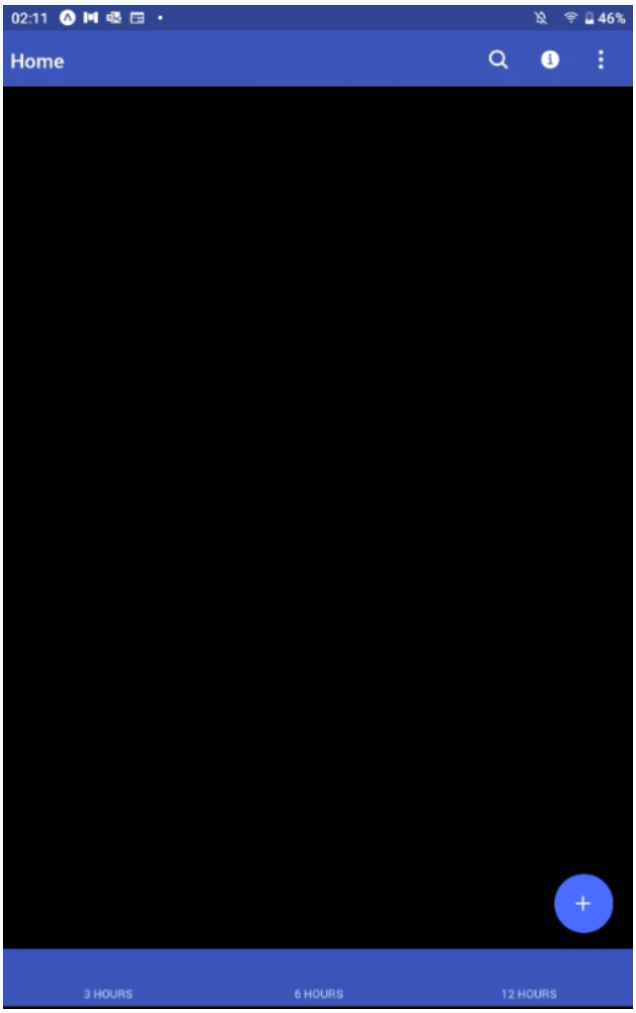
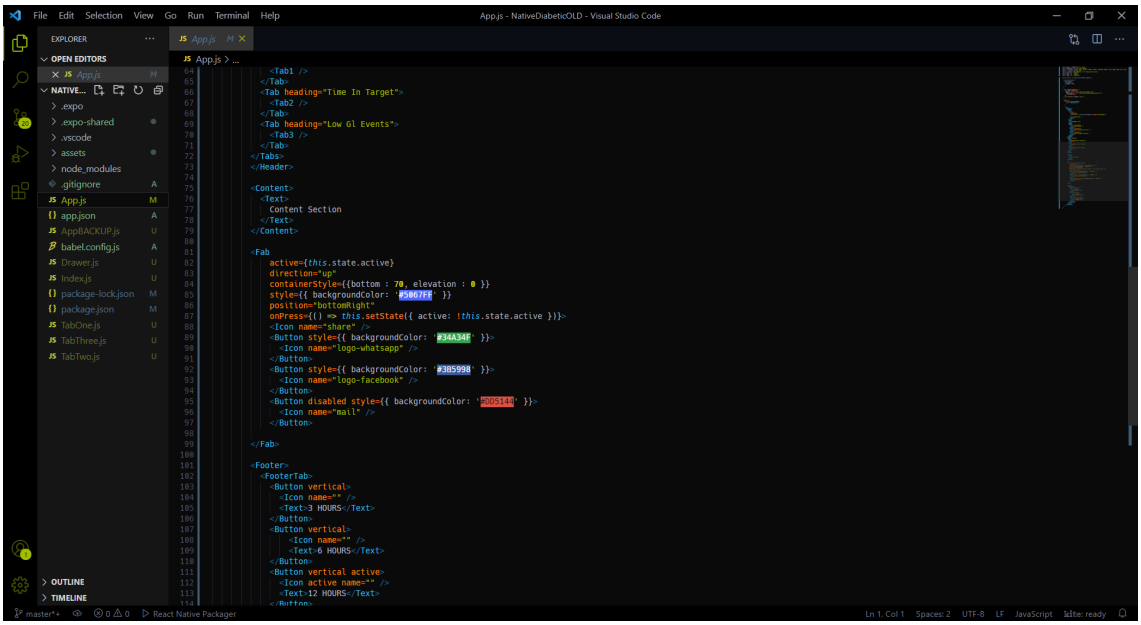


Figure 6.8: Component Code - App.js



6.6 Intros and Blood Sugar Chart Prototype

After successfully prototyping a home screen, the focus shifted to adding an introduction to the application. Since the application was of a medical nature, with ethics in mind, the decision was made to have a short notice to all users who open the app, explaining not to rely on the application for medical care but only to enhance an already solid care routine.

Figure 6.9: Intro Slider with Gesture Support

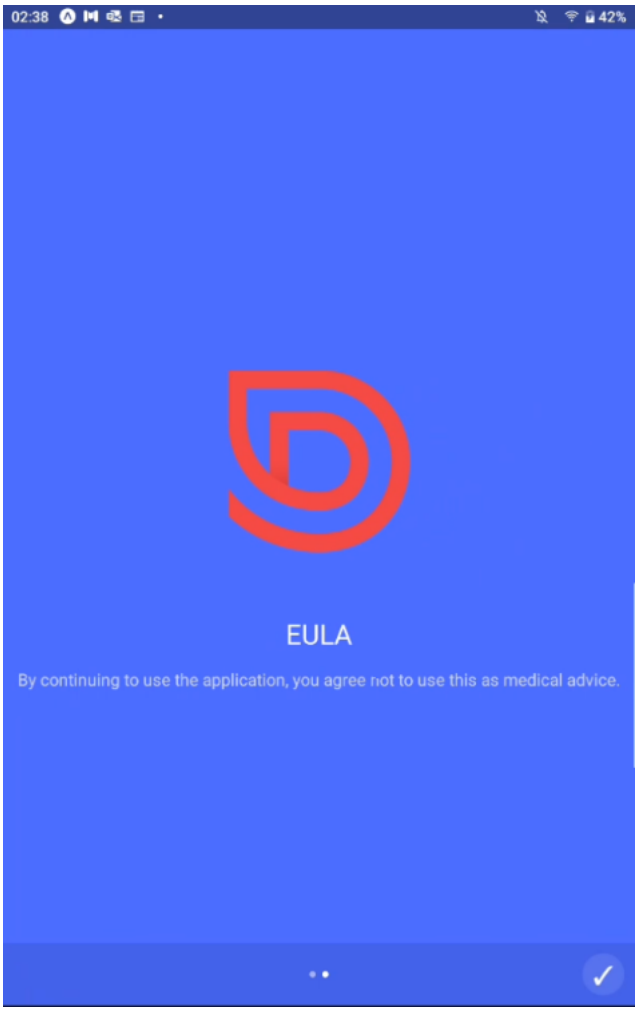
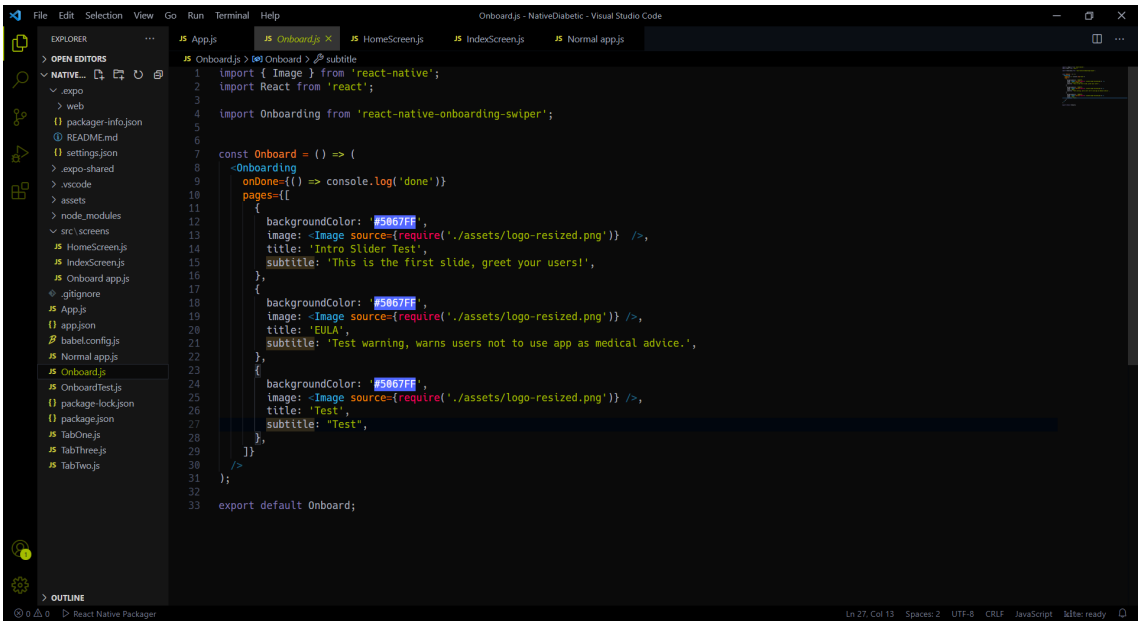
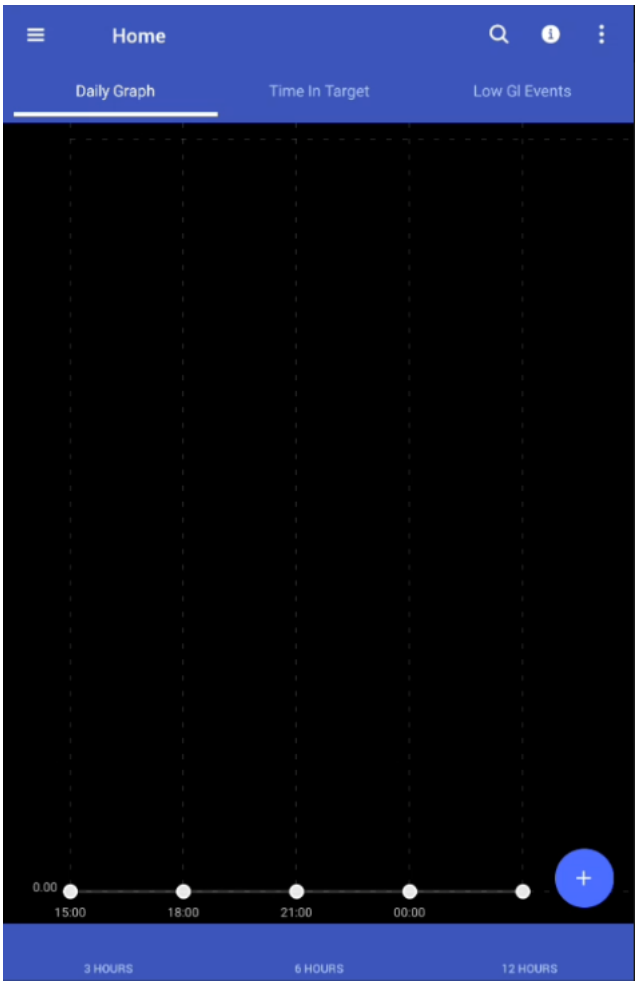


Figure 6.10: Component Code - Onboard.js



Shortly after the introduction sliders were completed for the application, the focus shifted to the main aspect of the application which was the chart display for the various aspects that would be logged in the application. This is where react-native-chart-kit was used to achieve this minimalist but feature full graph.

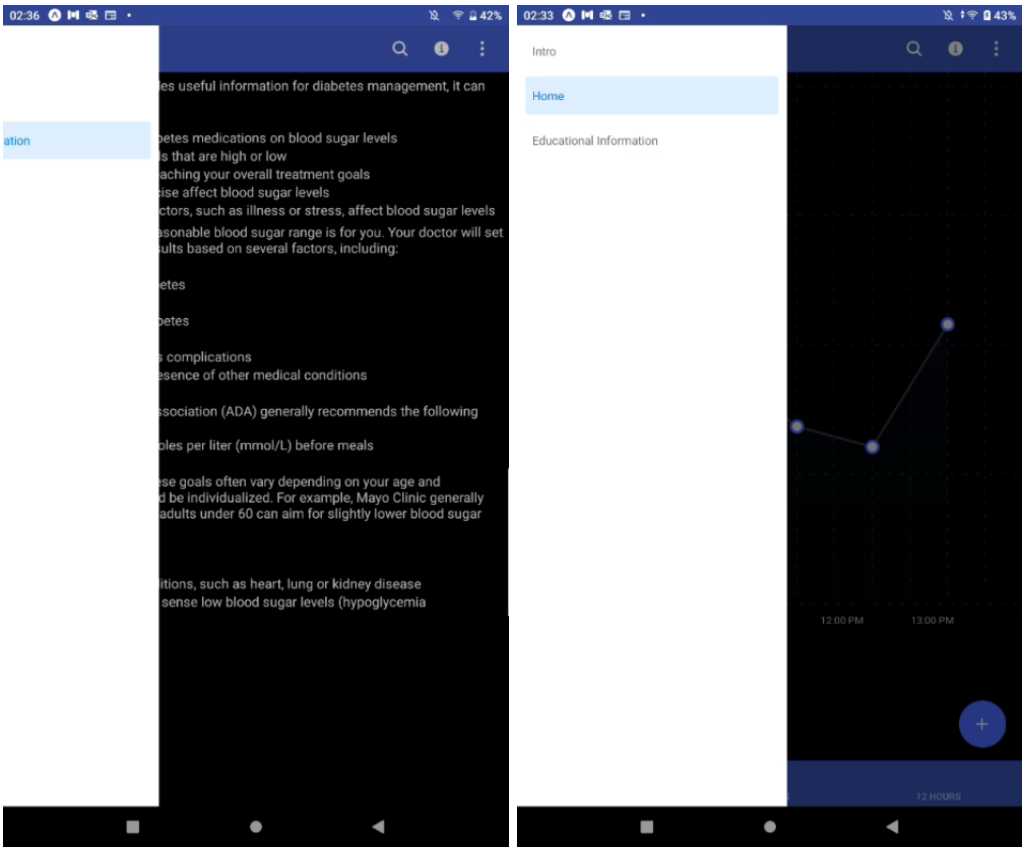
Figure 6.11: Home screen with Graph



6.7 Navigation Drawer and Iterating on the Graph

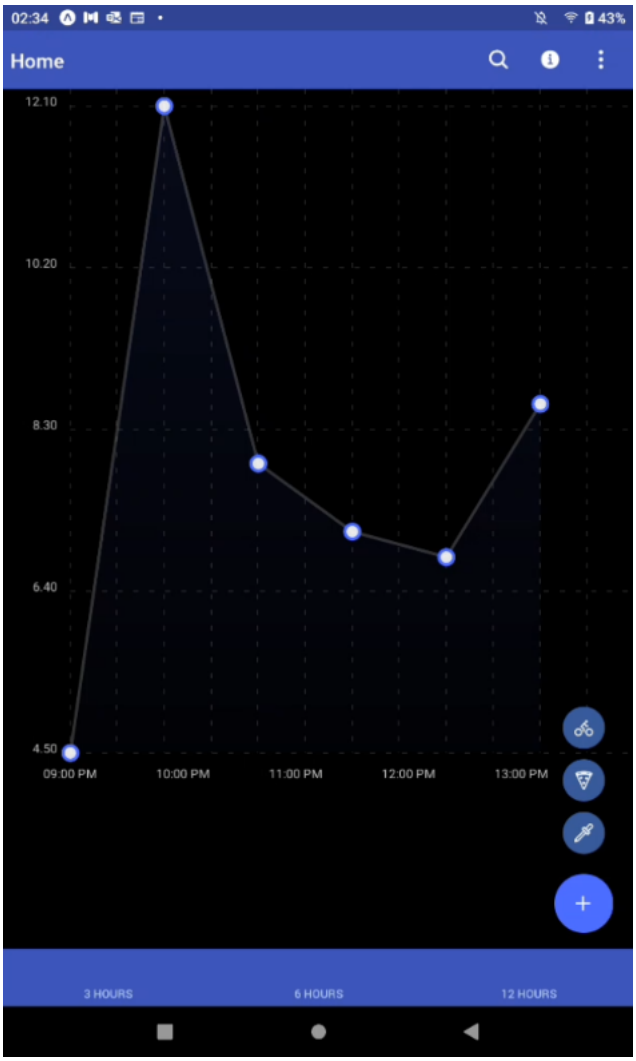
After implementing more than one application screen, it became obvious that a way for the user to handle gesture based movement was needed in the application. Continuing working with the **React navigation library**, a screen drawer with full gesture support was added to the application. This allows users to swipe from the left side of the screen inwards to open the screen drawer. From here users are able to select one screen from a list. At this point of the prototype a educational information screen was also added to test this functionality.

Figure 6.12: Navigation Drawer with Gesture Support - Swipe From Left Example



Subsequently, the prototype focus was to iterate on the chart in the applications home screen as this was the focus for the next few agile sprints. Dummy data was added to the chart and work began on adding dynamic chart labels and tool tips.

Figure 6.13: Home screen Graph with Data



6.8 Dynamic Chart Tooltips

After work on the chart kit matured, it became apparent that the first hurdle would be faced in the project. The floating action buttons previously mentioned were planned to be able to be individually pressed depending on the type of data the user wanted to input into the graph. Options would include food, exercise and diet habits. The issue arose when the lack of knowledge of the **React navigation library** which uses "states" to handle all data between buttons and screens in the application. While having this issue, work continued on the gesture based dynamic tool tips and was completed, finalising the

last build of the project application.

Figure 6.14: Input Test of Floating Action Buttons

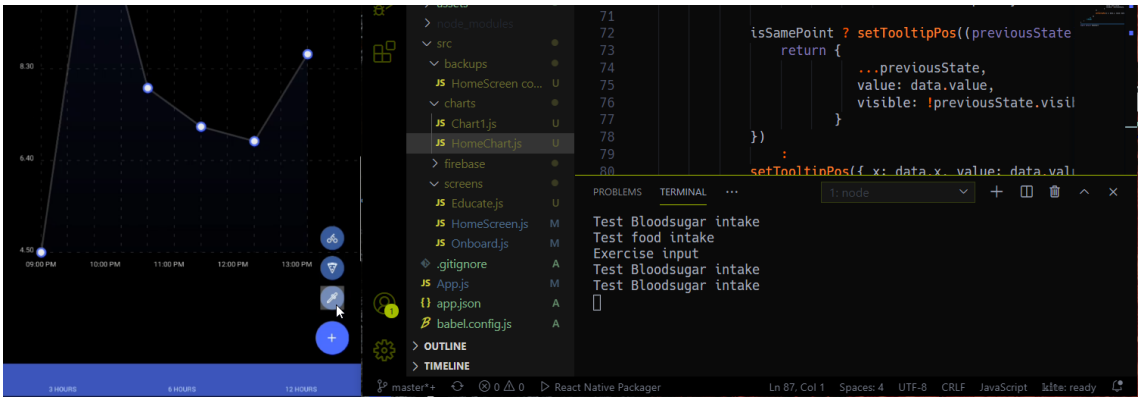
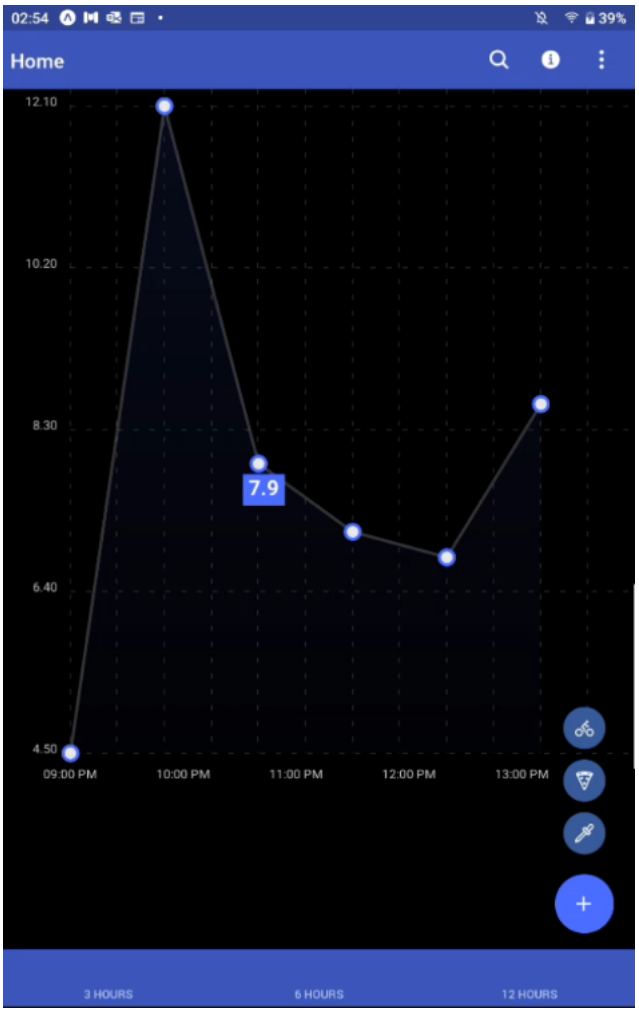


Figure 6.15: Home screen Graph with Dynamic Gesture Based Tooltips



Chapter 7

Conclusion

7.1 Introduction

This chapter is the final chapter of the thesis and concludes all final ideas and experiences while working on the project and thesis.

7.2 Literature Review

From my literature review of these papers and their materials, my understanding of how to approach and create a diabetic self-management application has greatly expanded and has been enhanced. It has given me the opportunity to read first hand the challenges and ideas that would help shape my application. All of the papers provided evidence based approaches to their studies which proved important in giving me the confidence that all the information I was researching and receiving was credible and of caliber. My research has solidified the planning and the required expectations I needed to decide my applications feature-set and I've gotten more concrete in my choices in this area.

7.3 Possible Future work

An area to possibly work on would be the chart aspect of the application, as mentioned in previous chapters the chart was supposed to be dynamic and feature user input but due to time constraints and lack of knowledge with the react navigation library it was not finalised.

Advanced graph logging and report viewing for the user. Allowing the user to see trends in their logging data.

Wear OS Integration for fitness tracking data was also planned but due to time constraints wasn't added in the final build of the application. A Fire base back end with accounts was also an idea for the project and would be a natural area to continue working on the project.

7.4 Reflections and Opinions

I've learned an amazing amount of skills and ideas, that previously to working on the project I would of never imagined. The project and thesis gave me a great way to challenge myself through the process of building an application and having to figure out the same issues many other developers have previously tackled before me. I've reflected on this and I came to the realisation that with programming the best thing to do is to break every problem down into smaller problems and work your way through. As you work through these problems the bigger picture will come together.

7.5 Conclusions

To conclude the thesis, much research was done on medical and software fields to come and create an application that tried to solve apparent issues in the market. While the application solved many of the issues I planned to tackle the realistic realisation that mobile application development is a complex and tough beast to tackle with many different aspects and skills to master. Solving every issue alone would be impossible, so work would have to be focused on by importance and user expectations.

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