Faculty of Electronics & Computer Technology and Engineering

DEVELOPMENT OF E-HEALTH EDUCATION SYSTEM FOR PEOPLE LIVING WITH DIABETES (WEB-BASED)

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Bachelor of Electronics Engineering Technology with Honours

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DEVELOPMENT OF E-HEALTH EDUCATION SYSTEM FOR PEOPLE LIVING WITH DIABETES (WEB-BASED)

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DEDICATION

I dedicate this bachelor degree project to my creator, Allah s.w.t the Almighty, my strong pillar, my source of inspiration, wisdom, knowledge, and understanding. He has been the source of my strength to accomplish this project throughout this degree.

To my beloved parents,

Haznan bin Onan Alias and Nor Azlyena binti Azis who consistently provide me their moral, spiritual, emotional, and financial support, who have inspired me and given me courage when I felt like giving up.

To my bestfriends,

Nurul Afifah, Nor Amirah, Azrra and Khalilah Aqilah for being pillars of support who played such important roles along the journey, as we mutually engaged in making sense of the various challenges we faced and in providing encouragement to each other at those times when it seemed impossible to continue.

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ABSTRACT

Diabetes is a chronic disease that has become a significant health concern globally, including Malaysia. The prevalence of diabetes in Malaysia has been steadily increasing over the years, posing a significant burden on the healthcare system and the affected individuals. This project aims to develop an innovative web-based e-health education system tailored specifically for people living with diabetes. The suggested method makes use of the internet's accessibility and the power of technology to deliver thorough diabetes education in a userfriendly and engaging way. The system incorporates a range of educational modules. This project is to enhance the current technology which eases the medical practitioner to monitor and get the update of the patient's glucose level without physically present. The objectives are to detect and monitor the patient's glucose level, and also to raise the patient's awareness of their sugar level. To learn about how the system is connected to the body through sensors that detect blood glucose level. By gently attaching a finger to the MAX30102 sensor board, these parameters are detected, and the data is shown on the website MediCoLink. This enables users to monitor their health status based on the gathered data, which can also be viewed via a smartphone through the Blynk application.

ABSTRAK

Diabetes adalah penyakit kronik yang telah menjadi kebimbangan kesihatan yang ketara di seluruh dunia, termasuk Malaysia. Kelaziman diabetes di Malaysia telah meningkat secara beransur-ansur sejak beberapa tahun, menimbulkan beban yang ketara kepada sistem penjagaan kesihatan dan individu yang terjejas. Projek ini bertujuan untuk membangunkan sistem pendidikan e-kesihatan berasaskan web yang inovatif yang disesuaikan khusus untuk penghidap diabetes. Kaedah yang dicadangkan menggunakan kebolehcapaian internet dan kuasa teknologi untuk menyampaikan pendidikan diabetes yang menyeluruh dengan cara yang mesra pengguna dan menarik. Sistem ini menggabungkan pelbagai modul pendidikan. Projek ini adalah untuk meningkatkan teknologi semasa yang memudahkan pengamal perubatan memantau dan mendapatkan kemas kini tahap glukosa pesakit tanpa kehadiran fizikal. Objektifnya adalah untuk mengesan dan memantau paras glukosa pesakit, dan juga untuk meningkatkan kesedaran pesakit tentang paras gula mereka. Untuk mengetahui tentang cara sistem disambungkan kepada badan melalui penderia yang mengesan tahap glukosa darah. Dengan melekatkan jari secara perlahan pada papan penderia MAX30102, parameter ini dikesan dan data ditunjukkan pada tapak web MediCoLink. Ini membolehkan pengguna memantau status kesihatan mereka berdasarkan data yang dikumpul, yang juga boleh dilihat melalui telefon pintar melalui aplikasi Blynk.

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CHAPTER 1

INTRODUCTION

1.1 Project Introduction

The disease known as diabetes is characterized by the body's inability to regulate blood sugar levels. There are three main types such as type 1, type 2, and gestational diabetes (during pregnancy). Type 1 happens when the immune system attacks insulin-producing cells, while type 2 occurs when the body doesn't respond well to insulin or doesn't make enough of it. If not managed properly, diabetes can cause serious health issues. Regular care and self-care education are important for managing diabetes well. To propose the development of an innovative IoT-based E-Health Education System for people living with diabetes. As the prevalence of diabetes increases, it is important to have access to high-quality education and resources to effectively manage the condition. Our web-based platform will harness the power of IoT to create an interconnected and comprehensive system. By using glucose meters, and connected medical devices, the system will enable real-time monitoring of health parameters and gather data accordingly. This valuable data will be utilized to deliver personalized educational content, and recommendations tailored to each individual's unique needs and circumstances. Additionally, the platform will facilitate remote access to healthcare professionals through virtual consultations and remote monitoring, ensuring convenience and improved access to diabetes care. Through the incorporation of IoT features, our E-Health Education System has the potential to transform diabetes management, leading to enhanced health outcomes and improved quality of life for individuals living with diabetes.

1.2 Project Background

Diabetes is a widespread chronic condition that affects a significant number of individuals globally. However, many people face challenges in accessing quality diabetes education, which hinders their ability to effectively manage the disease and maintain overall well-being. The emergence of Internet of Things (IoT) technology offers an opportunity to revolutionize healthcare and patient education. Our objective is to utilize IoT to develop a web-based E-Health Education System specifically tailored for individuals with diabetes. By integrating IoT into the system, it enable the real-time monitoring, data collection, and analysis of crucial health parameters like blood glucose levels. This empowers individuals by providing them with valuable insights into their health status, allowing them to proactively manage their condition. The IoT capabilities of the system also enhance the educational aspect, delivering personalized content and recommendations based on individual needs and circumstances. Users will have access to a range of interactive modules on the web-based platform. Furthermore, the integration of IoT enables remote access to healthcare professionals through virtual consultations and remote monitoring, removing geographical barriers and improving convenience. Through the development of this IoT-based E-Health Education System, our aim is to address the educational requirements of individuals living with diabetes, empowering them to effectively manage their condition, achieve better health outcomes, and enhance their overall quality of life.

1.3 Societal/Global Issue for Development Of E-health Education System For People Living with Diabetes.

By providing accessible diabetes education, closing the knowledge gap, and advancing just healthcare, the creation of an online e-health education system for diabetics addresses societal and global challenges. By providing thorough information on diabetes management, food, exercise, and medication, this program addresses the societal issue of limited access to diabetes education and support. By enabling remote consultations and communication with healthcare providers, it also tackles healthcare disparities by ensuring that people receive counsel no matter where they are. Additionally, the system addresses the widespread problem of insufficient diabetes monitoring by tracking glucose levels in real-time utilizing MAX30102 sensor technology, allowing for prompt modifications to treatment programs and improved diabetes management. Overall, this e-health education program strives to promote equity in healthcare delivery while enhancing the health and quality of life for diabetics, regardless of their socioeconomic status.

1.4 Problem Statement

The development of an e-health education system for people living with diabetes addresses several critical challenges. The difficulty in getting access to diabetes education is one of the main problems. Many diabetics encounter obstacles including geographic restrictions, a lack of facilities for specialised medical treatment, or financial limitations that keep them from accessing high-quality information about managing their illness. Access issues result in inadequate diabetes treatment and a higher risk of complications.

The lack of understanding and education among those with diabetes is another issue. Many people don't have a thorough grasp of managing diabetes, which includes the significance of making lifestyle changes, taking medications as prescribed, monitoring blood sugar levels, and spotting issues early. As a result, they may engage in poor self-care practices, leading to uncontrolled blood sugar levels and negative health outcomes.

Successful education and self-management depend on effective interaction and communication between healthcare professionals and diabetes patients. However, in conventional healthcare settings, the lack of ongoing support and time limits during consultations make it difficult to build trusting patient-provider relationships. In turn, diabetes education campaigns become less effective as a result. An e-health education system can increase communication by enabling people to interact with medical professionals, get direction, and ask questions about how to manage their diabetes.

Finally, it is essential to monitor and evaluate diabetes education programs in order to determine their success and make the necessary adjustments. Traditional data gathering techniques for monitoring and assessment are frequently manual and time-consuming, which might result in mistakes. By automating data collecting, an e-health education system can speed up this procedure and enable real-time tracking of progress and results. This makes it possible for medical professionals and educators to pinpoint problem areas and modify educational interventions to better serve the needs of people with diabetes.

1.5 Project Objective

In order to complete this project, there are a few objectives that must be archived. The objectives are:

a) To develop an e-Health education module for people living with diabetes using web-based platform.

b) To design a system that can monitor blood sugar level based on IoT devices.

c) To analyze the data performance of blood glucose level.

1.6 Scope of Project

The scope of this project are as follows:

a) Development of an e-Health module using a web-based platform (Google Sites) for individuals living with diabetes.

b) The module will provide comprehensive educational content and resources related to diabetes management.

c) Designing an IoT system using ESP32 for glucose monitoring.

d) Data will be sent to Thingspeak for further analysis and visualization.

e) The data also can be monitor through a smartphone via the Blynk application.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The goal of this literature review is to analyze previous projects and studies that are connected to Malaysians who are currently suffering a diabetic issue but who are unable to regulate themselves on a regular basis. This chapter concentrated on gaining new knowledge from numerous periodicals, books, articles, and online resources.

2.2 Understanding [Global/Current Issue] in the Literature

Understanding the global issue of developing a web-based e-health education system for people with diabetes involves recognizing the difficulties of limited accessibility to healthcare and diabetes education, the requirement for individualized approaches to managing diabetes, the significance of ongoing monitoring and self-management, and the significance of interdisciplinary cooperation. The literature highlights the promise of web-based platforms to close the accessibility gap, provide individualized instruction and feedback, enable practical glucose monitoring, and enable people to take an active role in their diabetes treatment. Researchers and practitioners can create efficient systems that address these problems and enhance the general health outcomes for people with diabetes globally by studying these problems.

2.3 Introduction of Diabetes

Diabetes is a chronic medical condition characterized by high levels of sugar (glucose) in the blood. It occurs when the body either does not produce enough insulin or cannot effectively use the insulin it produces. Insulin is a hormone produced by the pancreas that helps regulate blood sugar levels and allows cells to utilize glucose for energy. There are three main types of diabetes: type 1, type 2, and gestational diabetes (diabetes while pregnant).

2.3.1 Type 1 Diabetes

Type 1 diabetes is characterized by an autoimmune response, where the immune system erroneously targets and destroys the pancreas' insulin-producing cells. This leads to inadequate or absent insulin production within the body. Around 5-10% of individuals with diabetes are affected by type 1. Although type 1 diabetes commonly emerges during childhood or adolescence, it can also manifest at any stage of life. People living with type 1 diabetes need to administer daily insulin injections or utilize an insulin pump to regulate their blood sugar levels effectively.

2.3.2 Type 2 Diabetes

In type 2 diabetes, the body struggles to effectively utilize insulin, leading to elevated blood sugar levels. Approximately 90-95% of individuals with diabetes have type 2. This condition develops gradually over many years and is commonly diagnosed in adults, although it is increasingly being observed in children, teenagers, and young adults. Symptoms may not be immediately noticeable, underscoring the importance of blood sugar testing for individuals at risk. Type 2 diabetes can be prevented or delayed through adopting a healthy lifestyle, including weight loss, consumption of nutritious food, and regular physical activity.

2.3.3 Gestational Diabetes (Diabetes while pregnant)

Pregnant women without a history of diabetes may develop gestational diabetes. A pregnancy with gestational diabetes carries a higher risk of health issues for the unborn child. Fortunately, gestational diabetes usually goes away after giving delivery. On the other hand, it does raise the risk of type 2 diabetes in later life. Additionally, there is an increased probability that the child may experience obesity during childhood or adolescence and develop type 2 diabetes in the future.

2.4 What is blood glucose?

Blood glucose, also known as blood sugar, is the sugar present in our bloodstream. It serves as the primary source of energy for our body's cells and needs to be regulated for proper bodily functions. When eating carbohydrates, they are broken down into glucose during digestion and absorbed into the bloodstream. Insulin, produced by the pancreas, plays a vital role in regulating blood glucose levels by helping glucose enter cells for energy or storage. Maintaining blood glucose within a specific range is crucial. High levels (hyperglycemia) may indicate issues with insulin and can occur in diabetes, while low levels (hypoglycemia) can cause weakness and confusion. People with diabetes monitor their blood glucose levels to manage their condition effectively through medication, diet, and lifestyle adjustments, reducing the risk of complications. Overall, regulating blood glucose is important for optimal bodily function and overall health. Figure 2.1 below shows the blood glucose chart.

Blood Glucose Chart			
Mg/DL	Fasting	After Eating	2-3 Hours After Eating
Normal	80-100	170-200	120-140
Impaired Glucose	101-125	190-230	140-160
Diabetic	126+	220-300	200+

Figure 2.1 Blood glucose chart

2.5 E-Health technology

The use of digital tools, systems, and devices in healthcare to advance medical services, enhance patient care, and improve health outcomes is referred to as e-health technology, or electronic health technology. It comprises wearable technology, remote monitoring systems, telemedicine platforms, mobile health applications, electronic health records, and data analytics. E-health technology makes it possible to organise and transmit health information electronically, which makes it easier for stakeholders, patients, and healthcare providers to communicate effectively. Processes are streamlined, errors are decreased, accessibility is increased, and personalised care is supported. E-health technology empowers people to actively control their own health and enables practitioners to provide effective, patient-centered treatment, improving healthcare outcomes and population health. E-health technology has the potential to revolutionize healthcare delivery.

2.5.1 Apps that use for Diabetes monitoring

There are various applications are available to monitor diabetes and aid individuals in effectively managing their condition. These apps offer a range of features to track blood glucose levels, medication intake, diet, physical activity, and overall diabetes management. Well-known apps in this category include Glucose Buddy, mySugr, Diabetes:M, Glucosio, mySugr AcmySugr, and One Drop. They provide comprehensive tools such as logbooks, data analysis, reminders, and integration with other devices and health apps. These apps offer convenience, organization, and insights into diabetes management. However, it's important to note that while these apps can be valuable aids, it is essential to seek personalized advice and treatment guidance from healthcare professionals.

2.5.2 Technology for Diabetes Care

There are variety of e-health technologies are presently accessible to support diabetes care, aiming to enhance management, monitoring, and overall well-being for individuals with the condition. These technologies encompass Continuous Glucose Monitoring (CGM) systems that utilize sensors to deliver real-time glucose data, aiding individuals in making well-informed decisions regarding insulin dosage, diet, and physical activity. Insulin pumps offer a more precise and flexible means of administering insulin compared to manual injections. Telemedicine and remote monitoring technologies enable individuals to remotely connect with healthcare professionals, receiving guidance, support, and monitoring without requiring face-to-face visits. Mobile applications and digital tools specifically designed for diabetes care offer features such as glucose tracking, medication reminders, meal planning, and educational resources. Data analytics and artificial intelligence technologies analyze diabetes-related data to provide personalized recommendations and predictive insights. Web-based education platforms provide a wide array of educational resources and support networks. Collectively, these e-health technologies augment diabetes care by enabling real-time monitoring, personalized support, remote access to healthcare professionals, educational materials, and data-driven insights. It is crucial to utilize these technologies under the supervision and guidance of healthcare professionals to ensure the safe and effective management of diabetes.

2.6 IoT for Healthcare

For real-time monitoring and analysis, IoT technology in healthcare involves linking medical devices and sensors to gather and exchange data. This includes smart home medical devices, wearable fitness trackers, and equipment for remote patient monitoring. The gathered information is included into electronic health records so that medical professionals can access and examine it to make precise diagnoses and specialised treatment plans. IoT also makes telehealth and remote monitoring services possible, improving access to healthcare. By observing trends and foreseeing health problems, it aids in preventive care. Information about patients must be protected with security measures. IoT in healthcare generally boosts preventive care, remote access to healthcare services, and patient care.

2.7 IoT for Diabetes

By providing real-time monitoring and data collection, IoT (Internet of Things) technology has significantly improved diabetes care. People can make educated decisions regarding their use of insulin and lifestyle choices thanks to gadgets like continuous glucose monitors (CGMs), which check blood glucose levels and transmit data to linked devices. User-friendly interfaces are offered by mobile apps to track several facets of diabetes management. Telemedicine and remote monitoring are made possible by IoT, assisting healthcare professionals in remotely supporting patients. Personalised recommendations and predicative insights are provided by data analytics and AI systems. IoT technology generally enables people with diabetes to take greater control of their condition and get remote support from medical specialists.

2.8 Literature Review based on Several Research Paper

The fundamental goal of a literature review is to connect the project idea with the knowledge and ideas that have been produced on a particular subject. Prior to beginning this investigation, a literature analysis was conducted to gather data on the technology available and the methodologies used by other studies that were already working on the same subject. There are multiple techniques to check blood glucose level.

2.8.1 IOT Based Non-Invasive Glucose Monitoring System for Diabetic Patient

This article focused on an insole that allows users to check their blood glucose levels by placing their feet on the insoles. It offers details on gait mechanics and can be used in a variety of clinical settings. In this study, sensors are utilised to learn more about a diabetic person's infrared skin sensor. Patient adherence is a difficulty for wearable real-time monitoring and feedback. A number of sensors make up the insole. The pressure-sensing smart insole technology offered distinctive input to the patient and the healthcare professional in ways that helped prevent pressure and highlighted the significance of the non-invasive treatment recommended. Because it makes it much simpler to interpret the necessary data, real-time visualisation of pressure mapping that uses internet data is also included [1].

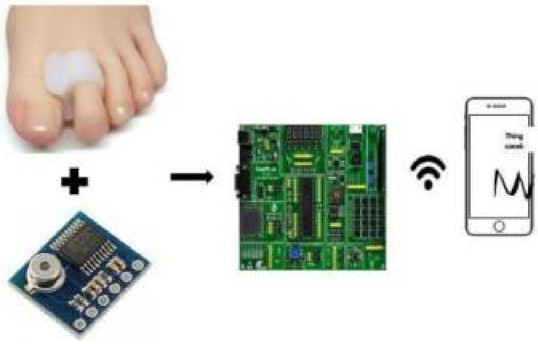

Figure 2.2 Block diagram of proposed system

2.8.2 A Portable Non-Invasive Blood Glucose Monitoring Device with IoT

Invasive blood glucose monitors that require finger piercings are the majority of what are available on the market. This approach is highly accurate yet typically uncomfortable and more likely to cause infections. Therefore, in order to reduce the concern associated with invasive glucose monitoring systems, it is desirable to develop low-cost noninvasive blood glucose monitoring. In order to create painless glucose testing techniques, non-invasive procedures were devised. In this project, it's using near infrared sensors, a portable non-invasive blood glucose monitoring system was created. The blood glucose concentrations are computed using this sensor, which is implanted at the fingertip to optionally measure blood sugar levels. After that, the signal is amplified and filtered before entering the microcontroller. Based on the voltages that were analysed and the glucose data that was to be displayed on the LCD and transmitted over Wi-Fi to a mobile phone, the patient's glucose level was anticipated. It is shown using an Android app called Blynk Apps [2].

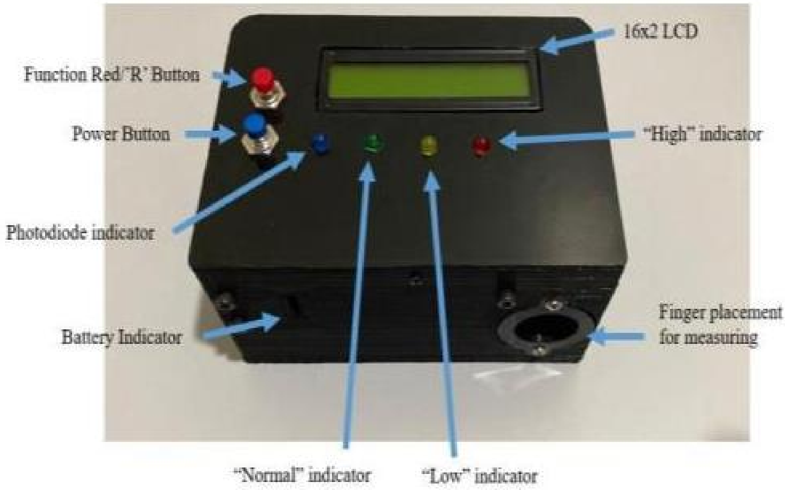

Figure 2.3 Prototype of a non-invasive blood glucose monitoring device

2.8.3 GSM based Needleless Blood Glucose Monitoring System

In this study, it suggest a design for a non-invasive, cost-effective glucose monitoring device that makes use of near-infrared spectroscopy. Furthermore, the GSM module attached to this gadget will facilitate wireless data sharing. As a result, the results can be quickly forwarded to the doctor for review. The collected results can be kept for future reference, as well as to analyse changes in blood glucose levels and modify medication dosage. The results of the current investigation demonstrate that our technology offers patients simple, hassle-free use in addition to accuracy levels comparable to those of commercially available systems [3].

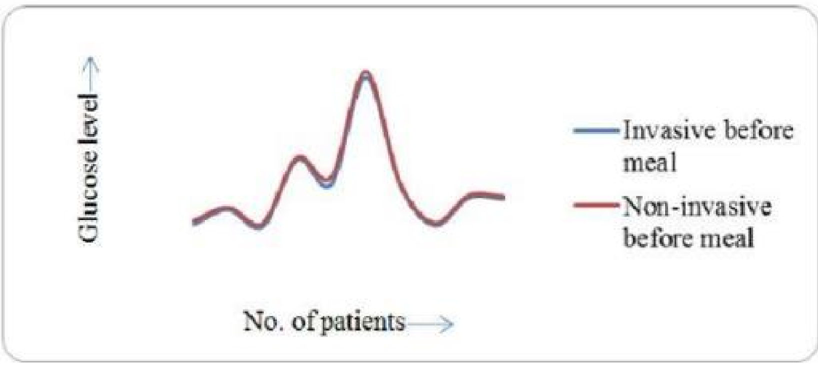

Figure 2.4 Graph showing invasive and non-invasive results of patients before meal

2.8.4 Pain-free Blood Glucose Monitoring Using Wearable Sensors

This study describes an innovative, painless blood glucose monitoring device that makes use of wearable sensors. The technology uses cutting-edge biosensors that can detect glucose levels in interstitial fluid continually, doing away with the need for uncomfortable finger pricks. Wireless transmission of the gathered data allows for real-time analysis and display on a mobile device. Modern technology is used by the system to guarantee accurate measurements while maintaining user comfort. Better diabetes treatment is made possible by continuous monitoring, and the system's lack of discomfort increases patient compliance and lowers the chance of complications. Integration with mobile devices makes it simple to share data with medical specialists, enabling individualised care and remote monitoring. Overall, this ground-breaking approach has the potential to revolutionise the treatment of diabetes and provide people the tools they need to live better lives [4].

2.8.5 An IoT Based diabetic patient Monitoring System Using Machine Learning and Node MCU

This study explores four alternative machine-learning algorithms for predictive analytics and introduces a new method for monitoring diabetes patients. The effectiveness and precision of the used algorithms are examined and compared to determine which one is optimal in terms of various parameters. Results from an experiment using the classification methods Naive Bayes, Support Vector Machine, Random Forest, and Simple CART on diabetic data. This simulation's goals are to assess the effectiveness of the categorization algorithms to employ and to suggest the most effective method for prediction [5].

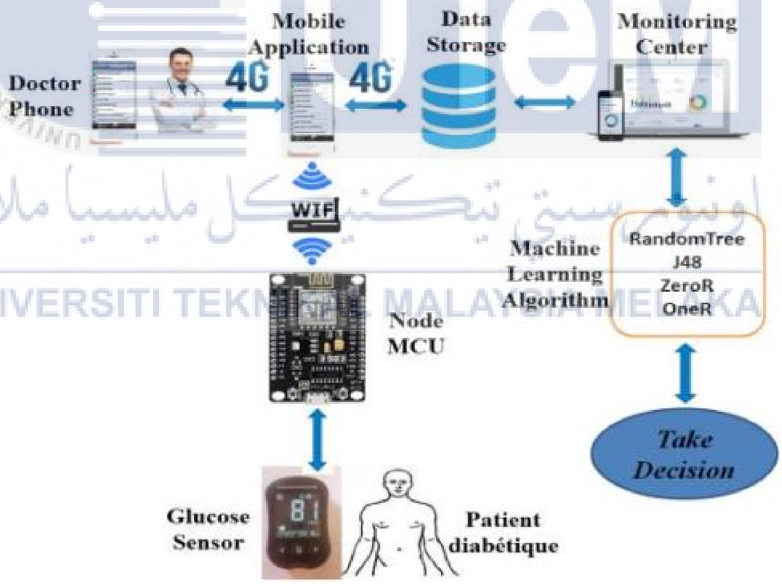

Figure 2.5 Proposed System

2.8.6 A Smart Glucose Monitoring System for Diabetic Patient

This paper presents an intelligent architecture for the surveillance of diabetic disease is presented. Using sensors built into smartphones and other smart portable devices, this architecture will enable doctors to remotely monitor the health of their patients. An intelligent algorithm was created for the proposed architecture to identify whether a parameter has exceeded a threshold, which may or may not imply urgency. To created a small portable gadget that can measure body temperature and the amount of glucose in the blood for diabetics in order to confirm that this system is operating as intended. To connect wirelessly to the smartphone, and created a secure technique [6].

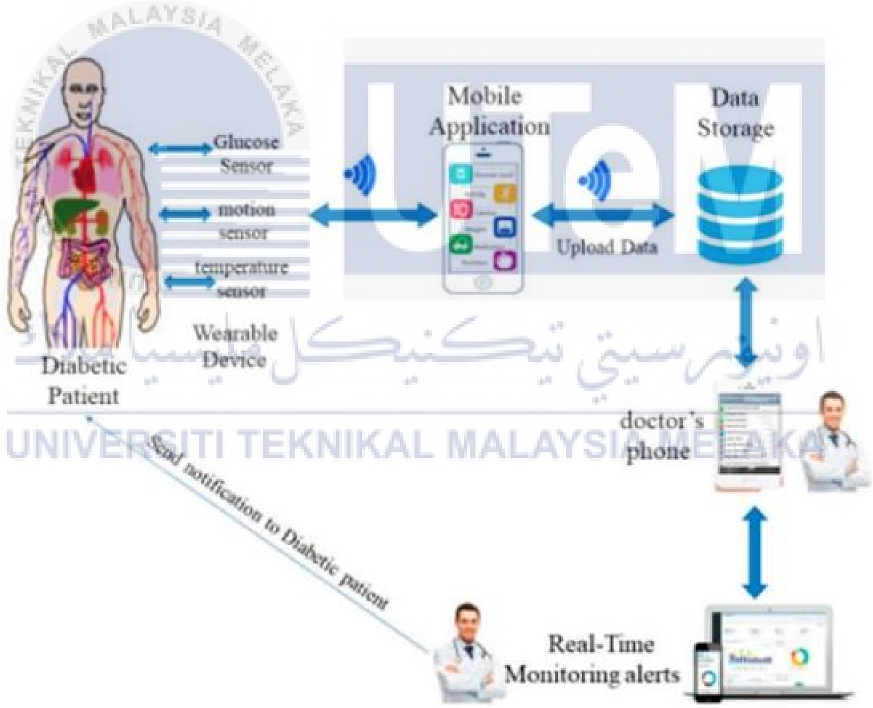

Figure 2.6 Proposed architecture for diabetic monitoring

2.8.7 Self-Care IoT Platform for Diabetic Mellitus

This study suggests an IoT-based intelligent self-care platform to help patients with chronic diabetes maintain blood glucose levels within the desired range. In instance, we created a number of gadgets under the name self-care IoT bundle. It is made up of five distinct kinds of sensors that measure blood sugar levels, physical activity, dietary intake, medication use, and sleeping patterns. With lifestyles that automatically affect the patient's blood glucose level, they can measure blood glucose levels. In order to show and analyse the data acquired from the IoT pack, we have created a self-care application. Therefore, the suggested self-care IoT platform captures the lifestyles and blood glucose levels with no record-keeping burden. Patients can identify unfavourable blood glucose management practises and change them by evaluating the accumulated information. Patients can identify harmful patterns in blood glucose management and change their lifestyle by evaluating the accumulated data [7].

Figure 2.7 The proposed internet of things (IoT)-based self-care platform for diabetics

2.8.8 IoT-Based Glucose Monitoring System

In order to measure the glucose level, this project employs a blood glucose sensor. The information from the sensor is retrieved and processed by the Arduino Uno, which serves as the brain and sends the data to the cloud using a Wi-Fi module. The information is then analysed and sent to the patient's and the doctor's smartphones. When the patient's blood sugar levels go above the acceptable limit, they will be warned and told how much insulin to take. If adjustments are required, the project can be redesigned using the iterative waterfall model [1].

2.8.9 Development of a Smart Glucose Monitoring Device

The goal of this work is to create a non-invasive diabetes monitoring system that is affordable, stress and pain-free and can measure glucose level immediately. The CPU, the data display section, the transmitter section (a light source), and the reception section (a photodiode) are the three components that make up the newly created glucose monitoring gadget. One side of the ear lobe is exposed to a Near Infrared (NIR) light, while the other side has a receiver that picks up the attenuated light and turns it into a voltage signal. The PIC16F877A microcontroller then amplifies, samples, and processes all of these factors, after which the glucose value is displayed on the LCD and transmitted via Bluetooth to an Android application [8].

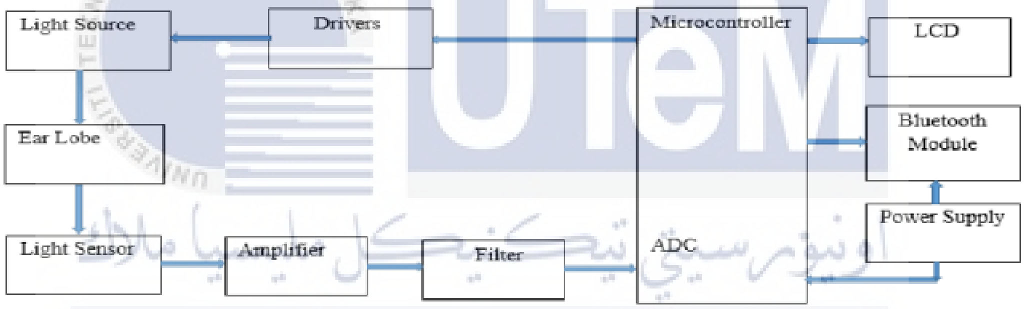

Figure 2.8 Components integration for the detection of glucose concentration

2.8.10 Development of a Noninvasive Blood Glucose Monitoring System Prototype: Pilot Study

Our study's objective was to provide details of a pilot test to evaluate the precision of a noninvasive glucose monitoring prototype that makes use of laser technology based on near-infrared spectroscopy. The Raspberry Pi, the Raspberry Pi camera, and a visible light laser are the components of our system. When a visible light laser penetrates epidermal tissue, the Raspberry Pi camera records a series of photos. An artificial neural network model uses the light absorption and scattering in the skin tissue to predict the glucose levels. TensorFlow, Keras, and Python programming were used to create this prototype. The prototype was tested on eight participants' fingers and ears as part of a pilot research. Blood glucose readings from the prototype were compared to those from glucometers that are currently on the market [9].

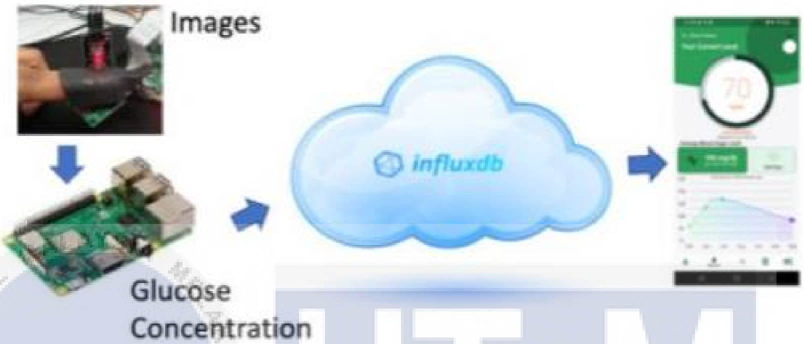

Figure 2.9 Overview of the proposed non-invasive blood glucose monitoring system

2.8.11 Development of Measuring Device for Non-Invasive Blood Sugar Levels Using Photodiode Sensor

In this study, a photodiode sensor will be used to design and construct a noninvasive blood sugar measurement system. So that everyone can use this equipment to noninvasively assess blood sugar, including both medical professionals and non-medical personnel. In this investigation, direct blood measurements were made using a photodiode sensor after blood was collected from numerous Miletus diabetic patients [10].

2.8.12 Non-invasive glucose estimation based on infrared using finger plethysmograph

Diabetes is the most common disease in the world, affecting 415 million of the 7.7 billion people that live there. An increase in blood sugar levels, which can affect the kidneys, heart, blood vessels, neurons, and other organs, causes diabetes. Blood sugar levels in diabetes individuals must be regularly monitored since they must be maintained within acceptable ranges. Therefore, it's imperative to often check the blood glucose levels of diabetic patients. The only method currently utilized to measure blood sugar levels is finger pricking, which is painful and carries a risk of infection. There is no discomfort and no chance of infection during the minimally invasive approach because the finger is not punctured. Therefore, it provide a non-invasive approach using an infrared sensor for transmission and receipt of rays from and to the fingertip in order to continuously monitor the glucose level. An IOT-based website can then record the outcome and display it in a mobile application [11].

Figure 2.10 Output Obtained on Prototype

2.8.13 A portable non-invasive blood glucose monitoring device

This study describes the creation of a near-infrared sensor-based portable non-invasive blood glucose monitoring system. The device provides an alternative to invasive procedures that might be uncomfortable and involve a risk of infection for determining blood glucose levels. Based on the user's body mass index (BMI), the device uses near infrared spectroscopy to assess the glucose content and displays real-time data along with dosage recommendations for insulin. In vitro and in vivo tests were performed to confirm the accuracy and dependability of the device. When compared to the widely used invasive finger-prick procedure, the findings showed an accuracy range of 4% to 16%. The device is a promising option for diabetes patients looking for convenient and non-invasive monitoring of their blood glucose levels due to its small size, painless operation, and accurate glucose detection [12].

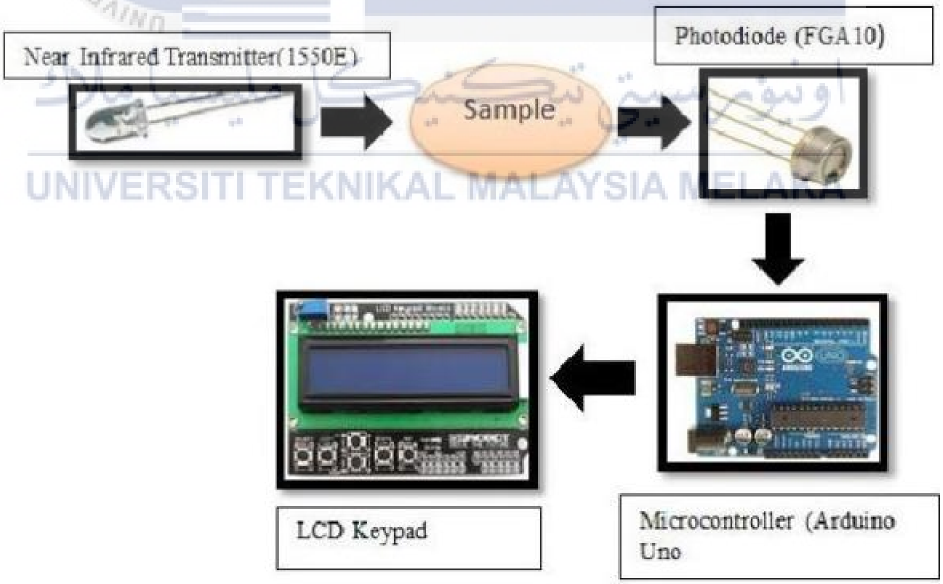

Figure 2.11 Block diagram of the portable non-invasive blood glucose monitoring device

2.8.14 Blood glucose level monitoring by non-invasive method using near infra red sensor

This paper introduces a method for monitoring blood glucose levels using a nearinfrared (NIR) sensor without the need for invasive finger pricks. The conventional fingerprick technique can be uncomfortable, costly, and risky for infection. The suggested noninvasive method, in contrast, makes use of the NIR sensor to monitor changes in light intensity after passing through the finger and enables determination of the glucose level. To gather and process NIR light, determine glucose levels, and offer real-time measurements, the system includes the NIR sensor, a photodetector, and an LCD display. For easier display and storage, the measured glucose data can be sent through Bluetooth to an Android application. To ensure accuracy and dependability, validation is carried out through calibration studies and comparison with intrusive finger-prick measurements. The NIR sensor-based noninvasive technique provides a painless and practical solution for routine blood glucose monitoring in diabetics [13].

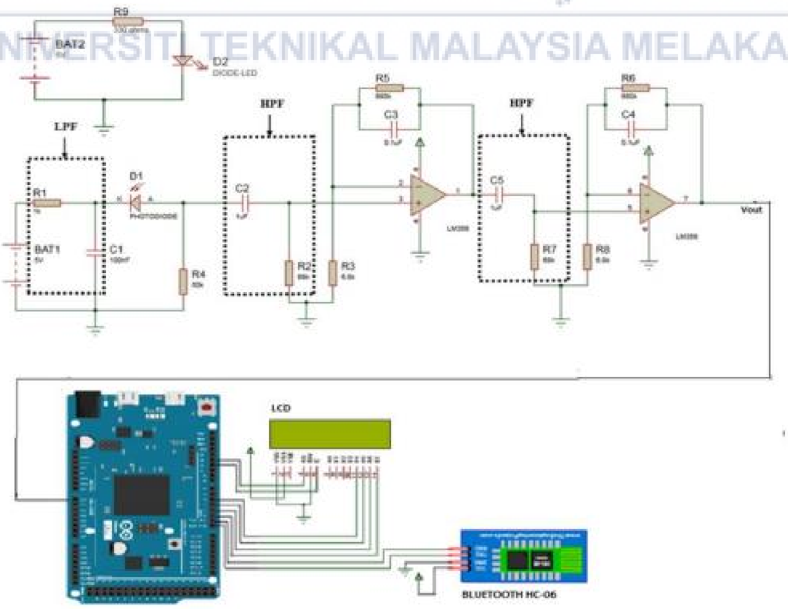

Figure 2.12 Circuit diagram of designed system

2.8.15 Research and design a non-invasive blood glucose measuring module

Infrared light with a wavelength of 1550 nm is used in this study to explain the research and design of a non-invasive blood glucose measurement module. The objective is to develop a simple and painless continuous glucose monitoring system that lowers the danger of infections and costs by doing away with the requirement for supplies. The module has a sensitive photodetector, an infrared light source, and algorithms for glucose analysis. Correlation values of 0.870 to 0.995 are obtained from studies performed on volunteers over a 10-day period in order to compare measurements with an intrusive device. The performance of the module may be improved further. This study makes a valuable noninvasive contribution to the development of a dependable continuous blood glucose monitoring system that will help with diabetes control and the avoidance of complications [14].

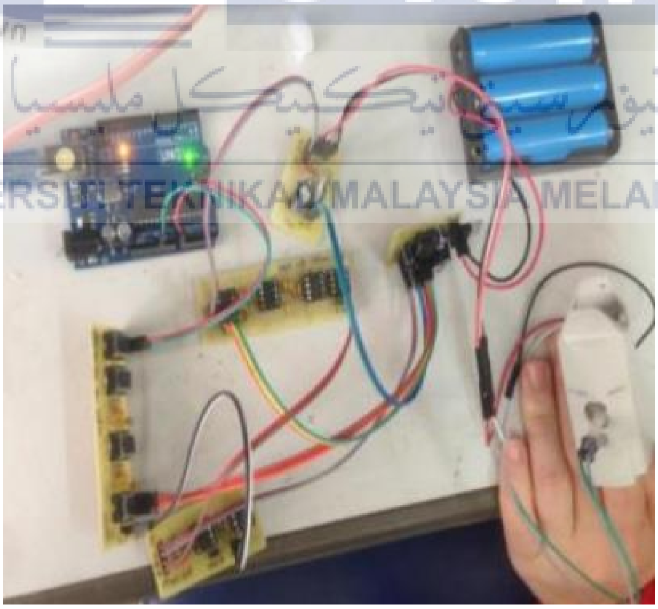

Figure 2.13 Design non- invasive blood glucose module

2.9 The Comparison of Selected Literature Review

Table 2.1 Comparison Between Previous Researchers

No.	Author	Year	Title	Components	Advantages	Disadvantages	Summary
1.	Baharuddin Mustapha, Nur Fatihah Khairul Munir, Siti Hajar Farhana Hasmuei	2022	**IOT Based Non-Invasive Glucose Monitoring System for Diabetic Patient**	• Insoles • Pressure sensor (infrared) • microcontroller (Arduino Uno)	• Continuous monitoring • Remote accessibility • Data-driven insights	• Accuracy concerns • Privacy and security risks • User acceptance and usability	The system uses wearable sensors to continuously monitor glucose levels and sends the data wirelessly to a central hub for analysis and storage. By eliminating the need for invasive methods, the system improves patient comfort and allows for remote monitoring and personalized care.
2.	Siti Nur Shahidah binti Anis,	2021	**A Portable Non-Invasive Blood Glucose**	• IR light emitter	• Non-invasive measurement,	• Accuracy limitations compared to invasive methods	A pain-free device has been created to measure glucose levels without pricking the

	Rozlan BinAlias		**Monitoring Device with IoT**	• Photodiode S5971 • ESP8266 • LCD	avoiding pain and discomfort • Continuous monitoring for real-time data • Portability and convenience for on-the-go use	• Dependence on reliable network connectivity • Technical complexity in development, maintenance, and troubleshooting	skin. Using Near-Infrared Spectroscopy, it sends glucose data to a smartphone via Wi-Fi. This device allows patients to monitor their glucose remotely, saving time and costs by avoiding hospital visits. It's useful not only for people with diabetes but also for anyone maintaining healthy glucose levels for a better lifestyle. Future improvements could focus on enhancing the device's precision, particularly when testing glucose in darker places.
3.		2017	**GSM based Needleless Blood Glucose**	• IR digital sensor • LCD	• Needleless • Convenience and portability	• Accuracy concerns	Aims to create a needleless blood glucose monitoring system using GSM technology.

	Mohiuddin Q		**Monitoring System**	• GSM module	• Real-time data transmission	• Reliance on network coverage • User acceptance and technical expertise	The system uses sensors to measure blood glucose levels without requiring painful finger pricks. The collected data is sent via GSM networks to a central monitoring station for analysis and remote monitoring. This innovative approach offers a simpler and less painful method of monitoring blood glucose levels for individuals with diabetes.
4.	Sarah Ali Siddiqui,	2017	**Pain-free Blood Glucose Monitoring Using Wearable Sensors**	• Wearable sensor • ESP32 • Arduino	• Pain-free monitoring • Continuous monitoring • Convenience and portability	• Accuracy concerns • Technical limitations • User acceptance and usability	Pain-free blood glucose monitoring using wearable sensors is a convenient way for people with diabetes to check their glucose levels. They wear small sensors on their body that

	Yuan Zhang						measure glucose without any pain. The sensor data is shown on a connected device, like a smartphone or watch, allowing users to see their glucose levels in real-time. This continuous monitoring helps with personalized diabetes management, and the data can be shared with healthcare professionals. Overall, pain-free blood glucose monitoring using wearable sensors is a comfortable and easy way to monitor and manage diabetes.
5.	Amine Rghioui, Assia Naja, Jaime	2020	**An IoT Based diabetic patient**	• Glucose sensor • ESP8266	• Real-Time Monitoring • Remote Monitoring	• Initial Setup and Complexity • Technical Dependencies	An IoT-based monitoring system designed for diabetic patients utilizes machine learning and NodeMCU to

	Lloret Mauri, Abedlmajid Oumnad		**Monitoring System Using Machine Learning and Node MCU**		• Early Detection and Intervention	• Potential Privacy Concerns	track vital signs and data in real-time. It enables prompt intervention from healthcare professionals and offers personalized treatment options. Patients actively engage in managing their health, and the system can connect with other devices. However, there may be some complexity during the initial setup, a need for stable internet and power, privacy considerations, and potential costs. Regular updates and technical support are crucial to ensure accurate and reliable functioning. In summary, this system enhances patient care and empowers individuals to take charge of their health.

6.	Amine Rghioui, Jaime Lloret, Mohamed Harane, Abdelmajid Oumnad	2020	**A Smart Glucose Monitoring System for Diabetic Patient**	• ESP8266 • Glucose sensor • Pedometer • Arduino nano	• Real-Time Monitoring • Continuous Monitoring • Improved Treatment	• Technical Complexity • User Experience • Training and Support	A smart glucose monitoring system designed for diabetic patients provides real-time tracking of glucose levels, continuous monitoring, remote access for healthcare professionals, personalized treatment insights, and improved self-management. It sends alerts and notifications, but there may be technical complexity during setup, privacy considerations, cost implications, and variations in user experience. In summary, this system enhances patient care and empowers individuals in managing their diabetes effectively.

7.	Jai-Chang Park, Seongbeom Kim, Je-Hoon Lee	2021	**Self-Care IoT Platform for Diabetic Mellitus**	• Loadcells • 24-bit ADC • 32-bit microcontroller • RTC • Bluetooth • LCD	• Personalized Care • Real-Time Monitoring • Healthy Lifestyle	• Technical Complexity • Privacy Concerns • Technical Support	The Self-Care IoT platform for Diabetic Mellitus helps people with diabetes take care of themselves. It uses advanced technology to personalize their care, including monitoring glucose levels, tracking medications, and managing their lifestyle. By providing real-time information and helpful resources, the platform empowers individuals to make informed decisions about their health. It supports them in leading a healthy lifestyle and effectively managing their condition.

8.	Aznida Abu Bakar Sajak	2020	**IoT-Based Glucose Monitoring System**	• Arduino UNO • Wi-Fi module • OLED	• Real-Time Monitoring • Enhanced Self-Management • Alerts and Notifications	• Technical Complexity • User Experience • Training and Support	This project enhances the traditional glucose meter by using a user-friendly platform like Blynk to display and notify healthcare professionals about glucose levels and insulin intake. The adoption of an IoT platform simplifies the monitoring process for caregivers and medical practitioners, offering potential benefits for widespread use in the future.

9.	Ilesanmi Daniyana, Smart Ikuponiyi, Lanre Daniyan, Ikenna Damian Uchegbu, Khumbulani Mpofu	2022	**Development of a Smart Glucose Monitoring Device**	• PIC16F877A • Photodiode • Bluetooth module • LCD	• Improved Accuracy • Real-time Alerts and Notifications • Data Analysis and Insights	• Technical Complexity • Maintenance and Sensor Replacements • Privacy and Data Security	This study presents a painless and non-invasive glucose monitoring device that provides quick and accurate measurements without blood samples or finger pricks. It can be adapted for continuous monitoring and additional health measurements. The device utilizes near-infrared light at 1550 nm to determine glucose levels based on output voltages from a photodiode.
10.	Amaryllis Mavragani	2022	**Development of a Noninvasive**	• Raspberry Pi	• Pain-Free Monitoring	• Accuracy and Reliability	This paper presents a noninvasive glucose monitoring system using IoT devices for

			Blood Glucose Monitoring System Prototype: Pilot Study	• KY-008 5mW Red Laser Transmitter • Camera	• Convenience and Ease of Use • Reduced Infection Risk	• Development Challenges • User Acceptance and Trust	diabetes management. It utilizes finger or ear images, avoiding the need for blood samples. An ANN model achieves 79% accuracy with finger images and 62% with ear images. Further research is needed to address limitations in database size, enclosure design, and external factors.
11.	Frendi Agung Dwi S,	2020	**Development of Measuring Device for**	• Photodiode • Atmega 328 • TFT LCD	• Non-invasive measurement	• Accuracy concerns • Calibration requirements	The device utilizes a photodiode sensor to detect changes in blood glucose levels

	Bedjo Utomo, Sumber		**Non-Invasive Blood Sugar Levels Using Photodiode Sensor**		• Convenience and ease of use • Real-time monitoring	• User acceptance and learning curve	through the skin. The development of this non-invasive measuring device presents a promising approach to blood sugar monitoring, offering a potentially more comfortable and convenient method for individuals with diabetes.
12.	Abith V, Deepika M, Gurumoorthy M, Karpaga Devi V, Nithya R	2021	**Non-Invasive Glucose Estimation Based On Infrared Using Finger Plethysmograph**	• Max30100 • Arduino UNO • HC-05 • LCD	• Non-invasive measurement • Reduced infection risk • Real-time monitoring	• Accuracy limitations • Calibration requirements • Cost considerations	The application of a new technology that can heavily innovate the device to make it cost efficient as a patient will need not to buy a glucometer kit and with slight innovation to the current design

							will be able to feasibly produce significantly better treatment for diabetes. This could improve the life of diabetic patients in future.
13.	R.A. Buda, M. Mohd. Addi	2014	**A Portable Non-Invasive Blood Glucose Monitoring Device**	• Nir (1550E) • Photodiode (FGA10) • Arduino Uno • LCD	• Portability • Non-invasive measurement • Continuous monitoring	• Accuracy concerns • Cost considerations • Interference and limitations	When measuring blood sugar levels without using needles, a portable non-invasive blood glucose monitoring gadget is a handy and compact instrument. It is portable and convenient to use anyplace. It detects the body's glucose levels using specialised sensors without generating any pain or

							discomfort. Users are able to make essential changes to their medication or food thanks to the device's fast results. However, accurate measurements depend on the device's precision and calibration. In order to effectively monitor blood glucose levels, efforts are being undertaken to enhance its functionality and make it more user-friendly.
14.	P.Daarani, A.Kavitha mani	-	**Blood Glucose Level Monitoring**	• NIR emitter • NIR receiver • Atmel SAM3X8E microcontroller.	• Painless • Cost-effective • Reduced infection risk	• Accuracy limitations • Calibration requirements	This paper suggests a noninvasive approach using near-infrared LED for measuring blood glucose levels, eliminating the pain, cost, and

			By Noninvasive Method Using Near Infra Red Sensor	• LCD • Bluetooth module (HC-05)		• User acceptance and learning curve	infection risks of invasive methods. The glucose level is displayed on both an LCD screen and a mobile app, and its accuracy is verified through error grid analyses. This portable monitor provides an efficient solution for managing diabetic patients' healthcare, applicable in both home and healthcare center settings.
15.	Duong Trong Luong, Nguyen Xuan Huy, Dao Viet Hung, Nguyen	2018	**Research and Design a Non-Invasive Blood Glucose Measuring Module**	• IR Led • photodiode • ICL 7660s • Arduino • UNO R3	• Painless and comfortable • Reduced infection risk • Convenience and ease of use	• Accuracy limitations • Regulatory approval • User acceptance and trust	Based on studies and test results, there is a significant shift in the infrared absorption of glucose at 1550 nm. The suggested device has practical applications. However, the measuring's level of accuracy needs to be improved, thus we

	Thai Ha, Nguyen Duc Thuan						must design hardware to support it. In the near future, we can accomplish more objectives in non-invasive blood glucose monitoring.

2.10 Summary

Finally, this project will benefit from a few papers comprises a literature review that explores existing research and studies relevant to the topic. It provides an overview of different approaches, methods, and technologies used in prior studies. The review discusses the pros and cons of non-invasive techniques, explores various sensors and technologies utilized, and highlights advancements in signal processing and data analysis. By synthesizing existing literature, the review identifies research gaps and establishes the basis for subsequent chapters, contributing to the overall knowledge and progress in the development of non-invasive blood sugar monitoring systems.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This comprehensive introduction to research methodology explores different scientific frameworks, methods, instruments, and techniques. The methodology focuses on using Arduino software and an infrared sensor to create a unique and user-friendly system or device. It follows a step-by-step approach that involves choosing a project title, conducting research, planning the project design and components, integrating hardware and software, analyzing the project, solving any issues, and writing a report. A flowchart is prepared to visualize the project's steps. It's important to understand the hardware and software resources before starting the project. This chapter emphasizes both the design technique and the overall equipment and research process flow.

3.2 Selecting And Evaluating Tools for A Sustainable Development

It is crucial to consider aspects like energy efficiency, scalability, accessibility, data security, remote communication capabilities, usability, and cost effectiveness when choosing and evaluating tools for the sustainable development of a web-based e-health education system for diabetics. Low energy consumption, adaptability to future technical improvements, compatibility with a range of devices, and compliance with accessibility regulations should all be priorities in the tools used. Additionally, they should provide strong data security measures, encourage remote connectivity to cut down on carbon emissions, provide a user-friendly experience, and be long-term cost-efficient. By taking into account these elements, the e-health education system may be created sustainably and offer people with diabetes an effective, safe, accessible, and eco-friendly platform.

3.3 Methodology

The goal of the project methodology “Development of e-Health Education System for People Living with Diabetes (web-based)” is to create a comprehensive web-based platform that integrates Arduino technology and a sensor to enhance the education and support provided to individuals living with diabetes. The methodology aims to develop an interactive and user-friendly system that combines web-based resources with Arduino hardware and sensor capabilities. By incorporating these technologies, the goal is to provide individuals with diabetes with innovative tools for self-monitoring and data collection. The ultimate objective is to improve diabetes self-management, empower individuals to make informed decisions about their health, and enhance overall health outcomes for people living with diabetes.

Figure 3.1 Research Methodology

3.4 System Block Diagram

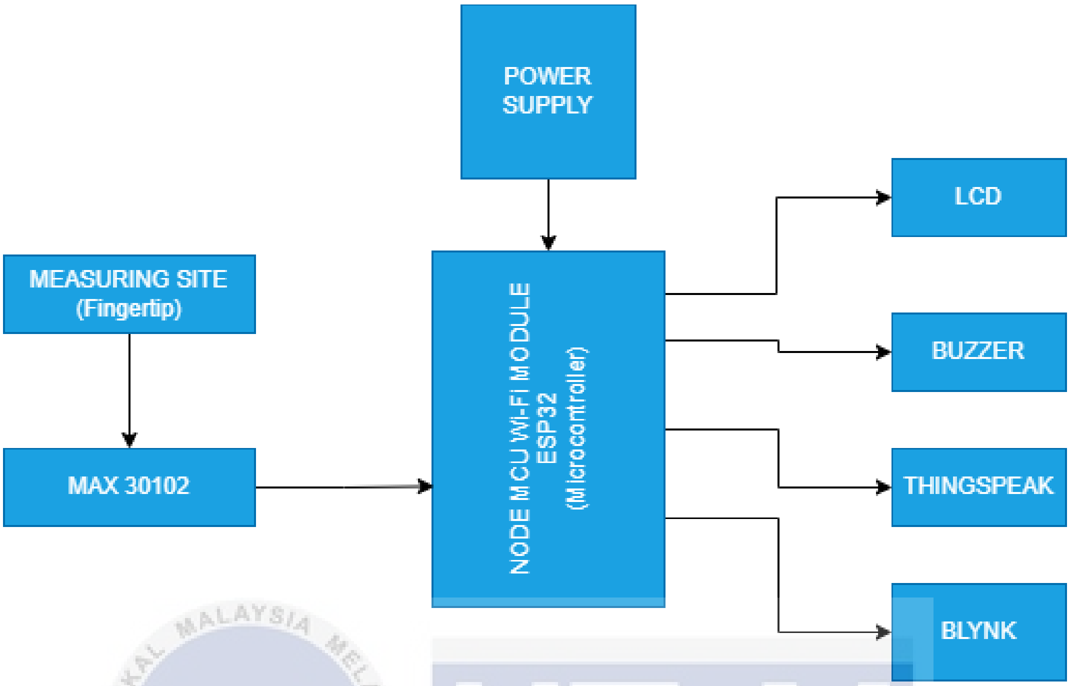

Figure 3.2 Block Diagram of Non-invasive Glucose Measurement System

The system architecture for an IoT-based non-invasive glucose monitoring system for diabetic patients consists of several interconnected components. At the core is the non-invasive glucose sensing module, which employs optical or other non-invasive techniques to measure glucose levels. The module is connected to a microcontroller unit (MCU) such as ESP 32, which serves as the central control center. The MCU processes and analyzes the data received from the sensing module and manages the overall system operation. Wireless connectivity, such as Wi-Fi, Bluetooth, or cellular networks, enables the MCU to connect to the internet. The system leverages cloud-based data storage and analysis, where the glucose data collected by the MCU is securely transmitted and stored. This cloud infrastructure provides scalable computing resources for data analysis, visualization, and long-term storage. A user-friendly mobile or web application allows diabetic patients and healthcare providers to access real-time glucose data, receive alerts, track historical trends, and set personalized thresholds.

3.5 Flowchart

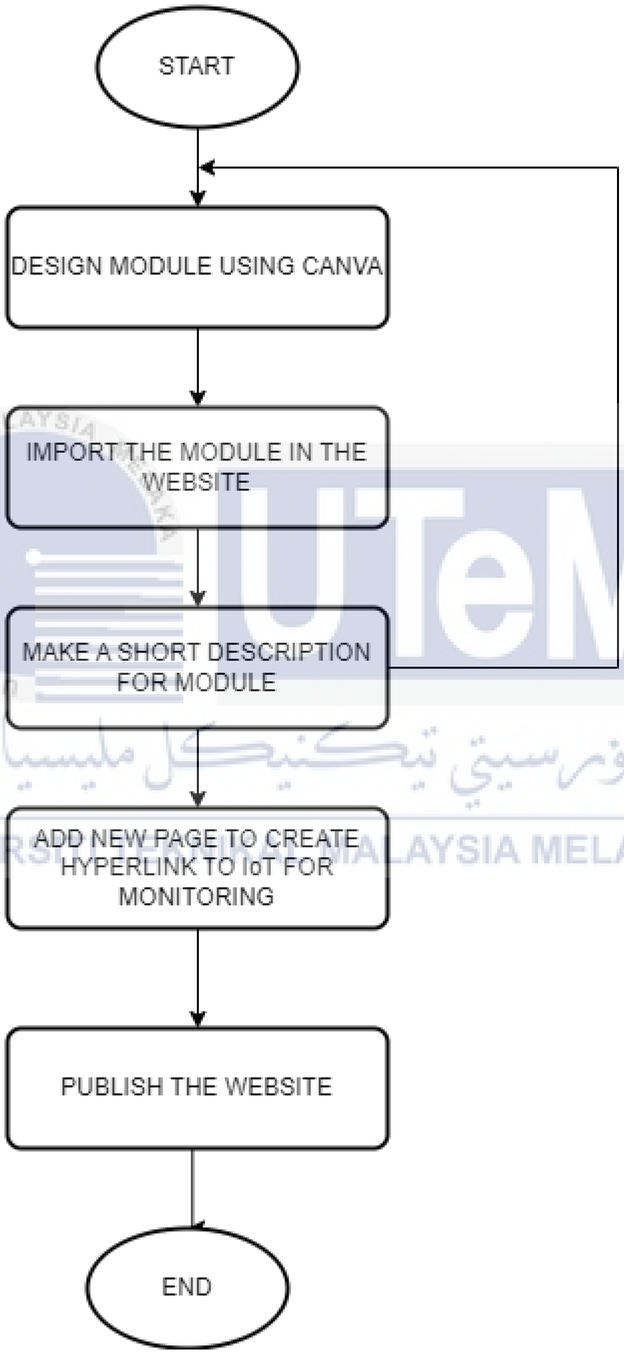

Figure 3.3 Flowchart of website process

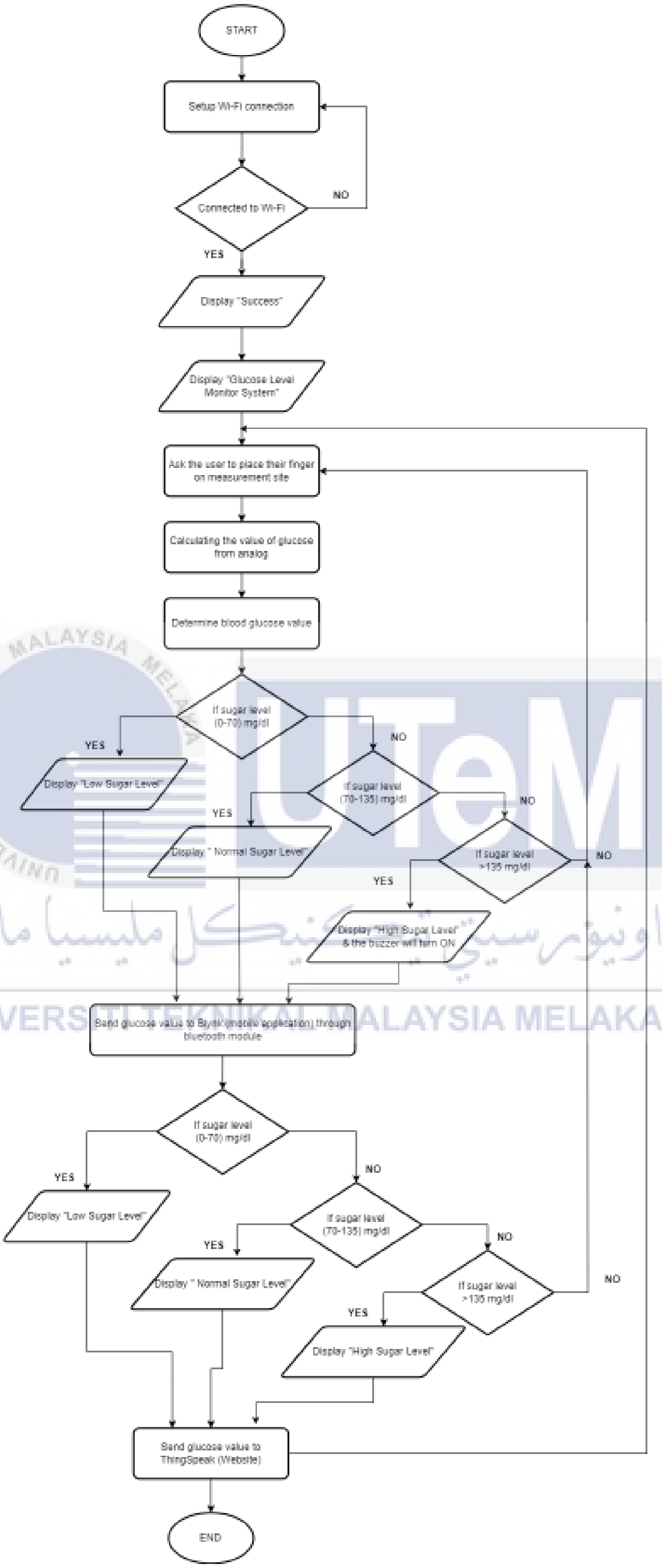

Figure 3.4 Flowchart of proposed work

3.6 Software Implementation

3.6.1 Arduino Software

Figure 3.5 Arduino IDE

Arduino IDE (Integrated Development Environment) as shown in Figure 3.5 is a program that simplifies writing and uploading code to Arduino boards. It acts as a user-friendly tool for programming and controlling the Arduino board. With the Arduino software, it can write code using an easy-to-understand language, compile it, and send it to the Arduino board. It provides helpful features like libraries and functions that make working with sensors and other electronic components easier. The software is available for Windows, macOS, and Linux, and it is designed to make programming Arduino boards accessible and enjoyable, even for beginners [15].

3.6.2 ThingSpeak

Figure 3.6 ThingSpeak

ThingSpeak in Figure 3.6 is a platform that helps to collect and analyze data from devices connected to the internet. It's like a cloud-based service that stores information from sensors or other internet-enabled devices. It can create channels to organize and store the data, and then use tools to visualize and understand it. ThingSpeak is often used in applications like monitoring the environment or controlling devices. It's a helpful tool for managing and analyzing data from connected devices [16].

3.6.3 Blynk

Figure 3.7 Blynk

Blynk is an Internet of Things (IoT) platform that provides various functions for creating and managing IoT projects. It allows users to design personalized interfaces using a mobile app, incorporating interactive elements like buttons and graphs for controlling and visualizing data. Blynk in Figure 3.7 supports connectivity with different hardware devices, enabling smooth communication with the Blynk Cloud. Real-time monitoring of sensor readings and device status is possible, while remote control capabilities allow users to activate switches and actuators remotely. Push notifications keep users informed about important events, and data logging and cloud integration features enable data storage and synchronization. Blynk also encourages collaboration through project sharing, facilitating the exchange of ideas within the IoT community [17].

3.6.4 Fritzing

Figure 3.8 Fritzing Software

An open-source program called Fritzing as shown in Figure 3.8 is used to create and record electronic projects. With a simple user interface that includes schematic, PCB, and virtual breadboard views, users can create and test circuits before they are physically implemented. A library of electronic parts is included with the software, and they are simple to drag and drop onto the virtual breadboard. Fritzing is a popular tool used by makers, educators, and hobbyists to prototype and distribute their electronic designs. It provides an easy-to-use yet powerful platform for both novice and expert electronics users.

3.7 Hardware Implementation

3.7.1 ESP 32

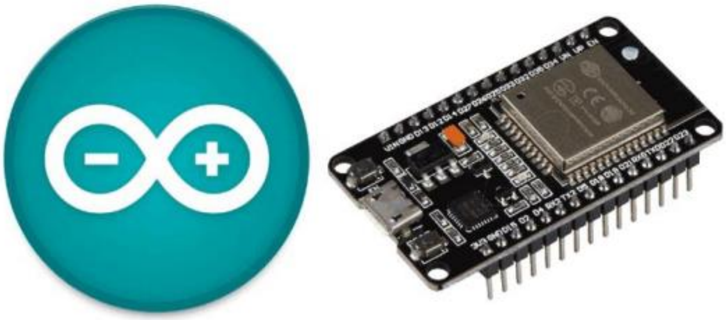

Figure 3.9 Microcontroller Esp32

The ESP32 as shown in Figure 3.9 is a versatile microcontroller module widely used for IoT applications. It features a dual-core processor running at up to 240 MHz, built-in Wi-Fi and Bluetooth connectivity, multiple GPIO pins, and a range of peripherals. With options for memory and storage, it supports multiple programming environments like Arduino IDE, ESP-IDF (Espressif IoT Development Framework) and MicroPython. The ESP32's power efficiency and extensive community support make it popular for projects in home automation, robotics, and various IoT applications [18].

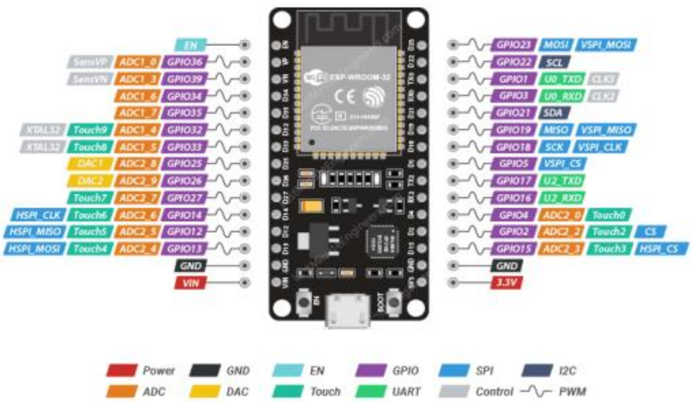

Figure 3.10 Esp32 PinOut Reference

There are several GPIO (General Purpose Input/Output) pins on the ESP32 microcontroller board in Figure 3.10 for connecting other components. These pins can be configured to act as PWM outputs, analogue inputs, or digital inputs or outputs. They have built-in pull-up or pull-down resistors and can also generate interrupts. GPIO pin counts and functionalities can vary depending on the ESP32 board being utilised [19].

3.7.2 Max30102

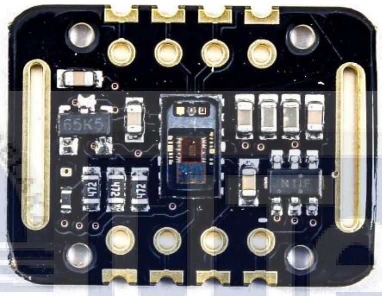

Figure 3.11 Max30102

In Figure 3.11 the MAX30102 is a sensor module designed for pulse oximetry and heart-rate monitoring. It integrates red and infrared LED drivers, a photodetector, and signal processing for photoplethysmography (PPG) into a single chip. Using PPG, the sensor measures changes in blood volume by emitting light into the skin and detecting the amount of light absorbed by the blood. This information allows the MAX30102 to calculate heart rate in beats per minute and estimate oxygen saturation levels in the blood. The compact design and integrated features make it a popular choice for wearable devices, health monitoring applications, and medical instruments for non-invasive vital sign monitoring.

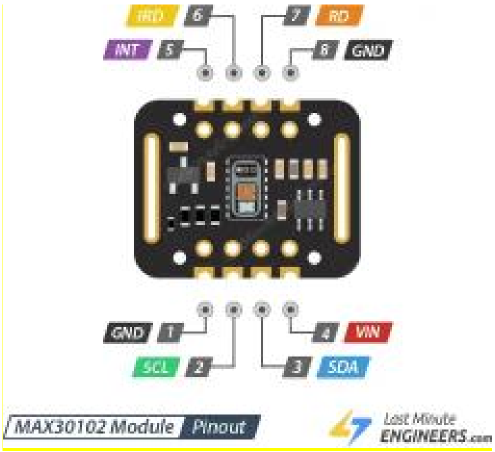

Figure 3.12 Max30102 PinOut Reference

3.7.3 LCD 16 x 2

Figure 3.13 LCD Display

Figure 3.13 shows a 16x2 LCD (Liquid Crystal Display) is a small screen that can show up to 16 characters in each of its two rows. It uses a special controller chip to communicate with other devices. It has a built-in backlight to make the display easier to see. You can adjust the contrast to make the characters clearer. It works with a low voltage power supply and can be controlled using libraries or code examples, especially with platforms like Arduino. People use it in projects like temperature displays, clocks, and simple information screens. It's an affordable and easy way to show text and basic information [22].

3.7.4 Buzzer

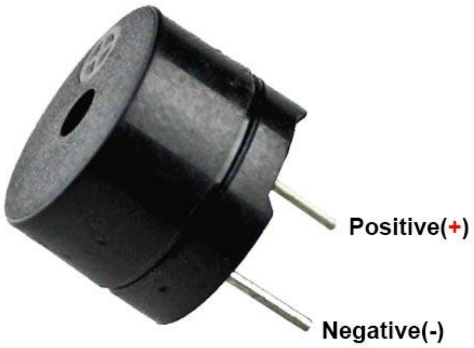

Figure 3.14 Piezo Buzzer

A piezo buzzer in Figure 3.14 functions as an electronic sound emitter, producing audible tones or notifications by harnessing the piezoelectric effect when exposed to an electrical voltage. Widely used in electronic gadgets, it produces sound through vibrations generated in a piezoelectric material upon the application of an electrical voltage. Piezo buzzers are frequently employed in alarms, timers, user interfaces, and assorted electronic systems to provide audible feedback, notifications, or acknowledgment tones. Their appropriateness for a range of applications, spanning consumer electronics to warning indicators in automobiles, is due to their compact size, minimal power usage, and uncomplicated design.

3.8 Summary

This chapter offers a suggested process for creating a fresh, efficient, and comprehensive plan to strengthen video security systems and reduce system vulnerabilities. To make sure that the process of implementing the project goes successfully, a flow chart of the project's progress has been made. Before starting this project, the components, both in terms of hardware and software, have been chosen. To make sure that the project's future development is effective, straightforward, and within budget, it is essential to carefully choose these components. To be certain that the circuits function properly, it is necessary to track any hardware issues. The project will, however, be permitted to advance to the stage of the final report.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and analyses development of keeping blood glucose levels under control is essential for people with diabetes. Systems for e-health education have the ability to inform and empower people about managing diabetes. The goal of this work is to create a MAX30102 sensor-based and web-based e-health education system for diabetics. The system seeks to deliver real-time blood glucose monitoring, individualized advice, and educational resources to improve self-management and general wellbeing by integrating the MAX30102 sensor. This part discussed the testing of the hardware and the output produced by the glucose sensor MAX30102. The result of the project can be seen through the notification send to Blynk and will be send to ThingSpeak which displayed the glucose data.

4.2 Software Development

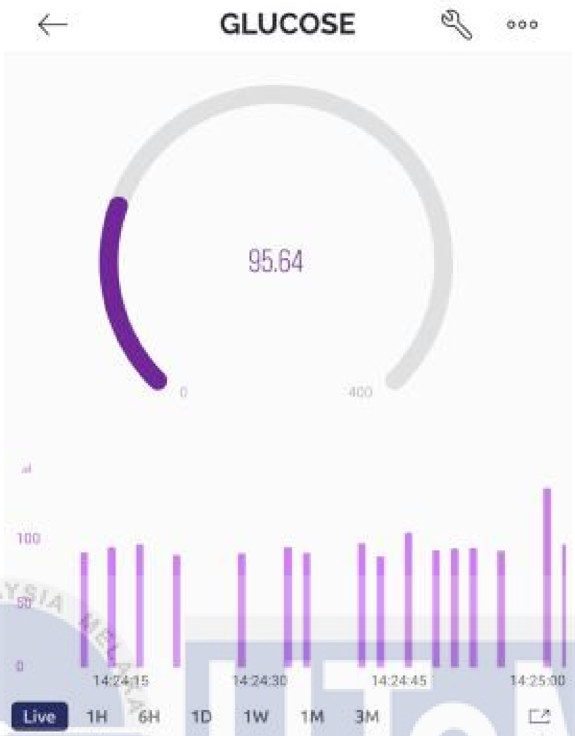

Figure 4.1 Project Dashboard on Mobile Application

An actual system that can be connected to the global Web and used for monitoring, controlling, or communicating is known as the Internet of Things (IoT). Blynk applications serve as the Internet of Things (IoT) in this project. Figure 4.1 shows the project dashboard on a Mobile Application using Blynk. The Blynk is an application that is developed to remotely operate hardware, show data from sensors, store and then visualize it. In this project, Blynk is utilized to display blood glucose values obtained from the input sensors MAX30102, and the notifications will pop up such as low sugar level, normal sugar level and high sugar level. Blynk can communicate with what has been programmed in Arduino IDE by using an authentication token that is suited only for one device. Once the Blynk is connected, the value from sensors MAX30102 is collected and immediately displayed to Blynk Application. In addition to displaying the value of sensors that are being utilized for this project, this dashboard is equipped with one gauge widgets and chart for blood glucose level.

4.3 Hardware Development

In this hardware development project, it can seamlessly integrated the ESP32 microcontroller with an LCD display, buzzer, and the MAX30102 sensor, creating a non-invasive blood glucose monitoring device. The size of circuit is sized down to fit into the final design casing box shown in Figure 4.2 and Figure 4.3 shows the components inside the casing box that are already attached to the casing box.

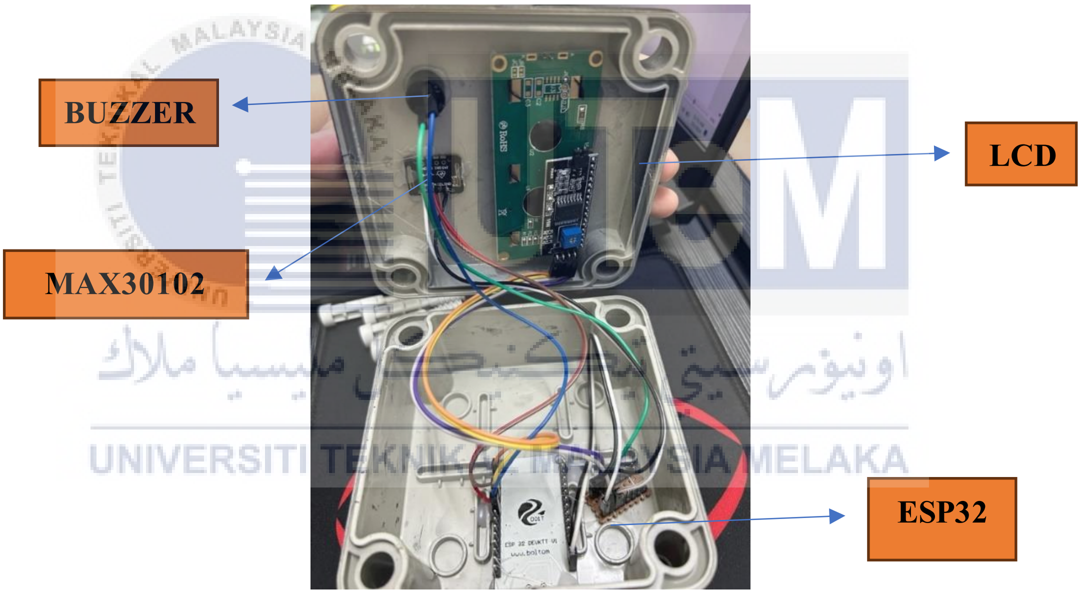

Figure 4.2 Hardware of the project

Figure 4.3 The final design for casing box

4.4 Project Integration

4.4.1 The connection of NodeMCU ESP32

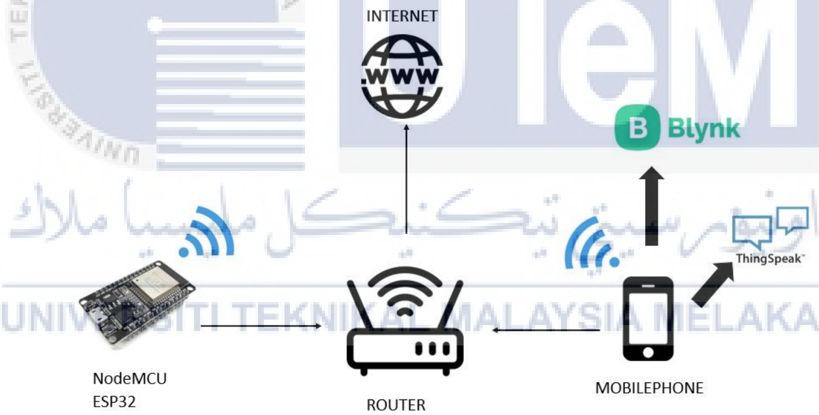

Figure 4.4 Block Diagram of internet connection with NodeMCU ESP32

The process of connecting the NodeMCU ESP32 to the internet in order to interact with the user's mobile Blynk application is depicted in Figure 4.4. The microcontroller, NodeMCU ESP32, will read all of the data from the input sensors and then transmit it to the user over the Internet of Things (IoT).

4.4.2 Glucose Devices

Figure 4.5 Glucose Devices on Blynk Application

Figure 4.5 shows the dashboard of the Blynk application. The user login into the Blynk account using the email and password that has been created for this Blynk application. Users can access the page that is already created and can monitor the application using their mobile phone.

4.4.3 Blynk Notification

Figure 4.6 shows the demonstration of how the MAX30102 sensor works. When the user put the finger on the measurement site the sensor will read the blood glucose value. If the sugar level (0-70) mg/dl displays “low sugar level”, next the sugar value (70-135) mg/dl will display “normal sugar level” and if the sugar level value (>135) mg/dl will display “high sugar level”. It shows that the notification will pop up as shown in Figure 4.7 and Figure 4.8 and it will be sent to the user. The user may know if their blood glucose level is low, normal or high by having this notification system delivered to their Blynk Application.

Figure 4.6 When the user put their finger on the measurement site it will display the blood glucose level

Figure 4.7 Notifications are sent on Blynk for "low sugar level" and "normal sugar level"

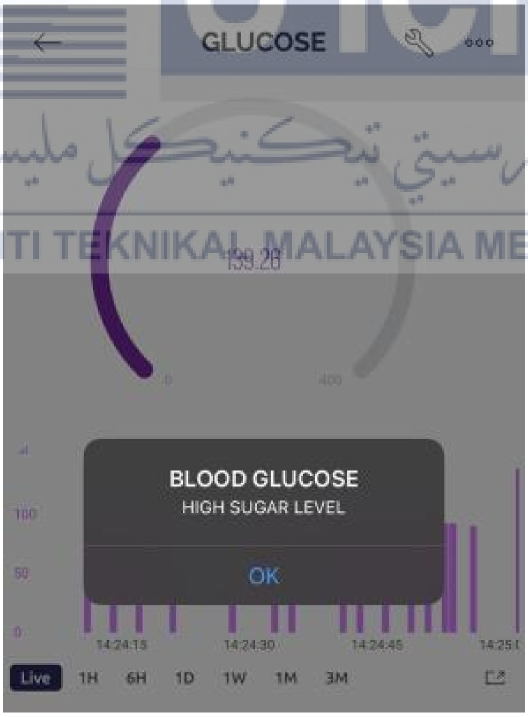

Figure 4.8 Notifications are sent on Blynk for "high sugar level"

4.4.4 LCD Display

The Figure 4.9 below shows how the LCD displays the output. Users may easily monitor their blood glucose levels and make educated decisions regarding their health because the LCD displays real-time blood glucose measurements.

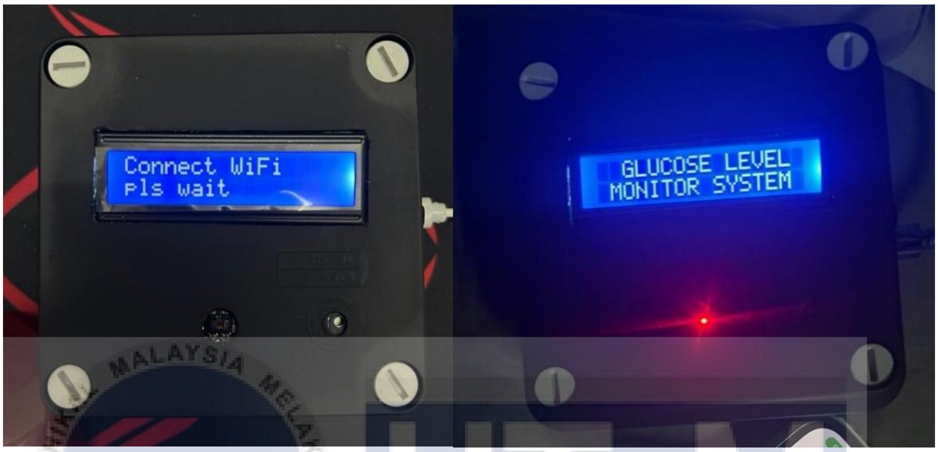

Figure 4.9 Shows how the output displays on LCD

4.4.5 ThingSpeak

ThingSpeak is an Internet of Things (IoT) platform that lets users gather, examine, and display data in real-time from sensors or other devices. It is an adaptable platform for creating and implementing IoT solutions, with capabilities like data storage, graphing, and integration with other IoT services. Figure 4.10 Shows the chart and numeric to display the blood glucose value for this project. ThingSpeak also exports the data that was already measured by using the MAX30102 sensor of blood glucose to Microsoft excel as shown in Figure 4.11 and Figure 4.12.

Figure 4.10 Data of blood glucose

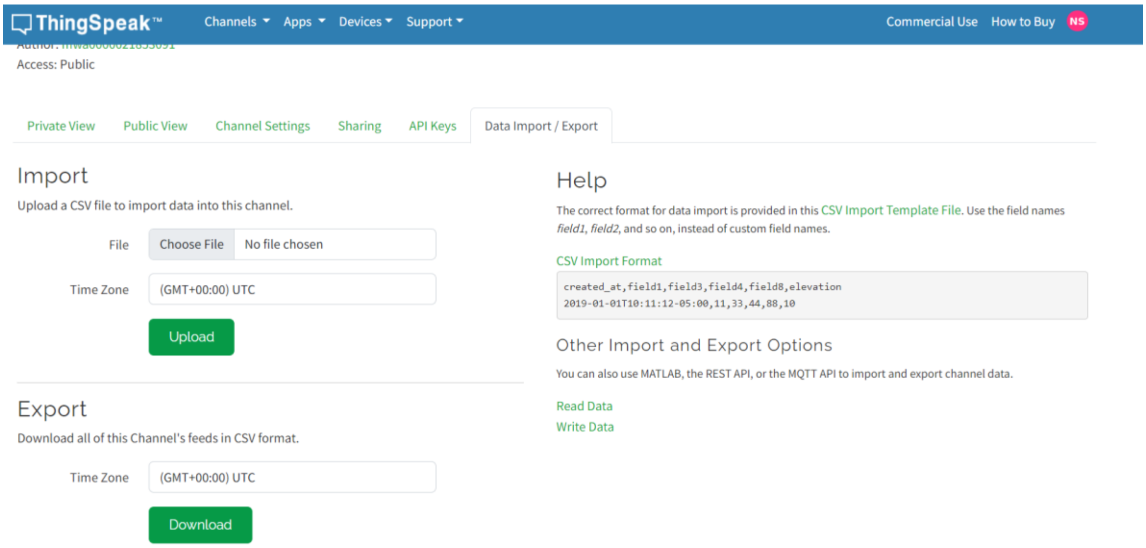

Figure 4.11 Data import/export in ThingSpeak

	A	B	C
73	2024-01-07T13:52:27	72	106.2725
74	2024-01-07T13:52:56	73	91.01777
75	2024-01-07T13:55:51	74	105.415
76	2024-01-07T13:58:40	75	92.30032
77	2024-01-07T14:00:26	76	107.1449
78	2024-01-07T14:05:31	77	89.33488
79	2024-01-07T14:10:22	78	83.14945
80	2024-01-07T14:10:50	79	102.6539
81	2024-01-07T14:11:55	80	102.5838
82	2024-01-08T02:04:08	81	100.0097
83	2024-01-08T02:04:31	82	101.2082
84	2024-01-08T02:04:53	83	102.7436
85	2024-01-08T02:05:19	84	101.7173
86	2024-01-08T02:07:20	85	0
87	2024-01-08T02:08:07	86	92.04909
88	2024-01-08T02:09:51	87	87.26484
89	2024-01-08T02:11:05	88	84.85046
90	2024-01-08T02:17:34	89	95.19493
91	2024-01-11T06:17:37	90	98.07388
92	2024-01-11T06:19:01	91	101.667
93	2024-01-11T06:19:33	92	86.60667
94	2024-01-11T06:20:07	93	83.96741
95	2024-01-11T06:23:29	94	90.31512
96	2024-01-11T06:23:58	95	92.35634
97	2024-01-11T06:24:38	96	0

Figure 4.12 Data in Microsoft Excel that has been exported in ThingSpeak

4.4.6 Website (Google Sites)

Figure 4.13 show the home website that is already created. This website has 4 modules that are designed for people with diabetes to use on a website like Google Sites is projected to provide complete instructional materials. Details on the many types of diabetes, including warning signs and symptoms, underlying diseases, and risk factors would be included. It would provide guidance on meal preparation, carbohydrate measurement, and the importance of physical activity and exercise in managing diabetes. It would provide information on how to effectively manage diabetes to reduce the risk of complications, including routine examinations, eye exams, foot care, and other preventative measures.

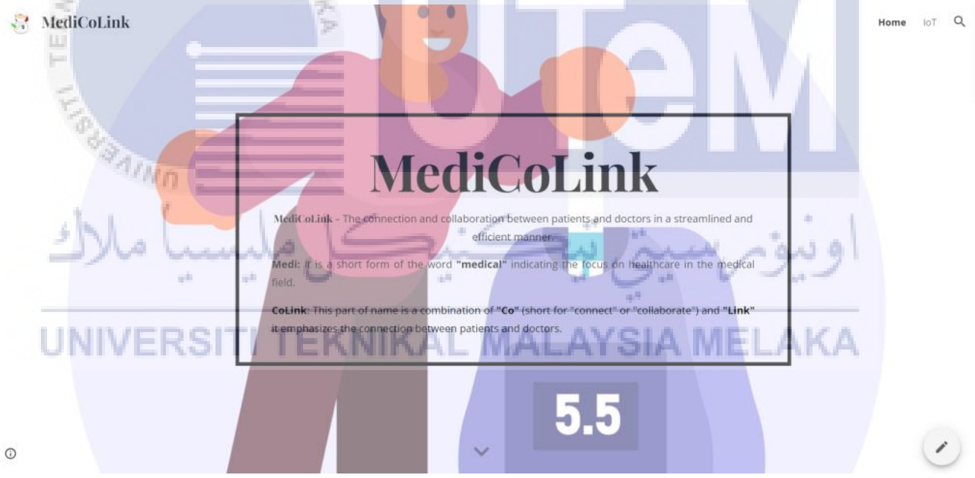

Figure 4.13 A website that has been created on Google Sites

4.5 Data Analysis

4.5.1 Experiment of Invasive vs Non-invasive Reliability Tests

To compare the readings between the developed prototype and the real glucometer (SinoCare ga-3) as shown in Figure 4.14 that is used or sold on the market. Figure 4.15 shows invasive techniques to measure glucose levels. This test is tested on 10 non-diabetes individuals using both techniques invasive and non-invasive. For invasive techniques use the glucometer devices (SinoCare ga-3) and the non-invasive techniques use a portable non-invasive blood glucose monitoring device. Table 4.1 and Table 4.2 compare the glucose readings from two method designs which are before a meal and after a meal. Once the measuring procedure is finished, the error percentage difference is calculated for each reading so that the two techniques may be compared using the equation as shows in Table 4.3.

$$Percentage\ error\ (\%) = \frac{\text{Glucose invasive} - \text{Glucose non} - \text{invasive}}{Glucose\ non - invasive}\ x\ 100$$

Figure 4.14 Glucometer Devices (SinoCare ga-3)

Figure 4.15 Glucose value for before meal and after meal using invasive techniques

Table 4.1 Comparison of invasive and non-invasive methods for measuring glucose concentration before meals

No.	Subject	Glucose concentration measurement			Percentage error (%)
		Invasive (mmol/L)	Non-invasive (mg/dL)	Non-invasive (mmol/L)	
1.	Person 1	5.5	98.07	5.4	1.85
2.	Person 2	4.9	76.00	4.2	16.67
3.	Person 3	5.8	86.61	4.8	20.83
4.	Person 4	5.4	83.97	4.7	14.90
5.	Person 5	6.1	90.32	5.0	22
6.	Person 6	5.0	81.10	4.5	11.11
7.	Person 7	5.9	102.65	5.7	3.51
8.	Person 8	5.6	100.00	5.5	1.82
9.	Person 9	5.2	89.33	5.0	4
10.	Person 10	5.3	88.30	4.9	8.16

Table 4.2 Comparison of invasive and non-invasive methods for measuring glucose concentration after meals

No.	Subject	Glucose concentration measurement			Percentage error (%)
		Invasive (mmol/L)	Non-invasive (mg/dL)	Non-invasive (mmol/L)	
1.	Person 1	6.9	104.21	5.8	19.00
2.	Person 2	7.8	126.10	7.0	11.43
3.	Person 3	7.2	107.23	6.0	20
4.	Person 4	6.5	102.22	5.7	14.04
5.	Person 5	8.9	135.1	7.5	18.70
6.	Person 6	7.3	110.95	6.2	17.74
7.	Person 7	6.7	99.10	5.5	21.82
8.	Person 8	7.5	124.30	6.9	8.70
9.	Person 9	6.3	104.50	5.8	8.62
10.	Person 10	8.1	138.70	7.7	13.00

4.5.2 Graph Analysis of Invasive and Non-invasive Glucose Concentration Measurement

The analysis of data provided a thorough examination of glucose concentration measurements, comparing the effectiveness and reliability of both invasive and non-invasive methods in monitoring blood glucose levels before and after meals. Figure 4.16 and Figure 4.17 show the graph of glucose measurement before and after meals.

The results show that there is a maximum of 22% percent difference in the glucose measurements by using two different methods with an invasive technique and a non-invasive technique. Figure 4.18 shows the results of percentage error before meal vs after meal. The percentage values obtained from the experiments may differ due to several factors, the measurement of glucose that do not contain other substances such as in the blood. Furthermore, factor from users also tends to affect the glucose measurements because each individual has various skin thickness.

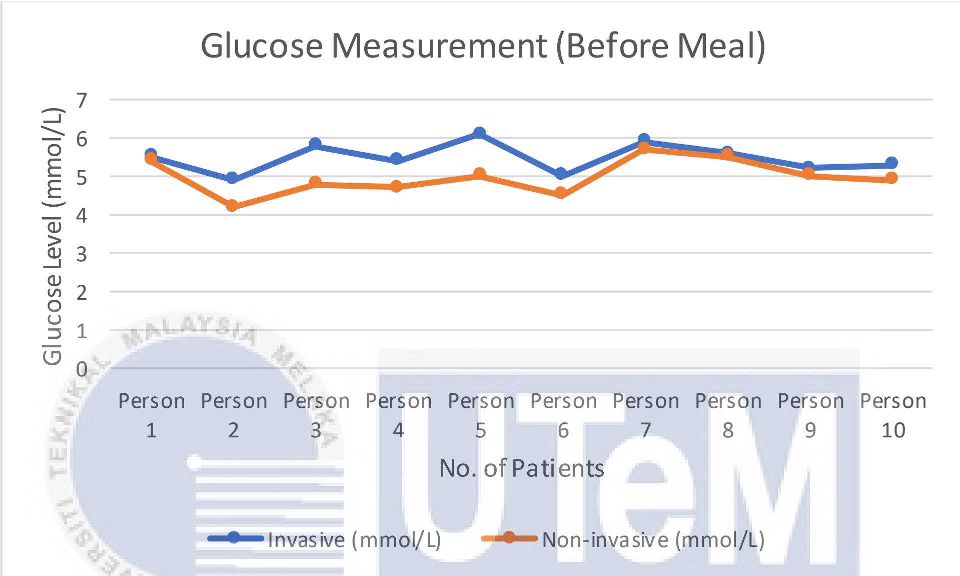

Figure 4.16 Results of 10 trial sample readings for glucose measurement (before meal)

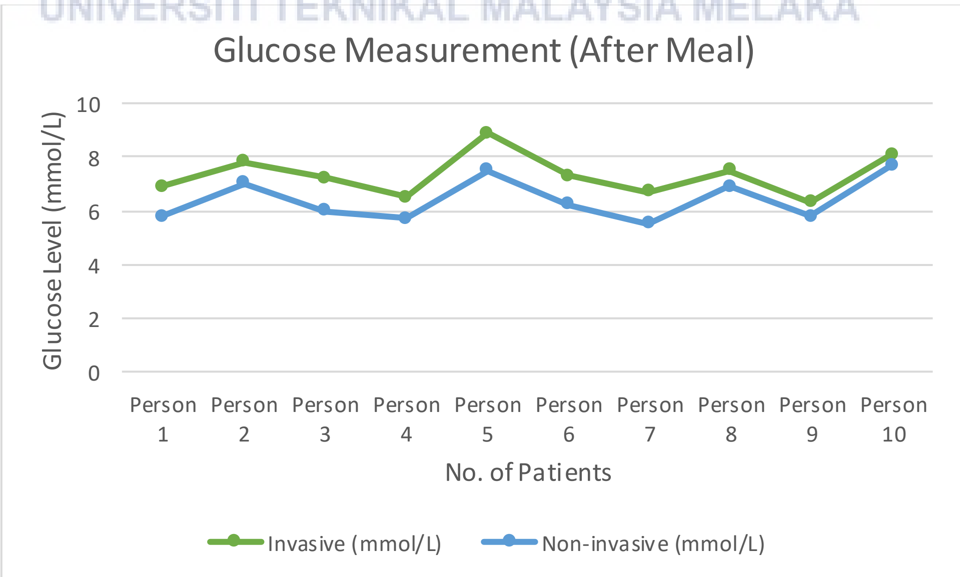

Figure 4.17 Results of 10 trial sample readings for glucose measurement (after meal)

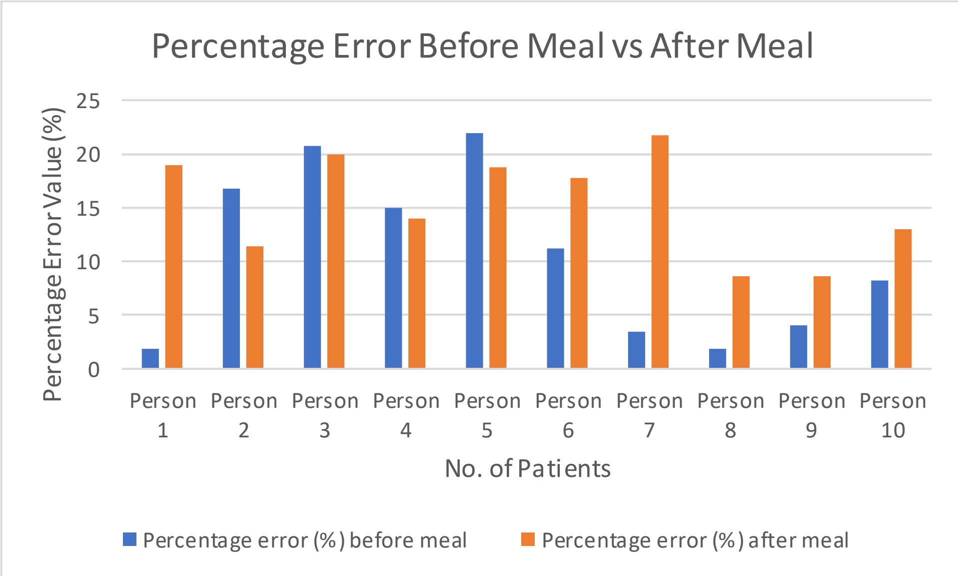

Figure 4.18 Results of percentage error before meal vs after meal

4.6 Summary

The creation of a web-based platform that combines real-time monitoring and education for diabetics is the goal of the MAX30102 sensor-based e-health education system. The system provides teaching tools, such as modules, to help users better understand managing diabetes. It features an MAX30102 sensor for non-invasive blood glucose testing and fast readings on the web interface. Users receive individualized comments and suggestions based on the data gathered, enabling them to choose their food, medications, and way of life with knowledge. For remote consultations and prompt interventions, the system also makes it easier to communicate with medical personnel. By providing accessibility, teaching, and monitoring, this e-health education system improves diabetes control while also enabling users to boost their general well-being.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the development of a web-based e-health education system for people living with diabetes offers significant benefits in empowering individuals to manage their condition effectively. By leveraging web-based technologies, such a system can provide accessible and interactive educational resources, real-time monitoring capabilities, and personalized support to diabetic patients. The project aims to enhance the knowledge and understanding of diabetes, promote self-care practices, and improve overall health outcomes for individuals living with this chronic condition. The web-based platform can serve as a comprehensive tool for education, self-management, and collaboration between patients and healthcare providers. With the successful development and implementation of this e-health education system, it has the potential to positively impact the lives of people with diabetes, enabling them to lead healthier and more informed lifestyles.

5.2 Potential for Commercialization

The potential for commercialization of an e-health education program for diabetics employing MAX30102 sensor technology is substantial. Tools that might assist people effectively manage their disease have a sizable market due to the rising prevalence of diabetes and the rising need for remote healthcare solutions. Web-based platforms and MAX30102 sensor technology can be used to deliver individualized education and monitoring, allowing people to track their blood glucose levels and make wise health decisions. This scalable and affordable solution may be integrated with current healthcare systems to provide seamless patient and healthcare professional experiences. Adoption can be accelerated by partnerships with healthcare organizations and other stakeholders, and revenue can be made through subscription models, licensing deals, and value-added services. Building confidence among users and stakeholders will depend on ensuring compliance with healthcare legislation and standards.

5.3 Future Works

Future work in the development of an e-health education system for people living with diabetes (web-based) can focus on several key areas such as:

i. A more advanced sensor system for Measurements of blood glucose levels and other important indicators may become more accurate and dependable as MAX30102 sensor technology continues to advance. To give users real-time and useful data, research and development activities should concentrate on enhancing the accuracy, speed, and usability of the sensors.

ii. The use of machine learning and artificial intelligence. The system can analyse enormous datasets and deliver individualised recommendations based on user health profiles by implementing AI and machine learning algorithms. The system can employ AI to learn from user behaviour and give individualised education, nutrition programmes, exercise routines, and medicine reminders based on each person's need.

iii. Expanding the system's interoperability with wearable gadgets like smartwatches, fitness trackers, and glucose monitors can make data integration and collection with wearables and IoT devices easier.

Integration with other Internet of Things (IoT) devices, including smart scales and kitchen appliances, can potentially offer insightful health information and encourage healthy habits.

iv. To upgrade the telemedicine system for public health that can include blood pressure and cholesterol readings once. Also able to upgrade and add modules from the Ministry of Health Malaysia to reverse/educate patients who already have diabetes to recover by following the guidelines of the Ministry of Health Malaysia.

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APPENDICES

Appendix A Gantt Chart PSM 1

ACTIVITY	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Confirmation project's title	PSM Briefing and The Registration					Mid Term Break								
Introduction (Chapter 1)														
Project progress														
Update Logbook														
Research journals (Literature review)														
Methodology (Chapter 3)														
Survey components and price														
Preliminary result analysis														
Full report progress														
Presentation PSM 1														

Appendix B Gantt Chart PSM 2

ACTIVITY	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
Details calculation and theory concept														
Project design finalization														
Hardware and sensor finalization														
Assemble hardware part														
Collecting the data														
Final documentation and report writing														
PSM 2 draft submission														
Preparation and Presentation														
Submission of final report														