A GAMIFIED MOBILE APP TO MONITOR PAIN FOR CHILDREN WITH CANCER

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Software Engineering

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"A GAMIFIED MOBILE APP TO MONITOR PAIN FOR CHILDREN WITH CANCER"** was prepared by **OOI THEAN CHUN** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Software Engineering at Universiti Tunku Abdul Rahman.

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ABSTRACT

The number of children diagnosed with cancer had been increased over years. Roughly 300,000 children aged from 0 to 19 years old have been diagnosed with cancer each year. Children are always tired and unmotivated due to the pain caused by the cancer and the side effects of the cancer treatment. Therefore, young cancer patients would probably have difficulty to communicate and handle pains they suffer from the cancer. The medical team are also facing challenge in gathering and managing patients pain data.

The first objective of the project was to develop a gamified mobile application to motivate the young cancer patient in doing the pain assessment with the medical team. The second objective was to develop a web application for the medical team to manage the young cancer patient. The proposed solution was a system consisted of a gamified mobile application and a web application. The target user for mobile application is the young cancer patient aged 7 – 11 years old whereas the target user for web application is the medical team.

Iterative development methodology was selected for the system development. The process started with planning, analysis, and design. System implementation phase was decomposed into three phases to set up server database, develop web application, and develop mobile application. The web application was developed using Laravel framework whereas the mobile application was developed using Unity.

Different tests were conducted after the system was developed. All the tests returned positive results. The system also scored 82 out of 100 in the system usability scale. The positive results have shown that, on average, the system is accepted by the users. However, the user acceptance test was not able to be conducted due to the Covid-19 pandemic situation in Malaysia. Therefore, the opinion and feedback were not able to be collected.

The project goal and the defined objectives have been achieved successfully. Both mobile application and web application have been developed according to the scope and requirements. Few limitations are identified for further enhancement, and the project concludes with some recommendations for future work.

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LIST OF SYMBOLS / ABBREVIATIONS

APPT	Adolescent Paediatric Pain Tool
Mhealth	Mobile health
CRIES	Crying, Requires Increased Oxygen Administration, Increased Vital Signs, Expression, Sleeplessness
NIPS	Neonatal Infant Pain Scale
FLACC	Face, Leg, Activity, Cry, Consolability
CHEOPS	Children's Hospital of Eastern Ontario Pain Scale
CRUD	Create, Read, Update, and Delete
FR	Functional Requirement
UI	User Interface
UX	User Experience
API	Application Programming Interface
MVC	Model-View-Controller
SMS	Short Message Service

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CHAPTER 1

INTRODUCTION

1.1 Introduction

As cancer has always been one of the causes of death in adults and the elderly, children have also started to become the victim of cancer. Furthermore, side effects of treatment such as pain, fatigue, and anxiety are torturing children during the treatment or even after the treatment. This demotivated them and making them have no interest in doing anything. To minimize the pain children are suffering, a proper pain assessment must be conducted to understand the pain they are going through. However, unmotivated children may have difficulty in communicating pain with the caretakers or medical staff. Therefore, this project aims to engage the young cancer patient in communicating pain with the caretakers or medical staff through a gamified mobile application. The application is also specially designed to improve their mood. Besides, a web portal is also developed for the medical team to manage the young cancer patient data better.

A survey questionnaire was used as the primary research approach to gather data. The target respondents are caretakers, parents of young cancer patients, nurses, and doctors in the paediatric cancer department. Besides, interviews and observation were also selected to understand more about the cancer treatment process, children's condition, and pain assessment process.

The proposed solution for this project is a cross-platform system that consists of a mobile application and web application. These applications are interconnected through a server. Young cancer patient data will be collected and save into the server, and the web application can retrieve it. The mobile application is divided into four main modules: a pain recorder, a mini game, a help communication channel and a personalized avatar. On the other hand, the web application consists of pain tracking and analysis features, and data management features.

1.2 Problem Background

Cancer is one of the main sources of death for children and youth around the world. It is a fact that roughly 300,000 children aged from 0 to 19 years old have been diagnosed with cancer each year (Cancer In Children, 2018). As reported by Azizah AM. et al., (2019), there were 3829 childhood cancer cases from 2012 to 2016 in Malaysia. The most common categories of childhood cancer being Leukaemia (39.1%), Lymphoma (12.8%), and Brain / Nervous System tumour (12.8%) (National Cancer Institute and Ministry of Health, n.d.).

The common way to cure cancer is to go through a treatment such as surgery, chemotherapy, radiotherapy, and others. According to Children's Cancer (2020), children with cancer have an impressive cure rate compared to adults, as over 70% of them are completely cured. However, going through cancer treatment is a torturing journey for cancer patients. For example, it normally takes around 3 to 6 months to complete a course of chemotherapy, although there is a possibility of early completion or later, depends on the patient's condition (Cancer Research UK, 2020). Also, cancer treatment is likely to cause many side effects to cancer patients physically and mentally. According to Ye et al., (2019), the most common side effects caused by cancer treatment are fatigue (93.7%), pain (76.1%), bad appetite (71.2%), sleep disturbance (65.4%), reduced in mobility (51.7%) and others. Children are also having difficulty sleeping, worrying about dying, feeling sad, feeling nervous, and others (Torres et al., 2019).

As pain being one of the most common symptoms, it is important to understand the pain such as cause, location, intensity to reduce the pain of children. Misinterpretation of pain will even hurt children more as medical team might prescribe the incorrect dose of drugs to patient hoping to reduce the pain. Understanding pain also help doctor to adjust the treatment process to increase the effectiveness in curing patient (The and British Pain Society, 2013). To effectively assess children pain, multiple pain assessment tools are introduced. Most common tools being Wong-Baker FACES scale, Poker chip tools, Numerical Analogue scale, Visual Analogue scale, and Adolescent Paediatric Pain Tool. These tools are designed to fit the cognition level of children in different age group. For example, Wong-Baker FACES scale is suitable for 3 – 18 years old and Poker Chip tool is suitable for 4 – 6 years old (Brand and Al-

Rais, 2019). Caretakers and nurse use one or multiple sets of tools to access children pain. Also, past records are kept for further analysis of the patient health condition.

1.3 Problem Statement

1.3.1 Challenges of the Young Cancer Patient in Communicating and Handling Pain

Pain assessment is important for caretakers and medical staff to provide a better pain management solution. Cooperation given by the young cancer patient is critical to obtain accurate pain results as they are the key to cure the patient. However, children are feeling tired, unmotivated, and lacking interest in thing around them due to the side effect of treatment. Anxiety and depression are also being diagnosed due to the fear of dying. They could be tired of doing pain assessment repeatedly. Apart from that, children also could not handle the pain themselves. The medical team usually helps children reduce pain through drugs and medication, but it is bad for health in the long run. Therefore, it is crucial to motivate children to communicate pain to caretakers and the medical team and reduce the pain temporarily in a nonpharmacologic way.

1.3.2 Patient Data Management Issue

Medical record serves as the critical data to understand the patient health condition. Most medical records are in paper form back then. Although most hospitals have a medical record management system to record child patient health condition, it still requires extra process as nurses need to enter the record manually. Human error could occur when the workload is increased. Human error is not allowed in the hospital as it could lead to possible fatal consequences. Analysis from incorrect data may cost the patient life. Therefore, the system should minimize manual data input to prevent human error.

1.4 Project Objectives

1. To develop a gamified mobile application to motivate the young cancer patient in doing the pain assessment with the medical team.
    1.1. To involve game elements and design that could help children in improving their mood.
2. To develop a web application for the medical team to monitor the pain condition of the young cancer patient as well as to manage the patient data

1.5 Proposed Solution

Figure 1.1 illustrated the overview of the proposed solution. The proposed solution is a cross-platform system consists of a mobile application and a web application. The mobile application is the gamified application for the young cancer patient to play, whereas the web application is the web portal for the medical team to manage and monitor children's patient condition.

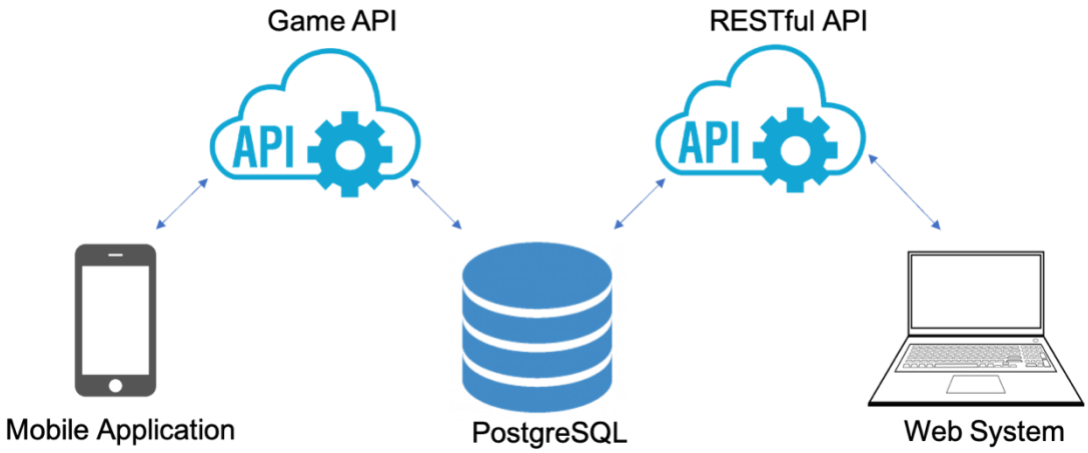

Figure 1.1: Solution Architecture

Mobile was selected as the platform to develop the application because it was more easily to be access by the patient. According to a survey in the UK, among the 2167 respondents aged from five to 16 years old, 53% of the youngster have a smartphone by around seven years old (Media, 2020). On the other hand, web is chosen to be the platform for the web application because the medical team needs to deal with a lot of data. Managing data through a personal computer is more convenient than a smartphone. By implementing a web application, the medical team can access the data everywhere with laptops or personal computer through internet browser as compared to the desktop application, which they need to have the actual software in the device.

Mobile application and web application use a server to communicate with each other. The server database is used to handle the young cancer patient data such as patient profile, pain data, and others through API provided by the game engine. Besides, the game data such as avatar and badges collected will also be stored in the server database. The medical team can access the data from the server through the RESTful API.

The technology selected to develop mobile application is Unity. Unity provides rich resources and packages for developers to develop game related application in different platform. There are a lot of built-in packages required by game such as game physics and animation controllers. As compared to other mobile application development tool such as react native and android studio, these development tools do not have enough resources for game programming like unity does. This could greatly increase the difficulty in developing the mobile application.

The technology selected to develop web application is Laravel framework. Laravel framework provides a full set of frameworks in developing both front-end system and back-end system. This framework uses MVC design pattern to simplify the connectivity between database, backend, and frontend. This has simplified development process and increased the maintainability in the future.

1.6 Proposed Approach

1.6.1 Research Approach

The first research approach selected was quantitative research approach. Alshamary (2017) stated that the quantitative approach aims to measure the data in a statistical, mathematical, or numerical way. This approach focuses on using numerical data to illustrate a specific phenomenon. A survey was used in this project to collect opinions from caretakers, parents of the young cancer patient, and the medical team. This is because hospital is not a safe place to visit in this period due to Covid-19. Survey is convenient for collecting a large amount of data from different hospitals or care centres in Malaysia compared to interviews and observation within a limited time.

The second research approach applied was qualitative research approach. Punch (2018 cited in McAllister (1995)) defined qualitative research as a research approach that collects data that is not in numerical forms such as process description, opinion towards an event, a subject definition, and others. An interview was used in this project to understand more about the cancer treatment and pain assessment process. Due to the survey's limitation in gathering non-numerical data, an interview is better because the respondent can express their idea or thought is a more descriptive way. Options provided in the survey questionnaire may not allow them to fully express their opinion and it is difficult to express the emotion through words. Furthermore, a different young cancer patient may have a different reaction towards the treatment. It is also easier for the interviewer to understand children's behaviour and perception of cancer treatment through interview and observation.

1.6.2 Development Approach

The selected development approach for this project was a phased development methodology. This methodology divides the project into different parts, to allow developer to work on the project incrementally. According to Powell-Morse (2016), this software development life cycle focuses on a simple implementation of the system, which then increases its complexity by adding more modules and features until the final system is completely developed.

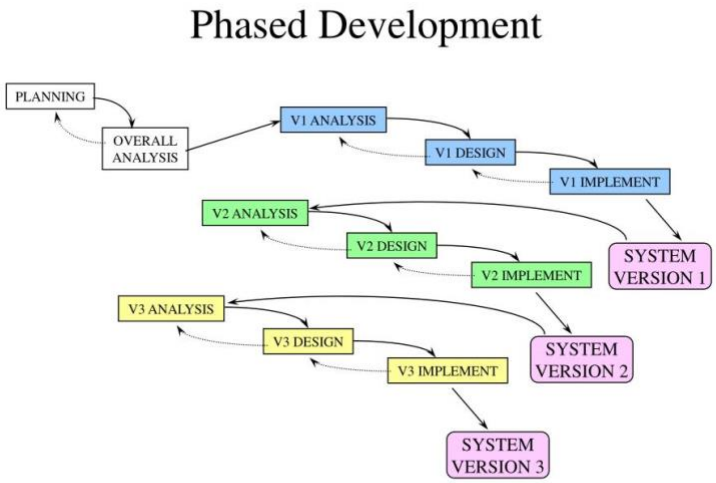

Figure 1.2: Phased Development Methodology (Powers, n.d.)

The biggest advantage of using this model over the other software development life cycle model is that it allows developers to test the subsystem and detect bugs or errors in the early stage (What is Iterative Model?, 2020). This final project deliverable is a complex system with two interconnected applications and databases on different platforms. It is better to test the completed module once at a time before moving to another module rather than testing all the modules together at once. It is difficult to revert once the final system is completed.

Furthermore, changes can be made at an early stage if the application's direction is incorrect, or the client feedback is poor. By splitting the application into a smaller part, it is easier to be redesigned and also redeveloped if the requirement has changed.

1.7 Project Scope

1.7.1 Target User

The **first end-user** is the young cancer patient aged from 7 years old to 11 years old. According to KITCHENER (2018), children aged from 7 years old to 11 years old are in the stage called concrete operational . Children can think logically about objects and events. This means that the cognitive development in children from 7 years old and above is more complete. They can understand objects and events such as pain and gives a more realistic description. The patient who is 7 years old and above usually use self-report tools as pain assessment tools without the assistant of the medical team.

Furthermore, both young cancer patients that are staying at home and hospital will be accepted as the end-user because some of the patients may prefer to stay at home as they only go to the hospital for checking and treatment. However, this project does not include the patient that is physically or mentally impaired. The **second end-user** is the medical staff (doctor/nurse). Medical staff accesses to the portal to view and analyse the data. The parents and caretakers could be the user to assist children in using the mobile application. Still, they would not be included as the end-user for the web application as the data collected is for the medical team to do further analysis.

1.7.2 System Scope

The mobile application will be available for android only. The android version should be android 9.0 and above to use the application. Any mobile application that uses the android operating system is eligible for this application. On the other hand, the web application will be available and accessible for all web browsers. Both mobile and web applications will be available in English only. Although both mobile and web applications are created, the mobile application is the main focus of this project. The web application would be the assistant to the mobile application to organize and analyse the data gathered. The focal ratio for mobile: the web is 7 : 3.

1.7.3 Application Features/Modules

1.7.3.1 Web Portal System

Pain Tracking and Analysis Feature

The web application will provide a dashboard for the user to have an overview the children's status. When a patient is selected, the portal should display the collected pain data in a meaningful way to give a better insight to the user.

Data Management Feature

The web application should allow users to manage the young cancer patient data such as add, edit, and delete operation. Users can add new young cancer patient, edit the incorrect data, or remove the unwanted and outdated data.

1.7.3.2 Mobile Application

Pain Recorder

This mobile application will provide a pain recorder for a young cancer patient to assess and record their pain. The time interval between each assessment can be adjusted to follow the hospital standard during the registration of the account. The pain recorder will combine different sets of current pain assessment tools for children to complete. Upon completion, children should receive points or badges as a reward to motivate them.

Platform Game

This mobile application should have a main platform game. A platform game is a 2d game that let user running left and right to reach a final goal. Children can collect coins, fighting enemies, etc. Children can also answer some primary/secondary school level questions to get extra coins or life. This game aims to distract them so that they will not always focus on the pain.

Help Feature

This mobile application should have a help feature for children to contact the medical team when they are having a great pain. The pains are spontaneous and inconsistent. Children could be strike by breakthrough pain and need help immediately. Help features could help them to notify the medical team as soon as possible.

Personalized Avatar

This mobile application should allow children to create a personal avatar to represent them in this game. Children can customize the avatar appearance such as clothes, weapons, skills, etc. Children can use the collected coin to purchase new effects in the shop. Having a personal avatar provides an immersive experience for children.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Mobile health (mhealth) is a new technology in the healthcare sector that utilized mobile technology such as phones, tablets, and wearables to provide healthcare support. Healthcare activities such as workout, pain tracking, and sleep quality monitoring are all under the term 'mhealth'. Numerous mobile applications related to health, such as calories tracker and fitness app, are available for users to use(Milward, 2019). However, most of the applications have problems keeping the user in constantly engaging with the application in the long run up until the rise of the gamification concept.

In recent years, gamification has been increasingly adopted in most applications and systems due to its ability to motivate people to promote certain behaviours changes or to achieve a specific goal. Game design elements such as level, points, and badges could be found in most of the systems nowadays (Hamari and Koivisto, 2015). Healthcare is also one of the sectors that largely applied the gamification concept to promote user engagement and change user behaviours. For example, the user receives points for completing a set of workouts and badges for working out continuously for a week. These game elements intend to reward the user when a certain amount of commitment is given to prolong application usage.

Besides using gamification in daily health-related activities such as workout and sleep tracking, this concept is also being applied to serious healthcare sector. The application of the gamified application to motivate patients with asthma (Hsia et al., 2020), diabetes (Alsaleh and Alnanih, 2020), hypertension (Cechetti et al., 2019), cancer (Fortier et al., 2016), are getting common in recent years. Therefore, this project is also aimed to utilize the power of gamification to effectively motivate young cancer patients to communicate pain with caretakers and the medical team. To increase the effectiveness of gamification, literature related to several areas are reviewed and analysed to gain a deeper insight. Below are the several main focuses of this section:

1. To understand the general idea of gamification and the underlying mechanism to promote user engagement with the gamified application.

2. To understand the psychological effects on the different combination of game design elements.
3. To understand more about the young cancer patient, pain assessment, and pain management.

2.2 Background of Gamification

2.2.1 Utilitarian Information System

In recent decades, people have been developing and creating utilitarian information systems to increase the efficiency in solving real world issues. This kind of system focuses solely on usefulness and effectiveness in providing user information, feedback, or solution to the problem. Therefore, a utilitarian information system is defined as an information system that is effective, useful, and practical (Lu, Liu and Fang, 2016).

The perceived ease of use and perceived practicality are the primary causes that influence user on the attitude and intention of continued use towards the utilitarian information system. For instance, the user would not want to use the accounting system if it could not solve the problem. Researches conducted by Davis (1989), Adams, Nelson and Todd (1992) and Jahangir and Begum (2008) show that perceived practicality and ease of use have a significant and positive impact on user attitude towards the system. Therefore, it is important for the system to effectively assist a user in solving the problem else it would be useless and eliminated in the future.

2.2.2 Hedonic Information System

The hedonic information system, on the other hand, is the total opposite of the utilitarian information system. When the utilitarian information system aims to deliver instrumental value, a hedonic information system is built to provide self-fulfilling to the users. Therefore, information systems that are built for home and leisure activities such as video games and karaoke system are strongly connected to the concept of hedonic. Hedonic information system usually deliver fun, enjoyment, and relaxation rather than production and solution to the user (Van Der Heijden, 2004).

Peter and Sherman (2006) have studied the reason that promotes users in using a hedonic information system, and Facebook has been selected to become the target system to be studied. The respondents identified entertainment and excitement, fun, social activities, and ease of use when using Facebook; these factors motivate or support the subjects to use Facebook continually. Abad, Díaz and Vigo (2010) research also show that perceived practicality, perceived ease of use, and perceived fun are able to be the determinant in influencing the user behavioural intention towards the system. As conclude from the research above, productivity and perceived usefulness are not the only factors that will affect the user attitude and intention of use towards an

information system; a system that is fun and provides enjoyment could also influence user behavioural intention.

2.2.3 The Rise of Gamification

During recent decades, utilitarian systems have always been the tool to assist human in solving a problem. Still, it lacks certain aspects that could motivate users for continued use. Repeatedly using the system to solve math problems could be effective, but it could lead to boredom and fatigue after the use of the system over a long period. To solve this problem, technology has started to involve the 'fun' aspect, a hedonic system into the utilitarian system (Koivisto and Hamari, 2019). According to Ramírez-Correa et al. (2019), although perceived usefulness is the key factor for a productive system, adding a feature that provides enjoyment could greatly increase the system's power. Therefore, more and more systems are starting to involve the hedonic or entertainment-oriented technologies to promote user engagement with the system. This development has slowly evolved and eventually become the concept of gamification.

2.3 Introduction of Gamification

Gamification has been understood as involving game elements such as points, badges, and levels into the system. However, there is still a lack of a standard scientific definition for gamification. The most used definition is "the use of game design elements in non-game contexts", which is proposed by Deterding, Dixon, et al. (2011 cited in Sailer et al., 2017). According to Deterding et al. (2011 cited in Hamari and Koivisto 2015), ‘gamefulness’ is the main focus of the gamification concept. The aim of involving gamification into the system is to provide hedonistic use, but the ultimate end goal for the system is commonly to provide utility use.

Gamification has become the main trend for developers to motivate users to engage with the system constantly. Many researches are focusing on the effect of gamification on promoting user engagement or changing user behaviours, and most of the results are positive (Alsaleh and Alnanih, 2020; Hwang and Choi, 2020; McAuliffe et al., 2020). As the number of researches about gamification escalates over a few years, Koivisto and Hamari (2019) have conducted a research to review the past gamification related researches to understand the overall gamification trend. Although most of the results are positive towards gamification's effectiveness, the number of mixed results is also extraordinary. Also, it is still a lack of empirical research to validate and prove the science behind gamification (Seaborn and Fels, 2015). Most developers are spamming points, badges, and levels into the system but do not understand how gamification can affect the user in giving the desired outcome.

2.4 The Science Behind Gamification

Extrinsic motivation and intrinsic motivation are the main factors that drive user behaviours. Extrinsic motivation happens when an external factor influences the human decision in performing an action or behaviours (Cherry, 2020). For example, parents will buy toys for children if they could score in the final exam. The toy has become the extrinsic motivation that motivates the student to study harder than usual. However, intrinsic motivation derives from the human without any external reward. A person is intrinsically motivated when he/she feels the behaviours or activity generates enjoyment or personal satisfaction (Adrienne Santos-Longhurst, 2019). In gamification, intrinsic motivation act as the major factor because of the enjoyment or satisfaction provided by the game design elements (Deterding et al., 2011; Hamari and Koivisto, 2015).

2.4.1 Self Determination Theory

Self-determination theory is concern about motivation on human. It can be used to explain the relationship between the specific game elements and the intrinsic motivation used in fulfilling the human needs satisfaction (Xi and Hamari, 2019). The self-determination theory categorizes human needs into three main categories: autonomy, relatedness, and competence (Orkibi and Ronen, 2017).

According to Ryan and Deci (2020), independence or freedom is the main aspect of autonomy. Autonomy concerns about the ability to have control over something and the freedom to make decisions. Competence on the other hand focuses on self-mastery and growth, which oneself personal satisfaction is fulfilled when he/she conquered challenges or developed new skills. The chances for growth, achievable challenges, and positive feedback are great to fulfil the need of competence. Last but not least, social connection and the feeling of belonging are the main concerns for relatedness needs. Higher relatedness needs satisfaction could be fulfilled if the person experienced a close social relationship or the involvement in a community.

2.4.2 Psychological Need Satisfaction and Game Design Elements

2.4.2.1 Game Design Elements and Autonomy Need Satisfaction

Based on Wee and Choong (2019), individual profile and flexible structure are the game design elements that can satisfy autonomy needs. Personal profile is like an avatar which provides the user the freedom to personalize or customize the character. For non-fixed structure, user experiences flexibility and freedom in selecting and performing tasks. Freedom in making a decision also highly fulfils the autonomy needs.

2.4.2.2 Game Design Elements and Competence Need Satisfaction

Competence need can be satisfied by badges, leader boards, challenge, feedback, points, levels, storyline, and short cycle times (Wee and Choong, 2019; Mekler et al., 2017; Sailer et al., 2017). Badges, points, and levels can act as feedback for the user to visualize their growth and the achievement gained during the use of the system.

2.4.2.3 Game Design Elements and Relatedness Need Satisfaction

Social related feature such as clan, friends, and chat are strongly related to relatedness need (Xi and Hamari, 2019). These elements create a community within the system and promote interaction among users. These elements provide a strong social involvement when users use chat boxes to chat with friends or received likes from other users (Sailer et al., 2017).

2.4.3 Game Design Elements Versus ‘Gameful’ Experience

Despite game design elements can fulfil the need satisfaction in a certain situation, some researchers do not find significant results even they applied the game design elements. Mekler et al., (2017) stated that the nature of the task could be a great influencer to the effectiveness of gamification. The image annotation task employed in the research could be meaningless and confusing to the user, thus decrease the satisfaction level. Also, it is important to create a 'gameful' experience to provide enjoyment to the user. Adding game element blindly to a system does not certainly create a 'gameful' experience for the user. This argument is further supported by Groening and Binnewies (2019) as they concluded their results greatly relied on the system design. Werbach (2014 cited in Groening and Binnewies, 2019) also described that gamification should not simply be understood as transferring game elements to

the system. There are still other aspects that could highly influence the effectiveness of gamification.

2.5 Effects of Gamification in Different Sectors

Until now, many systems have been found to have gamification as the approach in promoting user engagement or changing user behaviour in multiple sectors. According to a literature review conducted by Koivisto and Hamari (2019), 20 domains that had conducted studies related to gamification services are identified. Among the 462 papers gathered, the top five domains are education (42.4%), health (11.9%), software development or design (7.8%), crowdsourcing (6.9%), and business or management (6.3%). Other domains such as architecture, politics, and communication are also found to have gamification services, but the researches are limited.

Gamification is used in different sector to achieve different goals. Based on Putz, Hofbauer and Treiblmaier (2020) and Yildirim (2017), increasing student's performance, motivation, scholarly accomplishment, and attitudes toward class lessons are the main goal of applying the gamification concept. The key findings of different scholars summarized by Zainuddin et al. (2020) showed that involving the gamification concept in teaching and learning activities greatly increased students' scholarly achievement, performance, and attitude compared with traditional education style.

Besides, the marketing sector also applies the gamification concept to improve customer engagement, customer loyalty, and customer awareness with the brand (Xi and Hamari, 2020; Hsu and Chen, 2018; Hwang and Choi, 2020). All three researches results showed the gamification concept can positively affect customer behaviour in achieving marketing goals. Furthermore, gamification also works in promoting user's energy conservation behaviour. Studies from Johnson et al. (2017) and Iria et al. (2020) found a significant reduction in energy usage after the implementation of gamification to the mobile application as gamification creates a positive influence on user knowledge, behaviours, and user experience. However, Beck, Chitalia and Rai (2019) critiqued some of the application developers only apply one or two game design elements to flag it as gamification and resulting in an ineffective impact on changing user behaviour.

In short, gamification is found to have positive effects on the discovered sectors. Also, the education sector is the most affected as almost half of the researches are related to education, and most of it are having positive results. However, applying the gamification concept without the understanding may lead to insignificant or no results.

2.6 Gamification in Healthcare

Healthcare is one of the important sectors that implement gamification to persuade users towards health behaviour changes. Several scholars also confirmed that gamification is effective in promoting health behaviour change. Hsia et al. (2020) researched on the impact of a gamified application on children's asthma patients. A promising result shows that the gamified application improved user asthma control, knowledge, quality of life, and highly satisfied users. Fortier et al. (2016) has also conducted similar research to study the effect of gamified application on the management of children's cancer pain. Study shows that children enjoyed the program greatly and found this program is promising in minimizing children pain and symptoms. Research done by Alsaleh and Alnanih (2020) also confirmed that eating behaviours of children with diabetes had been improved after the use of a gamified health application that was designed for the intended purpose. Other studies also show that gamified health application can significantly motivate users towards a healthier behaviour change.

However, Johnson et al. (2016) argued that not all researches' results were positive. Among 19 scholars that have been reviewed, more than half (59%) are proved to have a positive effect, whereas the other 41% reported insignificant or null effects. Spillers and Asimakopoulos (2014 cited in Johnson et al., 2016) suggested developers should take care of user experience when implementing gamification into the system. Poor system design could lead to poor usability of the gamified applications, thus reduce the intention of continued use. Furthermore, Alahäivälä and Oinas-Kukkonen (2016) also reported that contextual factors must be considered to have a successful gamification experience. Still, this factor has been ignored by most of the studies so far. Overall, gamification is still a good tool that could positively impact healthcare, especially for behaviours change, but blindly applying game design elements may not lead to a significant positive outcome.

2.7 Young cancer patient, Pain Assessment, and Pain Management

Having a detailed understanding of the target user is also crucial in the development of a system. A perfect system for developers does not necessarily fit the user needs (Maguire and Bevan, 2002). The main target user of this project is not an ordinary user. Young cancer patients are already suffering from different pains caused by cancer and treatment. The system must be able to support the children, not to increase the pain.

2.7.1 Young cancer patient

2.7.1.1 Overall Understanding of Young cancer patient in Malaysia

As reported by Azizah AM. et al. (2019), leukaemia (41.4% in male, 37.9% in female), brain and nervous system (14.6% in male, 15.8% in female), and lymphoma(13.4% in male, 7.7% in female) are the top three cancers in children below the age of 14 years for both sexes. 3829 children aged from 0 to 18 years old are diagnosed with cancer in Malaysia. More than half of the cases were male (55.7%), and the rest are female (44.3%). In addition, leukaemia is reported as the most common childhood cancer since 2007 (National Cancer Institute and Ministry of Health, n.d.). Figure 2.1 summarized the percentage of childhood cancer from 2012 to 2016, and Figure 2.2 summarized the percentage of childhood cancer from 2007 to 2011.

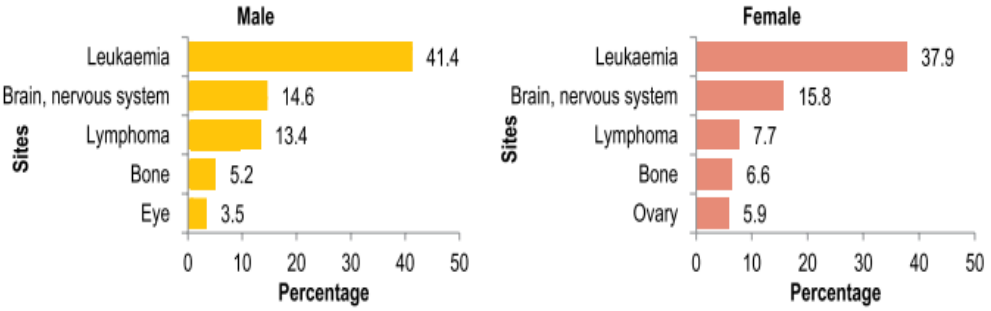

Figure 2.1: Young cancer patient Statistic Based On Gender From 2012 – 2016 (Azizah AM. et al., 2019)

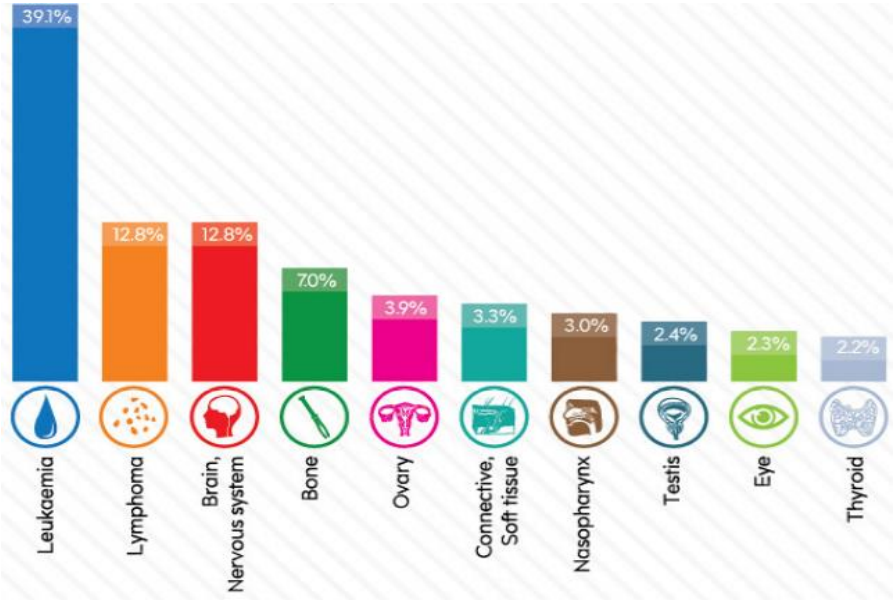

Figure 2.2: Young cancer patient Statistic From 2007 - 2011 (National Cancer Institute and Ministry of Health, n.d.)

2.7.1.2 Common Symptoms of the Young cancer patient

Cancer and the treatment, such as chemotherapy or radiotherapy, will lead to some negative side effects on the young cancer patient. According to Ye et al. (2019), fatigue, pain, and poor appetite are the top 3 common symptoms on all types of young cancer patients. Figure 2.3 shows the 15 most frequent symptoms found in the young cancer patients.

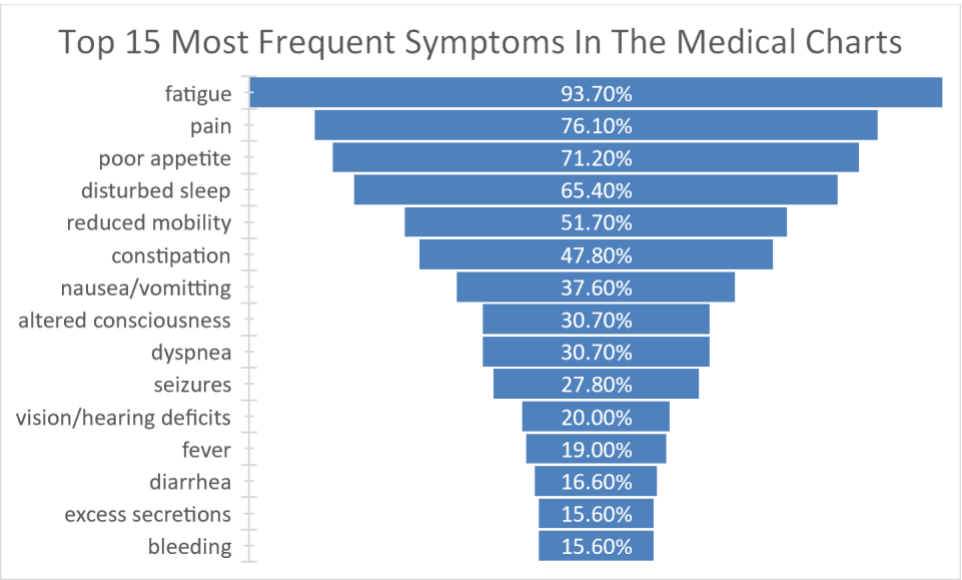

Figure 2.3: Top 15 Most Frequent Symptoms Found In Young cancer patient

Children with leukaemia, lymphoma, and solid tumours had higher chances in having bad appetite and diarrhoea, whereas children with central nervous system tumours had higher chances to have reduced mobility. Research done by Cheng et al. (2019) and Torres et al. (2019) also identified similar symptoms such as pain, anxiety, and worry on young cancer patients under eight years old. Furthermore, Madi and Clinton (2018) research reported that children were experiencing pain sometimes, and the pain duration normally lasts two hours or longer. Besides, only a few children were experiencing pain all the time. The forehead, the abdomen (right & left), and lower back (right & left) were the highest reported pain location among the participants. This result matches the results of the research conducted by Friedrichsdorf et al. (2007). Other than chronic pain, children are also found to suffer from breakthrough pain (Friedrichsdorf et al., 2007). Shooting, sharp, burning, and tingling were the terms that are used by patients to describe the breakthrough pain. 31% of children reported that the pain lasted for seconds, whereas the rest (63%) experienced breakthrough pain lasting for minutes.

2.7.2 Pain Assessment

Pain assessment is the process to identify and understand the pain in the young cancer patient. Several data such as type, intensity, duration, and location of pain are collected through the process. However, due to the different cognitive development stages in children, pain assessment tools must be selected appropriately to effectively collect pain data (Batalha et al., 2015). According to Piaget's Theory of Cognitive Development, there are four stages of cognitive development in a children (KITCHENER, 2018). Figure 2.4 below illustrated the detailed explanation of each cognitive development stage.

Piaget's Stages of Cognitive Development

Stage	Age range	What happens at this stage?
Sensorimotor	0-2 years old	Coordination of senses with motor responses, sensory curiosity about the world. Language used for demands and cataloguing. Object permanence is developed.
Preoperational	2-7 years old	Symbolic thinking, use of proper syntax and grammar to express concepts. Imagination and intuition are strong, but complex abstract thoughts are still difficult. Conservation is developed.
Concrete Operational	7-11 years old	Concepts attached to concrete situations. Time, space, and quantity are understood and can be applied, but not as independent concepts.
Formal Operational	11 years old and older	Theoretical, hypothetical, and counterfactual thinking. Abstract logic and reasoning. Strategy and planning become possible. Concepts learned in one context can be applied to another.

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Figure 2.4: Summary of Piaget's Stages of Cognitive Development (HQ, 2020)

Based on to Batalha et al. (2015), the pain assessment tool is categorized into one-dimensional tool and multidimensional tool. The one-dimensional tool examines a single aspect of the pain, such as intensity, location, or temporal pattern. In contrast, a multidimensional tool examines multiple aspects of the pain at once. Due to the limitation of a one-dimensional tool, many different pain assessment tools are developed to assess the pain's different aspects. For example, faces scales are used to assess pain intensity and body diagrams are used to assess pain location. Adolescent paediatric pain tool (APPT), on the other hand, is the multidimensional tool combined with multiple pain scales to collect multiple pain attributes (Fernandes et al., 2014).

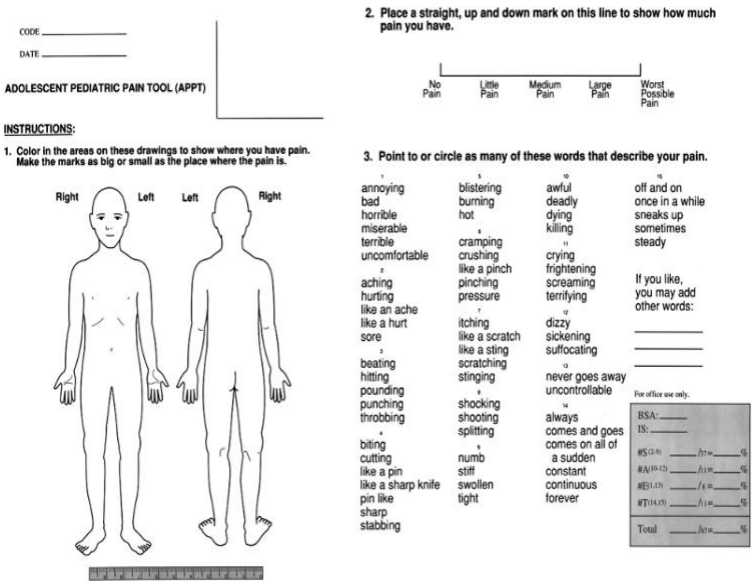


Figure 2.5: APPT (Protocol - Adolescent Paediatric Pain Tool, 2020)

Furthermore, Brand and Al-Rais (2019), Duffy et al. (2019), and Lebel (2005) have summarized the most frequently used pain assessment tools in Table 2.1 to provide a clear picture for the medical team so that the most appropriate pain assessment tools could be selected for different children. There are two types of pain assessment tools, which are behavioural type and self-reporting type. Behavioural type is commonly used on infant age from zero to two due to the limitation of cognition in identifying and describing pain. Contrarily, the self-reporting type is suitable for the children's age range from three years and above. However, the self-reporting pain assessment tool must be selected appropriately based on the difficulty in using the tools. For example, simple tools such as face scale are more appropriate for younger children than tools with difficult words such as APPT.

Table 2.1: Summary of Pain Assessment Tools

Pain assessment tool	Ages	Type	Brief description
CRIES	Neonate	Behavioural	Observed for crying, oxygen requirement, facial expression and changes in vital signs.

Table 2.1 (Continued)

NIPS	**< 1 year old**	**Behavioural**	0-12-point scale to observe facial expression, cry, the pattern of breathing, arms, legs, and the arousal condition (Neonatal Infant Pain Scale (NIPS) Ages Birth - One Year, n.d.).
FLACC	2 months – 7 years old	Behavioural	Face, legs, Activity, Cry, Consolability 0-10-point scales.
CHEOPS	1 – 5 years old	Behavioural	Children's Hospital of Eastern Ontario pain scale. A 4 – 18-points scale to examine crying, facial expression, verbal expression, position of legs, and wound.
Wong-Baker Faces scale	3 – 18 years old	Self-report	Six drawing faces with increasing distress expression for children to choose the one closest to them.
Revised Faces scale	4 – 18 years old	Self-report	Six semi realistic faces ranging from neutral to distressed expression for children to choose the one closest to them.
Numerical analogue scale	5 – 18 years old	Self-report	A list of consecutive number for patient to quantify the pain.
Visual Analogue scale	7 – 18 years old	Self-report	A 10cm line with lowest intensity description labelled at one end and highest intensity description labelled at another end. Children marked a line within the 10cm line to show the intensity.
Adolescent Paediatric Pain Tool (APPT)	8 – 18 years old	Self-report	Combination of body diagram and several words and graphic scales.

2.7.3 Pain Management

Young cancer patients are experiencing all kinds of pain throughout the cancer treatment. Therefore, the pain must be well managed to reduce the suffering of children with cancer. Pain management has been categorized into two different approaches: pharmacologic pain management and nonpharmacologic pain management.

Pharmacologic pain management refers to the use of different opioids to reduce the pain in the young cancer patient. Mercadante (2004) and Duffy et al. (2019) stated that opioids are the main approach for children with cancer to reduce pain. An appropriate dose of opioids could effectively reduce the intensity of pain for the young cancer patient that is experiencing great pain. However, Lebel (2005) argued that opioid use is discouraged due to the potential side effect caused by the opioid, and it could somehow increase the burden of the children. Morphine, fentanyl, sufentanil, methadone, and hydromorphone are common opioids for children.

Nonpharmacologic pain management helps patient to reduce pain without the use of medications. Physical-based therapies, cognitive behavioural therapies, mindfulness-based stress reduction, distraction methods, mind and body practices, and traditional practices are the main types of nonpharmacologic pain management approaches (Duffy et al., 2019). Jibb et al. (2015 cited in Duffy et al., 2019) stated that 69% of the studies in a literature review reported that nonpharmacological pain management approaches have positive effect in reducing the patient's pain. Lebel (2005) also reported that different activities, such as mindfulness-based and relaxation activities, are useful for children to reduce pain and anxiety.

In short, all young cancer patients are unique; thus, their body condition should be carefully analysed to match the most suitable approach. None of the approaches is the universal answer to cancer pain. A different approach is to be applied in a different situation to have the best effect. Therefore, the pain management approach should be selected appropriately to reduce the pain effectively.

2.8 Review of Similar Systems

There are several similar systems for patients to record and monitor their pain. However, most of the systems are designed for adults and do not include game design elements. All the identified systems are filtered, and the relevant systems are selected for the review. The main criteria for the relevant systems are the system must be designed for children and the system must include game design elements. After a few round of selection, six similar systems that matches both the requirements are found. However, three of them are not available for download as they are not published to the app store. Therefore, the overall look and the features will be extracted from the published research paper. This section reviewed the selected similar systems to investigate the systems' common features and functions to understand the necessary feature to be implemented into the proposed system. Table 2.2 listed out all the existing systems and the sources for these systems.

Table 2.2: Similar Systems and The Sources

Application Name	Source
Pain Squad	Apple App Store, Google Play Store
ICPCN	Apple App Store, Google Play Store
Achy Penguin	Apple App Store
Pain Buddy	Research paper (Fortier et al., 2016)
Quest – Te Whitianga	Research paper (Christie et al., 2019)
ASTHMAXcel Adventures	Research paper (Hsia et al., 2020)

2.8.1 Game Design Elements of The Systems

Based on the systems' cross-analysis, it is found that all the systems rely heavily on graphics and cartoons to promote engagement with the children. Animal and human cartoons are the major cartoons that act as communicator in the application to assist the children. Besides, most of the system have a main theme for the application to provide immersive experience to children as they will think they are in the world. The themes found in the applications are polis division, wildlife, and adventure island.

Furthermore, personalized avatar is also found to be one of the most applied game design elements. Surprisingly, some of the most popular game design elements that are largely applied to other applications such as badges, points, and levels are only found in half of the systems. Other game design elements such as narrative, challenges, virtual coin, leader boards, progression, and avatar store are found in only one or two systems. Only one of the systems does not include a game design element at all. It is still included in this review because it is a pain assessment tool built for children. All the identified game elements in each system are listed out in Table A-1 in appendix A.

2.8.2 Common Features of The Systems

After the system review, pain recorder and game are the features that are implemented by most of the systems. The genre of games is different from each other. Some of the games are mini games for relaxation, while some of the games are the adventure-like game that provides a story for children to follow. Furthermore, some of the applications have a diary feature for children to record their thoughts and experiences. A few of them also provide the pain tracker and analysis statistic feature. All the available features in each system are listed out in Table A-2 in Appendix A.

2.8.3 Pain Assessment Tool Used in Pain Recorder

A combination of several pain scales is found in most systems as the assessment tool for the pain recorder. Most of the systems use Adolescent Paediatric Pain Tool as the main assessment tool for the pain recorder. Other pain scales, such as Wong Baker's face scale and visual analogue scale, are also used in the pain recorder. All the scales that use graphics are redesigned to fit the theme of the application. For example, the human body diagram and Wong Baker face scale are changed into animals to fit the

wildlife theme. All the pain scales used in each system are listed out in Table A-3 in Appendix A.

2.8.4 Implication of System Review

Based on the finding above, the game design elements that should be included in this project are theme, narrative, and personalized avatar. Other game design elements such as points, badges, and levels should be selected with consideration to increase the effectiveness of gamification. This is because the application that implemented inappropriate design elements that are not fit with the design of the application could result in insignificant motivation effects. The application should also be designed with graphics and cartoons to be more favourable by children.

According to the review result, pain recorder will be the necessary feature for this project as it is also the core function of the application. A combination of different pain scales is recommended to collect different aspects of the pain. Adolescent Paediatric Pain Tool and Wong Baker Face scales are also suggested to be used in this project. Besides, this mobile application should also include a game for children to play. However, the game genre should be implemented based on the theme and narrative of the application to enhance the overall "gameful" environment and immersive experience. The pain tracker and analysis tool will not be included in the mobile application as this project is implementing this feature in the web application for the medical team. The diary feature will not be included as the feature for this project because it is out of scope. However, it should be taken into consideration for future updates.

Table 2.3: Summary of System Review Findings

Game elements	Feature	Pain assessment tools
narrative	Pain recorder	APPT
theme	game	Wong Baker face scale
Personalized avatar		Other suitable scales
Other suitable game elements		

2.9 Conclusion

In conclusion, this literature review has investigated all the major areas in gamification and young cancer patients, and some insight were gathered. Overall, gamification has a positive impact on the healthcare sector, but it is not a guaranteed success in all cases. The effectiveness of gamification is heavily relying on the overall design of the application. Developers should study the needs satisfaction of the target user to provide developer ideas in selecting suitable game design elements to fit into the application. Also, the application should provide 'gameful' experience with the use of game design elements. This is an important aspect that must be considered carefully during the design of the application for this and future projects.

Next, several of pain assessment tools are identified based on several studies. Results suggested the developer selects the appropriate tools based on the children's age and body condition. A combination of different pain scales is also recommended to gain more insight into the pain. To help children to reduce the pain level in a nonpharmacologic way, the game of the system could mimic the activities or design to achieve a similar outcome.

Finally, the necessary features of the new system are identified through the comparison of similar existing systems. A rough idea of the system design is also acquired based on the comparison. The results also pointed out some matters needing attention for the developer to be aware of during the design of the application.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

This chapter reported about the selected development methodology on this project. All phases in the life cycle were explained in detail in the subchapters. Furthermore, the development tools used in this project were also identified and described in this chapter. Lastly, a work breakdown structure and Gantt chart were included at the end of this chapter.

3.2 Methodology

The selected development methodology for this project was phased development methodology. Planning, analysis and design, implementation and testing, and closing are the four main phases in this development methodology. Figure 3.1 showed the implementation of the phased development of this project. Each phase was conducted once and proceed to the next phase when all the tasks in the current phase were completed. However, the implementation and testing phase were conducted repeatedly until the system was fully developed due to the structure of the system. Separation of system development ensured the feature with top priority to be implemented first over the low priority feature. Furthermore, phased development allowed the developer to build the separate application once at a time because this project only has one developer, hence building multiple applications simultaneously is challenging and risky. After the system had been fully developed, the final phase would be conducted to close the project.

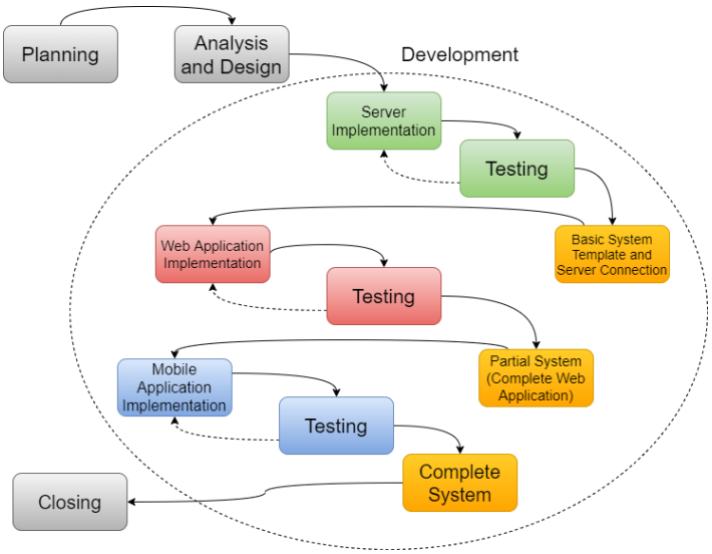


Figure 3.1: Phased Development Project Life Cycle

3.2.1 Planning

3.2.1.1 Project Proposal

The planning phase of this project consists of two major parts, project proposal, and requirement gathering and elicitation. The second part would be proceeded once the supervisor accepted the proposal. The first activity in the planning phase was to identify the problem the young cancer patient faced during their cancer treatment process. Due to the lack of knowledge in the healthcare field, several articles and literature were reviewed to understand more about the young cancer patient and the cancer treatment process. After a detailed analysis of the problem, several issues faced by young cancer patients were identified. After all main issues were identified, the objectives of this project were established. Project objectives act as guidance for the team to follow throughout the entire system development life cycle.

The following activity after the project objectives establishment was the project solution proposal. An overall picture of the system was described in this activity to give a rough idea about the final project deliverable. Then, the planning phase continued with the selection of project methodology. The focus of this activity was to select a suitable research methodology and development methodology for this project. Afterward, project scopes were also developed to set the boundary of the project. Several aspects, such as user scope, system scope, and feature scope, were set after the process was completed. The deliverable of this part was a project proposal, and it was submitted to the supervisor for approval.

3.2.1.2 Requirement Gathering and Elicitation

As the proposal got approved, the planning phase proceeded with the requirement gathering and elicitation part. The first activity of this part was requirement gathering. The questionnaire was distributed, and similar existing systems were reviewed and compared to gather requirements. Besides, several scholars about gamification and game design elements were also reviewed to select the game design element for the mobile application. Also, an interview session was conducted to gather more insight on children with cancer and also the pain assessment process. The gathered results were analysed, and the requirements were finalized after the requirement elicitation process.

3.2.1.2.1 Questionnaire and Interview

Survey questionnaires and interviews were the main requirement gathering techniques for this project. The survey questionnaire was created using Google Forms to collect more data within a limited time. The questionnaire comprised of four main sections with different focus. Section one identified the respondent background, such as gender, career, and caretaking experience. Section two focused on children under treatment. Section three focused on the pain assessment process and the last section focused on system function recommendation. The survey was conducted for three months long due to the difficulty in getting sufficient responses. The questionnaire was distributed to many hospitals and care centres, but only a few responses were received due to the pandemic. The medical team were currently focusing on handling the patient infected with Covid-19. Thus, the responses received did not meet the target respondent of the survey.

On the other hand, the interview focused on collecting descriptive data such as the pain assessment process and pain management process that could not be collected by the questionnaire distributed. Unfortunately, only one respondent from the survey was able to attend the interview session. A phone interview was conducted over face-to-face interviews because of the pandemic as well because the hospital is not safe to be entered currently to prevent the spreading of viruses.

3.2.1.2.2Review on Existing Systems

Six similar systems were reviewed and compared to extract similar game design elements, system features, and pain assessment tools. Three of the systems are available in-app store, but the other three are taken through the scholar papers because they are not available for download. Luckily, this did not cause a problem as all the system details are described clearly in the scholar paper. After the comparison, the common elements that most of the system possess were concluded as follow:

1. Game design elements
    a. Avatar
    b. Theme
    c. Story
2. System feature
    a. Pain recorder
    b. Mini game
3. Pain assessment tools
    a. APPT
    b. Wong Baker Face scale

3.2.1.3 Project Scheduling

Project scheduling was the last activity in the planning phase after all the details of the project are confirmed. Firstly, a detailed work breakdown was conducted, and a work breakdown structure was developed. The work breakdown structure included all the necessary tasks to be completed in every phase. Work breakdown structure was created to prevent the developer from skipping necessary tasks and conducting an unrelated task.

Secondly, a Gantt chart was created by following the work breakdown structure. Each task has been listed according to the life cycle, and all the task consisted of a start date, an expected duration to complete the task, and end date. Gantt chart allows the developer always to monitor the work progress to ensure the entire development process is parallel with the normal schedule.

3.2.2 Analysis and Design

Analysis and design were the second phases in the phased development life cycle. It started as soon as the planning phase has ended. An in-depth analysis of the project scope was conducted to design the system. With the analysis results, several diagrams were created better to understand the system's structure before actual implementation. The drawn diagrams were used case diagram, data model diagram, and data flow diagram. Use case descriptions were also developed to provide detailed information of all use cases.

Furthermore, the prototype of the system was also created to illustrate the design of the system. Issues could be identified through the system prototype and resolved before implementing the system to minimize unnecessary mistakes. In this project, different prototypes were prepared because this system consists of two different applications. However, the prototypes only focus on the design and simple interaction on the application alone. Both applications would not be connected to the server in this prototyping process.

3.2.3 Development and Testing

The development life cycle was proceeded to the development and testing phase after confirming the design of the system. This phase was going to split into three sub-phase and conduct iteratively to complete the system. The first phase focused on setting up the server and the connection between the application and the database. Then, the second phase focused on developing the web application, and the last phase focused on developing the mobile application. The second phase and third phase were separated into several subphases according to the priority of the feature. The feature with the highest priority was developed and tested first before the other. At the end of each sub-phase, the features developed were combined and tested together to ensure the system can work smoothly without problems.

3.2.3.1 Phase One

In phase one, all the tools required for development and testing were set up. Next, the base application folder for both applications were generated to set up the server's connection later. After that, the server and database were set up, and the connection among server, database, and different applications were configured and tested to ensure the connection are correctly established.

In summary, tasks in phase one focused on the setup and connection configuration of the system. The reason for setting up server and database connection first before application development was to ensure the developer could conduct testing smoothly as most of the system's features require a database to perform CRUD function. Setting up servers and databases in the middle of development may cause problems and delay the project.

3.2.3.2 Phase Two

The development of web application started in phase two. Phase two was decomposed into several sub development and testing phase according to the priority of the feature of a web application such as analysis feature, followed by a dashboard feature, and data exportation feature. Each feature developed was followed by a unit testing to identify bugs in that feature. After all the developed features were combined, and system testing was conducted to ensure the web application runs smoothly.

3.2.3.3 Phase Three

The development of mobile application started in phase three. As like phase two, phase three was also separated into sub-phases according to the priority of the feature of the mobile application. However, after unit testing was done for all the features, integration testing was conducted for some interrelated features to ensure the combined features are working without problems. Finally, system testing was also conducted to test the mobile application.

3.2.4 Closing

After the system was completed, usability testing was conducted to validate the final system. Then, the system's documentation was created, which consisted of the

explanation of the system, the screenshot of the final output, and the explanation of the functionalities. After that, the documentation of the project was compiled and finalized. Finally, presentation slide was prepared to report about the project process and final deliverables.

3.3 Development Tools

3.3.1 Visual Studio Code

Visual studio code is the main development tool for this project. Visual studio code is a powerful code editor that supports a wide range of programming languages such as Java, Python, HTML, CSS, PHP, and others. Besides, Visual studio code is available for all three main operating systems: Windows, macOS, and Linux. This allows developers with different operating systems to develop in the same software without worrying about the configuration problem. Furthermore, visual studio code offers countless of extension to help developers to streamline the development process. An extension such as auto formatter helps developers restructure and rearrange ugly code indentation, auto tag completer that closes the HTML tag automatically, and others are ready to be used after a simple installation process.

3.3.2 WampServer

WampServer is the local development server used to run the web-based project. A web-based project that uses server scripting language such as PHP will need a server to preview the outcome. Moreover, local development servers are free and do not require an internet connection to run. A local server will be created in the local machine for development use. The server also provides free database services such as MySQL for developers to store the data temporarily. Local development server is also easy to set up because everything necessary, such as the Apache server, MySQL database, and PHP, will be installed and set up together through the server installer. Developers only need to link the project to the server in the configuration file, and the project is ready to run.

3.3.3 Heroku

Heroku is an online platform for system hosting. Heroku is selected for system hosting because it is convenience, efficient, and also free to use. Also, Heroku cooperates with PostgreSQL in providing a free online database system for developers to use. Therefore, developers do not need to set up server in one platform and connect to database in another platform.

3.3.4 Composer

Composer is a dependency management tool built for PHP. Because this project is using the Laravel framework instead of pure PHP, thus composer is necessary for the project to create a dependency with the Laravel framework. Using the composer will simplify the interaction between user and third-party libraries such as Laravel because the composer will handle all the complicated libraries and allow users to deal with the function straight away.

3.3.5 PHPUnit

PHPUnit is the testing tool used in this project to run the test cases for the web application. PHPUnit offers a wide range of test functions such as combining related tests into one test suite, skipping tests, and prebuilt test doubles to mock the behaviour. Developers can download PHPUnit through the composer or from the website. Composer is preferred because it will automatically set up PHPUnit for the project. Developers only need to write the test case, and PHPUnit will do the rest.

3.3.6 Unity Engine

Unity engine is the development tool for mobile application because the mobile application relies heavily on game graphics and mechanism. Unity engines provide lots of interactive tools for developers to build games with less coding. Graphics can be added straightaway onto the scene with zero coding required. Unity engine also provides multi-platform game development such as PC, android, and iOS. Using the Unity engine will save a lot of time for this project as it minimizes the difficulty of building a fun, interactive game.

3.3.7 Visual Studio

Visual Studio is used to write the game script for the game in the mobile application. This is because the game script used by Unity Engine is mostly written in C# language, the language created by Microsoft. Furthermore, Visual Studio has been working with Unity to provide the best development platform for game development. Feature such as IntelliSense suggests correct code for C# programmers, and powerful refactoring tool to organize the code neatly (Build Unity Games with Visual Studio, 2020).

3.3.8 Axure RP

Axure RP provides a platform to create a prototype without coding. A simple static UI such as wireframes can be created to show the interface flow or a full prototype with interactive UI that could act when the user triggered an event that can also be done using Axure RP.

3.4 Work Breakdown Structure

1.0 Planning

- 1.1 Analyse the Project Title
- 1.2 Study Background of The Problem
- 1.3 Define Problem Statements
- 1.4 Define Project Objectives
- 1.5 Propose Project Solution
  - 1.5.1 Study Similar Solution
  - 1.5.2 Compare Similar Solution
  - 1.5.3 Finalize Project Solution
- 1.6 Propose Project Approach
  - 1.6.1 Propose Research Approach
    - 1.6.1.1 Research on Research Approaches
    - 1.6.1.2 Compare Research Approaches
    - 1.6.1.3 Finalize Research Approaches
  - 1.6.2 Propose Development Approach
    - 1.6.2.1 Study Different Development Approaches
    - 1.6.2.2 Compare Development Approaches
    - 1.6.2.3 Finalize Development Approaches
- 1.7 Define Project Scope
  - 1.7.1 Identify Target Users
  - 1.7.2 Identify System Scope
  - 1.7.3 Identify Covered Features
- 1.8 Requirement Gathering
  - 1.8.1 Conduct Survey
    - 1.8.1.1 Formulate Questions
    - 1.8.1.2 Distribute Questionnaire
    - 1.8.1.3 Analyse Questionnaire Findings
  - 1.8.2 Conduct Interview
    - 1.8.2.1 Schedule Interview Session
    - 1.8.2.2 Prepare Interview Question
    - 1.8.2.3 Contact Interviewee
    - 1.8.2.4 Interview

1.8.2.5 Analyse Result

1.8.3 Review Similar Systems

1.8.3.1 Prepare Cross Analysis Table

1.8.3.2 Review Pain Squad

1.8.3.3 Review Achy Penguin

1.8.3.4 Review ICPCN

1.8.3.5 Review Pain Buddy

1.8.3.6 Review Asthmaxcel

1.8.3.7 Review Quest – Te Whitianga

1.8.3.8 Record Details in Cross Analysis Table

1.8.3.9 Identify Common Elements

1.8.3.9.1 Identify Common Game Design Elements

1.8.3.9.2 Identify Common Features

1.8.3.9.3 Identify Common Pain Assessment Tools

1.8.3.10 Select Recommended Feature

1.8.3.11 Select Game Design Elements

1.8.3.12 Select Pain Assessment Tools

1.8.4 Literature Review

1.8.4.1 Review Gamification Concept

1.8.4.1.1 Study Gamification Background

1.8.4.1.2 Study Game Design Elements

1.8.4.1.3 Review Gamification Effects

1.8.4.2 Understand Young cancer patient

1.8.4.2.1 Study Young cancer patient in Malaysia

1.8.4.2.2 Understand Common Symptom of Young cancer patient

1.8.4.3 Review Pain Assessment Process

1.8.4.3.1 Compare Pain Assessment Tools

1.8.4.3.2 Study Pain Management Process

1.9 Requirement Elicitation

1.9.1 Select Recommended Feature

1.9.2 Select Game Design Elements

1.9.3 Select Pain Assessment Tools

1.9.4 Draft Requirement List

1.9.5 Examine Requirement List

1.9.6 Refine Requirement List

1.10 Project Scheduling

1.10.1 Create Work Breakdown Structure

1.10.1.1 Identify Main Activities

1.10.1.2 Breakdown Activities into Smaller Task

1.10.2 Create Gantt Chart

1.10.2.1 Determine Task Dependency

1.10.2.2 Estimate Duration

1.10.2.3 Draft Gantt Chart

1.10.2.4 Examine Gantt Chart

1.10.2.5 Finalize Gantt Chart

2.0 Analysis and Design

2.1 Design Use Case Diagram

2.2 Generate Use Case Description

2.3 Design UI Flow Diagram

2.4 Design Data Model Diagram

2.5 Design Data Flow Diagram

2.6 Create Prototype

2.6.1 Create Web Application Wireframe

2.6.2 Create Mobile Application Wireframe

3.0 Development Phase One

3.1 Set Up Connection

3.1.1 Create Mobile Application Repository

3.1.2 Create Web Application Repository

3.1.3 Setup Server

3.1.4 Setup Database

3.1.5 Connect Application to Server

3.1.6 Connect Application to Database

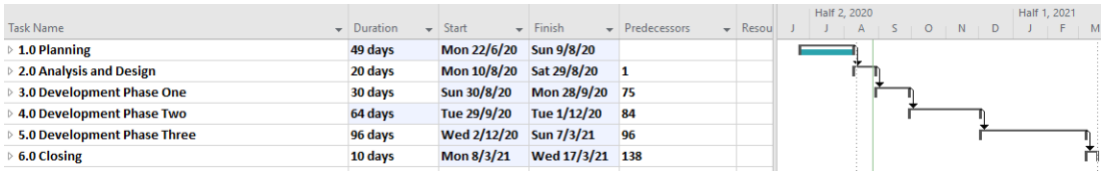
3.2 Connection Testing

3.2.1 Test the Connection Between Application and Server

3.2.2 Test the Connection Between Application and Database

3.5 Gantt Chart

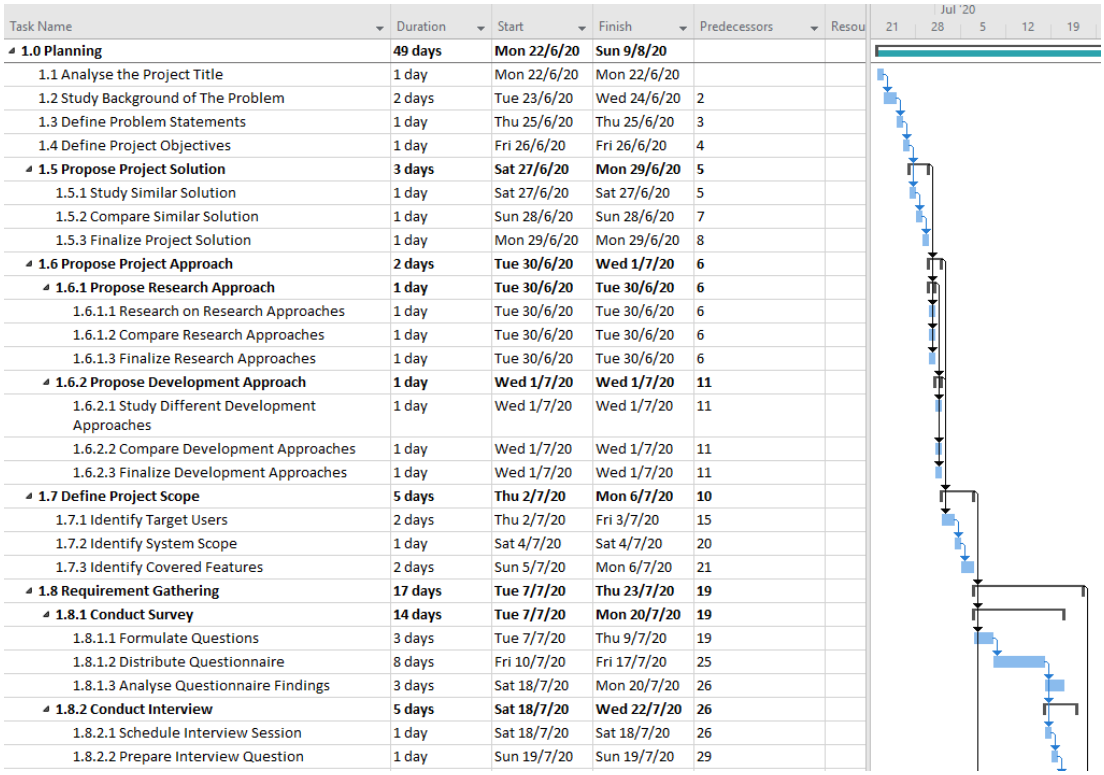
3.5.1 Overview of The Project Timeline



Task Name	Duration	Start	Finish	Predecessors	Resou
1.0 Planning	49 days	Mon 22/6/20	Sun 9/8/20		
2.0 Analysis and Design	20 days	Mon 10/8/20	Sat 29/8/20	1	
3.0 Development Phase One	30 days	Sun 30/8/20	Mon 28/9/20	75	
4.0 Development Phase Two	64 days	Tue 29/9/20	Tue 1/12/20	84	
5.0 Development Phase Three	96 days	Wed 2/12/20	Sun 7/3/21	96	
6.0 Closing	10 days	Mon 8/3/21	Wed 17/3/21	138	

Figure 3.2: Project Timeline Overview

3.5.2 Planning Phase Timeline



Task Name	Duration	Start	Finish	Predecessors	Resou
1.0 Planning	**49 days**	**Mon 22/6/20**	**Sun 9/8/20**		
1.1 Analyse the Project Title	1 day	Mon 22/6/20	Mon 22/6/20		
1.2 Study Background of The Problem	2 days	Tue 23/6/20	Wed 24/6/20	2	
1.3 Define Problem Statements	1 day	Thu 25/6/20	Thu 25/6/20	3	
1.4 Define Project Objectives	1 day	Fri 26/6/20	Fri 26/6/20	4	
1.5 Propose Project Solution	**3 days**	**Sat 27/6/20**	**Mon 29/6/20**	**5**	
1.5.1 Study Similar Solution	1 day	Sat 27/6/20	Sat 27/6/20	5	
1.5.2 Compare Similar Solution	1 day	Sun 28/6/20	Sun 28/6/20	7	
1.5.3 Finalize Project Solution	1 day	Mon 29/6/20	Mon 29/6/20	8	
1.6 Propose Project Approach	**2 days**	**Tue 30/6/20**	**Wed 1/7/20**	**6**	
1.6.1 Propose Research Approach	**1 day**	**Tue 30/6/20**	**Tue 30/6/20**	**6**	
1.6.1.1 Research on Research Approaches	1 day	Tue 30/6/20	Tue 30/6/20	6	
1.6.1.2 Compare Research Approaches	1 day	Tue 30/6/20	Tue 30/6/20	6	
1.6.1.3 Finalize Research Approaches	1 day	Tue 30/6/20	Tue 30/6/20	6	
1.6.2 Propose Development Approach	**1 day**	**Wed 1/7/20**	**Wed 1/7/20**	**11**	
1.6.2.1 Study Different Development Approaches	1 day	Wed 1/7/20	Wed 1/7/20	11	
1.6.2.2 Compare Development Approaches	1 day	Wed 1/7/20	Wed 1/7/20	11	
1.6.2.3 Finalize Development Approaches	1 day	Wed 1/7/20	Wed 1/7/20	11	
1.7 Define Project Scope	**5 days**	**Thu 2/7/20**	**Mon 6/7/20**	**10**	
1.7.1 Identify Target Users	2 days	Thu 2/7/20	Fri 3/7/20	15	
1.7.2 Identify System Scope	1 day	Sat 4/7/20	Sat 4/7/20	20	
1.7.3 Identify Covered Features	2 days	Sun 5/7/20	Mon 6/7/20	21	
1.8 Requirement Gathering	**17 days**	**Tue 7/7/20**	**Thu 23/7/20**	**19**	
1.8.1 Conduct Survey	**14 days**	**Tue 7/7/20**	**Mon 20/7/20**	**19**	
1.8.1.1 Formulate Questions	3 days	Tue 7/7/20	Thu 9/7/20	19	
1.8.1.2 Distribute Questionnaire	8 days	Fri 10/7/20	Fri 17/7/20	25	
1.8.1.3 Analyse Questionnaire Findings	3 days	Sat 18/7/20	Mon 20/7/20	26	
1.8.2 Conduct Interview	**5 days**	**Sat 18/7/20**	**Wed 22/7/20**	**26**	
1.8.2.1 Schedule Interview Session	1 day	Sat 18/7/20	Sat 18/7/20	26	
1.8.2.2 Prepare Interview Question	1 day	Sun 19/7/20	Sun 19/7/20	29	

Figure 3.3: Planning Phase Timeline

Task Name	Duration	Start	Finish	Predecessors	Resou
1.8.2.3 Contact Interviewee	1 day	Mon 20/7/20	Mon 20/7/20	30	
1.8.2.4 Interview	1 day	Tue 21/7/20	Tue 21/7/20	31	
1.8.2.5 Analyse Result	1 day	Wed 22/7/20	Wed 22/7/20	32	
1.8.3 Review similar systems	**4 days**	**Tue 7/7/20**	**Fri 10/7/20**	**19**	
1.8.3.1 Prepare cross Analysis Table	1 day	Tue 7/7/20	Tue 7/7/20	19	
1.8.3.2 Review Pain Squad	1 day	Wed 8/7/20	Wed 8/7/20	35	
1.8.3.3 Review Achy Penguin	1 day	Wed 8/7/20	Wed 8/7/20	35	
1.8.3.4 Review ICPCN	1 day	Wed 8/7/20	Wed 8/7/20	35	
1.8.3.5 Review Pain Buddy	1 day	Wed 8/7/20	Wed 8/7/20	35	
1.8.3.6 Review ASTHMAXcel	1 day	Wed 8/7/20	Wed 8/7/20	35	
1.8.3.7 Review Quest - Te Whitianga	1 day	Wed 8/7/20	Wed 8/7/20	35	
1.8.3.8 Record Details in Cross Analysis Table	1 day	Thu 9/7/20	Thu 9/7/20	41	
1.8.3.9 Identify Common Elements	**1 day**	**Fri 10/7/20**	**Fri 10/7/20**	**42**	
1.8.3.9.1 Identify Common Game Design Elements	1 day	Fri 10/7/20	Fri 10/7/20	42	
1.8.3.9.2 Identify Common Features	1 day	Fri 10/7/20	Fri 10/7/20	42	
1.8.3.9.3 Identify Common Pain Assessment Tools	1 day	Fri 10/7/20	Fri 10/7/20	42	
1.8.4 Literature Review	**13 days**	**Sat 11/7/20**	**Thu 23/7/20**	**34**	
1.8.4.1 Review Gamification Concept	**9 days**	**Sat 11/7/20**	**Sun 19/7/20**	**34**	
1.8.4.1.1 Study Gamification Background	3 days	Sat 11/7/20	Mon 13/7/20	34	
1.8.4.1.2 Study Game Design Elements	3 days	Tue 14/7/20	Thu 16/7/20	49	
1.8.4.1.3 Review Gamification Effects	3 days	Fri 17/7/20	Sun 19/7/20	50	
1.8.4.2 Understand Child Cancer Patient	**2 days**	**Mon 20/7/20**	**Tue 21/7/20**	**48**	
1.8.4.2.1 Study Child Cancer Patient in Malaysia	1 day	Mon 20/7/20	Mon 20/7/20	48	
1.8.4.2.2 Understand Common Symptom of Child Cancer Patient	1 day	Tue 21/7/20	Tue 21/7/20	53	
1.8.4.3 Review Pain Assessment Process	**3 days**	**Tue 21/7/20**	**Thu 23/7/20**	**53**	
1.8.4.3.1 Compare Pain Assessment Tools	2 days	Tue 21/7/20	Wed 22/7/20		
1.8.4.3.2 Study Pain Management Process	1 day	Thu 23/7/20	Thu 23/7/20	56	
1.9 Requirement Elicitation	**7 days**	**Fri 24/7/20**	**Thu 30/7/20**	**23**	

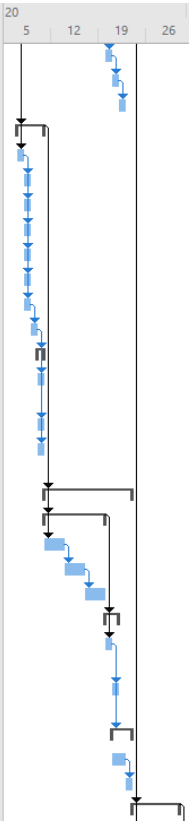


Figure 3.4: Planning Phase Timeline (Continued)

Task Name	Duration	Start	Finish	Predecessors	Resou
1.9.1 Select Recommended Feature	1 day	Fri 24/7/20	Fri 24/7/20	23	
1.9.2 Select Game Design Elements	1 day	Fri 24/7/20	Fri 24/7/20	23	
1.9.3 Select Pain Assessment Tools	1 day	Fri 24/7/20	Fri 24/7/20	23	
1.9.4 Draft Requirement List	2 days	Sat 25/7/20	Sun 26/7/20	61	
1.9.5 Examine Requirement List	2 days	Mon 27/7/20	Tue 28/7/20	62	
1.9.6 Refine Requirement List	2 days	Wed 29/7/20	Thu 30/7/20	63	
1.10 Project Scheduling	**10 days**	**Fri 31/7/20**	**Sun 9/8/20**	**58**	
1.10.1 Create Work Breakdown Structure	**4 days**	**Fri 31/7/20**	**Mon 3/8/20**	**58**	
1.10.1.1 Identify Main Activities	2 days	Fri 31/7/20	Sat 1/8/20	58	
1.10.1.2 Breakdown Activities into Smaller Task	2 days	Sun 2/8/20	Mon 3/8/20	67	
1.10.2 Create Gantt Chart	**6 days**	**Tue 4/8/20**	**Sun 9/8/20**	**66**	
1.10.2.1 Determine Task Dependency	2 days	Tue 4/8/20	Wed 5/8/20	66	
1.10.2.2 Estimate Duration	1 day	Thu 6/8/20	Thu 6/8/20	70	
1.10.2.3 Draft Gantt Chart	1 day	Fri 7/8/20	Fri 7/8/20	71	
1.10.2.4 Examine Gantt Chart	1 day	Sat 8/8/20	Sat 8/8/20	72	
1.10.2.5 Finalize Gantt Chart	1 day	Sun 9/8/20	Sun 9/8/20	73	

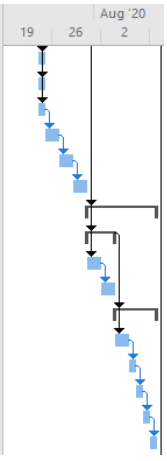


Figure 3.5: Planning Phase Timeline (Continued)

3.5.3 Analysis and Design Phase Timeline

Task Name	Duration	Start	Finish	Predecessors	Resou
2.0 Analysis and Design	**20 days**	**Mon 10/8/20**	**Sat 29/8/20**	**1**	
2.1 Design Use Case Diagram	1 day	Mon 10/8/20	Mon 10/8/20	1	
2.2 Generate Use Case Description	1 day	Tue 11/8/20	Tue 11/8/20	76	
2.3 Design UI Flow Diagram	2 days	Wed 12/8/20	Thu 13/8/20	77	
2.4 Design Data Model Diagram	2 days	Fri 14/8/20	Sat 15/8/20	78	
2.5 Design Data Flow Diagram	2 days	Sun 16/8/20	Mon 17/8/20	79	
2.6 Create Prototype	**12 days**	**Tue 18/8/20**	**Sat 29/8/20**	**80**	
2.6.1 Create Web Application Wireframe	4 days	Tue 18/8/20	Fri 21/8/20	80	
2.6.2 Create Mobile Application Wireframe	8 days	Sat 22/8/20	Sat 29/8/20	82	

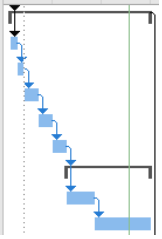


Figure 3.6: Analysis and Design Phase Timeline

3.5.4 Development Phase One Timeline

Task Name	Duration	Start	Finish	Predecessors	Resou
3.0 Development Phase One	**30 days**	**Sun 30/8/20**	**Mon 28/9/20**	**75**	
3.1 Set Up Connection	**21 days**	**Sun 30/8/20**	**Sat 19/9/20**	**75**	
3.1.1 Create Mobile Application Repository	3 days	Sun 30/8/20	Tue 1/9/20	75	
3.1.2 Create Web Application Repository	3 days	Wed 2/9/20	Fri 4/9/20	86	
3.1.3 Setup Server	7 days	Sat 5/9/20	Fri 11/9/20	87	
3.1.4 Setup Database	2 days	Sat 12/9/20	Sun 13/9/20	88	
3.1.5 Connect Application to Server	3 days	Mon 14/9/20	Wed 16/9/20	89	
3.1.6 Connect Application to Database	3 days	Thu 17/9/20	Sat 19/9/20	90	
3.2 Connection Testing	**9 days**	**Sun 20/9/20**	**Mon 28/9/20**	**85**	
3.2.1 Test the Connection Between Application and Server	3 days	Sun 20/9/20	Tue 22/9/20	85	
3.2.2 Test the Connection Between Server and Database	3 days	Wed 23/9/20	Fri 25/9/20	93	
3.2.3 Test the Connection Between Application and Database	3 days	Sat 26/9/20	Mon 28/9/20	94	

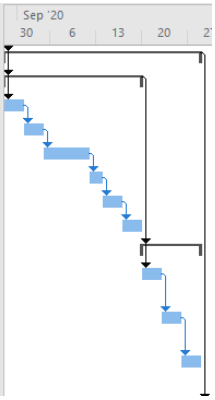


Figure 3.7: Development Phase One Timeline

3.5.5 Development Phase Two Timeline

Task Name	Duration	Start	Finish	Predecessors	Resou
4.0 Development Phase Two	**55 days**	**Tue 29/9/20**	**Sun 22/11/20**	**84**	
4.1 Web Application Development	**41 days**	**Tue 29/9/20**	**Sun 8/11/20**	**84**	
4.1.1 Create Web Application UI Framework	1 day	Tue 29/9/20	Tue 29/9/20	84	
4.1.2 Create Login Feature	**5 days**	**Wed 30/9/20**	**Sun 4/10/20**	**98**	
4.1.2.1 Create Login UI	1 day	Wed 30/9/20	Wed 30/9/20	98	
4.1.2.2 Create Registration UI	1 day	Thu 1/10/20	Thu 1/10/20	100	
4.1.2.3 Implement Registration Algorithm	2 days	Fri 2/10/20	Sat 3/10/20	101	
4.1.2.4 Implement Login Algorithm	1 day	Sun 4/10/20	Sun 4/10/20	102	
4.1.3 Test Login Feature	**2 days**	**Mon 5/10/20**	**Tue 6/10/20**	**99**	
4.1.3.1 Test login algorithm	1 day	Mon 5/10/20	Mon 5/10/20	99	
4.1.3.2 Test registration algorithm	1 day	Tue 6/10/20	Tue 6/10/20	105	
4.1.4 Create analysis feature	**13 days**	**Wed 7/10/20**	**Mon 19/10/20**	**104**	
4.1.4.1 Create Analysis Page UI	1 day	Wed 7/10/20	Wed 7/10/20	104	
4.1.4.2 Implement Algorithm to Retrieve Patient Data	2 days	Thu 8/10/20	Fri 9/10/20	108	
4.1.4.3 Implement Algorithm to Generate Different Analysis	4 days	Sat 10/10/20	Tue 13/10/20	109	
4.1.4.4 Implement Algorithm to Display Chart and Graph	3 days	Wed 14/10/20	Fri 16/10/20	110	
4.1.4.5 Implement Algorithm to Send Notification	3 days	Sat 17/10/20	Mon 19/10/20	111	
4.1.5 Test Analysis Feature	**3 days**	**Tue 20/10/20**	**Thu 22/10/20**	**107**	
4.1.5.1 Examine the Accuracy of Analysis Result Displayed	2 days	Tue 20/10/20	Wed 21/10/20	107	
4.1.5.2 Test the Notification Algorithm	1 day	Thu 22/10/20	Thu 22/10/20	114	
4.1.6 Create Patient Data Management Feature	**10 days**	**Fri 23/10/20**	**Sun 1/11/20**	**113**	
4.1.6.1 Create Patient Data Management UI	1 day	Fri 23/10/20	Fri 23/10/20	113	
4.1.6.2 Implement Algorithm to Add New Patient	2 days	Sat 24/10/20	Sun 25/10/20	117	
4.1.6.3 Implement Algorithm to Retrieve Selected Patient Data	2 days	Mon 26/10/20	Tue 27/10/20	118	
4.1.6.4 Implement Algorithm to Display Selected Patient Data	2 days	Wed 28/10/20	Thu 29/10/20	119	

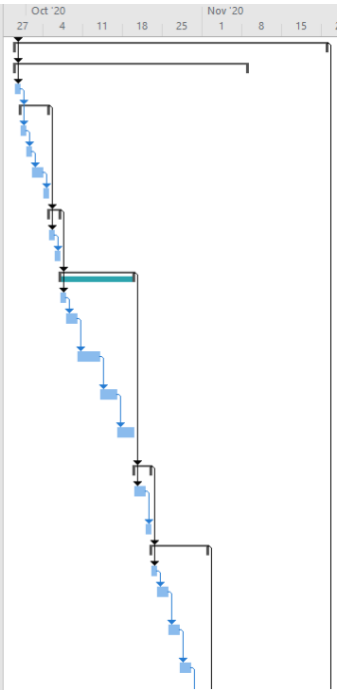


Figure 3.8: Development Phase Two Timeline

Task Name	Duration	Start	Finish	Predecessors	Resou
4.1.6.4 Implement Algorithm to Display Selected Patient Data	2 days	Wed 28/10/20	Thu 29/10/20	119	
4.1.6.5 Implement Algorithm to Update Selected Patient Data	2 days	Fri 30/10/20	Sat 31/10/20	120	
4.1.6.6 Implement Algorithm to Remove Selected Patient	1 day	Sun 1/11/20	Sun 1/11/20	121	
4.1.7 Test Patient Data Management Feature	**3 days**	**Mon 2/11/20**	**Wed 4/11/20**	**116**	
4.1.7.1 Test the Add New Patient Function	1 day	Mon 2/11/20	Mon 2/11/20	116	
4.1.7.2 Examine the Accuracy of Selected Patient Data	1 day	Mon 2/11/20	Mon 2/11/20	116	
4.1.7.3 Test the Update Patient Data Function	1 day	Tue 3/11/20	Tue 3/11/20	125	
4.1.7.4 Test the Remove Patient Function	1 day	Wed 4/11/20	Wed 4/11/20	126	
4.1.8 Combine All Developed Feature	4 days	Thu 5/11/20	Sun 8/11/20	123	
4.2 Web Application System Testing	**14 days**	**Mon 9/11/20**	**Sun 22/11/20**	**128**	
4.2.1 Test the Flow of System	14 days	Mon 9/11/20	Sun 22/11/20	128	

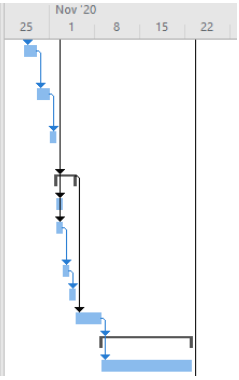


Figure 3.9: Development Phase Two Timeline (Continued)

3.5.6 Development Phase Three Timeline

Task Name	Duration	Start	Finish	Predecessors	Resou
5.0 Development Phase Three	**89 days**	**Mon 23/11/20**	**Fri 19/2/21**	**96**	
5.1 Mobile Application Development	**88 days**	**Mon 23/11/20**	**Thu 18/2/21**	**96**	
5.1.1 Create Mobile Application Framework	2 days	Mon 23/11/20	Tue 24/11/20	96	
5.1.2 Create Login Feature	**5 days**	**Wed 25/11/20**	**Sun 29/11/20**	**133**	
5.1.2.1 Create login UI	2 days	Wed 25/11/20	Thu 26/11/20	133	
5.1.2.2 Implement Login Algorithm	3 days	Fri 27/11/20	Sun 29/11/20	135	
5.1.3 Test Login Feature	**2 days**	**Mon 30/11/20**	**Tue 1/12/20**	**134**	
5.1.3.1 Insert Dummy User Data	1 day	Mon 30/11/20	Mon 30/11/20	134	
5.1.3.2 Test Login Algorithm	1 day	Tue 1/12/20	Tue 1/12/20	138	
5.1.4 Create Main Menu UI	2 days	Wed 2/12/20	Thu 3/12/20	137	
5.1.5 Create Pain Recorder Feature	**12 days**	**Fri 4/12/20**	**Tue 15/12/20**	**140**	
5.1.5.1 Create Pain Recorder UI	2 days	Fri 4/12/20	Sat 5/12/20	140	
5.1.5.2 Design Pain Scales Graphic	2 days	Sun 6/12/20	Mon 7/12/20	142	
5.1.5.3 Implement Algorithm to Interact with Pain Scales	3 days	Tue 8/12/20	Thu 10/12/20	143	
5.1.5.4 Combine Pain Scales	2 days	Fri 11/12/20	Sat 12/12/20	144	
5.1.5.5 Implement Algorithm to Upload Pain Data to Server	3 days	Sun 13/12/20	Tue 15/12/20	145	
5.1.6 Test Pain Recorder Feature	**2 days**	**Wed 16/12/20**	**Thu 17/12/20**	**141**	
5.1.6.1 Test the Pain Assessment Process	1 day	Wed 16/12/20	Wed 16/12/20	141	
5.1.6.2 Examine the Accuracy of Data Received from The Process	1 day	Thu 17/12/20	Thu 17/12/20	148	
5.1.7 Create Game Feature	**30 days**	**Fri 18/12/20**	**Sat 16/1/21**	**147**	
5.1.7.1 Design Game Graphics	**9 days**	**Fri 18/12/20**	**Sat 26/12/20**	**149**	
5.1.7.1.1 Design Game Character	3 days	Fri 18/12/20	Sun 20/12/20	147	
5.1.7.1.2 Design Game Background	3 days	Mon 21/12/20	Wed 23/12/20	152	
5.1.7.1.3 Design Game Tile Set	3 days	Thu 24/12/20	Sat 26/12/20	153	
5.1.7.2 Develop Character Action	5 days	Sun 27/12/20	Thu 31/12/20	154	
5.1.7.3 Develop Game Mechanics	13 days	Fri 1/1/21	Wed 13/1/21	155	
5.1.7.4 Compile Game Components	3 days	Thu 14/1/21	Sat 16/1/21	156	
5.1.8 Test Game Feature	**4 days**	**Sun 17/1/21**	**Wed 20/1/21**	**150**	
5.1.8.1 Test Game Character Action	2 days	Sun 17/1/21	Mon 18/1/21	150	

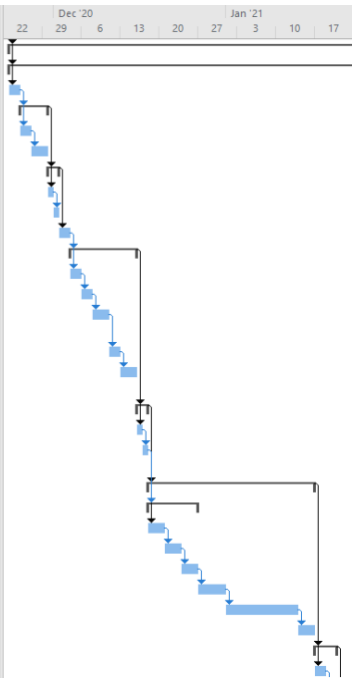
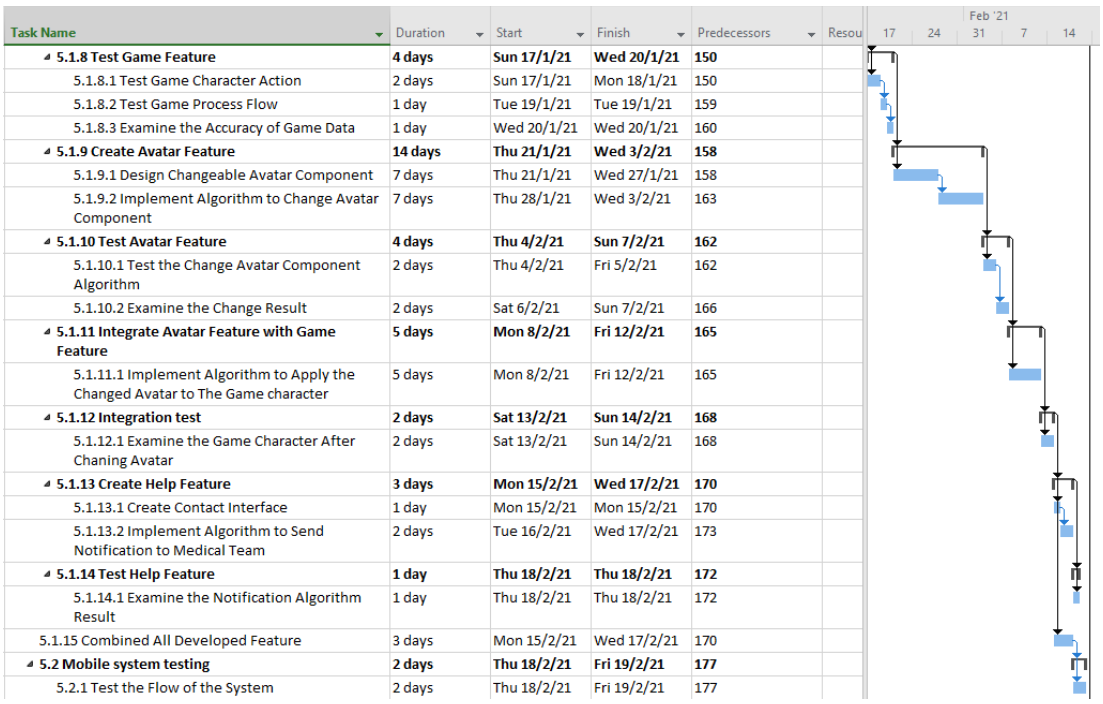


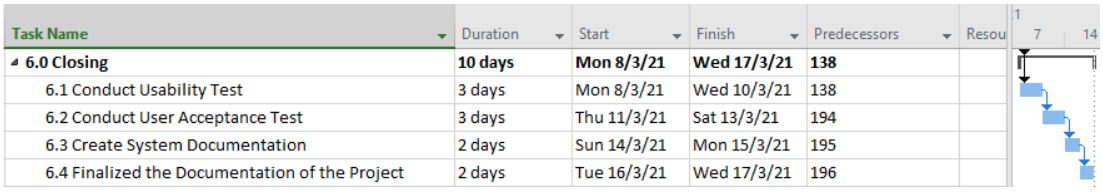
Figure 3.10: Development Phase Three Timeline



Task Name	Duration	Start	Finish	Predecessors	Resou
5.1.8 Test Game Feature	**4 days**	**Sun 17/1/21**	**Wed 20/1/21**	**150**	
5.1.8.1 Test Game Character Action	2 days	Sun 17/1/21	Mon 18/1/21	150	
5.1.8.2 Test Game Process Flow	1 day	Tue 19/1/21	Tue 19/1/21	159	
5.1.8.3 Examine the Accuracy of Game Data	1 day	Wed 20/1/21	Wed 20/1/21	160	
5.1.9 Create Avatar Feature	**14 days**	**Thu 21/1/21**	**Wed 3/2/21**	**158**	
5.1.9.1 Design Changeable Avatar Component	7 days	Thu 21/1/21	Wed 27/1/21	158	
5.1.9.2 Implement Algorithm to Change Avatar Component	7 days	Thu 28/1/21	Wed 3/2/21	163	
5.1.10 Test Avatar Feature	**4 days**	**Thu 4/2/21**	**Sun 7/2/21**	**162**	
5.1.10.1 Test the Change Avatar Component Algorithm	2 days	Thu 4/2/21	Fri 5/2/21	162	
5.1.10.2 Examine the Change Result	2 days	Sat 6/2/21	Sun 7/2/21	166	
5.1.11 Integrate Avatar Feature with Game Feature	**5 days**	**Mon 8/2/21**	**Fri 12/2/21**	**165**	
5.1.11.1 Implement Algorithm to Apply the Changed Avatar to The Game character	5 days	Mon 8/2/21	Fri 12/2/21	165	
5.1.12 Integration test	**2 days**	**Sat 13/2/21**	**Sun 14/2/21**	**168**	
5.1.12.1 Examine the Game Character After Chaning Avatar	2 days	Sat 13/2/21	Sun 14/2/21	168	
5.1.13 Create Help Feature	**3 days**	**Mon 15/2/21**	**Wed 17/2/21**	**170**	
5.1.13.1 Create Contact Interface	1 day	Mon 15/2/21	Mon 15/2/21	170	
5.1.13.2 Implement Algorithm to Send Notification to Medical Team	2 days	Tue 16/2/21	Wed 17/2/21	173	
5.1.14 Test Help Feature	**1 day**	**Thu 18/2/21**	**Thu 18/2/21**	**172**	
5.1.14.1 Examine the Notification Algorithm Result	1 day	Thu 18/2/21	Thu 18/2/21	172	
5.1.15 Combined All Developed Feature	3 days	Mon 15/2/21	Wed 17/2/21	170	
5.2 Mobile system testing	**2 days**	**Thu 18/2/21**	**Fri 19/2/21**	**177**	
5.2.1 Test the Flow of the System	2 days	Thu 18/2/21	Fri 19/2/21	177	

Figure 3.11: Development Phase Three Timeline (Continued)

3.5.7 Closing Phase Timeline



Task Name	Duration	Start	Finish	Predecessors	Resou
6.0 Closing	**10 days**	**Mon 8/3/21**	**Wed 17/3/21**	**138**	
6.1 Conduct Usability Test	3 days	Mon 8/3/21	Wed 10/3/21	138	
6.2 Conduct User Acceptance Test	3 days	Thu 11/3/21	Sat 13/3/21	194	
6.3 Create System Documentation	2 days	Sun 14/3/21	Mon 15/3/21	195	
6.4 Finalized the Documentation of the Project	2 days	Tue 16/3/21	Wed 17/3/21	196	

Figure 3.12: Closing Phase Timeline

3.6 Conclusion

The system development life cycle selected for this project is phased development methodology. Four main stages of this methodology were identified, and the processes and activities were described according to the respective stage. Besides, seven tools were identified and selected to be the main development tools in this project. Lastly, a work breakdown structure and a Gantt chart of the project were included for reference.

CHAPTER 4

PROJECT SPECIFICATION

4.1 Introduction

In this chapter, specification of the project was defined through the analysis of the gathered requirements. Use case diagrams, interface flow diagram, and system user interface were designed and were included in this chapter to provide a clearer image on the designs and functionalities of the system.

4.2 Facts finding

4.2.1 Questionnaire

A survey was conducted with the medical team in the paediatric cancer department of the hospital or cancer care centre. The number of expected responses was 30 but only 16 responses were collected. The questionnaire was sent to the hospital and cancer care centre around the world, and the collected responses were analysed and summarized.

4.2.1.1 Personal Information

Table 4.1 summarized the background of the respondents. More than half of the respondents of this survey is female. The ratio of gender is not constant because the questionnaire was distributed randomly but it does not affect the results. Besides, around half of the respondents are doctors, followed by nurse, pharmacist, and physiotherapist. In addition, 87.5% of them have done a healthcare related job. Also, around half of the respondent has taken care of children aged from 2 – 11 years old. Fortunately, only one of them has no experience in taking care of children with cancer. Based on the personal information gathered, the data of this survey has integrity and accuracy as most of the respondent are healthcare related and experienced.

Table 4.1: Respondent Background Summary

Characteristic	Numbers	Characteristic	Numbers
Gender		**Relationship with Children**	
Male	5 (31.3%)	Doctor	9 (56.3%)
Female	11 (68.8%)	Nurse	5 (31.3%)
		Pharmacist	1 (6.3%)
		Physiotherapist	1 (6.3%)
Healthcare Related Job		**Years of experience in taking care of children**	Numbers
Yes	14 (87.5%)	Less than 1 year	10 (62.5%)
No	2 (12.5%)	1 to 2 years	1 (6.3%)
		2 to 5 years	1 (6.3%)
		More than 5 years	3 (18.8%)
		No experience	1 (6.3%)

Table 4.1 (Continued)

Children's age ranges the respondent has taken care before	Number of Respondents
0 – 2 years old	5 (31.3%)
2 – 7 years old	8 (50%)
7 – 11 years old	9 (56.3%)
11 years old and above	6 (37.5%)

4.2.1.2 Children That Undergo Treatment

In this section, several questions were set to understand more about the children undergo cancer treatment as children with cancer are the main target user of this project. It is important to understand more about them in order to tailor the application that fit them best.

Figure 4.1 shows the common symptoms a young cancer patient has throughout the cancer treatment. Pain and nausea are the most common symptoms with 14 votes, followed by vomit with 13 votes, lack of energy and fatigue with 11 votes, and lack of appetite with 10 votes. Results shows that children are having several symptoms throughout the treatment, matching with the literature reviewed. This proved that it is important to have a feature in helping children to reduce the pain they are suffering.

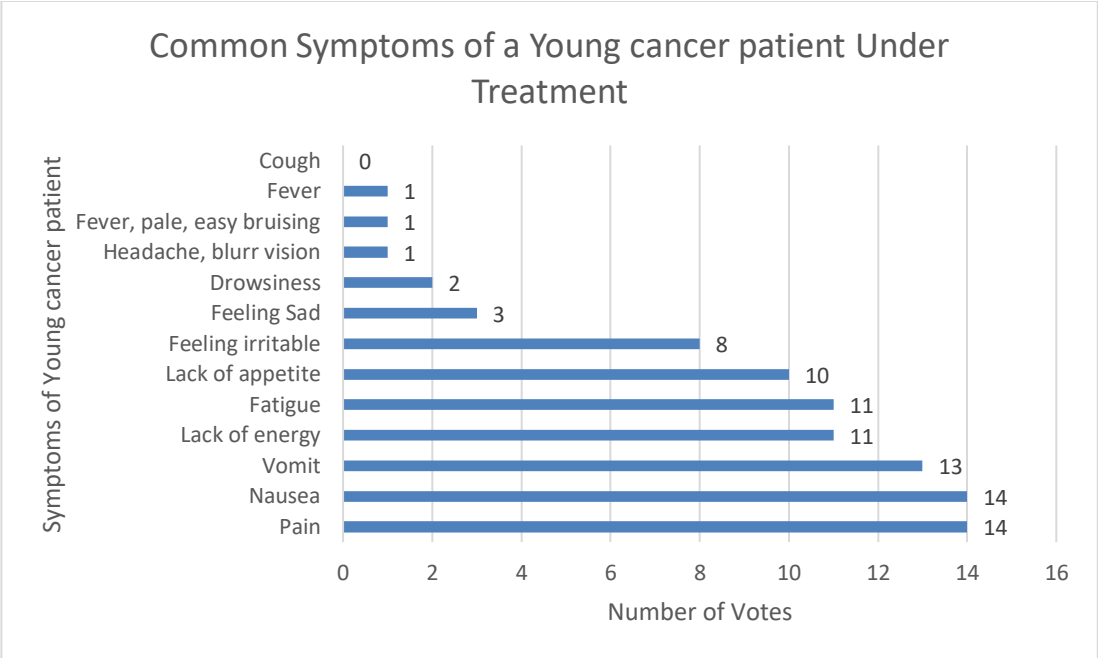


Figure 4.1: Common Symptoms of a Young cancer patient Undergo Treatment

Figure 4.2 shows the time interval between each pain assessment session. Over half of the respondents voted 4 to 6 hours as the time interval between each pain assessment session. Also, around 30% of the respondent voted 2 to 6 hours as the standard time interval. As from the results analysed, the application should be able to customize the pain assessment interval or pre-set the pain assessment interval to around 4 to 8 hours.

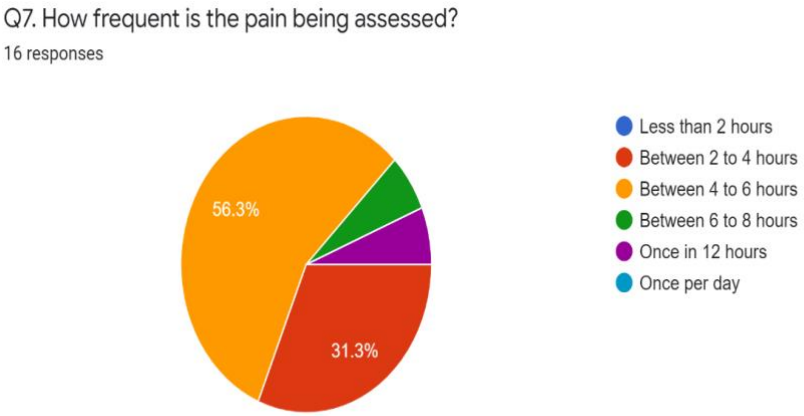


Figure 4.2: The Time Interval Between Pain Assessment

Figure 4.3, Figure 4.4, and Figure 4.5 studies the children reaction during the pain assessment process. The results gathered from all three question are even and consistent. Almost half of the respondents agreed that children are not willing to do the pain assessment. However, the percentage of disagreement is also close to the percentage of agreement with the difference of 2% only. Besides, children also feel irritable when doing pain assessment with almost half of the votes (43.8%). They could be frustrated, fatigue, or lack of interest in doing the pain assessment. At last, around half of the respondents agree that children are having difficulty in describing pain (56.3%). Children at younger age may not understand the pain and the way to express them. Based on the results, the application should be designed appropriately to attract children to use the pain recorder in the application. Also, the tools should be easy for children to understand to increase the accuracy of the pain identified.

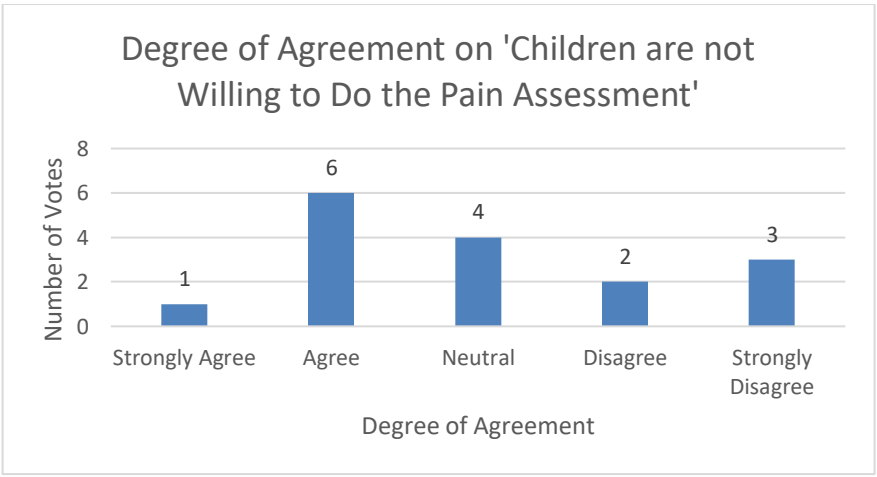


Figure 4.3: Degree of Agreement on Children Willingness in Doing Pain Assessment

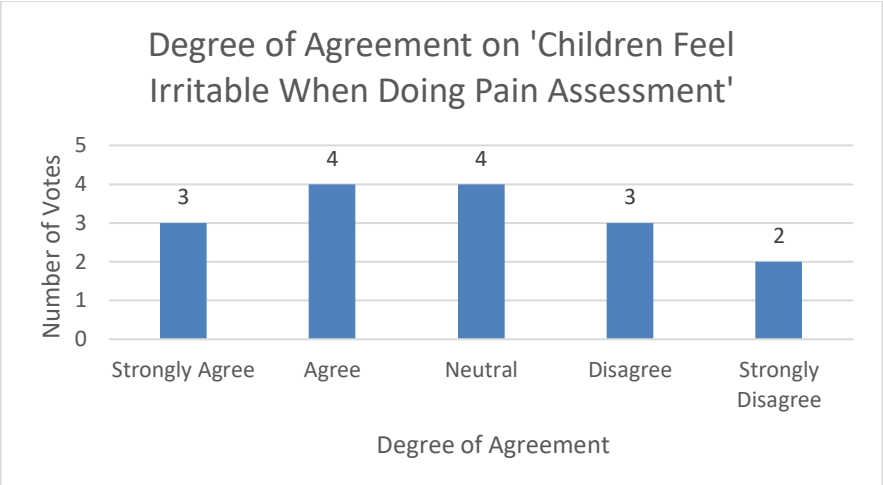


Figure 4.4: Degree of Agreement on 'Children Feel Irritable When Doing Pain Assessment'

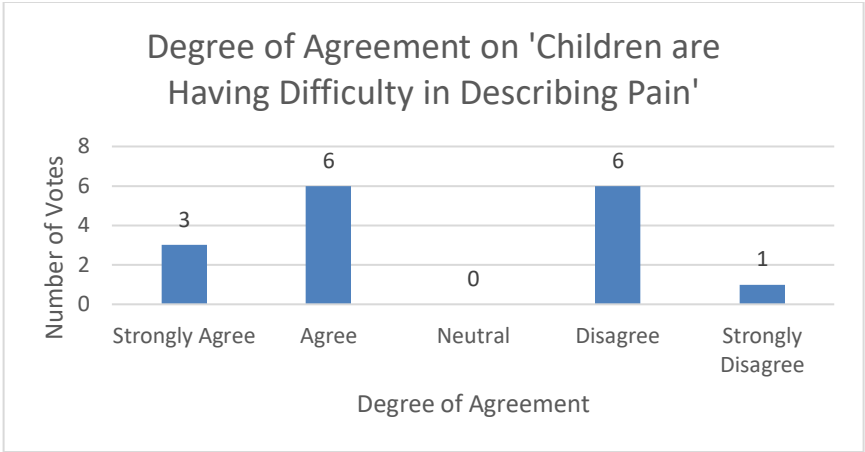


Figure 4.5: Degree of Agreement on 'Children are Having Difficulty in Describing Pain'

Table 4.2 summarized the pain assessment processes described by the respondents. Based on the Table 4.2, most of the respondents use pain assessment scales to assess the pain. Other techniques such as observation and direct questioning are rarely used in assessing children pain. Only two respondents use the combination of different technique such as pain assessment scales and observation during the process. All in all, the pain assessment process in the application should include pain assessment scales based on the results gathered.

Table 4.2: Pain Assessment Process Summary

Pain assessment process	Number of Respondents
Use pain assessment scales (Visual assessment scale, Wong Baker face, FLACC etc.)	10
Observation	1
Direct questioning	1
Combined technique (pain assessment scales + observation etc.)	2
Others	2

4.2.1.3 Pain Assessment Tools

In this section, several questions were set to understand more about the pain assessment tools used in the pain assessment process in order to select the suitable pain assessment tools to be included in the pain assessment process.

Figure 4.6 shows the most common pain scales to be used in pain assessment process. Among the provided options, faces scales has the highest number of votes (93.8%), followed by numeric rating scales (81.3%), and visual analogue scales (56.3%). As from the data gathered, these three scales are suitable to be included in the pain recorder feature.

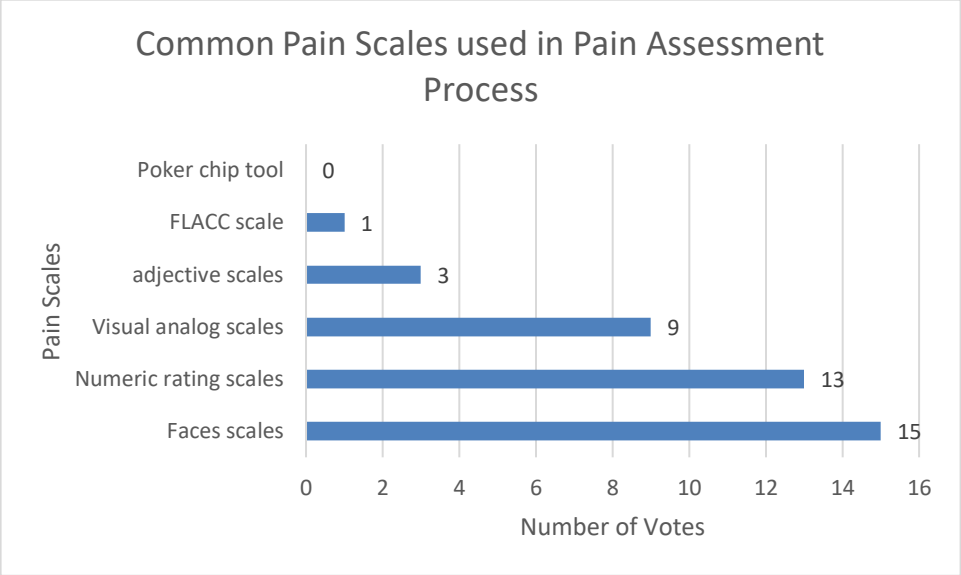


Figure 4.6: The Tools Used in Pain Assessment

Figure 4.7 and Figure 4.8 illustrates the effectiveness of the pain assessment tools in providing useful information for medical team to understand more about the pain. Results shows that the pain assessment tools can provide useful information about the patient pain. Also, about half of the respondent thinks that the tools are easy to analyse. This is important as some of the tools may provide useful information, but it takes a long time to extract and analyse the data.

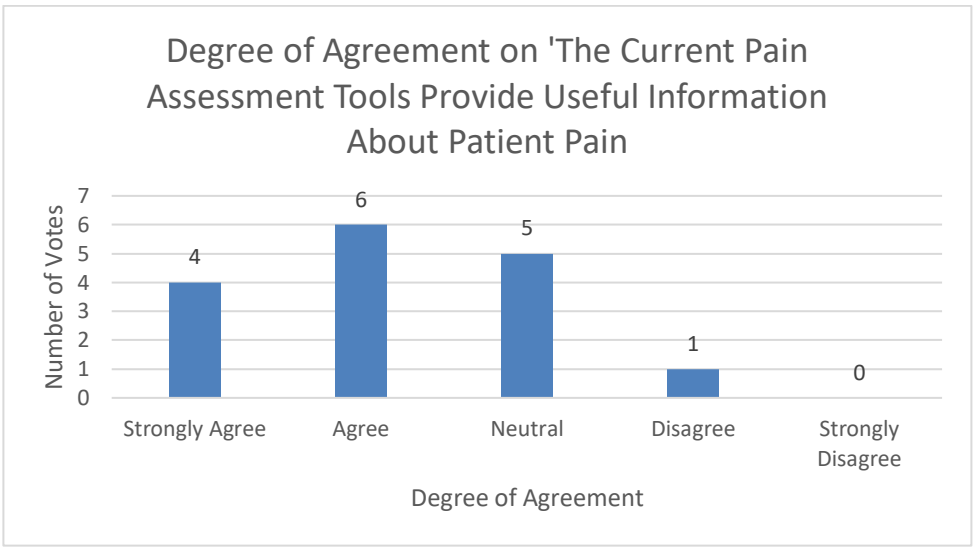


Figure 4.7: Degree of Agreement on 'The Current Pain Assessment Tools Provide Useful Information about Patient Pain'

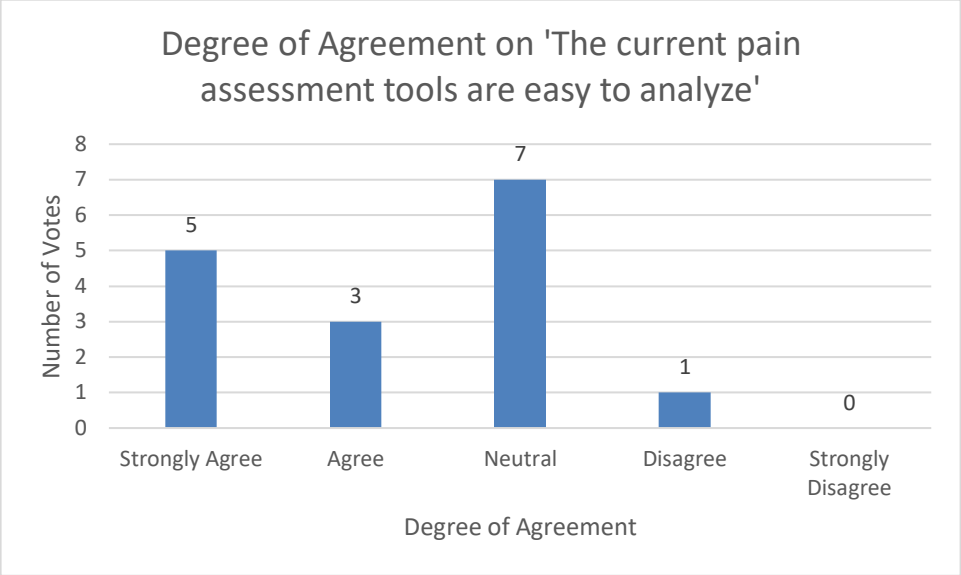


Figure 4.8: Degree of Agreement on 'The Current Pain Assessment Tools are Easy to Analyse'

Figure 4.9 represents the degree of agreement on 'the young cancer patient has no problem in using pain assessment tools. Results shows that over 50% of the respondents disagreed on the statements. This indicates that children are facing problems when using the pain assessment tools. Several problems such as the choice of pain assessment tools, or the design of pain assessment tools could affect the performance of the pain assessment tools. However, the actual problems are not discovered by this survey.

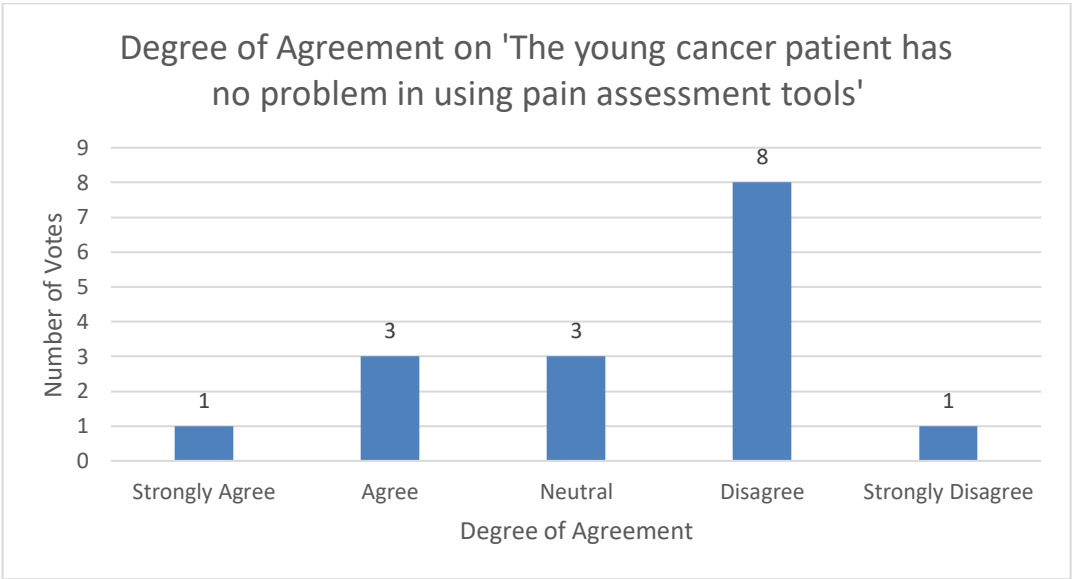


Figure 4.9: The Degree of Agreement on 'The Young Cancer Patient Has No Problem in Using Pain Assessment Tools'

Figure 4.10 describe the way of keeping the pain records by the respondents. The purpose of this question is to understand the how the pain records are being kept by the respondent. According to the results below, all three ways are being used by over half of the respondents. Although there are respondents use hospital system to keep the record, many respondents also keep the paper record. This could link to the problem statement of the project as paper record could be difficult to keep and organize. A system that could save and organize the pain records automatically could help the medical team in solving the problem.

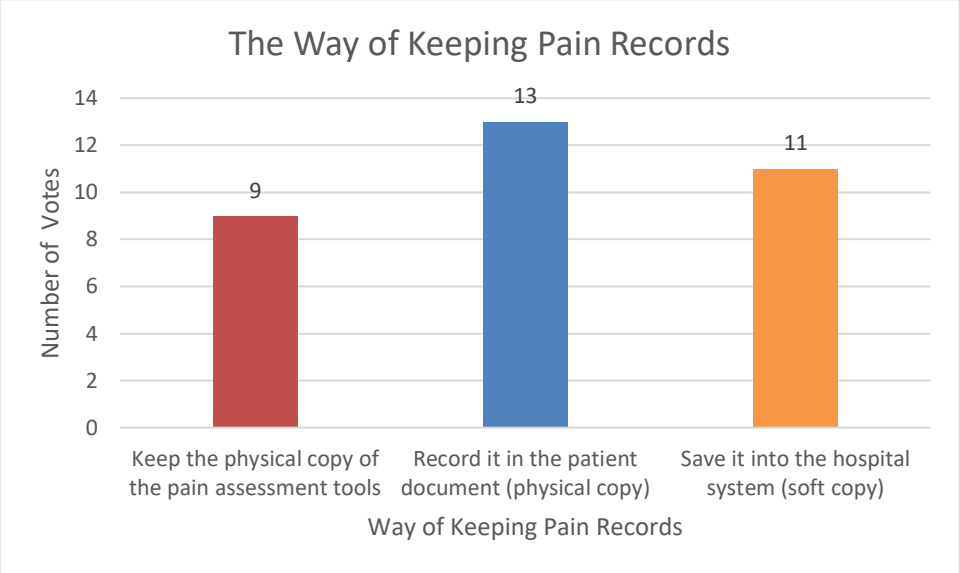


Figure 4.10: The Way of Pain Records Being Kept

4.2.1.4 System Features

In this section, several questions were set to collect respondent's opinion on the system feature suggested and the feature the respondent would like to have in the system.

Figure 4.11 displays the opinion of the respondent on the mobile application features proposed in the project. Results show that the mini game feature is the most voted feature by the respondents with 14 votes (87.5%), followed by the pain assessment feature with 13 votes (81.3%), and the help feature with 8 votes (50%). However, only 7 respondents (43.8%) thinks that the education feature (question bank) is needed to be implemented into the mobile application. The help feature was not proposed as the mobile application feature, but it has more votes compared to the education feature. Besides, Table 4.3 summarised the new recommendation from the respondents. As shown in Table 4.3, four respondents suggested to have parental

control feature, three respondents suggested to have pain relief technique education feature, and one respondent suggested to have medication timer feature. Therefore, these features should be examined to determine whether which of it should be implemented.

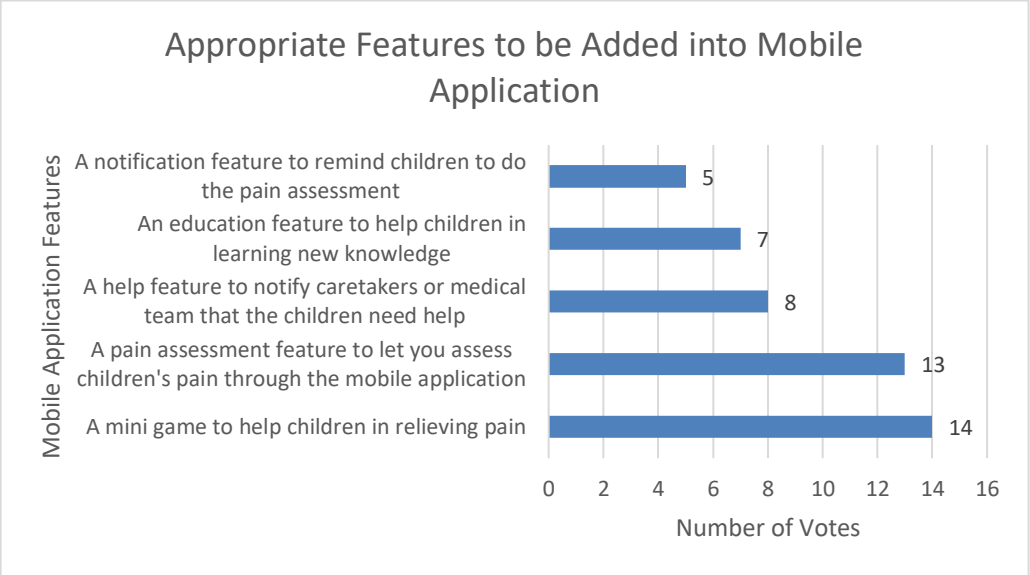


Figure 4.11: The Suitable Features To Be Added To The Mobile Application

Table 4.3: Summary of Suggested Mobile Application Features

Suggestion (Mobile Application)	Number of Respondents
Parental control	4
Pain Relief technique education	3
Medication timer	1
No	8

Figure 4.12 displays the opinion of the respondent on the web application features proposed in the project. Results show that the pain data analysis feature is the most voted feature by the respondents with 15 votes (93.8%), followed by online data storage feature with 10 votes (62.5%), and the data exportation feature with 8 votes (50%). Children profile management feature has the lowest votes (37.5%) indicates it is the least important feature in the web application. Besides, Table 4.4 summarised the new recommendation from the respondents. As shown in Table 4.4, five respondents suggested to have a secured system, two respondents suggested to have education feature, and one respondent suggested to have pain analysis feature. The

suggested features will be adopted except for education feature because it has only one vote, and it is out of scope.

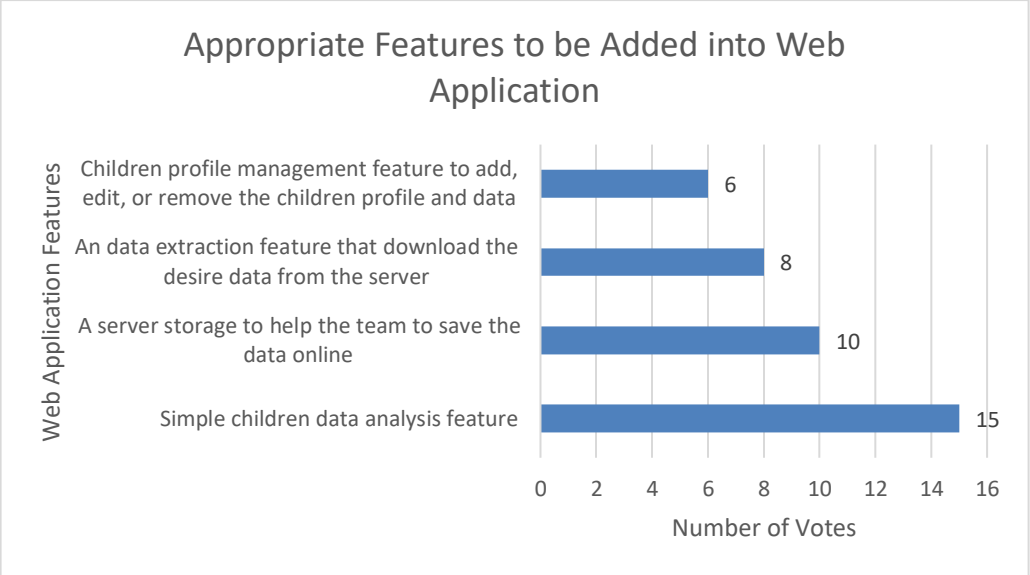


Figure 4.12: The Suitable Features to be Added to the Web Application

Table 4.4: Summary of Suggested Web Application Feature

Suggestion (Web Application)	Number
Secured system	5
Education	2
Pain pattern, duration analysis	1
No	8

4.2.1.5 Summary

The survey has provided useful information to the problems in the project. Children with cancer are suffering from different kind of pains and having difficulty in communicating pain. Furthermore, the most used pain assessment tools and the effectiveness of the tools are also identified. Lastly, the proposed features are examined through the survey and several new suggestions are found and taken into consideration. The complete survey responses are included in Appendix B.

4.2.2 Summary of Interview

One interview session was conducted with Doctor Ong to understand more about the children with cancer and the pain assessment process. Doctor Ong is a paediatrician specialized in paediatric haematology and oncology. He is currently working in Borneo medical centre in Kuching Sarawak. He has been looking after children with cancer since 2008.

According to Doctor Ong, children with cancer are ranged from 0 years old (infant) until adolescent around 15 or 16 years old. The most common symptoms are pain, nausea, and vomit. However, different cancer types and treatments would have different side effects towards children. Doctor Ong also stated that children are not usually sad. They only feel bad or awful when they feel pain. Also, children in different age group may have different way to express pain. Children with younger age may scream or cry whereas elder children could express pain with words.

The pain assessment process usually conducted through observation, direct questioning, or pain scales depends on different age group. Among all the technique, pain scale is the most common one because it is simple and understandable by older children. Also, the pain assessment will be conducted according to the ward round, usually two to three times per day based on the schedule of different patients. When the children are suffering from great pain, medicine will be provided by the medical team to reduce the pain level. The medicine is also determined by the analysis of the pain scale such as the increasing of pain over a few assessments.

Lastly, Doctor Ong suggested the mobile application should allow children to update the pain whenever they feel the pain. Also, it should also allow children to ask for help through the application when they are having great pain. Besides, the analysis feature of the web application should be able to tell the trend of the pain based on real time data. Also, the web application should notify medical team if the pain level is increasing or reaching a severe level.

Overall, the information provided by Doctor Ong matches with the data gathered through survey and literature review. Also, the overall idea on children with cancer and the pain assessment process are also clarified through this interview. The feature suggested will be examined and take into consideration. The full interview question and answer is included in the Appendix C.

4.3 Requirements Specification

The requirements specification of the project is categorized into functional requirements and non-functional requirements. Besides, the functional requirements of the system are further separated into functional requirements for mobile application and functional requirements for web application. Non-functional requirement on the other hand, has been categorized into availability requirements, reliability requirements, maintainability requirements, security requirements, usability requirements, and performance requirements.

4.3.1 Mobile Application

4.3.1.1 Functional Requirements

FR001 - The system shall allow user to log in with provided account.

FR002 - The system shall allow user to create profile and avatar during first time login.

FR003 - The system shall allow user to view account profile.

FR004 - The system shall allow user to record pain.

FR005 - The system shall allow user to customize avatar.

FR006 - The system shall allow user to play mini game.

FR007 - The system shall allow user to send message to medical team.

4.3.1.2 Non-Functional Requirements

1. Performance requirements
    1.1. The system shall respond to user input within 0.1 second.
    1.2. The system shall handle 99% of the exception without crashing the application.
2. Compatibility requirements
    2.1. The system shall run smoothly with android 9.0 and above.
    2.2. The system shall be able to run smoothly in device with different screen size.
3. Security requirements
    3.1. The system must authenticate user with valid account.
    3.2. The system must not allow user to login with invalid credentials.
4. Usability requirements
    4.1. The system must be easy to use with no complicated process.
    4.2. The system must have a user-friendly user interface.

4.3.2 Web application

4.3.2.1 Functional requirements

FR008 - The system shall allow user to log in with correct account.

FR009 - The system shall allow user to register a new account.

FR010 - The system shall allow user to manage own profile.

FR011 - The system shall allow user to perform simple CRUD function on young cancer patient profile.

- The system shall allow user to add new patient.
- The system shall allow user to view the list of registered patients.
- The system shall allow user to view selected patient profile.
- The system shall allow user to edit patient profile.
- The system shall allow user to remove patient from system.

FR012 - The system shall allow user to search patient.

FR013 - The system shall allow user to view the patient data analysis chart.

FR014 - The system shall allow user to view message sent by young cancer patient.

4.3.2.2 Non-functional requirements

1. Performance requirements
   1.1. The system shall respond to user input within 0.1 second.
   1.2. The system shall have the maximum of 5 second response time with the maximum of file size downloaded.
   1.3. The system shall handle 99% of the exception without crashing the application.
2. Compatibility requirements
   2.1. The system shall run smoothly with Google Chrome, Firefox, and Microsoft edge.
3. Reliability requirements
   3.1. The system must always display accurate and consistent patient data.
4. Availability requirements
   4.1. The system shall be available 90% of the time in a week when the device is connected to internet.

5. Security requirements
    5.1. The system must authenticate user with valid account.
    5.2. The system must not allow user to login with invalid credentials.
6. Usability requirements
    6.1. The system must be easy to use with no complicated process.
    6.2. The system must have a user-friendly user interface.

4.4 Use Case Diagram and Use Case Description

4.4.1 Mobile Application

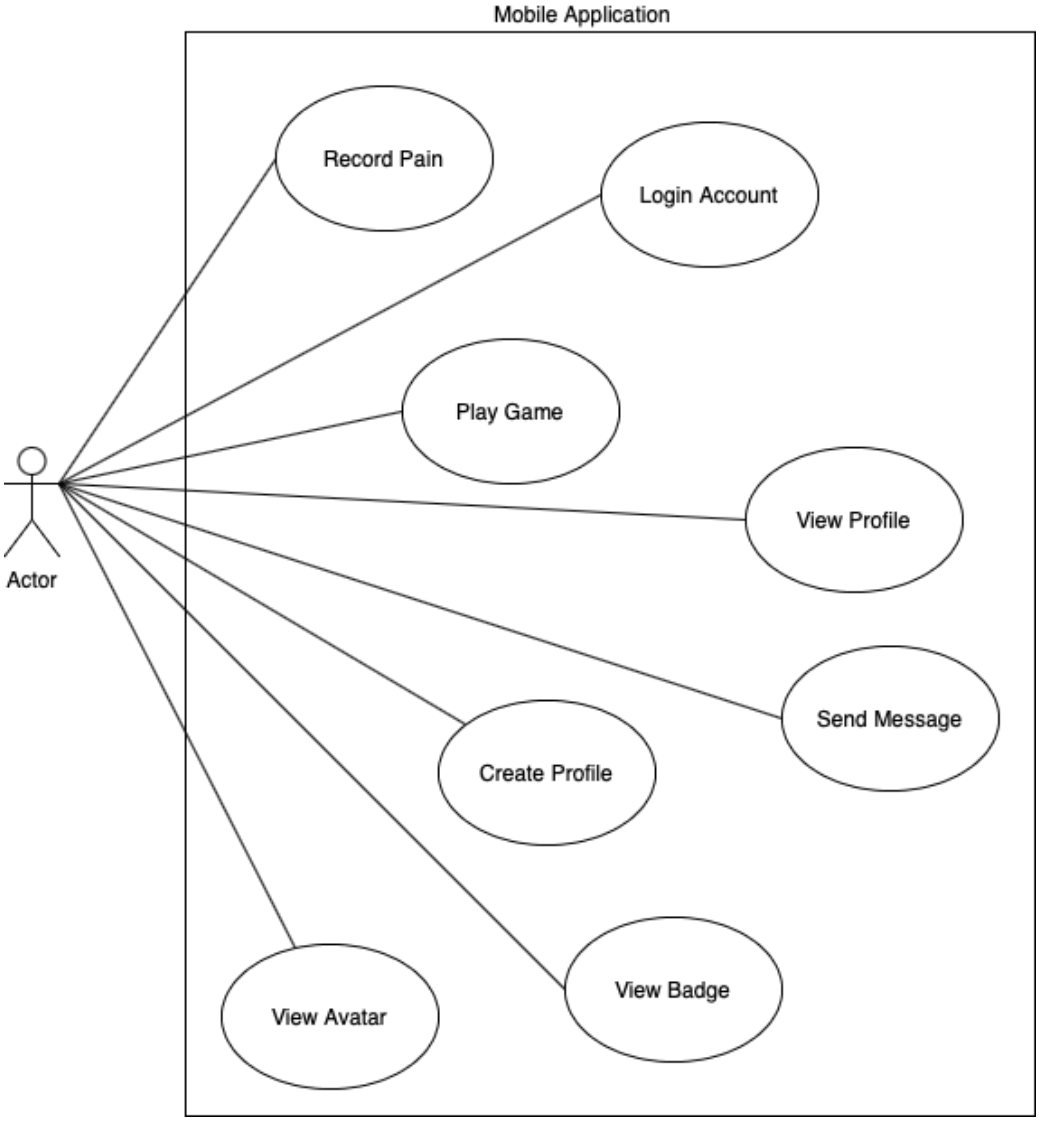


Figure 4.13: Mobile Application Use Case Diagram

Table 4.5: Login Account Use Case Description

<table>
<tr><td colspan="2">Name: Login Account</td><td>ID: UC001,UC009</td><td>Priority: High</td></tr>
<tr><td colspan="2">Actor: Young cancer patient, Medical Staff</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="4">Stakeholder's Information:
Young cancer patient: person who wants to use the mobile application.
Medical Team: person who wants to use the web application to manage young cancer patient data.</td></tr>
<tr><td colspan="4">Summary of Use Case:
This use case describes the process of logging into the application by user.</td></tr>
<tr><td colspan="4">Triggering Situation:
When the user wants to access to the application to perform certain action.</td></tr>
<tr><td colspan="4">Relationship:
- Association: Young cancer patient, Medical Staff
- Include: -
- Extend: Register New Account</td></tr>
<tr><td colspan="4">Normal Event Flow:
<u>Young cancer patient</u>
1. The young cancer patient fills up username and password in the login form.
2. The system displays main menu page if the credentials is valid, display error message otherwise.

<u>Medical Staff</u>
1. The medical staff fills up username and password in the login form.
2. The system displays main menu page if the credentials is valid, display error message otherwise.</td></tr>
<tr><td colspan="4">Sub Event Flow:
-</td></tr>
</table>

Table 4.6: Play Game Use Case Description

Name: Play Game	ID: UC002	Priority: High
Actor: Young cancer patient	Type: Detail, Essential	
Stakeholder's Information: Young cancer patient: person who uses the mobile application to play the game.		
Summary of Use Case: This use case describes the process of playing game in the mobile application.		
Triggering Situation: When the user wants to play the game in the mobile application.		
Relationship: - Association: Young cancer patient - Include: - - Extend: -		
Normal Event Flow: 1. The young cancer patient taps on the play game button. 2. The system displays the game menu. 3. The young cancer patient taps on the game function. 4. The system renders the game. 5. The young cancer patient plays the game. 6. The system prompts a message when the game is over. 7. The system closes the game and redirect young cancer patient back to main menu.		
Sub Event Flow: -		
Exception flow: 1. The young cancer patient selects the game function. 2. The system prompts an error message telling the play time limit is over.		

Table 4.7: View Profile Use Case Description

<table>
<tr><td>Name: View Profile</td><td>ID: UC003</td><td>Priority: Medium</td></tr>
<tr><td>Actor: Young cancer patient</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="3">Stakeholder’s Information:
Young cancer patient: person who uses the mobile application to view the user profile details such as name, badges, and avatar.</td></tr>
<tr><td colspan="3">Summary of Use Case:
This use case describes the process of checking the user profile details in the mobile application.</td></tr>
<tr><td colspan="3">Triggering Situation:
When the user wants to view the profile details in the mobile application.</td></tr>
<tr><td colspan="3">Relationship:
- Association: Young cancer patient
- Include: -
- Extend: -</td></tr>
<tr><td colspan="3">Normal Event Flow:
1. The young cancer patient taps the profile button.
2. The system navigates to profile page.
3. The system display profile details such as name, number of badges earned, and current avatar.
4. Sub event flow S-1 is performed if the young cancer patient wants to check all the badges available in the system.</td></tr>
<tr><td colspan="3">Sub Event Flow:
S-1: View all badges available
1. The young cancer patient taps the “view all badges” button.
2. The system displays all the badges available in the system.</td></tr>
</table>

Table 4.8: Create Profile Use Case Description

<table>
<tr><td>Name: Create Profile</td><td>ID: UC004</td><td>Priority: High</td></tr>
<tr><td>Actor: Young cancer patient</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="3">Stakeholder’s Information:
Young cancer patient: person who uses the mobile application to create the account profile for the first-time login.</td></tr>
<tr><td colspan="3">Summary of Use Case:
This use case describes the process of creating a new profile during the first-time login of the mobile application.</td></tr>
<tr><td colspan="3">Triggering Situation:
When the user wants to create a new profile in the mobile application for the first-time login.</td></tr>
<tr><td colspan="3">Relationship:
- Association: Young cancer patient
- Include: -
- Extend: -</td></tr>
<tr><td colspan="3">Normal Event Flow:
1. The young cancer patient logins with the account provided by the medical team.
2. The system redirects young cancer patient profile creation page if the credentials are correct.
3. The young cancer patient enters the profile name.
4. The young cancer patient saves the profile.</td></tr>
<tr><td colspan="3">Sub Event Flow:
-</td></tr>
</table>

Table 4.9: Record Pain Use Case Description

<table>
<tr><td>Name: Record Pain</td><td>ID: UC005</td><td>Priority: High</td></tr>
<tr><td>Actor: Young cancer patient</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="3">Stakeholder’s Information:
Young cancer patient: person who wants to record the pain in the mobile application.
Caretakers: person who assists young cancer patient when they could not complete the pain assessment themselves.</td></tr>
<tr><td colspan="3">Summary of Use Case:
This use case describes the process of recording pain in the mobile application.</td></tr>
<tr><td colspan="3">Triggering Situation:
When the user wants to use the mobile application to record their pain.</td></tr>
<tr><td colspan="3">Relationship:
- Association: Young cancer patient
- Include: -
- Extend: -</td></tr>
<tr><td colspan="3">Normal Event Flow:
1. The young cancer patient taps on the pain recorder button.
2. The system renders and displays the pain recorder.
3. The young cancer patient interacts (pull and tap) with the pain scale to record the pain.
4. The system saves the pain data.</td></tr>
<tr><td colspan="3">Sub Event Flow:
-</td></tr>
</table>

Table 4.10: Send Message Use Case Description

Name: Send Message	ID: UC006	Priority: High
Actor: Young cancer patient	Type: Detail, Essential	
Stakeholder's Information: Young cancer patient: person who uses the mobile application to contact the medical team.		
Summary of Use Case: This use case describes the process of sending message to the medical team through the mobile application.		
Triggering Situation: When the user wants to contact the medical team in the mobile application.		
Relationship: - Association: Young cancer patient - Include: - - Extend: -		
Normal Event Flow: 1. The young cancer patient taps the help button at the main menu. 2. The system prompts a confirmation message to confirm young cancer patient's action. 3. The young cancer patient taps the confirm button. 4. The system notifies the medical team through the web application.		
Sub Event Flow: -		

Table 4.11: View Avatar Use Case Description

Name: View Avatar	ID: UC007	Priority: High
Actor: Young cancer patient	Type: Detail, Essential	
Stakeholder's Information: Young cancer patient: person who uses the mobile application to customize the game avatar.		
Summary of Use Case: This use case describes the process of customizing game avatar in the mobile application.		
Triggering Situation: When the user wants to customize the game avatar in the mobile application.		
Relationship: - Association: Young cancer patient - Include: - - Extend: -		
Normal Event Flow: 1. The young cancer patient taps the profile button. 2. The system navigates to profile page. 3. The young cancer patient taps on avatar button. 4. The system displays current avatar. 5. The young cancer patient changes the avatar parts. 6. The system saves the changes.		
Sub Event Flow: -		

Table 4.12: View Badge Use Case Description

<table>
<tr><td>Name: View Badge</td><td>ID: UC008</td><td>Priority: High</td></tr>
<tr><td>Actor: Young cancer patient</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="3">Stakeholder’s Information:
Young cancer patient: person who uses the mobile application to view the unlocked badges.</td></tr>
<tr><td colspan="3">Summary of Use Case:
This use case describes the process of viewing badges in the mobile application.</td></tr>
<tr><td colspan="3">Triggering Situation:
When the user wants to view badges in the mobile application.</td></tr>
<tr><td colspan="3">Relationship:
- Association: Young cancer patient
- Include: -
- Extend: -</td></tr>
<tr><td colspan="3">Normal Event Flow:
1. The young cancer patient taps the profile button.
2. The system navigates to profile page.
3. The young cancer patient taps on badges button.
4. The system displays all badges.</td></tr>
<tr><td colspan="3">Sub Event Flow:
-</td></tr>
</table>

4.4.2 Web Application

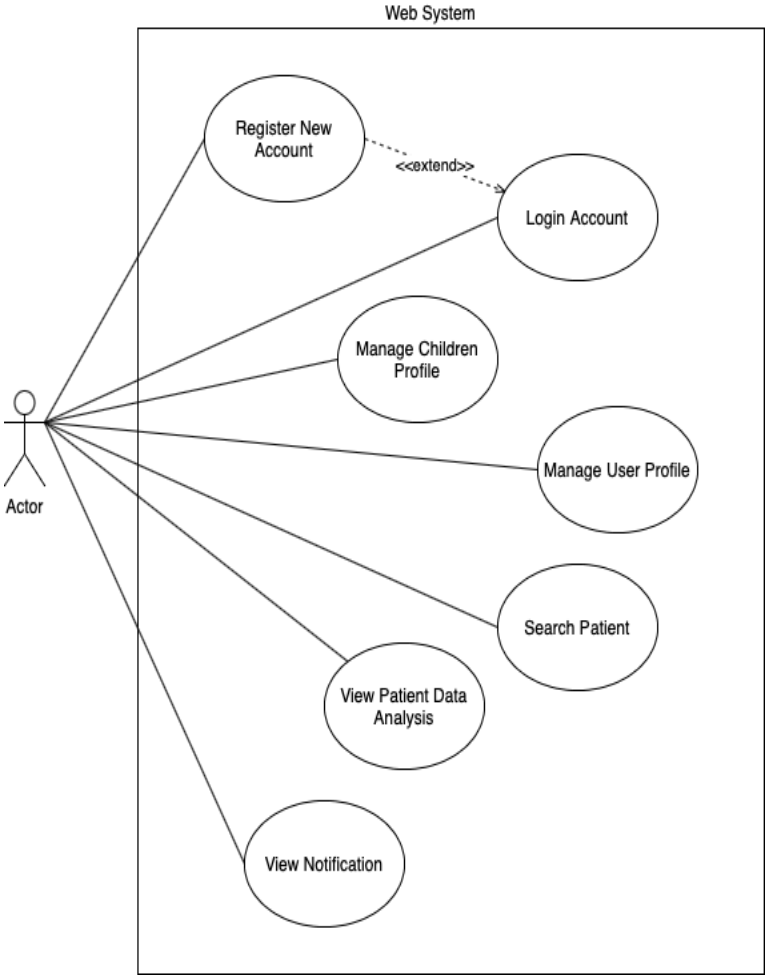


Figure 4.14: Web Application Use Case Diagram

Table 4.13: Register New Account Use Case Description

<table>
<tr><td>Name: Register New Account</td><td>ID: UC010</td><td>Priority: High</td></tr>
<tr><td>Actor: Medical Staff</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="3">Stakeholder’s Information:
Medical Staff: person who is the new user of the web application.</td></tr>
<tr><td colspan="3">Summary of Use Case:
This use case describes the process of registering a new account of the web application by the user.</td></tr>
<tr><td colspan="3">Triggering Situation:
When the user wants to use the web application for the first time.</td></tr>
<tr><td colspan="3">Relationship:
- Association: Medical staff
- Include: -
- Extend: -</td></tr>
<tr><td colspan="3">Normal Event Flow:
1. The medical staff selects the register function in the login form.
2. The system navigates medical staff to registration page.
3. The medical staff fills up all the required field in the registration form and register.
4. The system saves the new account information.
5. The system redirects the medical staff back to login page.</td></tr>
<tr><td colspan="3">Sub Event Flow:
-</td></tr>
</table>

Table 4.14: Manage Children Profile Use Case Description

<table>
<tr><td>Name: Manage Children Profile</td><td>ID: UC011</td><td>Priority: High</td></tr>
<tr><td>Actor: Medical Staff</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="3">Stakeholder’s Information:
Medical Staff: person who uses the web application to manage young cancer patient profile.</td></tr>
<tr><td colspan="3">Summary of Use Case:
This use case describes the process of managing child cancer profile such as adding, viewing, editing and removing young cancer patient profile.</td></tr>
<tr><td colspan="3">Triggering Situation:
When the user wants to add a new young cancer patient in the web application.</td></tr>
<tr><td colspan="3">Relationship:
- Association: Medical staff
- Include: -
- Extend: -</td></tr>
<tr><td colspan="3">Normal Event Flow:
<u>Adding new patient</u>
1. The medical staff selects add new patient function.
2. The system displays the patient registration form.
3. The medical staff fills up the registration form and confirm.
4. The system displays the mobile application account registration form.
5. The medical staff fills up the registration form and confirm.
6. The system creates a new account.

<u>View patients list</u>
1. The medical staff selects view all patient functions.
2. The system displays the patient lists that is registered under the medical staff.

<u>View patient profile</u>
1. The medical staff selects patient lists.</td></tr>
</table>

2. The system displays the patient lists under the medical staff.
3. The medical staff searches the patient name or id.
4. The medical staff selects a patient.
5. The system displays the selected patient data.

Edit patient profile

1. The medical staff selects view patient lists function.
2. The system displays the patient lists under the medical staff.
3. The medical staff searches the patient name or id.
4. The medical staff selects a patient.
5. The system displays the patient data.
6. The medical staff selects the edit function.
7. The system displays the data to be edited.
8. The medical staff edits the patient profile and save.
9. The system saves the new data.

Remove Patient

1. The medical staff selects view patient list function.
2. The system displays the patient list under the medical staff.
3. The medical staff searches the patient name or id.
4. The medical staff selects a patient.
5. The system displays the patient data.
6. The medical staff selects the remove function.
7. The system prompts a confirmation message to confirm the action.
8. The medical staff confirms the remove action.
9. The system removes the patient account.

Sub Event Flow:

Table 4.15: View Patient Data Analysis Use Case Description

<table>
<tr><td>Name: View Patient Data Analysis</td><td>ID: UC012</td><td>Priority: High</td></tr>
<tr><td>Actor: Medical staff</td><td colspan="2">Type: Detail, Essential</td></tr>
<tr><td colspan="3">Stakeholder’s Information:
Medical staff: person who uses the web application to view the patient data analysis.</td></tr>
<tr><td colspan="3">Summary of Use Case:
This use case describes the process of generating analysis in the web application.</td></tr>
<tr><td colspan="3">Triggering Situation:
When the user wants to view the patient data analysis in the web application.</td></tr>
<tr><td colspan="3">Relationship:
- Association: Medical staff
- Include: -
- Extend: -</td></tr>
<tr><td colspan="3">Normal Event Flow:
1. The medical staff selects patient lists.
2. The system displays the patient lists under the medical staff.
3. The medical staff selects a patient.
4. The system displays the selected patient data.
5. The medical staff selects analysis function.
6. The system displays the analysis of the selected patient.</td></tr>
<tr><td colspan="3">Sub Event Flow:
-</td></tr>
</table>

Table 4.16: View Message Use Case Description

Name: View Message	ID: UC013	Priority: High
Actor: Medical staff	Type: Detail, Essential	
Stakeholder's Information: Medical staff: person who uses the web application to view the message sent by young cancer patient.		
Summary of Use Case: This use case describes the process of checking message in the web application.		
Triggering Situation: When the user wants to view the message in the web application.		
Relationship: - Association: Medical staff - Include: - - Extend: -		
Normal Event Flow: 1. The medical staff selects the notification function. 2. The system displays all messages. 3. The medical staff selects an unread message. 4. The system displays the message detail.		
Sub Event Flow: -		

Table 4.17: Manage User Profile Use Case Description

Name: Manage User Profile	ID: UC014	Priority: Medium
Actor: Medical staff	Type: Detail, Essential	
Stakeholder's Information: Medical staff: person who uses the web application to manage user profile.		
Summary of Use Case: This use case describes the process of managing user profile in the web application.		
Triggering Situation: When the user wants to manage the user profile from the web application.		
Relationship: - Association: Medical staff - Include: - - Extend: -		
Normal Event Flow: 1. The Medical staff selects the name under the profile picture. 2. The system displays the profile. 3. The medical staff selects edit profile. 4. The medical staff updates the profile details and save.		
Sub Event Flow: -		

Table 4.18: Search Patient Use Case Description

Name: Search Patient	ID: UC015	Priority: High
Actor: Medical staff	Type: Detail, Essential	
Stakeholder's Information: Medical staff: person who uses the web application to search a specific patient.		
Summary of Use Case: This use case describes the process of searching patients in the web application.		
Triggering Situation: When the user wants to search a patient in the web application.		
Relationship: - Association: Medical staff - Include: - - Extend: -		
Normal Event Flow: 1. The medical staff selects patient lists. 2. The system displays the patient lists under the medical staff. 3. The medical staff enter a search criteria. 4. The system uses the search criteria to retrieve the patient from database. 5. The system displays the search result.		
Sub Event Flow: -		

4.5 Interface Flow Diagram

4.5.1 Mobile Application

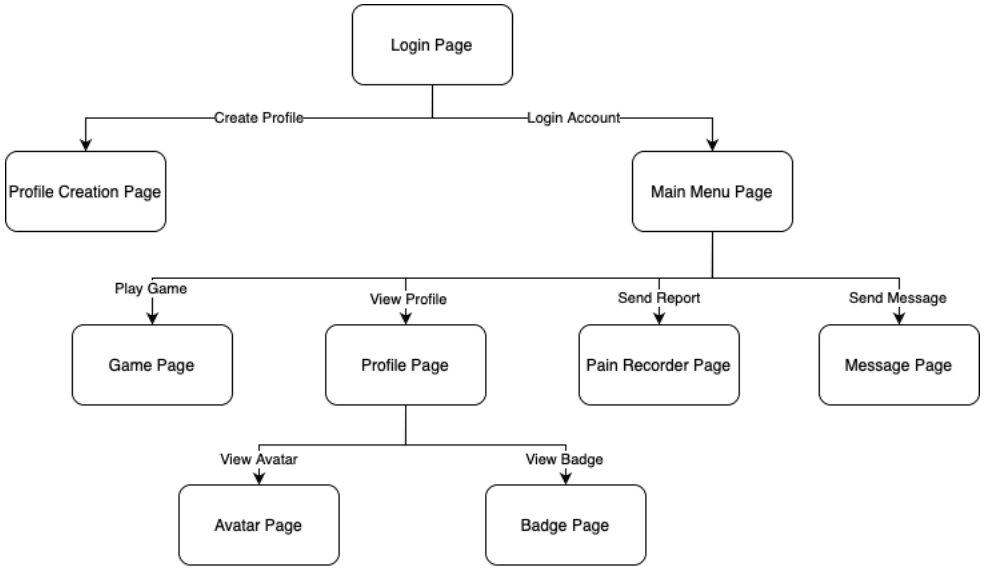


Figure 4.15: Mobile Application Interface Flow Diagram

4.5.2 Web Application

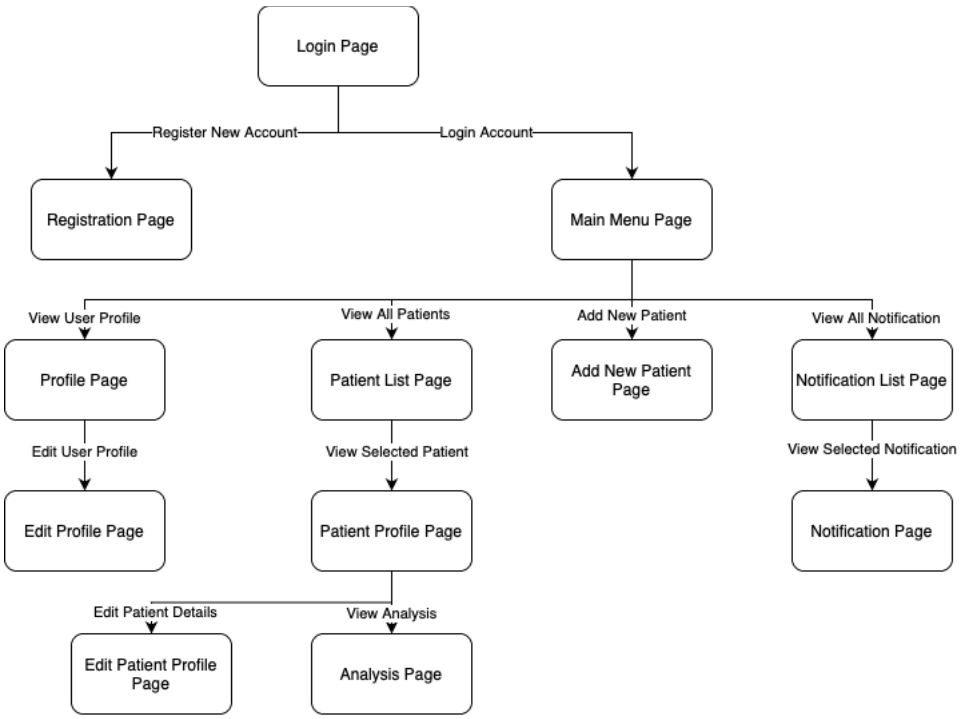


Figure 4.16: Web Application Interface Flow Diagram

4.6 Conclusion

In short, this chapter analysed the survey results and interview results. Most of the data collected supported the problems of this project. Also, the user requirements are also gathered and validated through the collected data. There are total of 16 functional requirements for the system. The complete functional requirements and non-functional requirements are listed in this chapter after the requirement analysis section. Finally, use case diagrams and use case descriptions are also included to describe the possible functionalities in the system.

CHAPTER 5

SYSTEM DESIGN

5.1 Introduction

Different designs have been applied in the system to makes the system more structural, understandable and maintainable. In this chapter, system architecture design, entity relationship design, data flow design, and user interface design will be discussed.

5.2 System Architecture Design

5.2.1 Web Application

The system architecture for the web application is Heroku's architecture. This is because the web application will be hosted in a hosting platform called Heroku. Heroku's architecture is design by using several platform stacks with different components and functions in different stacks. The core stacks are language runtime, libraries, operating system, and other infrastructure for supporting scalable web apps development. (An overview of Heroku's architecture, 2021)

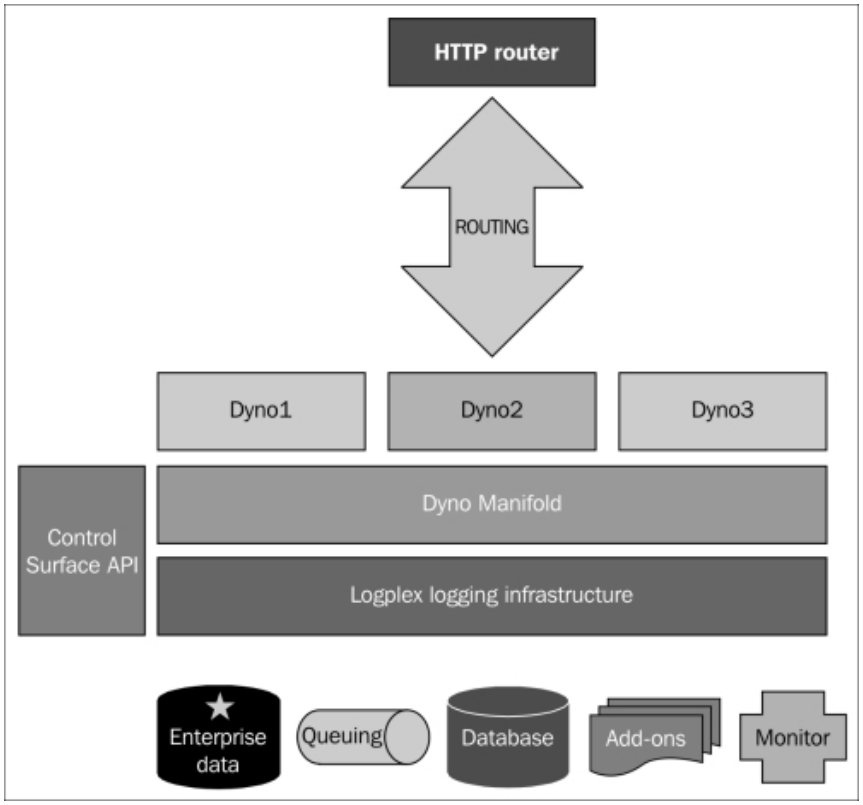


Figure 5.1: Heroku Architecture (An overview of Heroku's architecture, 2021)

Figure 5.1 shows the high-level architecture of Heroku Cloud Hosting Platform. The completed web application will be published to a cloud container named Dyno such as Dyno1 in the Figure 5.1 above. Dyno is a virtual container running on the dyno manifold. Dyno is fully isolated from other Dynos to prevent system mixing. Dyno manifold is the foundational block to execute and run the working environment on Heroku. All the published dynos will be running in the Dyno manifold to keep the system active online. (An overview of Heroku's architecture, 2021)

In order to receive HTTP request from the browser, Heroku has also implemented a HTTP router to receive and process all the relevant HTTP requests. A routing mesh technology in HTTP router will process the incoming HTTP requests and route it to the correct dynos for further processing. Furthermore, Heroku also includes cloud database in the system architecture. This system has connected to the PostgreSQL provided by Heroku for data storing. Heroku architecture has streamlined the entire process from receiving HTTP requests up to storing data in Heroku cloud database. This architecture has further increased the performance of the web application.

5.2.2 Mobile Application

As for mobile application, Unity's architecture is normally component based. An application built with Unity combines different functional components to become a complete system. (Unity's Architecture, 2021)

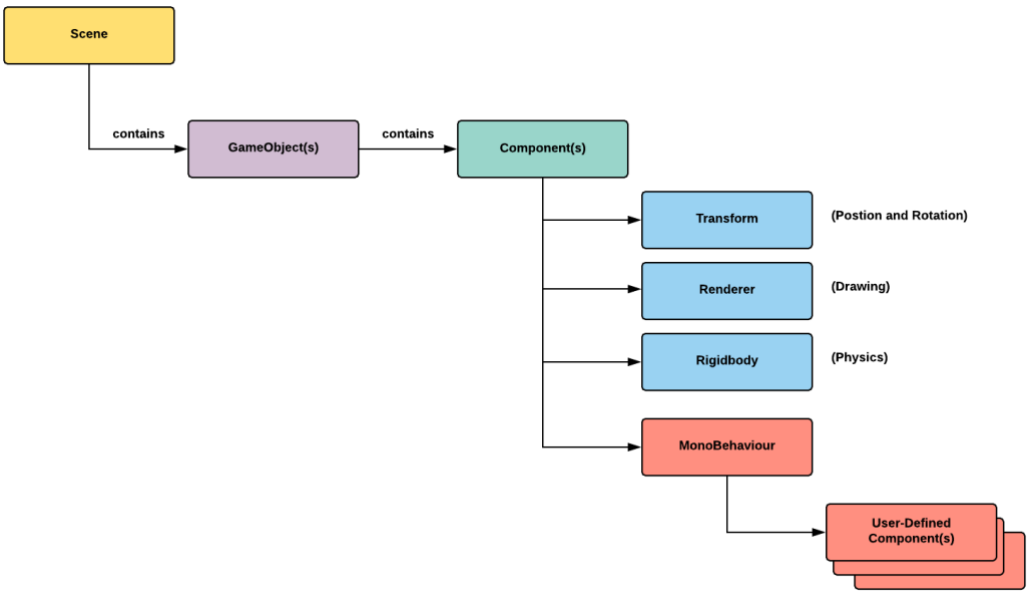


Figure 5.2: Unity Architecture (Unity's Architecture, 2021)

Figure 5.2 shows the high-level architecture of a Unity application. The biggest component in the application being the scene of each screen. For example, the mobile application is this system consists of login scene, main menu scene, game scene and others. Each of the scenes contains more components such as image, button, input, and others relevant components. Unity builds application from a single component, slowly build up with more components and formed the hierarchy shown in the figure 5.2.

5.2.3 System Interoperability

Although two applications applied different architectures, they could still interact with each other through the APIs because both systems use the same database to manage the relevant data. For example, when the medical team uses web application to add a new patient, a game account for the mobile application will be created and save into the database. Then, the mobile application would retrieve the account username and password to validate with the account username and password the young cancer patient entered in the login screen. With the appropriate APIs built in the applications, systems with different architectures are still able to connect to each other seamlessly.

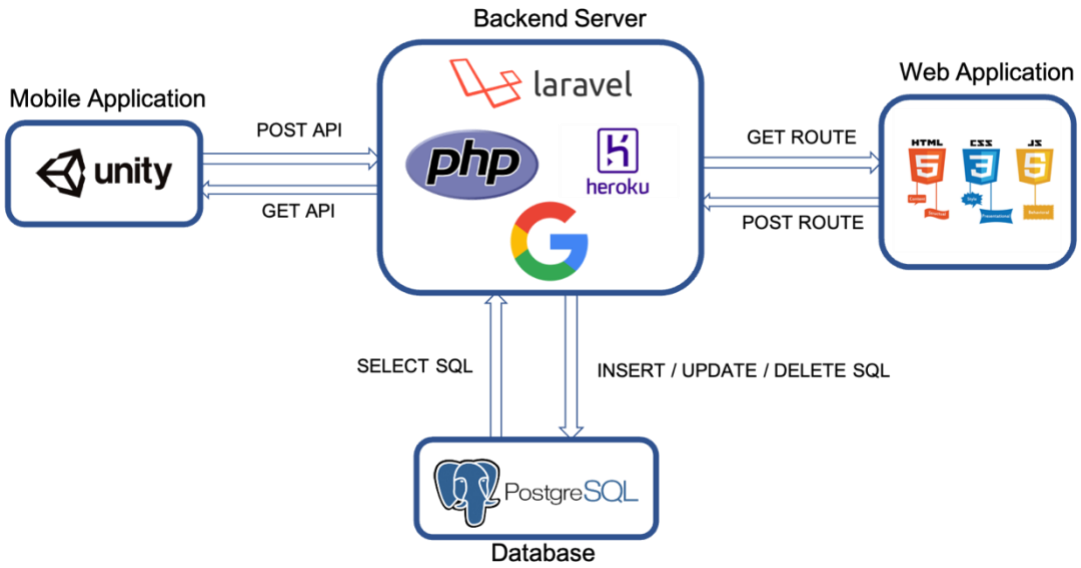


Figure 5.3: Overall System Architecture

5.3 Database Architecture

5.3.1 Database Schema

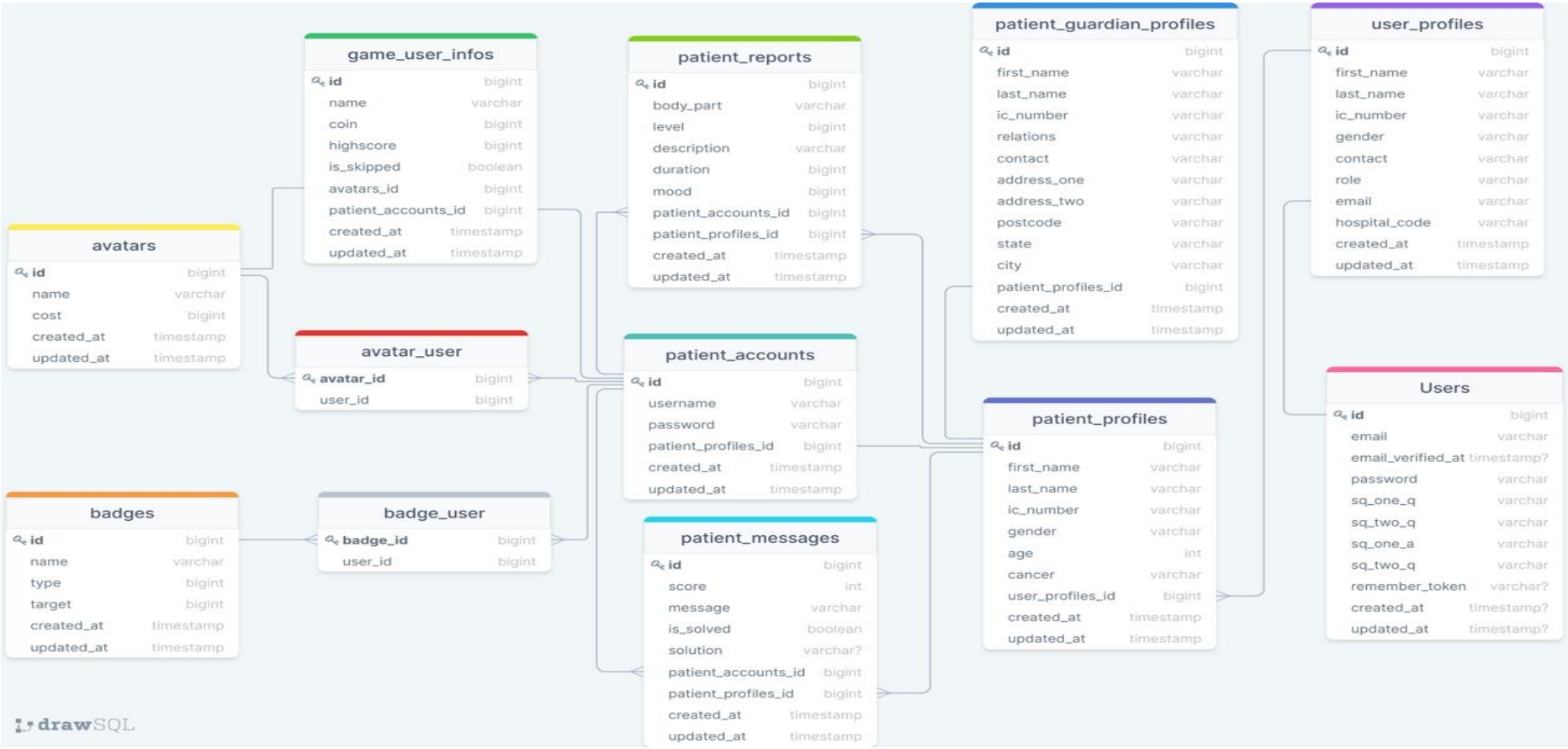


Figure 5.4: Database Schema

5.3.2 Table Description

Table 5.1: Table Description for Database Schema

Table Name	Description
users	Contains user account details for web application
user_profiles	Contains user profile details
patient_profiles	Contains patient profile details
patient_guardian_profiles	Contains patient guardian profile details
patient_accounts	Contains user account details for mobile application
patient_reports	Contains all the reports details sent by the young cancer patient from mobile application.
patient_messages	Contains all the message details sent by the young cancer patient from mobile application.
game_user_infos	Contains all the game info such as coins and highscore that are associated with the patient accounts.
avatars	Contains all the avatar details for the mobile application.
badges	Contains all the badge details for the mobile application.
avatar_user	Contains the composite keys to identify the avatars linked with the user account in mobile application.
badge_user	Contains the composite keys to identify the badges linked with the user account in mobile application.

5.3.3 Data Flow Diagram

5.3.3.1 Context Diagram

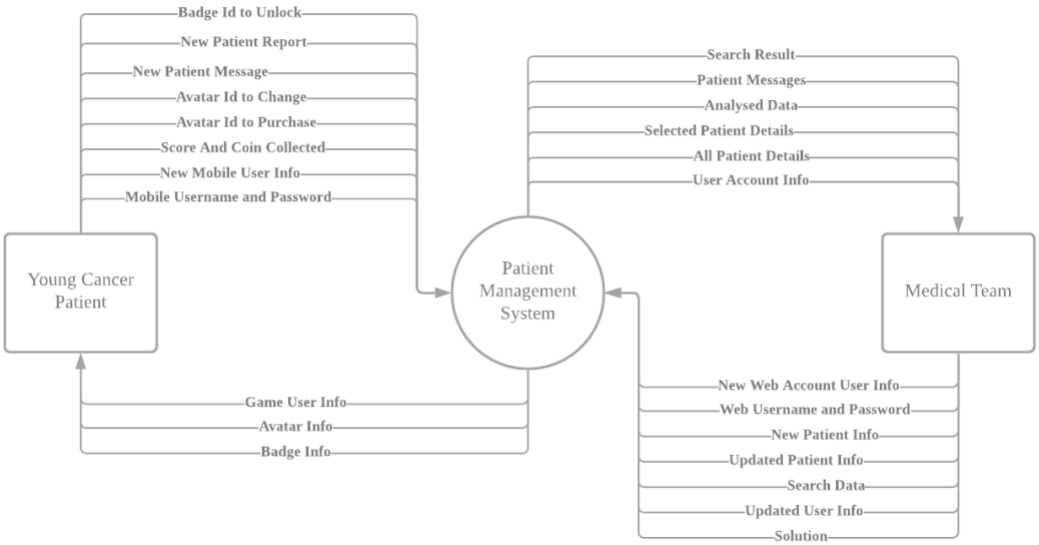


Figure 5.5: Context Diagram

5.3.3.2 Data Flow Diagram Level 0 (Web Application)

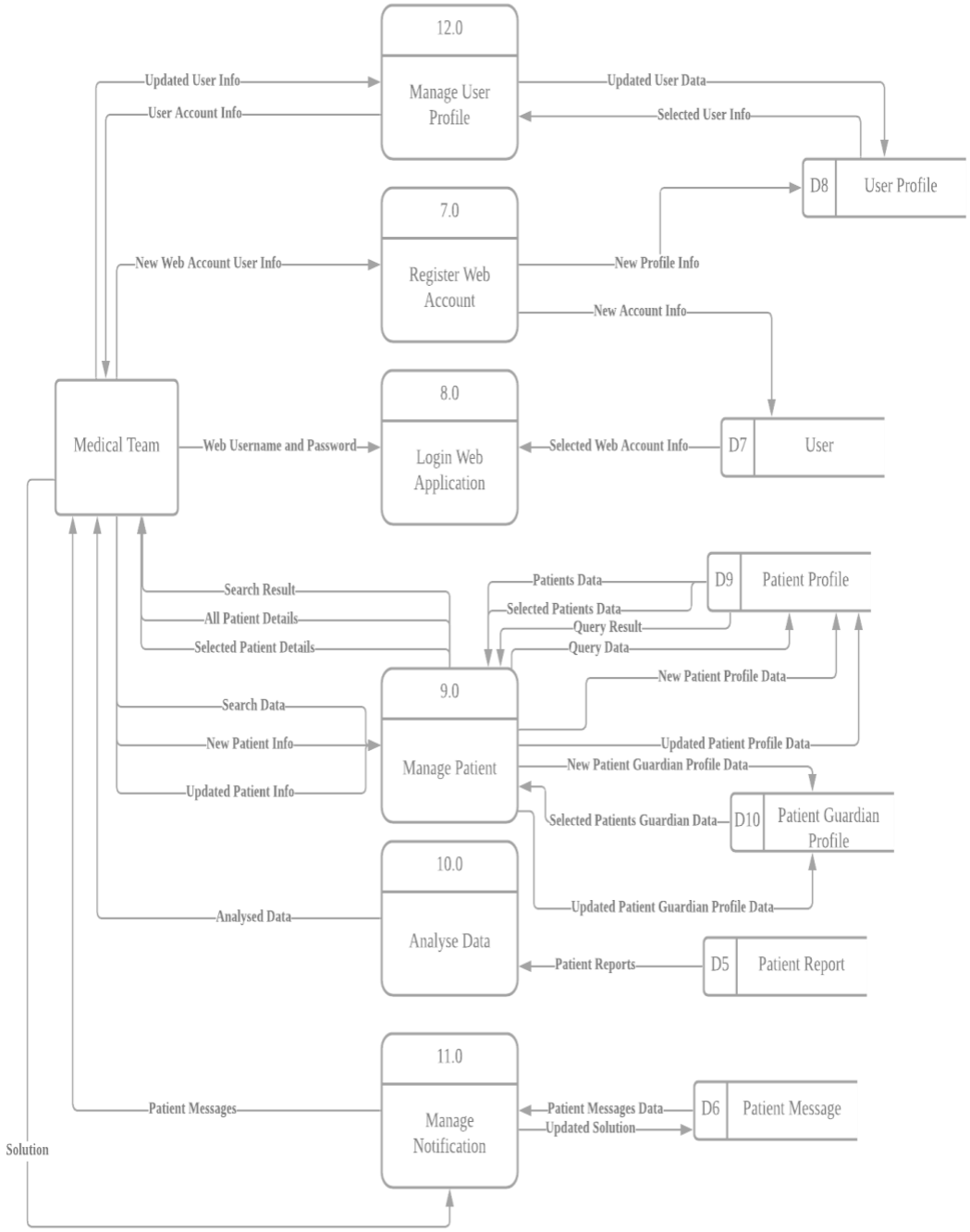


Figure 5.6: Data Flow Diagram Level 0 – Web Application

5.3.3.3 Data Flow Diagram Level 1 (Web Application 9.0 Manage Patient)

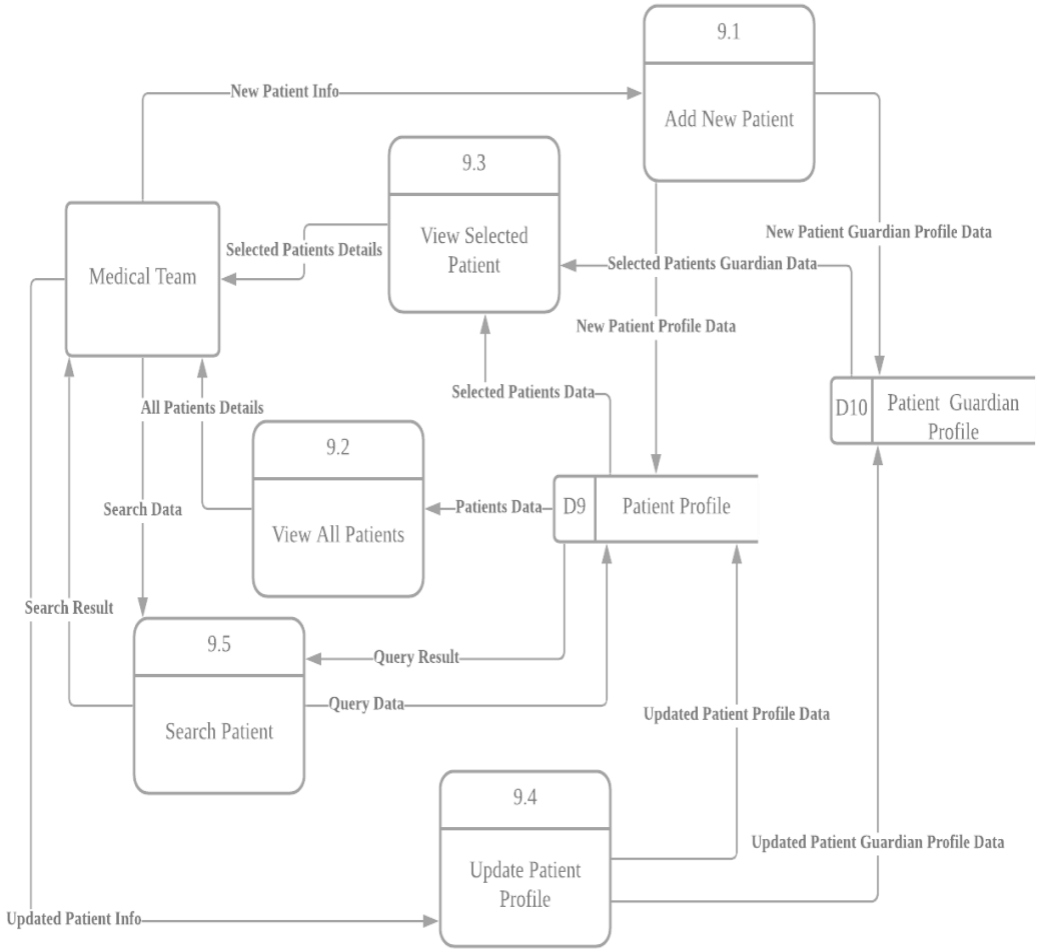


Figure 5.7: Data Flow Diagram Level 1 – 9.0 Manage Patient

5.3.3.4 Data Flow Diagram Level 1 (Web Application 11.0 Manage Notification)

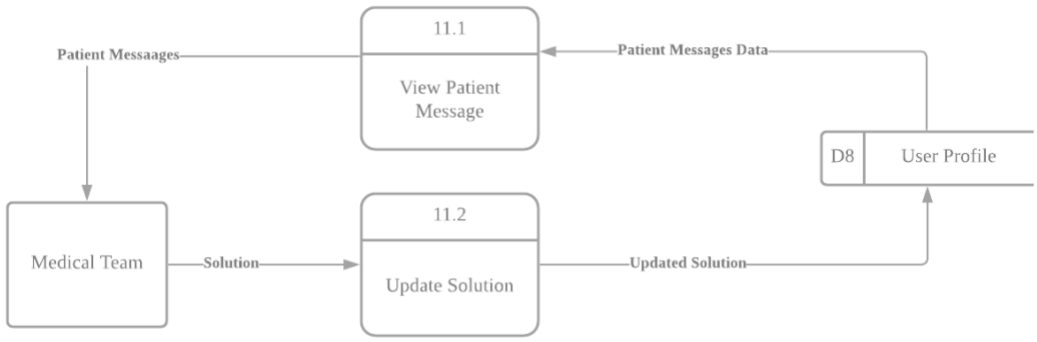


Figure 5.8: Data Flow Diagram Level 1 – 11.0 Manage Notification

5.3.3.5 Data Flow Diagram Level 1 (Web Application 12.0 Manage User Profile)

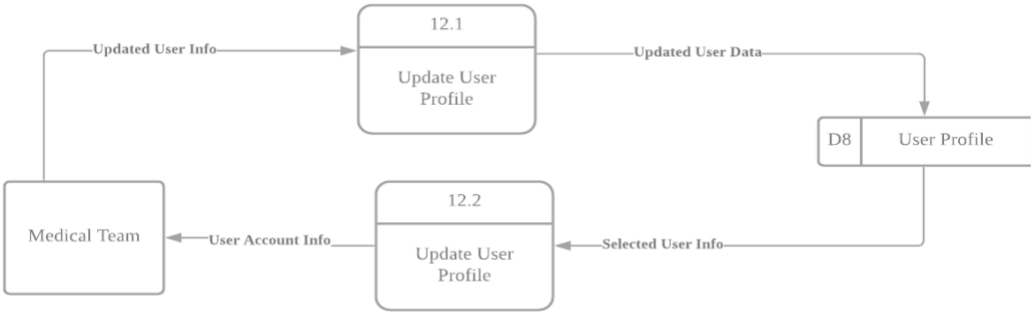


Figure 5.9: Data Flow Diagram Level 1 – 12.0 Manage User Profile

5.3.3.6 Data Flow Diagram Level 0 (Mobile Application)

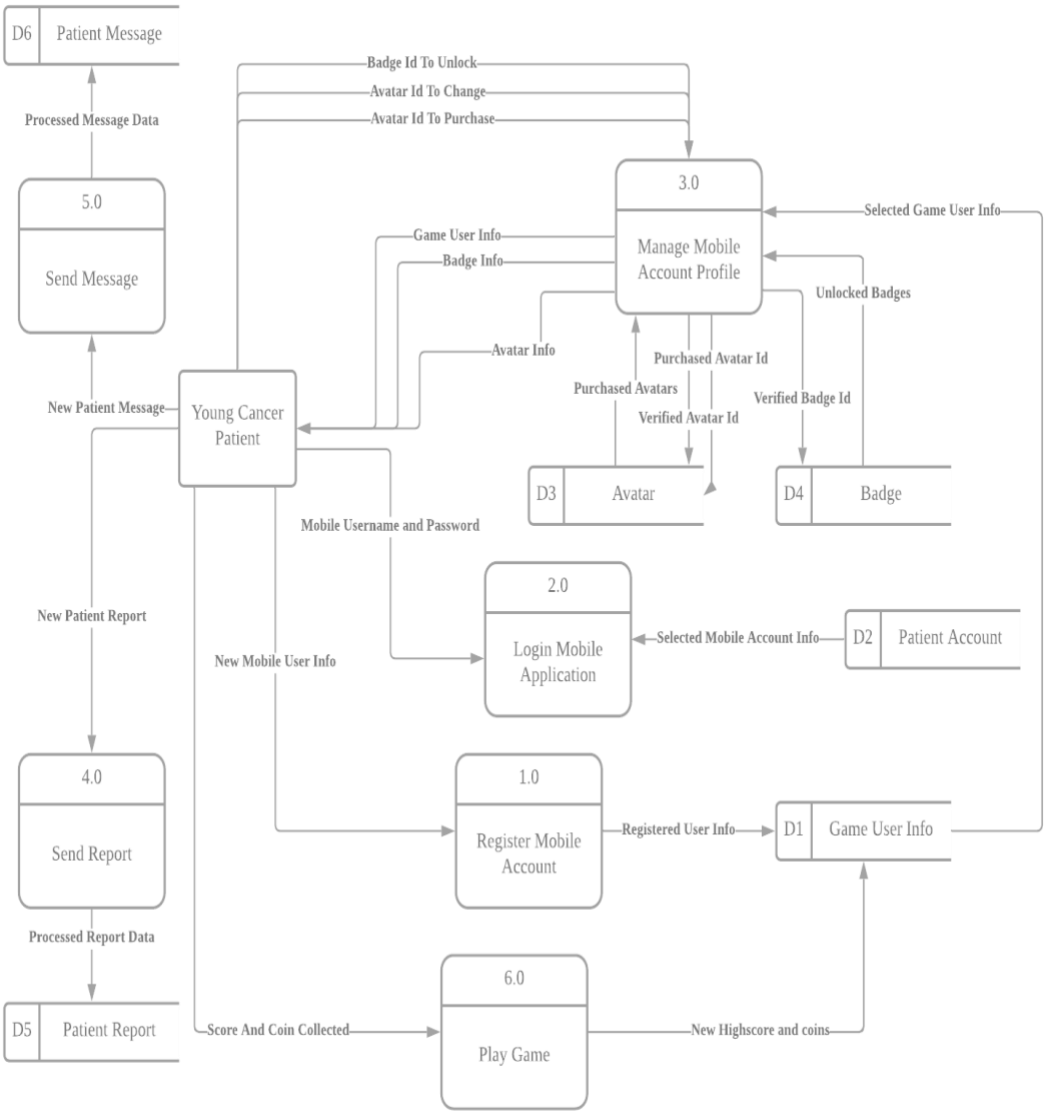


Figure 5.10: Data Flow Diagram Level 0 – Mobile Application

5.3.3.7 Data Flow Diagram Level 1 (Mobile Application 3.0 Manage Mobile Account Profile)

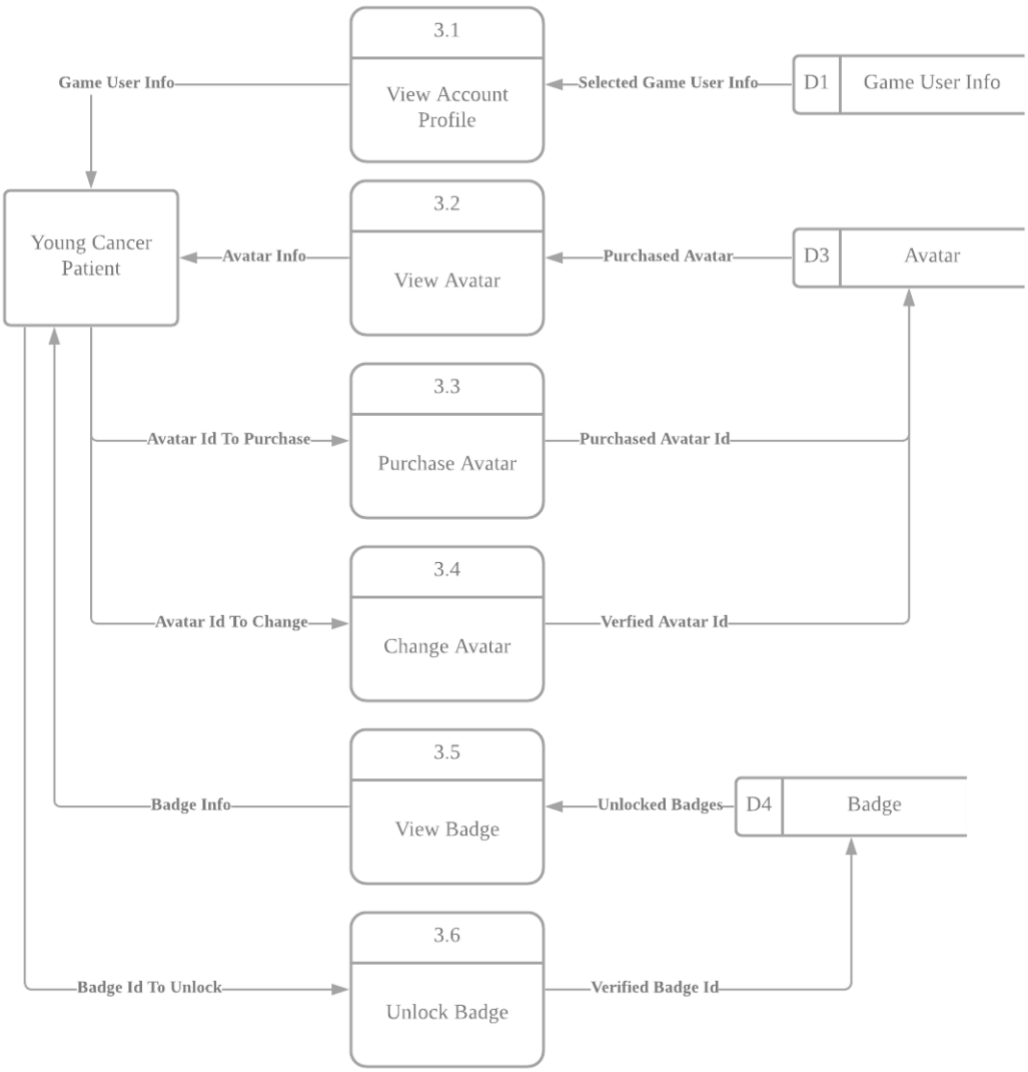


Figure 5.11: Data Flow Diagram Level 1 – 3.0 Manage Mobile Account Profile

5.4 User Interface Design

5.4.1 Web Application

1. Login Page

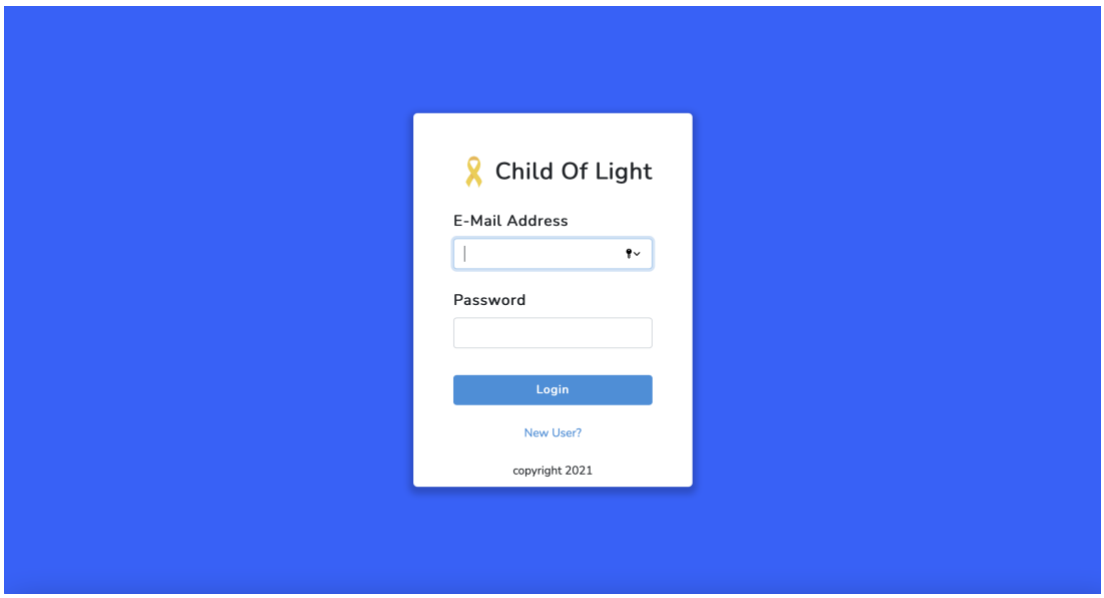


Figure 5.12: Login Page

2. Registration Page

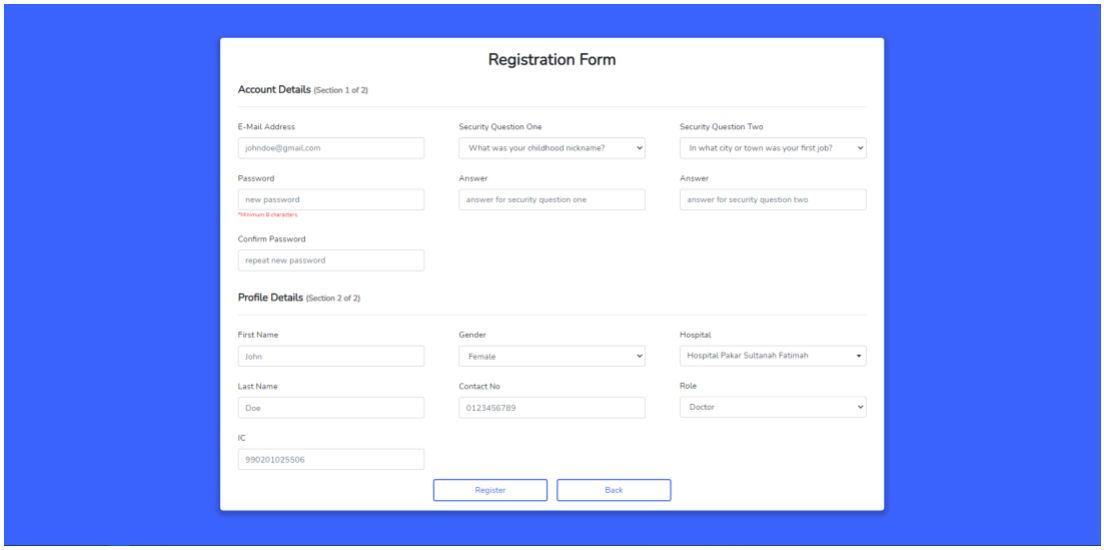


Figure 5.13: Registration Page

3. Main Menu Page

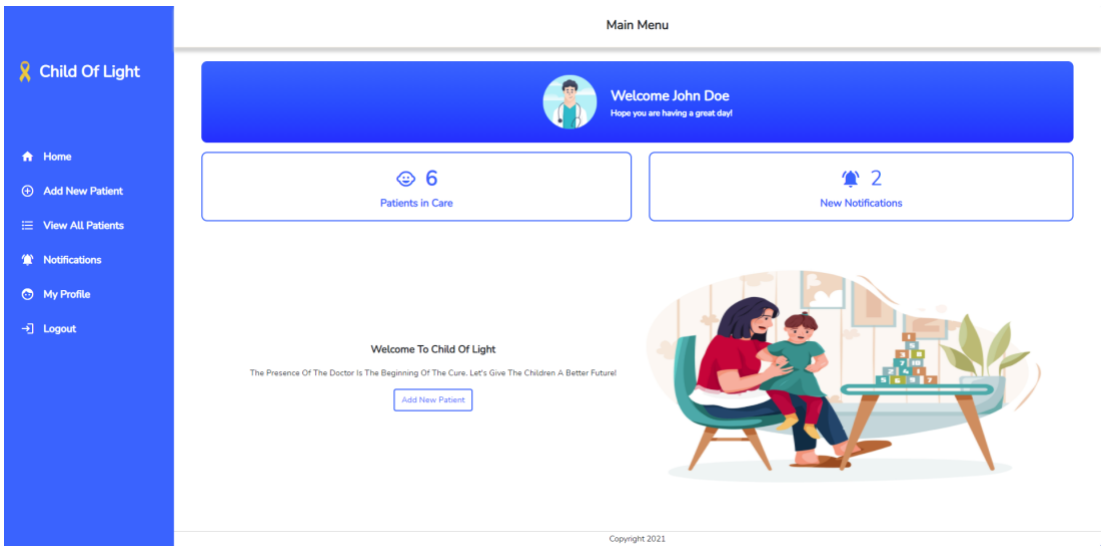


Figure 5.14: Main Menu Page

4. Add New Patient Page

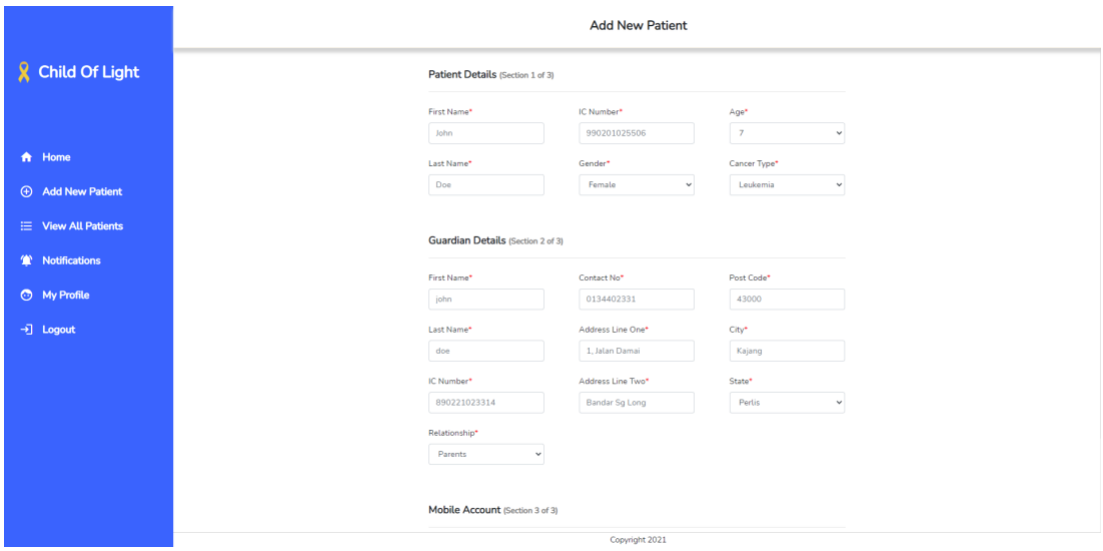


Figure 5.15: Add New Patient Page

5. Patient List Page

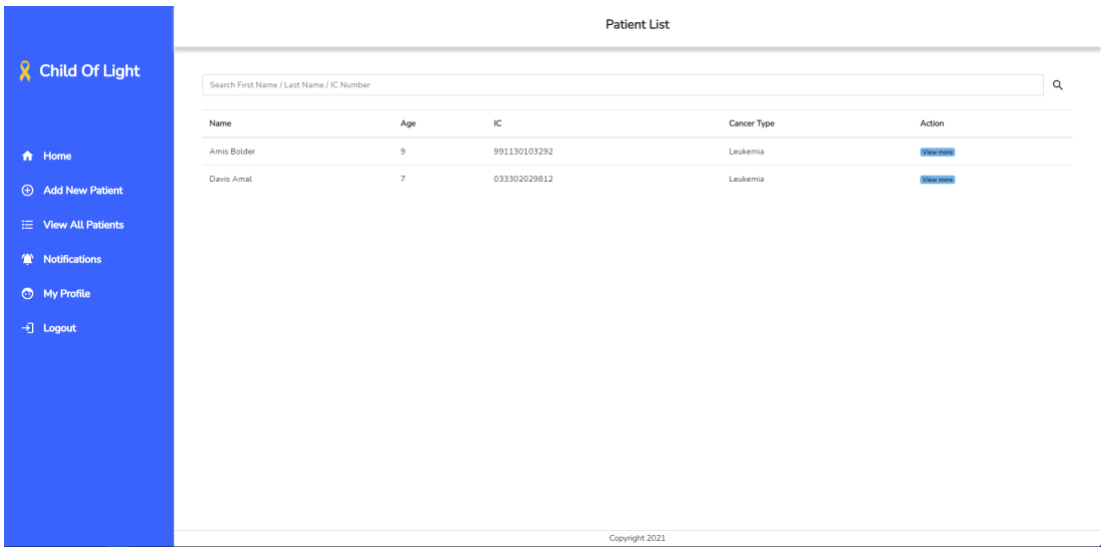


Figure 5.16: Patient List Page

6. Patient Detail Page

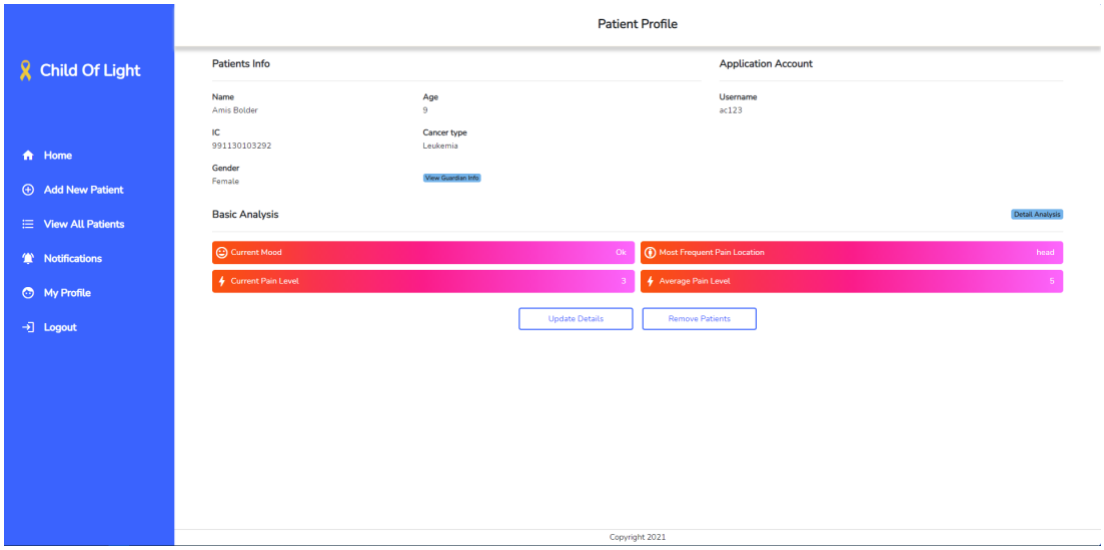


Figure 5.17: Patient Detail Page

7. Patient Guardian Profile Page

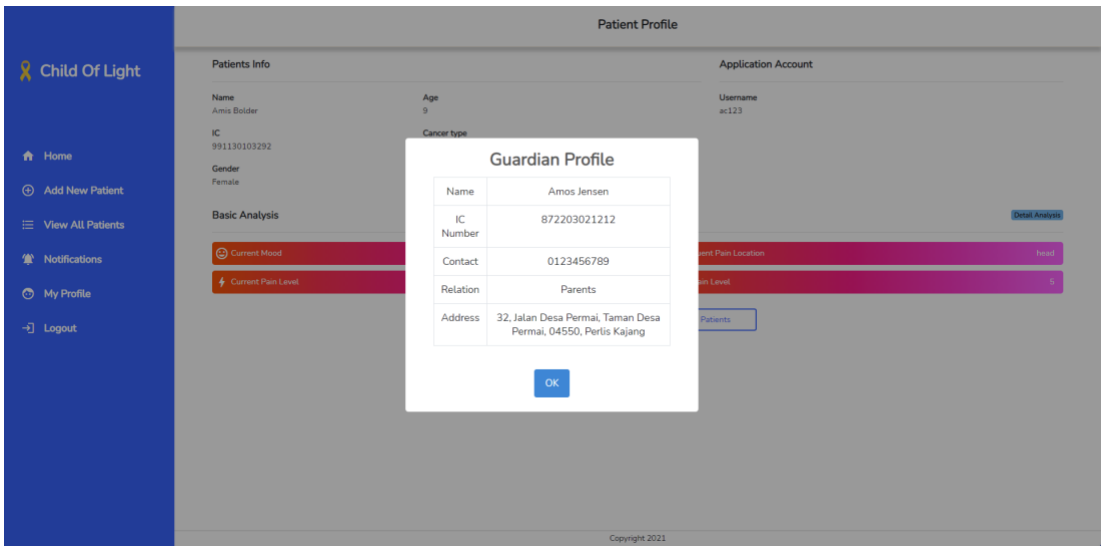


Figure 5.18: Patient Guardian Profile Page

8. Detail Analysis Page

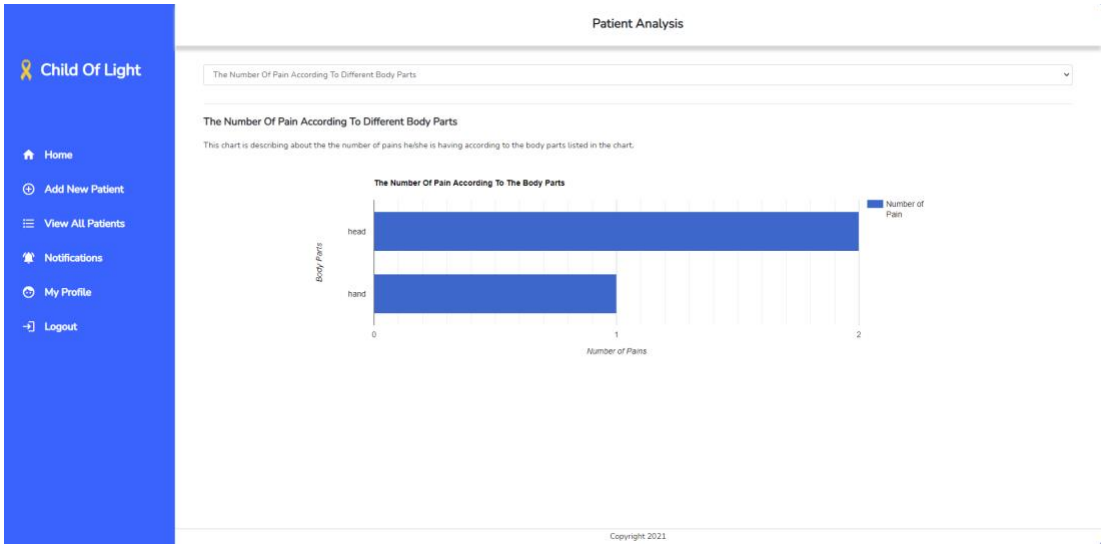


Figure 5.19: Detail Analysis Page

9. Edit Patient Detail Page

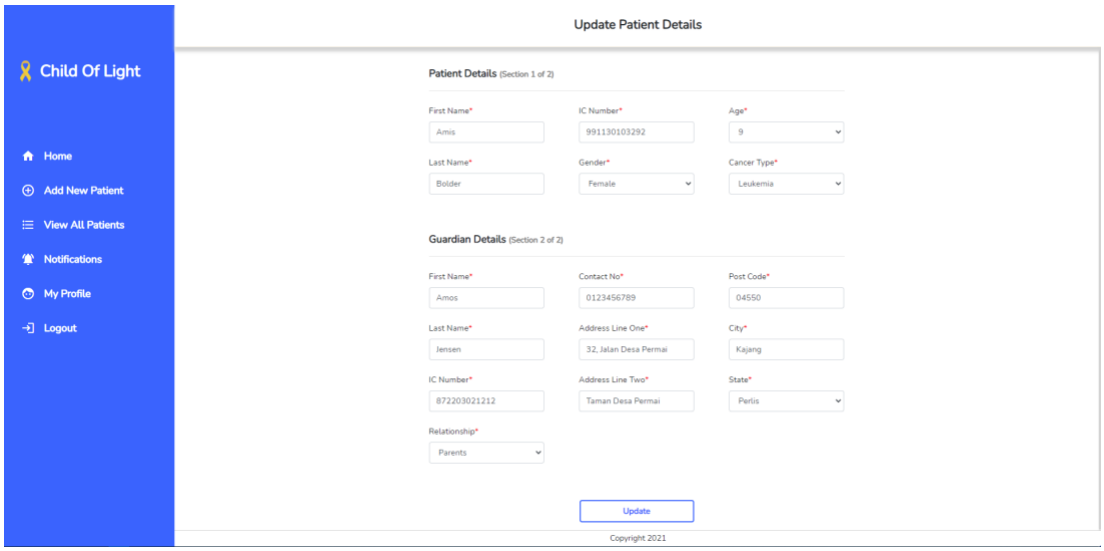


Figure 5.20: Edit Patient Detail Page

10. Notification List Page

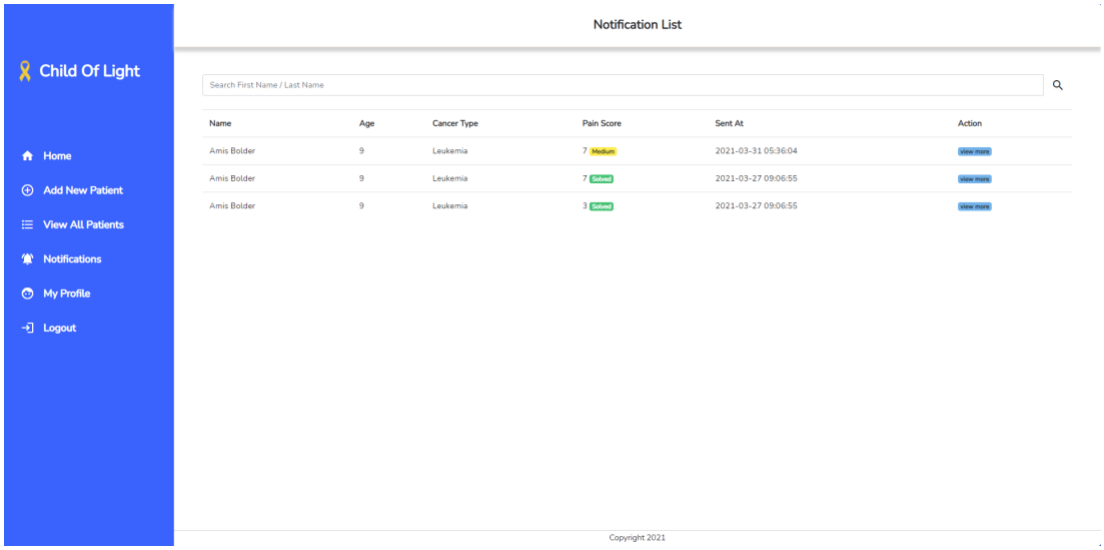


Figure 5.21: Notification List Page

11. Notification Detail Page

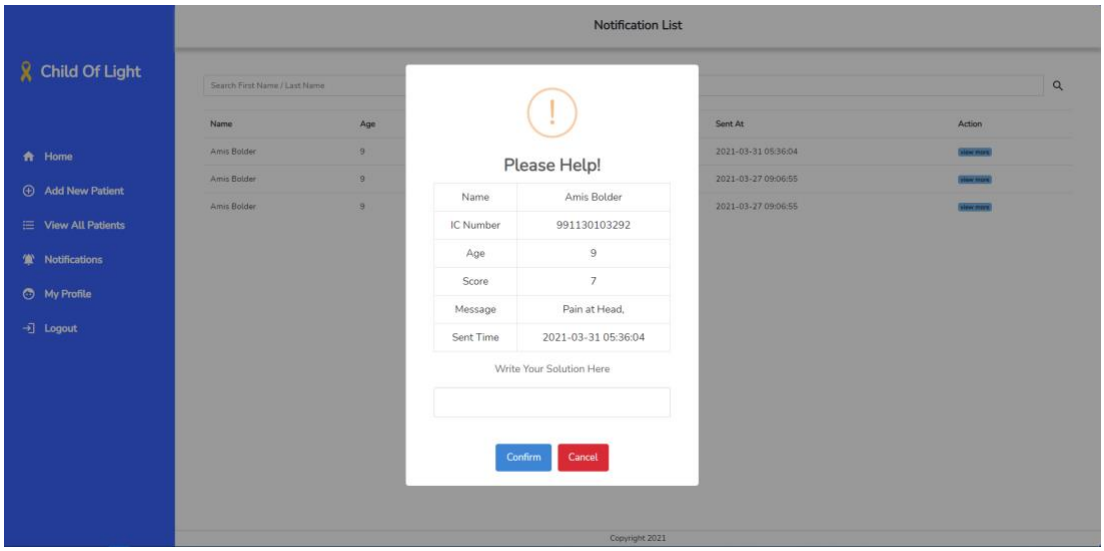


Figure 5.22: Notification Detail Page

12. Notification Detail Page (Solved)

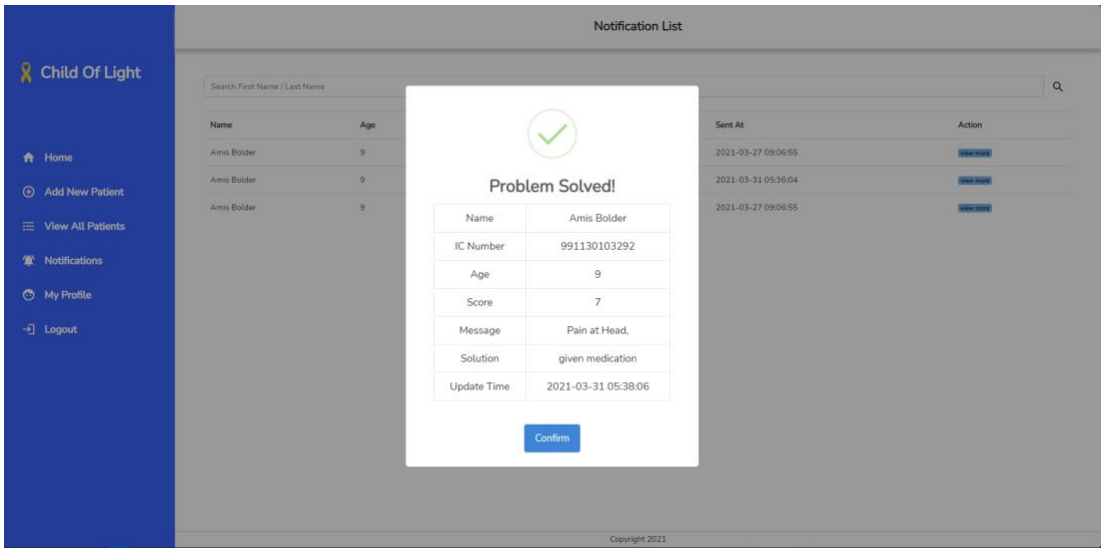


Figure 5.23: Notification Detail Page (Solved)

13. User Profile Page

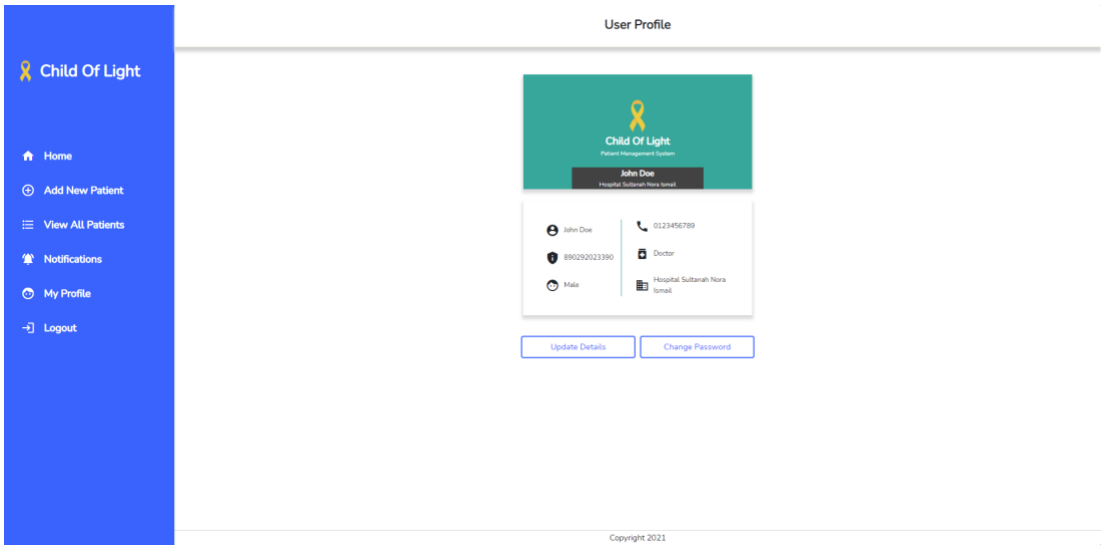


Figure 5.24: User Profile Page

14. Update Profile Page

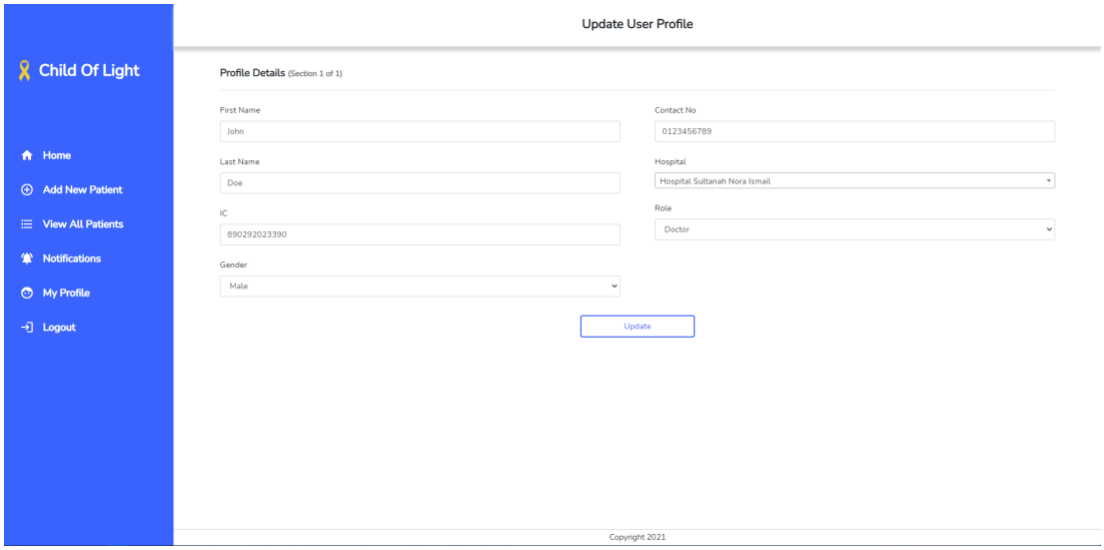


Figure 5.25: Update Profile Page

15. Reset Password Page

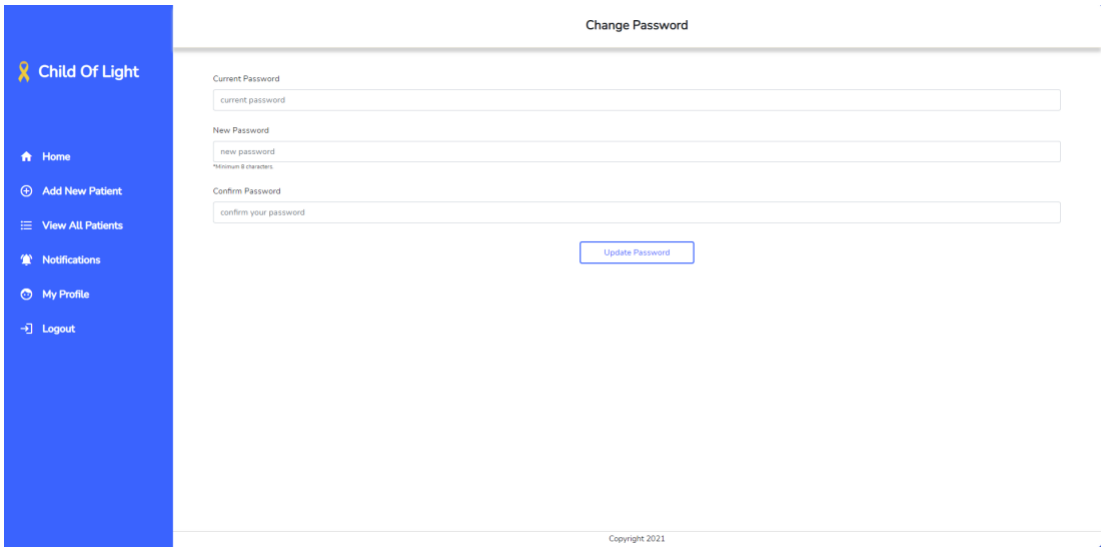


Figure 5.26: Reset Password Page

5.4.2 Mobile Application

1. Login Screen

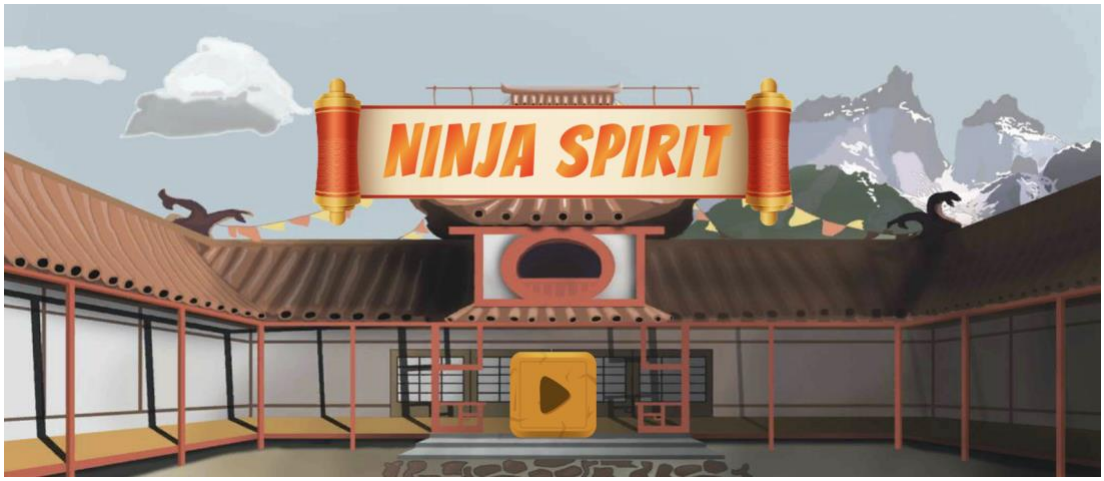


Figure 5.27: Login Screen

2. Registration Screen

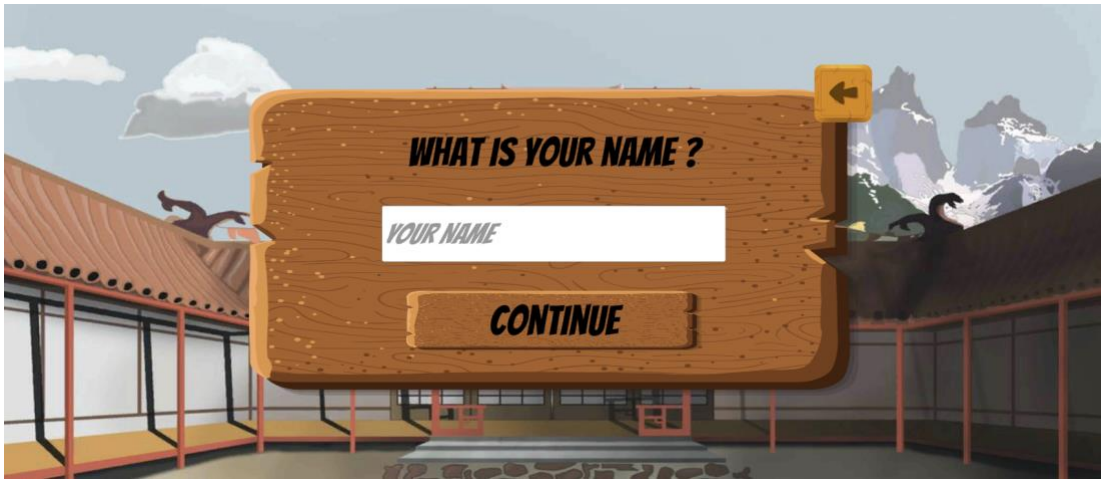


Figure 5.28: Registration Screen

3. Main Menu Screen

Figure 5.29: Main Menu Screen

4. Game Screen

Figure 5.30: Game Screen

5. Profile Screen

Figure 5.31: Profile Screen

6. Avatar Screen

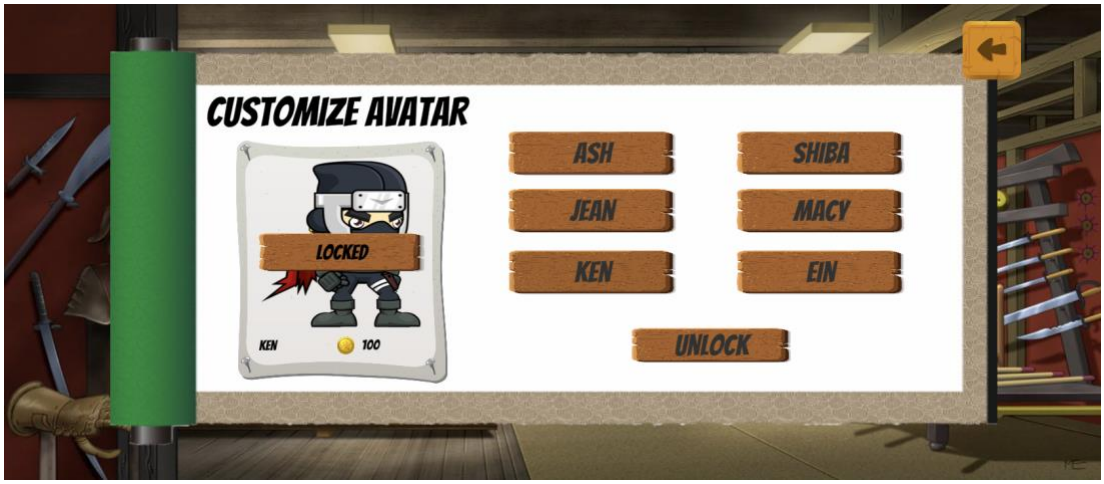


Figure 5.32: Avatar Screen

7. Badge Screen

Figure 5.33: Badge Screen

8. Report Screen

Figure 5.34: Report Screen

9. Message Screen

Figure 5.35: Message Screen

CHAPTER 6

SYSTEM IMPLEMENTATION

6.1 Introduction

This chapter focuses on the system implementation of the project. It covers major implementation in this project such as the implementation of gamification concept in the mobile application, data analysis in web application, APIs implementation and others.

6.2 Implementation of Gamification

Gamification concept is implemented in the mobile application by using different techniques such as relevant graphics and audio to attract the user to use the application. The sub-sections below will explain the implementation of different game elements in the mobile application.

6.2.1 Theme

The theme setting of the mobile application is based on a Japanese character setting called ninja. This theme is selected because the setting of ninja is about getting stronger after all the suffering. This is because their training is strenuous and exhausting, just like what the young cancer patient is suffering right now. The purpose of providing this theme is to let the young cancer patient to mimic ninja, to learn to be perseverance and learn to become stronger after all the suffering from pain.

In order to create the immersive environment, all the graphics and audio selected for the mobile application are close to the feeling of Japanese-style such as wooden panel, dojo background, and background music with traditional Japanese instrument.

Figure 6.1: Login Screen

6.2.2 Challenges

Game feature in the mobile application is designed as an infinite platform runner to bring in the challenge game element. Infinite platform runner creates infinite platform for player to keep running until the player die in the game. Different challenge mechanism such as obstacles, enemy and random generated platform was also implemented to increase the difficulty of the game. Player could try to break the highest score they had when they are playing the game.

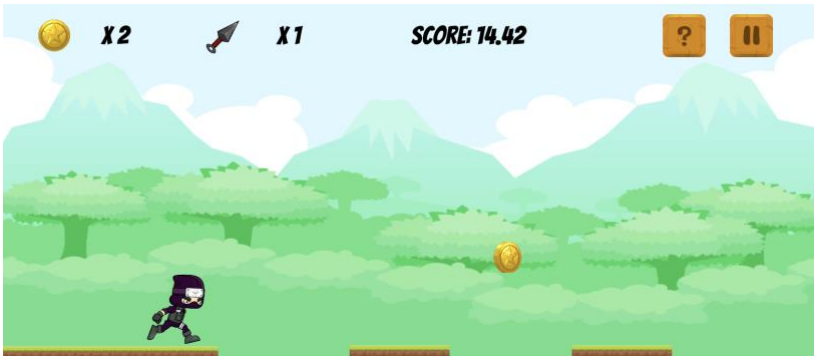


Figure 6.2: Game Screen

6.2.3 Avatars

This mobile application includes different avatars for the young cancer patient to select. There are free avatars and avatars to be purchased with the coin collected from the game. This also creates a challenge for the user if they want to purchase the desire avatar from the shop. After purchasing the avatars, user can change the avatar freely according to their preference.

Figure 6.3: Avatar Screen

6.2.4 Badges

This mobile application also contains different badges waiting to be unlocked by the user. After the user has achieved a target set in the mobile application, the badge will be unlocked and display in the badge scene. For example, report badge will be unlocked if the user has sent 5 reports through the mobile application.

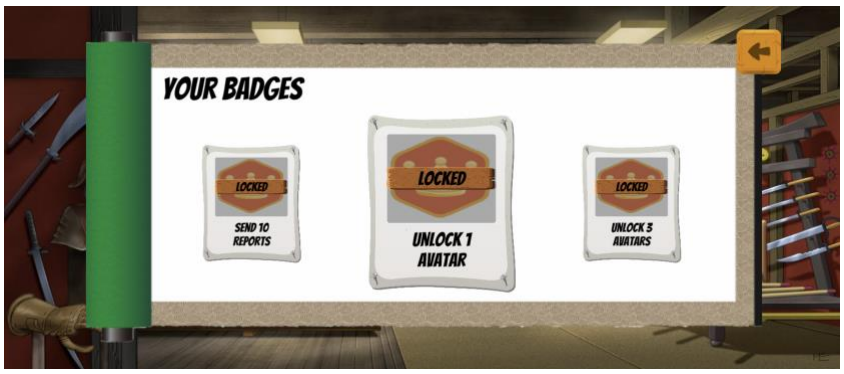


Figure 6.4: Badge Screen

6.3 UX Design for children

UX design for children is not as easy as UX design for adults. The knowledge and cognition of children in different age stages are different and most of it are limited. Therefore, complicated user interface may lower children's interest in using the application. According to Kosa (2018) and Molnár (2018), children aged 6 years old onwards know how to read, but limited in vocabulary. Developers must avoid using complicated words in the system that will confuse the children. Moreover, children aged 9 – 12 years old typically know simple interaction with the device such as swipe and scroll. Developers could add more interaction but still need to keep it simple to use. Below are also some of the core UX design for children across all ages:

- Children requires instant feedback.
- Keep the application simple.
- Prevent content heavy application.

UX design for children is one of the critical elements for the mobile application because the target users are cancer patient aged 7 – 11 years old. In order to provide the best experience to them, the mobile application strictly followed the guidance in developing UX for children. For example, the reporting process decomposed into five sections and each of the section only contains one simple question. Also, the application uses simple words to avoid the confusion. The gesture in the application is also restricted to tap, scroll, and swipe only.

6.4 Data Analysis and Visualization

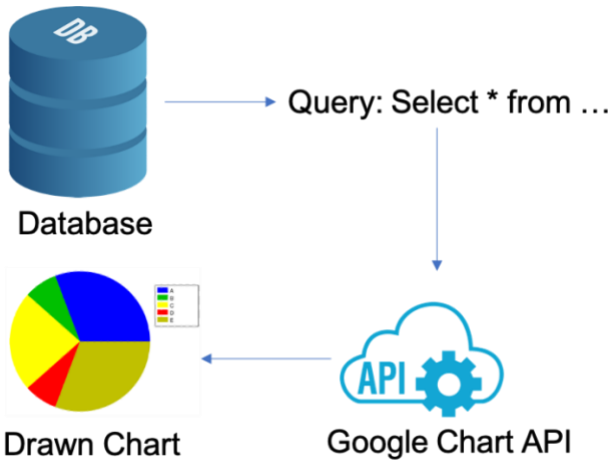


Figure 6.5: Process of Drawing Chart

Web application utilized chart package provided by Google to visualize the data sent by young cancer patient. Google Chart provides rich amount of chart such as pie chart, line chart, scatter plot and other useful packages and resources for the developer to use. Based on Figure 6.1 above, all the relevant data are selected and retrieved from the database to feed into the Google Chart API. After retrieving the selected data, a data table will be created by following the format defined in Google Chart package. Each of the function defined to draw the respective chart will use the data table to plot the graph accordingly.

6.5 API Creation and Routing

Laravel framework provides developers a convenient solution in creating RESTful API for system and database communication. By using Laravel framework, developers are able to differentiate and categorize APIs and normal routing in different files. In the routes folder generated by Laravel framework, developers can keep all the normal routing definition in web.php and APIs definition in api.php. This has improved the maintainability of the code in future.

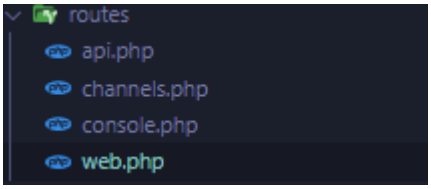


Figure 6.6: Route files

6.5.1 Normal Routing Endpoints

Table 6.1: Route Description for Authentication Controller

Routes (Auth)	Types	Description
/login	GET	Route to login page
/login	POST	Verify login input and redirect to main menu
/register	GET	Route to register page
/register	POST	Register new web application account
/password/reset	GET	Route to send email to reset password page
/password/reset	POST	Reset password
/password/email	POST	Send reset password link to email
/password/reset/{token}	GET	Route to specific password reset page
/logout	POST	Logout account

Table 6.2: Route Description for Patient Controller

Routes (Patients)	Types	Description
/patients	GET	Route to patients list page
/patients/create	GET	Route to add new patient page
/patients/store	POST	Add new patient
/patients/{id}	GET	Route to view selected patient page
/patients/{id}/edit	GET	Route to edit selected patient page
/patients/{id}	PUT	Update patient detail
/patients/{id}	DESTROY	Delete patient
/patients/search	GET	Return search result
/patients/search	POST	Search patients
/patients/{id}/analyse	GET	Analyse patients

Table 6.3: Route Description for Notification Controller

Routes (Notifications)	Types	Description
/notifications	GET	Route to notifications list page
/notifications/{id}	GET	Route to view selected notification page
/notifications/{id}	PUT	Update notification detail

Table 6.4: Route Description for User Controller

Routes (Users)	Types	Description
/users/{id}	GET	Route to view user profile page
/ users/{id}/edit	GET	Route to edit user profile page
/ users/{id}	PUT	Update user profile detail

Table 6.5: Route Description for Home Controller

Routes (Home)	Types	Description
/	GET	Route to main menu page

6.5.2 API Endpoints

Table 6.6: APIs for Mobile Application

API Routes	Types	Description
/api/ninjaspirits/login	POST	Verify login input
/api/ninjaspirits/firstLogin	POST	Register user account for mobile application
/api/ninjaspirits/changeAvatar	PUT	Update to selected avatar
/api/ninjaspirits/unlockAvatar	POST	Unlock a new avatar
/api/ninjaspirits/{id}/getAvatars	GET	Get all available avatars
/api/ninjaspirits/unlockCoinBadge	POST	Unlock coin badge if target is hit
/api/ninjaspirits/unlockAvatarBadge	POST	Unlock avatar badge if target is hit
/api/ninjaspirits/unlockReportBadge	POST	Unlock report badge if target is hit
/api/ninjaspirits/{id}/getAllBadges	GET	Get all available badges
/api/ninjaspirits/updateScore	POST	Update game high score
/api/ninjaspirits/{id}/getScore	GET	Get game high score and coin number
/api/ninjaspirits/sendReport	POST	Add report to database
/api/ninjaspirits/sendMessage	POST	Add message to database
/api/ninjaspirits/{id}/loadProfile	GET	Load profile info
/api/ninjaspirits/showTutorial	PUT	Update tutorial state

6.6 Heroku Deployment

Heroku provides a very simple way for developers to deploy their system online. According to the Heroku official documentation, Heroku supports most of the mainstream backend language such as Node.js, Python, PHP, and many others.

6.6.1 Procfile

Procfile is a command file that is used by Heroku to execute during app start up. This file must be included in the root folder of the project for Heroku to execute on start up. Many type of command such as task to run and web server configuration can be added to the file for start-up execution in future.

6.6.2 Brief Deployment Process

1. Prepare a Laravel Project (Web application)
2. Initialize the Laravel project to become a git project
3. Create a Procfile according to the backend programming language used.
4. Add the Procfile to root folder of the project.
5. Connect remote access on Heroku through git.
6. Create an application on Heroku through git.
7. Push the Laravel project to Heroku.
8. Set up cloud database with Heroku PostgreSQL if needed.
9. Launch the deployed system through Heroku website (floating-caverns-07171).

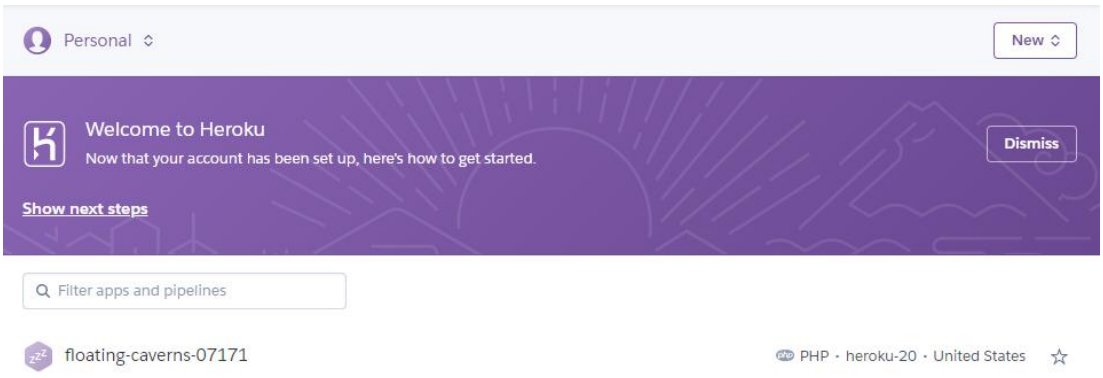


Figure 6.7: Deployed System in Heroku Web Site

6.7 Conclusion

This chapter provides concepts on some of the critical implementation such as implementation of gamification concept, implementation of chart analysis, implementation of APIs endpoints, and also system deployment. Each implementation section describes the main concept, the way of implementing in the projects and examples to provide a clearer image.

CHAPTER 7

SYSTEM TESTING

7.1 Introduction

This chapter reports the different tests conducted on this project. The five type of tests conducted are unit test, integration test, system test, usability test, and also user acceptance test.

7.2 Use Cases, Functional Requirement, and Test Cases

Testing is very important process for developers to ensure the system is functioning appropriately. There are all kinds of testing that can be conducted for different purpose such as unit testing to test the functionality of a single component or user usability testing to test the overall usability of the system. However, as the test cases grows, developer could be overwhelmed by the number of test cases and this may cause developer to produce redundant or irrelevant test cases that is not constructive to the system. Therefore, this chapter has included a few simple traceability matrices to help readers to roughly understand the purpose of each test cases. The traceability matrices also connected the test cases with the relevant functional requirements and use cases to understand the objective of the particular test case.

7.2.1 Use Case Table

Table 7.1 lists out all the use cases in both mobile application and web application. The main contents of this table are the Use Case ID, the Use Case Name, and the specific system that each use case is associating to. The purpose of the summary table is to show the traceability matrices in Table 7.2.

Table 7.1: Use Case Summary Table

Use Case ID	Use Case Name	System
UC001	Login Account	Mobile Application
UC002	Play Game	Mobile Application
UC003	View Profile	Mobile Application
UC004	Create Profile	Mobile Application
UC005	Record Pain	Mobile Application
UC006	Send Message	Mobile Application
UC007	View Avatar	Mobile Application
UC008	View Badge	Mobile Application
UC009	Login Account	Web application
UC010	Register New Account	Web application
UC011	Manage Children Profile	Web application
UC012	View Patient Data Analysis	Web application
UC013	View Message	Web application
UC014	Manage User Profile	Web application
UC015	Search Patient	Web application

7.2.2 Functional Requirement Traceability Matrix

Table 7.2 lists out all the functional requirements proposed in previous chapter. The structure of the table is similar as the use case summary table which consists of functional requirement id, functional requirement statement and system. The last column (related use case id) links the particular functional requirement to the appropriate use case in Table 7.1.

Table 7.2: Functional Requirement Summary Table

Functional Requirement ID	Functional Requirement Statement	System	Related Use Case ID	Related Test Case ID
FR001	The system shall allow user to log in with provided account.	Mobile Application	UC001	ITC030-ITC032
FR002	The system shall allow user to create profile and avatar during first time login.	Mobile Application	UC004	ITC033-ITC034
FR003	The system shall allow user to view account profile.	Mobile Application	UC003, UC008	ITC041-ITC047, ITC050-ITC051
FR004	The system shall allow user to record pain.	Mobile Application	UC005	ITC048
FR005	The system shall allow user to customize avatar.	Mobile Application	UC007	ITC037-ITC040
FR006	The system shall allow user to play mini game.	Mobile Application	UC002	UTC025-UTC033, ITC035-ITC036, ITC052
FR007	The system shall allow user to send message to medical team.	Mobile Application	UC006	ITC049
FR008	The system shall allow user to log in with correct account.	Web application	UC009	ITC001-ITC004
FR009	The system shall allow user to register a new account.	Web application	UC010	ITC005-ITC006
FR010	The system shall allow user to manage own profile.	Web application	UC014	ITC011-ITC016

Table 7.3: Functional Requirement Summary Table (Continued)

FR011	The system shall allow user to perform simple CRUD function on young cancer patient profile.	Web application	UC011	ITC017-ITC025
FR012	The system shall allow user to search patient.	Web application	UC015	ITC026-ITC027
FR013	The system shall allow user to view the patient data analysis chart.	Web application	UC012	ITC028-ITC029
FR014	The system shall allow user to view message sent by young cancer patient.	Web application	UC013	ITC007-ITC010

7.3 Unit Test

Unit testing is one of the testing that was conducted in the project. Unit testing is a testing that is focus on individual component of the module. Web application used PHPUnit whereas mobile application used Unity Test Runner to test. Unit testing has been applied in both applications to ensure that all the components run correctly.

7.3.1 Web application

PHPUnit is a testing framework built solely for PHP language. Also, Laravel framework has included PHPUnit as the primary testing kit and simplified the testing process for web developer. There were total of 24 test cases for the web application. Although all the **unit test cases for web application did not relate to any of the functional requirement** as shown in Table 7.3, but the **objective of the test cases were focus on the relationship between models**. This was to ensure the relationship between different entities in the server were connected correctly.

Table 7.4: Unit Test Cases Table (Web application)

Test Case ID	Test Case Name	Test Case Description	Model	Status
UTC001	Test Has One Game User Info	Examine whether **avatar model** has one to one relationship with **game user info model**	Avatar Model	Pass
UTC002	Test Belongs to Many Accounts	Examine whether **avatar model** has many to many relationships with **patient account model**		Pass

Table 7.5: Unit Test Cases Table (Web application) (Continued)

UTC003	Test Belongs to Many Accounts	Examine whether **badge model** has many to many relationships with **patient account model**	Badge Model	Pass
UTC004	Test Belongs to Avatar	Examine whether **game user info model** has one to one relationship with **avatar model**	Game User Info Model	Pass
UTC005	Test Belongs to Account	Examine whether **game user info model** has one to one relationship with **patient account model**		Pass
UTC006	Test Has Many Messages	Examine whether **patient account model** has one to many relationships with **patient message model**	Patient Account Model	Pass
UTC007	Test Has Many Report	Examine whether **patient account** model has one to many relationships with **patient report model**		Pass
UTC008	Test Belongs to Patient	Examine whether **patient account model** has one to one relationship with **patient profile model**		Pass
UTC009	Test Has One Game User Info	Examine whether **patient account model** has one to one relationship with **game user info model**		Pass

Table 7.6: Unit Test Cases Table (Web application) (Continued)

UTC010	Test Belongs to Many Avatars	Examine whether **patient account model** has many to many relationships with **avatar model**		Pass
UTC011	Test Belongs to Many Badges	Examine whether **patient account model** has many to many relationships with **badge model**		Pass
UTC012	Test Belongs to Patient	Examine whether **patient guardian profile model** has one to one relationship with **patient profile model**	Patient Guardian Profile Model	Pass

Table 7.7: Unit Test Cases Table (Web application) (Continued)

UTC013	Test Belongs to Patient	Examine whether **patient message model** has many to one relationship with **patient profile model**	Patient Message Model	Pass
UTC014	Test Belongs to Account	Examine whether **patient message model** has many to one relationship with **patient account model**		Pass
UTC015	Test Has Many Messages	Examine whether **patient profile model** has one to many relationships with **patient message model**	Patient Profile Model	Pass
UTC016	Test Has Many Reports	Examine whether **patient profile model** has one to many relationships with **patient report model**		Pass
UTC017	Test Has One Account	Examine whether **patient profile model** has one to one relationship with **patient account model**		Pass
UTC018	Test Has One Guardian	Examine whether **patient profile model** has one to one relationship with **patient guardian profile model**		Pass

Table 7.8: Unit Test Cases Table (Web application) (Continued)

UTC019	Test Belongs to User	Examine whether **patient profile model** has many to one relationship with **user profile model**		Pass
UTC020	Test Belongs to Patient	Examine whether **patient report model** has many to one relationship with **patient profile model**	Patient Report Model	Pass
UTC021	Test Belongs to Account	Examine whether **patient report model** has many to one relationship with **patient account model**		Pass
UTC022	Test Belongs to User	Examine whether **user profile model** has one to one relationship with **user model**	User Profile Model	Pass

Table 7.9: Unit Test Cases Table (Web application) (Continued)

UTC023	Test Has Many Patients	Examine whether **user profile model** has one to many relationships with **patient profile model**		Pass
UTC024	Test Has One User Profile	Examine whether **user model** has one to one relationship with **user profile model**	User Model	Pass

Figure 7.1: Web Application Unit Test

7.3.2 Mobile Application

Mobile application consists of 9 test cases. All test cases are focused on game feature in the mobile application. Other features such as report feature, and message feature are more associated with APIs to complete the function. All the APIs are tested in the integration test in the next section.

Table 7.10: Unit Test Cases Table (Mobile Application)

Test Case ID	Test Case Name	Test Case Description	Related FR ID	Status
UTC025	Test Default Coin Amount	Examine if the default number of coins is 0 when user entered the game.	FR006	Pass
UTC026	Test Default Kunai Amount	Examine if the default number of kunai is 0 when user entered the game.		Pass
UTC027	Test Default Score	Examine If the default score is 0 when user entered the game.		Pass
UTC028	Test Enemy Default Health	Examine if the default health of the enemy is 50 when user entered the game.		Pass
UTC029	Test Coin Is Updated Real Time	Examine if the coin is updated when the player has touched the coin in game.		Pass
UTC030	Test Kunai Is Updated Real Time	Examine if the kunai is updated when the player collected new kunai or when the player has thrown the kunai.		Pass
UTC031	Test Player Is Dead Real Time	Examine whether the game over menu pop if the system detected the player is dead.		Pass
UTC032	Test Player Is Running Real Time	Examine whether the character is running when the game starts.		Pass
UTC033	Test Score Is Updated Real Time	Examine whether the score is updated when the player is not dead yet.		Pass

Figure 7.2: Mobile Application Unit Test

7.4 Integration Test

Integration tests comprise of testing the interoperability between different modules to make sure the modules can communicate and interact with each other correctly. Both web application and mobile application used PHPUnit to conduct integration test. In this project, integration test focuses on API calling and data transferring between modules to ensure all the data displayed are correct and appropriate. Mobile application consists of 23 test cases on APIs calling whereas web application consists of 29 test cases on data processing and traveling between controllers and views.

7.4.1 Web application

Table 7.11: Integration Test Summary Table (Web Application - Login)

Test Case ID	Test Case Name	Test Case Description	Related FR ID	Status
ITC001	Test to Login Page	Test whether the user can navigate to login page	FR008	Pass
ITC002	Test Cannot Go Back to Login Page If Authenticated	Test whether the system will block user from going back to login back if user has already login		Pass
ITC003	Test Login with Correct Credential	Test whether the system will allow user to login with correct credential		Pass
ITC004	Test Login with Incorrect Credential	Test whether the system will block user from login with incorrect credential		Pass

Table 7.12: Integration Test Summary Table (Web Application - Registration)

Test Case ID	Test Case Name	Test Case Description	Related FR ID	Status
ITC005	Test to Registration Page	Test whether the user can navigate to registration page	FR009	Pass
ITC006	Test Register New User Account	Test whether the system will register the new account with the data entered by user		Pass

Table 7.13: Integration Test Summary Table (Web Application - Notification)

Test Case ID	Test Case Name	Test Case Description	Related FR ID	Status
ITC007	Test to Notification Page	Test whether the user can navigate to notification page	FR014	Pass
ITC008	Test Show Notification Detail Invalid Id	Test whether the system will block user from going to notification detail page with invalid id		Pass
ITC009	Test Update Notification Detail Valid Id	Test whether the system will update the notification details with the valid id		Pass
ITC010	Test Update Notification Detail Invalid Id	Test whether the system will block user from updating the notification details with invalid id		Pass

Table 7.14: Integration Test Summary Table (Web Application – User Profile)

Test Case ID	Test Case Name	Test Case Description	Related FR ID	Status
ITC011	Test to Show User Profile Page Valid Id	Test whether the user can navigate to user profile page with valid id	FR010	Pass
ITC012	Test to Show User Profile Page Invalid Id	Test whether the system will block user from navigating to user profile page with invalid id		Pass
ITC013	Test to Edit User Profile Page Valid Id	Test whether the user can navigate to edit user profile page with valid id		Pass

Table 7.15: Integration Test Summary Table (Web Application – User Profile)

ITC014	Test to Edit User Profile Page Invalid Id	Test whether the system will block user from navigating to edit user profile page with invalid id	FR010	Pass
ITC015	Test Update User Profile Valid Id	Test whether the user can update the user profile with valid id		Pass
ITC016	Test Update User Profile Invalid Id	Test whether the system will block user from updating user profile with invalid id		Pass

Table 7.16: Integration Test Summary Table (Web Application - Patient)

Test Case ID	Test Case Name	Test Case Description	Related FR ID	Status
ITC017	Test to Patient List Page	Test whether the user can navigate to patient list page	FR011	Pass
ITC018	Test to Create New Patient Page	Test whether the user can navigate to create new patient page		Pass
ITC019	Test to Show Patient Page Valid Id	Test whether the user can navigate to patient details page with valid id		Pass
ITC020	Test to Show Patient Page Invalid Id	Test whether the system will block user from navigating to patient details page with invalid id		Pass
ITC021	Test to Edit Patient Page Valid Id	Test whether the user can navigate to edit patient page with valid id		Pass
ITC022	Test to Edit Patient Page Invalid Id	Test whether the system will block user from navigating to edit patient page with invalid id		Pass
ITC023	Test Create New Patient	Test whether system will create new patient with the data entered by user		Pass
ITC024	Test Update Patient Valid Id	Test whether system will update the patient details with valid id		Pass

Table 7.17: Integration Test Summary Table (Web Application - Patient)

(Continued)

ITC025	Test Update Patient Invalid Id	Test whether the system will block the patient from updating patient details with invalid id	FR011	Pass
ITC026	Test Patient Search Valid Search	Test whether the system will return correct result with valid search criteria	FR012	Pass
ITC027	Test Patient Search Invalid Search	Test whether the system will not return anything with invalid search criteria		Pass
ITC028	Test Analyse Patient Valid Id	Test whether the system will produce analysis chart with valid id	FR013	Pass
ITC029	Test Analyse Patient Invalid Id	Test whether the system will not produce analysis chart with invalid id		Pass

Figure 7.3: Web Application Integration Test

7.4.2 Mobile Application

Table 7.18: Integration Test Summary Table (Mobile Application)

Test Case ID	Test Case Name	Test Case Description	Related FR ID	Status
ITC030	Test Login	Test whether the user can login with correct credentials	FR001	Pass
ITC031	Test Login User Not Found	Test whether the system will block user from login with invalid username		Pass
ITC032	Test Login Invalid Password	Test whether the system will block user from login with invalid password		Pass
ITC033	Test First Time Login	Test whether the system will redirect user to create profile screen if user is logging for the first time	FR002	Pass
ITC034	Test Register New Account After First Time Login	Test whether the system will create the new account based on the data entered by user		Pass
ITC035	Test Update Score	Test whether the coin score and game score will be updated after the game has ended	FR006	Pass
ITC036	Test Get Score	Test whether the coin score and game high score will be retrieved from database		Pass
ITC037	Test Change Avatar	Test whether the user can change avatar	FR005	Pass
ITC038	Test Get All Avatars	Test whether the system will retrieve all avatars unlocked by user		Pass
ITC039	Test Unlock Avatar	Test whether the user can unlock avatar with coins		Pass
ITC040	Test Unlock Avatar Insufficient Coin	Test whether the system will block user from unlocking avatar with insufficient coin		Pass
ITC041	Test Unlock Coin Badge Success	Test whether the system will unlock coin badge when the target has reached	FR003	Pass

Table 7.19: Integration Test Summary Table (Mobile Application) (Continued)

ITC042	Test No Coin Badge to Unlock	Test whether the system will not unlock the coin badges if the target is not reached	FR003	Pass
ITC043	Test Unlock Report Badge Success	Test whether the system will unlock report badge when the target has reached		Pass
ITC044	Test No Report Badge to Unlock	Test whether the system will not unlock the report badges if the target is not reached		Pass
ITC045	Test Unlock Avatar Badge Success	Test whether the system will unlock avatar badge when the target has reached		Pass
ITC046	Test No Avatar Badge to Unlock	Test whether the system will not unlock the avatar badges if the target is not reached		Pass
ITC047	Test Get All Badges	Test whether the system will retrieve all the badges unlocked by user		Pass
ITC048	Test Send Report	Test whether the user can send report and store the data in correct database table	FR004	Pass
ITC049	Test Send Message	Test whether the user can send message and store the data in correct database table	FR007	Pass
ITC050	Test Load Profile Valid Id	Test whether the system will load the profile according to the id given	FR003	Pass
ITC051	Test Load Profile Invalid Id	Test whether the system will not load the profile if the id is invalid		Pass
ITC052	Test Show Tutorial	Test whether the system will update the tutorial state in database	FR006	Pass

Figure 7.4: Mobile Application Integration Test

7.5 Code Quality Review

Code quality review examines on the different aspect of the code such as the reliability, security, code coverage and others. The system was conducted using code quality review through an online platform called SonarCloud. SonarCloud is a website that helps developers to analyse the code quality of their project continuously. When the code is updated in the remote branch such as GitHub, SonarCloud will automatically re-examine the code again. Figure 7.5 shows the code quality score based on the different aspects. The system overall quality is great as all the aspect got the A grade. However, there are 4.1% of code duplications in the project. The score could be better when the duplicated blocks is reduced.

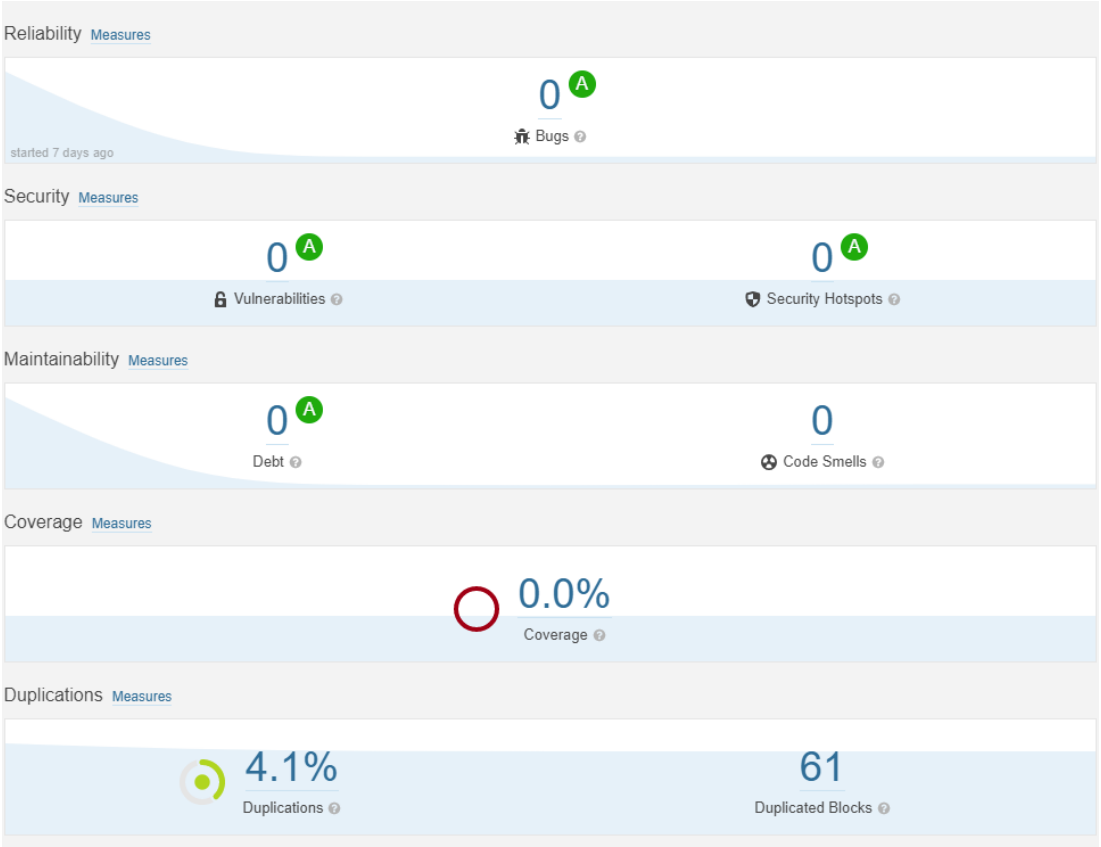


Figure 7.5: Code Quality Review Report

7.6 Usability Test

Usability test is another kind of software test method which focuses on the overall performance of the developed system. This test method usually involves users in the test compared to unit test and integration test which only tested through the test program. The objective of usability test in this project was to evaluate the performance, usability, effectiveness and user-friendliness of the system. A total of six users (three novice and three expert) was involved in the test. Each user was given a test case. The test scenario was given together with the test case for user to run through. During the usability testing, user was not interrupted by the supervisor and all the actual result was recorded in the test case template for evaluation. The final result of the usability test was discussed in the result and discussion section below. The sample test cases were included in Appendix D.

7.6.1 System Usability Scale

System Usability Scale is one of the most popular scale used to evaluate the system usability (System Usability Scale (SUS), 2020). It consists of 10 statements for users to rank from one to five after they completed the all the test scenarios. System usability scale was selected in evaluating the system usability because it was systematic and reliable. According to Thomas (2020), the system could be examined by calculating the system usability score based on the result of the statements collected from the users. After calculating the final system usability score, the final score could be compared with the industry standard which is 68 marks. If the score is above 68 means the system has achieved high usability standard and is ready to be used.

To calculate the final system usability scale score:

- Minus 1 from the score gotten in all the odd numbered questions
- Minus the obtained score from 5 in all the even numbered questions
- Sum all the new value and multiply the sum by 2.5

The final score should be less than or equals to 100 only.

7.6.2 Result & Discussion

7.6.2.1 Usability Test Result

Table 7.20: Usability Test Case Summary Table

Test Case ID	Test Case Name	Status
USTC001	Register New Account in Web application	Pass
USTC002	Log in Into Web application	Pass
USTC003	Add New Patient in Web application	Pass
USTC004	View All Patients in Web application	Pass
USTC005	View Selected Patient in Web application	Pass
USTC006	Search Patient in Web application	Pass
USTC007	Analyse Patient in Web application (No Data)	Pass
USTC008	View Notification in Web application (No Data)	Pass
USTC009	View User Profile in Web application	Pass
USTC010	Edit User Profile in Web application	Pass
USTC011	Change Password in Web application	Pass
USTC012	Logout in Web application	Pass
USTC013	Login into Mobile Application	Pass
USTC014	Create New Account Profile in Mobile Application	Pass
USTC015	Play Game in Mobile Application	Pass
USTC016	View Profile in Mobile Application	Pass
USTC017	Change Avatar in Mobile Application	Pass
USTC018	Unlock Avatar in Mobile Application	Pass
USTC019	View Badge in Mobile Application	Pass
USTC020	Send Message in Mobile Application	Pass
USTC021	Send Report in Mobile Application	Pass
USTC022	Analyse Patient in Web application (With Data)	Pass
USTC023	View Notification in Web application (With Data)	Pass
USTC024	Update Notification Detail in Web application (With Data)	Pass

Table 7.21: Tester Feedback Summary Table

Tester	Feedback
1	Nope
2	Game was fun and interesting
3	None
4	Analysis button can be placed in home screen or somewhere more noticeable
5	Good Job
6	The website is slow sometime

According to Table 7.18, all the usability tests scenarios conducted by all testers passed successfully. This indicated that all the features implemented in both mobile application and web application were functioning properly. Also, mobile application and web application were also able to interact with each other properly through the online server deployed. Furthermore, based to Table 7.19, the overall feedback from testers were positive. Tester 2 thought the game was fun and interesting. However, tester 4 thought that the analysis button is not noticeable and should be moved to somewhere obvious. This is a user experience suggestion, and it was implemented after the test to further improve the user experience. Besides, tester 6 experienced higher loading time sometime when the web application is loading. The problem with high loading time is caused by the low performance of the server. The performance of the free server provided by Heroku has been limited to a bottleneck hence causing the loading time problem. The only solution to this problem is to upgrade the server hardware to a higher performance hardware.

7.6.2.2 System Usability Scale Score

Table 7.22: System Usability Scale Score Table

Tester	Question										Total Score * 2.5
	1	2	3	4	5	6	7	8	9	10	
1	3	4	4	4	3	3	4	4	3	4	36*2.5=90
2	4	3	3	4	3	3	3	3	4	4	34*2.5=85
3	3	4	4	3	4	4	4	3	3	3	35*2.5=87.5
4	4	4	4	4	3	4	4	3	3	4	37*2.5=92.5
5	4	0	4	0	4	0	4	0	4	0	20*2.5=50
6	3	3	4	4	4	3	4	4	4	4	37*2.5=92.5

Average SUS score = (90+85+87.5+92.5+50+92.5)/6 = 82.92

The average system usability scale score obtained is 82.92 which is higher than the industry standard of 68. The system also scored within the range of good and excellent based on the acceptability score figure below. Falling in the acceptable score range indicates that the system usability is great enough for normal user to use without problem. The summary of questionnaire is included in Appendix E.

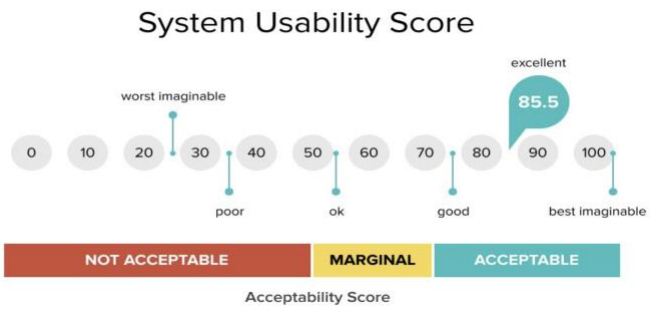


Figure 7.6: System Usability Scale (Smyk, 2020)

7.7 User Acceptance Test

User acceptance test is different from the previous tests such as integration test and usability test. User acceptance test does not focus on bug discovery but the user acceptance on the system in solving the problem they have. A bug free system does not necessarily pass the user acceptance test because the most critical aspect that user use to evaluate the system is the ability in solving the problem. In this project, the main purpose of developing this system is to assist the medical team in monitoring the young cancer patient health condition remotely. Besides, this system also aims to help the young cancer patient to lessen discomfort or pain caused by the cancer.

7.7.1 User Acceptance Test Plan

The user acceptance test was planned to conduct within two different user groups which is the young cancer patient and the medical team. The young cancer patient group would be focused on the acceptance of mobile application whereas the medical team group would be focused on the acceptance of the web application. There were two different sets of survey designed to collect feedback from both user group because the data needed for evaluation were different.

7.7.1.1 Young Cancer Patient Group

A one-week-long experiment was initially planned to be conducted to test the acceptance of the mobile application in the group of young cancer patient. Ten young cancer patients would have the access to the mobile application and used it every day for one-week-long. Caretakers would need to assist them during the daily reporting activities. After a week, a small interview would have been conducted with the young cancer patient to collect their opinion about the mobile application.

Table 7.23: User Acceptance Test Question (Young Cancer Patient)

Question	Multiple Choices
1. How old are you?	7 / 8 / 9 / 10 / 11
2. Do you like the ninja theme	Yes / No / Maybe
3. Do you feel relaxed when you are playing the game?	Yes / No / Maybe
4. Do you feel pain when you are playing the game?	I still feel a lot of pain / I felt lesser pain / Don’t know

Table 7.24: User Acceptance Test Question (Young Cancer Patient) (Continued)

5. Are you happy when you are playing the game?	Yes / No / Maybe
6. Are you happy when you unlocked a new avatar?	Yes / No / Maybe
7. Are you happy when you unlocked a new badge?	Yes / No / Maybe
8. Are you happy when you break the high score?	Yes / No / Maybe
9. Do you think the report function is easy to use?	Yes / No / Maybe
10. Do you think the message function is easy to use?	Yes / No / Maybe

7.7.1.2 Medical Team Group

A thinking aloud testing was initially planned to be conducted to test the acceptance of the web application in the group of medical teams. Five medical team members would have been invited to conduct the test. They were required to think aloud when they were using the system. Tester (developer of this project) would stay near them and observe their action and reaction towards the system. After that, a small interview would have been conducted to collect the feedback.

Table 7.25: User Acceptance Test Question (Medical Team)

Question	Likert Scale (1 – 5)
1. The system is user friendly.	(SD) 1 – 5 (SA)
2. The system provides me a simple way to manage the children data.	(SD) 1 – 5 (SA)
3. The basic analysis provided in patients detail page is informative.	(SD) 1 – 5 (SA)
4. The detail analysis chart provided in analysis page is informative.	(SD) 1 – 5 (SA)
5. The chart provided helps me in making a better decision.	(SD) 1 – 5 (SA)
6. The notification feature allows me to provide assistant to the patient faster.	(SD) 1 – 5 (SA)

7.7.2 Challenges in Conducting User Acceptance Test

Unfortunately, the planned user acceptance test was not able to be conducted due to the pandemic situation in Malaysia right now. Starting from 18 March 2020, Malaysia had the first lockdown. The average number of cases of covid-19 maintains around 1000 and above since January 2021. In such a case, people without valid permit are not allowed to cross the state nationwide. Also, Malaysian government has allocated most of the human resource to help the Covid-19 patients in hospitals. Therefore, it is difficult to approach both medical teams and the young cancer patients in such situation. The questionnaires were included in the Appendix F.

7.8 Conclusion

This chapter provides the result of different type of tests. Positive results obtained from different tests indicated that the system is complete, functional and usable. However, the absence of user acceptance test result was crucial as the result could have provided a better insight about the acceptance on the system.

CHAPTER 8

CONCLUSION

8.1 Introduction

This project was started from June 2020 and used approximately seven months long to complete. The project started with the problem statement, proposed solutions, and the user requirements which were discussed in the first four chapters. As the proposal was confirmed and approved in Oct 2020, the development of the system started. Chapter five and Chapter six discuss about the system design and the implementation concept of the system. After the cross-platform system was completed, several tests were also conducted and was discussed in Chapter seven. This chapter is the final chapter of the project. This chapter discusses the achieved objectives, limitations of the project, and also some recommendations for future improvement.

8.2 Objective Examination

The project objectives defined in Chapter one were successfully achieved with the completion of the system.

The first objective is to develop a gamified mobile application to motivate the young cancer patient in doing the pain assessment with the medical team. This objective was achieved by developing the mobile application with the implementation of different game elements. Game elements are able to stimulate the intrinsic motivation towards the young cancer patients hence increase their interest in using the mobile application. Report feature was also developed successfully in the mobile application to ease the process for young cancer patient to report their body condition to the medical team. Report feature also used a lot of graphics and simple question to attract the interest and attention from them. The implementation of game element also achieved the sub objective which is to include game element to improve the mood of the young cancer patient.

The second objective is to develop a web application for the medical team to manage young cancer patients' data. The second objective was achieved by developing a web application for the medical team. The web application can add the patients' data and display the data in a structural way. The application also provides analysis chart for the medical team to analyse the data.

8.3 Limitation

Despite the main objectives of the project have been achieved, there are still some limitations discovered in both the system and the project.

The first limitation was the limited performance of the analysis feature. The analysis feature is currently only allowed the medical team to select few predefined charts to view. The medical team was not able to select or customize the chart according to the data they wanted to analyse. Besides, the analysis chart was generated based on simple query extraction from the database only. It was not smart enough to generate a detailed or insightful analysis to the medical team.

The second limitation was the limited performance of the notification feature. The web application was not able to instantly notify the medical team through any available channel such as email, SMS, or push notifications. The notification sent by the young cancer patient was only displayed in the web application. Therefore, the medical team must constantly access to the web application to check for the new notifications.

The third limitation was the network scalability of the mobile application. The mobile application currently must connect to internet to function properly. This is because all the data needed was required to retrieve from the online server. The mobile application was not able to temporarily store the data in local database and synchronize it to the online server when the internet connection is restored. In other words, the mobile device must always connect to internet in order to use the mobile application.

The last limitation was the attractiveness of the mobile application towards female cancer patients. The current theme of the mobile application was a ninja theme. This theme is more heroic, adventurous, and more suitable for male patients. Ninja theme might not be able to attract the female cancer patients to continuously use the mobile applications throughout the treatment cycle.

8.4 Recommendation for Future Work

In enhancing the system to better solve the problem of the user, the system should be improved and added more features continuously. Table 8.1 lists the recommendation for any developers who may have interests in enhancing the system. The recommendations are not limited to the items in Table 8.1, any constructive suggestions are welcomed to further improve the system.

Table 8.1: System Recommendation Summary Table

No	Recommendation	Description
1	Better System Performance and Security	The current system is deployed in Heroku and utilized the free online database PostgreSQL. However, the web application does not have SSL certification. The web application should obtain a SSL certificate and migrate the system to hospital own server for better performance and security.
2	Live Notification Update	The current system could implement live notification update to send instant notification to the medical team as soon as possible. Different channels such as email, SMS, or mobile push notification are available to be implemented.
3	In depth data analysis with artificial intelligence	The current system only used simple data query to extract data from the database. By implementing artificial intelligence, the system could learn many different data analysis patterns, training different data hence increase the data accuracy.

Table 8.2: System Recommendation Summary Table (Continued)

4	Database Localization and Synchronization	The current mobile application only works when there is internet connection. The future updates should implement database localization to allows the mobile application to function even without internet connection. The mobile application would automatically sync all the data stored in local database to the online server when the internet connection is restored.
5	More Mobile Application Theme Choice	The current mobile application theme applied may not be able to attract female cancer patients to continuously use the application. Therefore, more variety of theme and design could be implemented into the mobile application to provide more options for the young cancer patients to choose. They would be able to select their desire theme to play hence increase their motivations and mood when they are using the mobile application.

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APPENDICES

APPENDIX A: Similar System Review

TABLE A-1: Game Elements Found in Each System

Game elements	Pain Squad	ICPCN	Achy Penguin	Pain Buddy	Quest – Te Whitianga	ASTHMAXcel Adventures
Level	✓	✗	✗	✗	✓	✓
Badge	✓	✗	✗	✗	✓	✗
Achievement	✓	✗	✗	✗	✓	✓
Point	✗	✗	✗	✗	✓	✗
Avatar	✗	✗	✓	✓	✓	✓
Theme	✓	✗	✓	✓	✓	✓
Narrative	✗	✗	✗	✗	✓	✓
Rewards	✗	✗	✗	✓	✓	✗
Tutorial	✗	✗	✓	✗	✗	✗
Leaderboards	✗	✗	✗	✗	✓	✗
Progression	✗	✗	✗	✗	✓	✓
Social engagement	✗	✗	✗	✗	✓	✗

TABLE A-2: Features Found in Each System

Feature	Pain Squad	ICPCN	Achy Penguin	Pain Buddy	Quest – Te Whitianga	ASTHMAXcel Adventures
Pain recorder	✓	✓	✓	✓	✗	✗
Game	✗	✗	✓	✗	✓	✓
Education tool	✗	✗	✓	✓	✓	✓
Diary	✗	✗	✗	✓	✓	✗
Pain analysis	✓	✗	✗	✗	✗	✗

TABLE A-3: Pain Scales Found in Each System

Pain Scale	Pain Squad	ICPCN	Achy Penguin	Pain Buddy
APPT	✓	✓	✓	✓
Face scale	✗	✓	✓	✗
Numerical analogue scale	✗	✓	✓	✗
Visual analogue scale	✓	✗	✗	✗
Descriptive scales	✓	✓	✗	✗

APPENDIX B: Complete Survey Result

FIGURE B-1: Summary of Q1

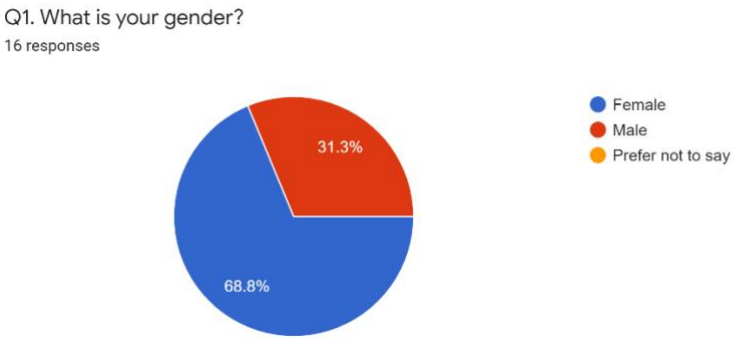


FIGURE B-2: Summary of Q2

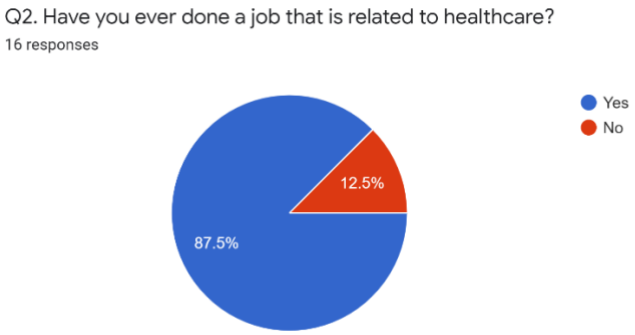


FIGURE B-3: Summary of Q3

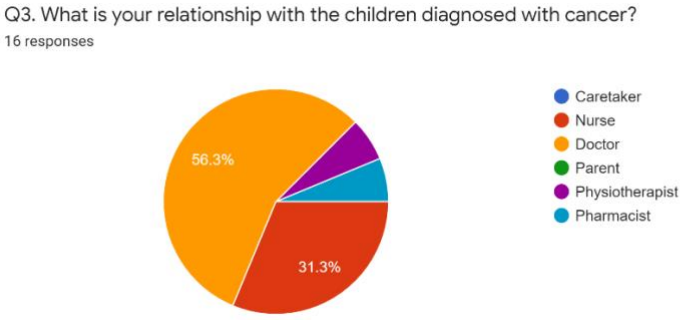


FIGURE B-4: Summary of Q4

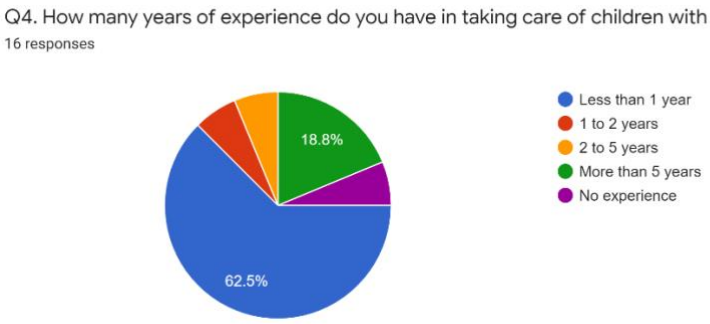


FIGURE B-5: Summary of Q5

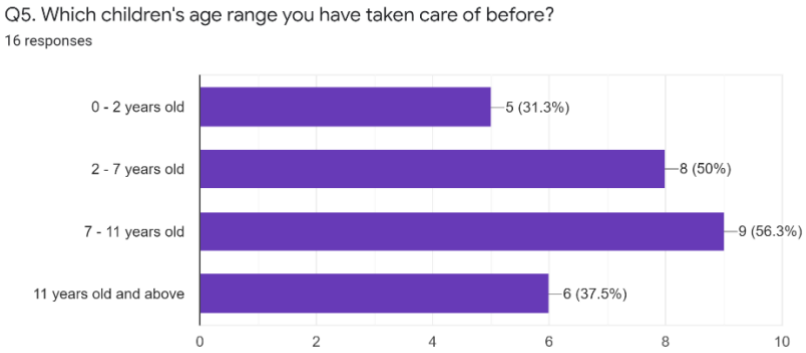


FIGURE B-6: Summary of Q6

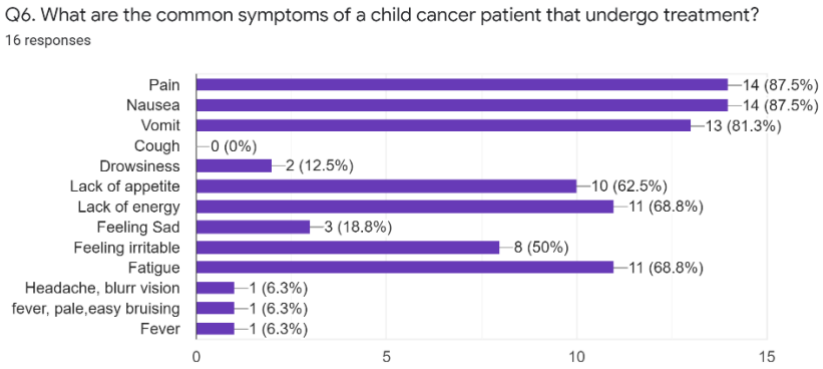


FIGURE B-7: Summary of Q7

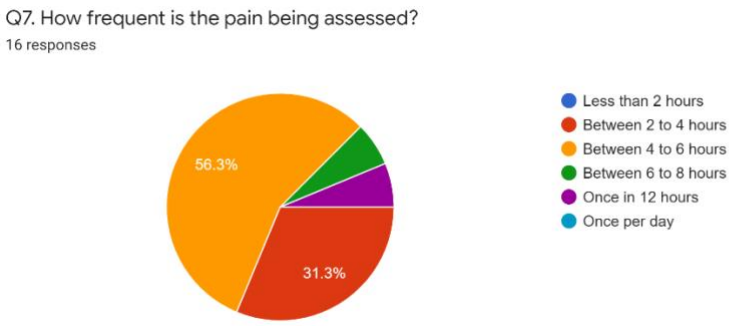


FIGURE B-8: Summary of Q8

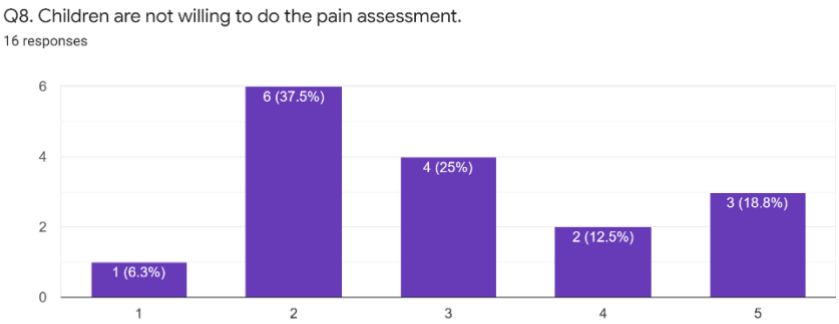


FIGURE B-9: Summary of Q9

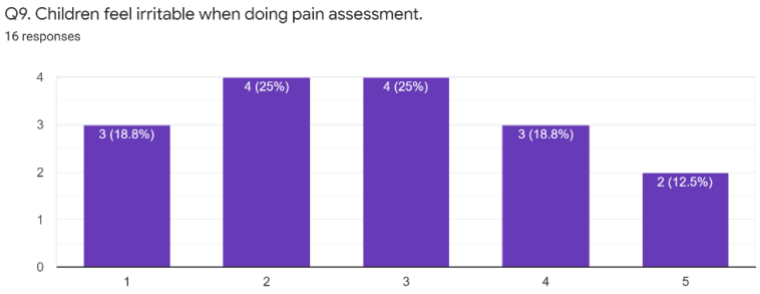


FIGURE B-10: Summary of Q10

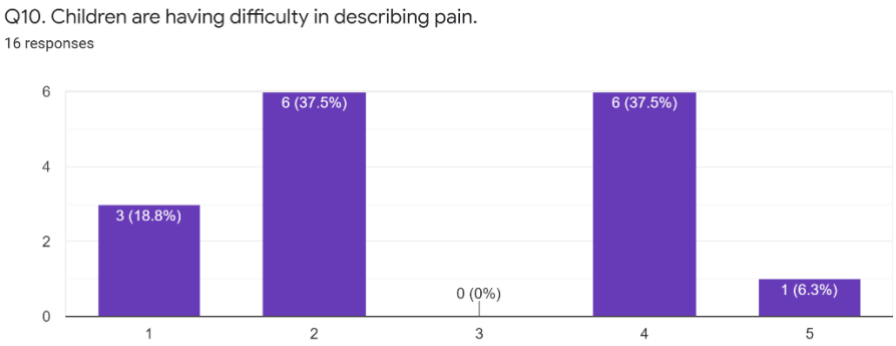


FIGURE B-11: Summary of Q11

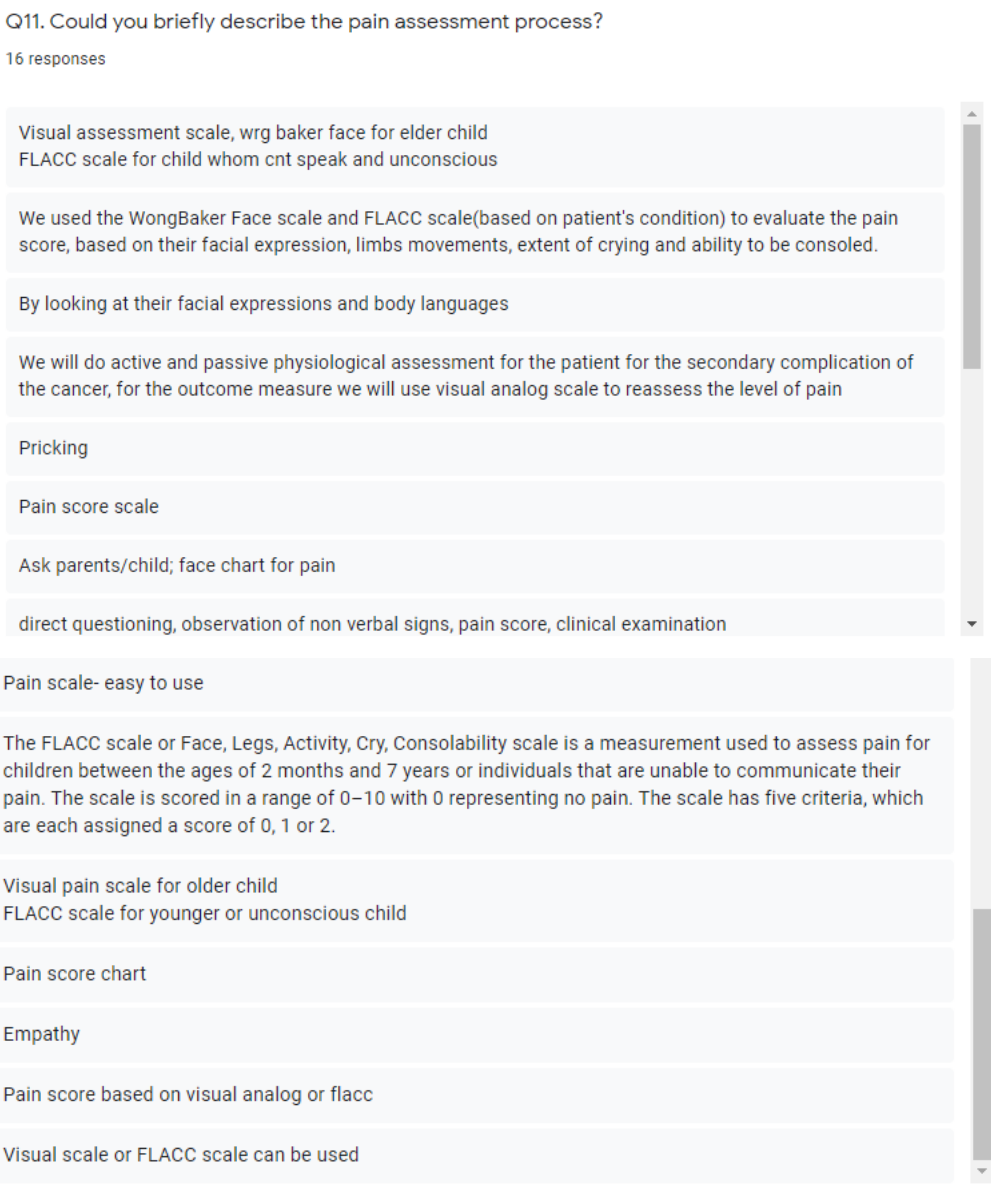


FIGURE B-12: Summary of Q12

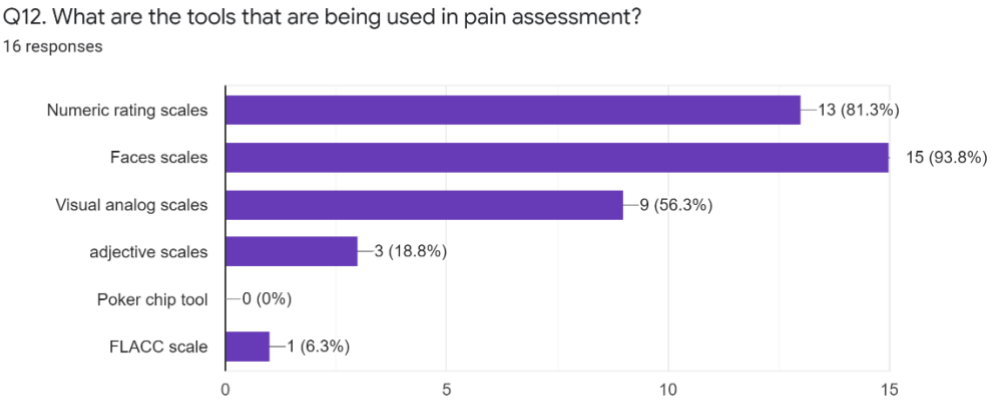


FIGURE B-13: Summary of Q13

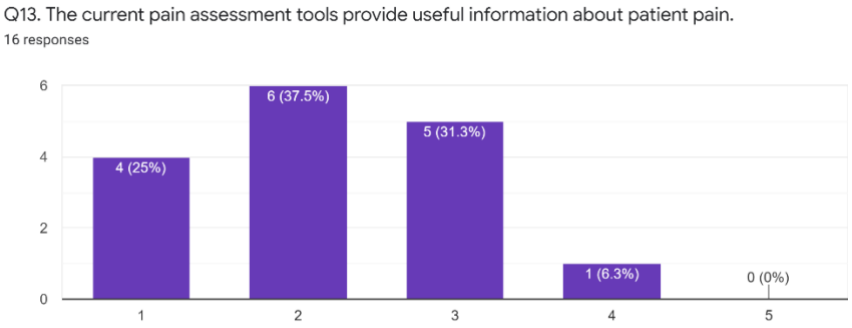


FIGURE B-14: Summary of Q14

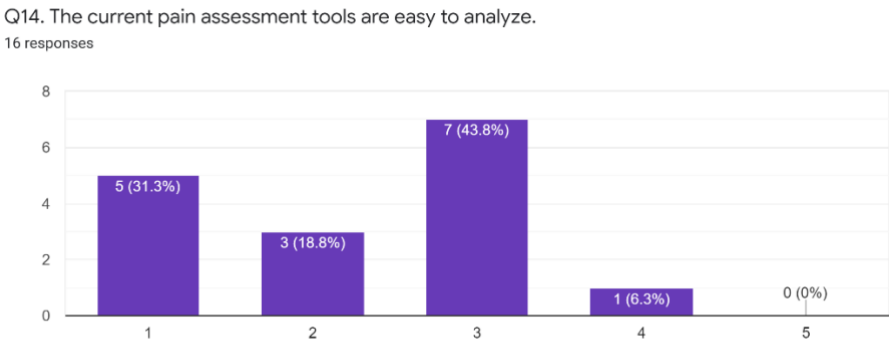


FIGURE B-15: Summary of Q15

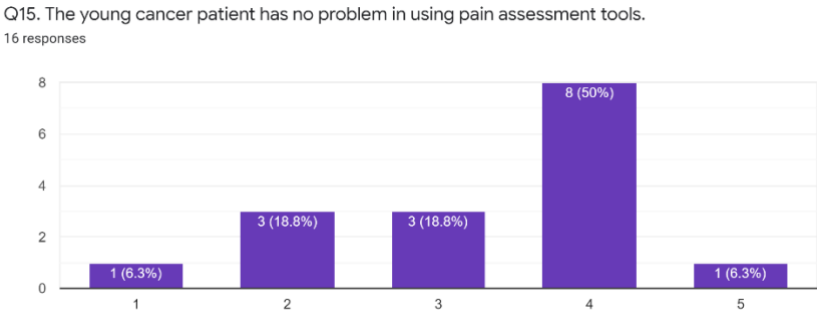


FIGURE B-16: Summary of Q16

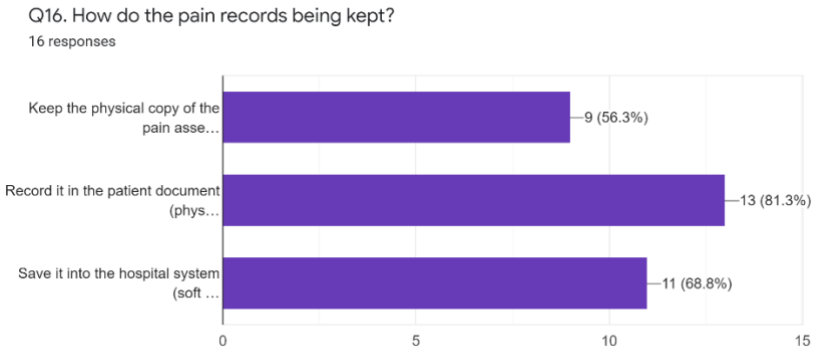


FIGURE B-17: Summary of Q17

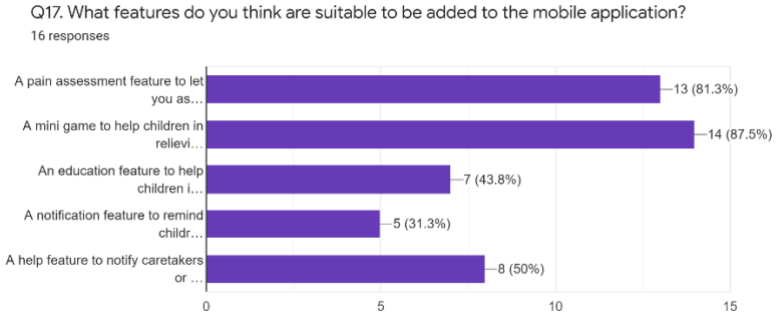


FIGURE B-18: Summary of Q18

Q18. Any other suggestion you would is important to be included in the mobile application?

16 responses

No
Parental control, emergency calling
Provide pain relief technique education by cartoon character to attract child attention
Time medication
techniques to reduce / control pain
Pain management for each cumulative pain scale chart.
Parental control
Parental controls
-

FIGURE B-19: Summary of Q19

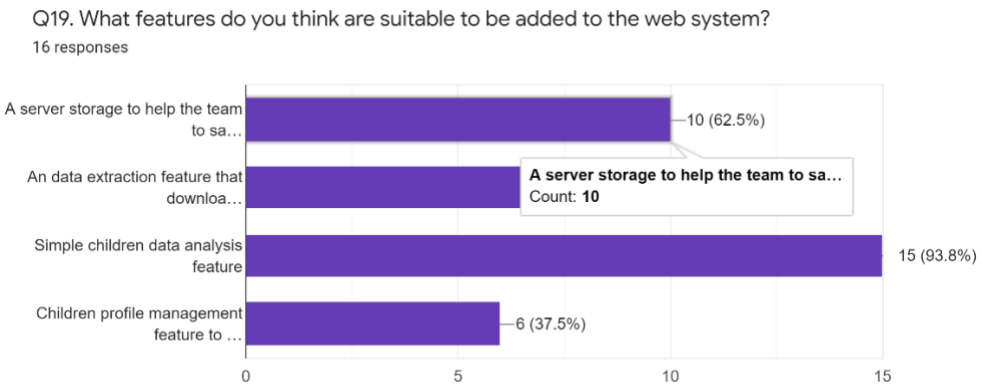
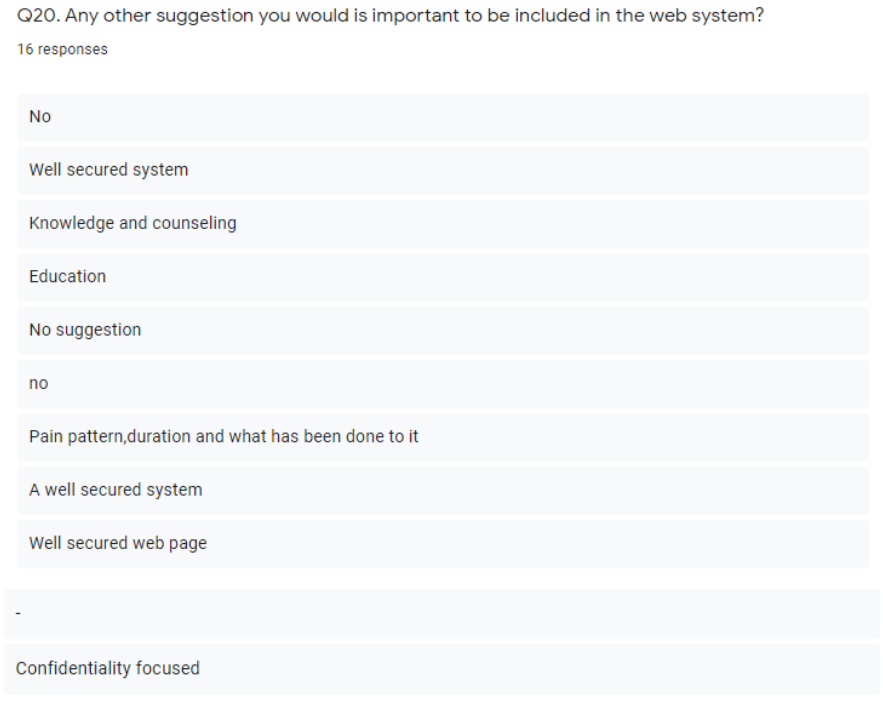


FIGURE B-20: Summary of Q20



APPENDIX C: Complete Interview Question & Answer

Q1. Could you introduce yourself?

I am a paediatrician, specialized in paediatric haematology and oncology. I am currently working in Borneo medical centre in Kuching Sarawak. Previously, I was looking after children with cancer and blood disorder in Sabah and Labuan from 16th of July 2008 until 2nd January 2014.

Q2. Could you briefly describe about the children with cancer?

There are many types of children with cancer. Children with cancer can be age ranged for new-born until adolescent around 15 to 16 years old. Some of them are under treatment since they are born. The most common symptoms found on children with cancer are pain, nausea, and vomit. The symptoms and side effects are varied depends on the cancer type and also treatment type. For example, children undergo chemotherapy are more likely to have nausea and vomit compared to other treatments.

Q3. Could you tell me about how children usually feel?

It depends on the pain frequency and children ability to express their feeling. I would not tell you children are always sad or depress. Children feels bad and awful when the pain kicks in, but they are feeling good if the pain are absent. They could be playing around with toys or parents when there is no pain. Also, younger children might not understand the pain well, they might be crying or screaming to express their pain. Older children could be better in expressing their pain through words.

Q4. How is the pain assessment being conducted?

It depends on the age group of the children with cancer. Children that are too younger to understand and express their pain such as infant and children that age from 2 to 4 years old, observation or questioning with the parents is the main pain assessment process. Pain assessment scale will be used for the children that are old enough to understand and express pain. The most used scales are face scales and number scales. Children could point at the face or the number to indicate the intensity of pain. The pain assessment process will be conducted normally two times a day during the ward

round. Doctor or nurse would visit the children and ask about their pain. Some children condition that are more severe would be three or four times per day.

Q5. How is the pain being managed?
Medicine are usually the main way to reduce the pain. We will give the children some medicine based on the pain level they are having.

Q6. How do you analyse the pain scale?
We normally do simple analysis on the pain scale such as looking for the trend of the pain. If the pain level increased continuously or reached a severe level, action should be taken to reduce the pain level.

Q7. What do you think about the proposed system?
I think the application should allow the children to update the pain whenever they need to. It could have the regular pain assessment session between few hours, but it should also be accessible by the children when they are feeling pain. Also, it would be better if the children could contact the medical team when they are having great pain such as the bell button in the ward. It is good to have a mobile application as many children nowadays have their own phones or have access to their parent's phone. Besides, the analysis should tell the trend of the pain through maybe chart or graph to indicates whether the pain level is increasing or decreasing. The system should update the data real time so the team would know the latest condition of the children. If the pain level is too high, the system should also notify the medical team to help the kids immediately.

APPENDIX D: Sample Usability Test Case

TABLE D-1: Test Case 1

Test Case ID	USTC001	Tester Name		Pass/Fail	
Test Case Name	Register New Account in Web application				
Test Case Description	To test the register functionality and the process flow in the web application				
Test Case Scenario		Test Data			
1. User navigate to registration page from login page 2. User fill up all the required details 3. User confirm and submit to register the account		-			
Expected Result		Actual Result			
- The system displays a notification telling that the account has been registered successfully					

TABLE D-2: Test Case 2

Test Case ID	USTC002	Tester Name		Pass/Fail	
Test Case Name	Log in Into Web application				
Test Case Description	To test the log in functionality and the process flow in the web application				
Test Case Scenario		Test Data			
1. User navigate to login page 2. User enter username and password 3. User press login button		-			
Expected Result		Actual Result			
- The system redirects user into main menu page					

TABLE D-3: Test Case 3

Test Case ID	USTC003	Tester Name		Pass/Fail	
Test Case Name	Add New Patient in Web application				
Test Case Description	To test the add new patient functionality and the process flow in the web application				
Test Case Scenario			Test Data		
1. User navigate to add new patient page 2. User fill up all the required details 3. User confirm and submit to register the new patient			-		
Expected Result			Actual Result		
- The system redirects user back to main menu page - The system displays a notification telling that the patient has been added - The number of patients in care is 1					

TABLE D-4: Test Case 4

Test Case ID	USTC004	Tester Name		Pass/Fail	
Test Case Name	View All Patients in Web application				
Test Case Description	To test the display all patient's functionality and the process flow in the web application				
Test Case Scenario			Test Data		
1. User navigates to view all patients page			-		
Expected Result			Actual Result		
- The system displays all the patients added					

TABLE D-5: Test Case 5

Test Case ID	USTC005	Tester Name		Pass/Fail	
Test Case Name	View Selected Patient in Web application				
Test Case Description	To test the show selected patient functionality and the process flow in the web application				
Test Case Scenario			Test Data		
1. User navigates to view all patient's page 2. User select a patient user wants to see all the details			-		
Expected Result			Actual Result		
- The system redirects user to patient details page - All the details are displayed correctly					

TABLE D-6: Test Case 6

Test Case ID	USTC006	Tester Name		Pass/Fail	
Test Case Name	Search Patient in Web application				
Test Case Description	To test the search patient functionality and the process flow in the web application				
Test Case Scenario			Test Data		
1. User navigates to view all patient's page 2. User search patients by using first name / last name / ic			-		
Expected Result			Actual Result		
- The system displays the patients that matches the record					

TABLE D-7: Test Case 7

Test Case ID	USTC007	Tester Name		Pass/Fail	
Test Case Name	Analyse Patient in Web application (No Data)				
Test Case Description	To test whether the web application works correctly when user access analyses patient functions but there is no data				
Test Case Scenario			Test Data		
1. User navigates to view all patient's page 2. User selects a patient to navigate to patient details page 3. User press analyse button			-		
Expected Result			Actual Result		
- The system redirects user to analysis page - No chart is displayed					

TABLE D-8: Test Case 8

Test Case ID	USTC008	Tester Name		Pass/Fail	
Test Case Name	View Notification in Web application (No Data)				
Test Case Description	To test whether the web application works correctly when user access view notification functions but there is no data				
Test Case Scenario			Test Data		
1. User navigates to view notifications page			-		
Expected Result			Actual Result		
- The system redirects user to view notifications page - No data is displayed					

TABLE D-9: Test Case 9

Test Case ID	USTC009	Tester Name		Pass/Fail	
Test Case Name	View User Profile in Web application				
Test Case Description	To test the view user profile functionality and the process flow in the web application				
Test Case Scenario			Test Data		
1. User navigates to view user profile page			-		
Expected Result			Actual Result		
- The system redirects user to view user profile page - The user profile details are displayed correctly					

TABLE D-10: Test Case 10

Test Case ID	USTC010	Tester Name		Pass/Fail	
Test Case Name	Edit User Profile in Web application				
Test Case Description	To test the view user profile functionality and the process flow in the web application				
Test Case Scenario			Test Data		
1. User navigates to view user profile page 2. User press update details button to navigate to edit user profile page 3. User edit any details 4. User confirm and update the details			-		
Expected Result			Actual Result		
- The system redirects user to view user profile page - The system displays a notification telling that the user profile is updated successfully - The user profile details are displayed correctly					

TABLE D-11: Test Case 11

Test Case ID	USTC011	Tester Name		Pass/Fail	
Test Case Name	Change Password in Web application				
Test Case Description	To test the change password functionality and the process flow in the web application				
Test Case Scenario			Test Data		
1. User navigates to view user profile page 2. User press change password button to navigate to change password page 3. User change the password 4. User confirm and update the password 5. System logout user 6. User login again with new password			-		
Expected Result			Actual Result		
- The system redirects user to main menu page					

TABLE D-12: Test Case 12

Test Case ID	USTC012	Tester Name		Pass/Fail	
Test Case Name	Logout in Web application				
Test Case Description	To test the Logout functionality in web application				
Test Case Scenario			Test Data		
1. User press logout button in navigation bar			-		
Expected Result			Actual Result		
- The system logout user					

TABLE D-13: Test Case 13

Test Case ID	USTC013	Tester Name		Pass/Fail	
Test Case Name	Login into Mobile Application				
Test Case Description	To test the login functionality in mobile application				
Test Case Scenario			Test Data		
1. User press start button 2. User enter the account username and password 3. User press login button			-		
Expected Result			Actual Result		
- The system redirects user to profile creation screen to enter username and select new avatar					

TABLE D-14: Test Case 14

Test Case ID	USTC014	Tester Name		Pass/Fail	
Test Case Name	Create New Account Profile in Mobile Application				
Test Case Description	To test the register new account profile functionality in mobile application				
Test Case Scenario			Test Data		
1. User enter a name 2. User select an avatar			-		
Expected Result			Actual Result		
- The system redirects user to main menu screen					

TABLE D-15: Test Case 15

Test Case ID	USTC015	Tester Name		Pass/Fail	
Test Case Name	Play Game in Mobile Application				
Test Case Description	To test the play game functionality in mobile application				
Test Case Scenario			Test Data		
1. User tap on play button			-		
Expected Result			Actual Result		
- The system redirects user to game screen - The player starts running after countdown					

TABLE D-16: Test Case 16

Test Case ID	USTC016	Tester Name		Pass/Fail	
Test Case Name	View Profile in Mobile Application				
Test Case Description	To test the view profile functionality in mobile application				
Test Case Scenario			Test Data		
1. User tap on profile button			-		
Expected Result			Actual Result		
- The system redirects user to profile screen - All the data displayed are correct					

TABLE D-17: Test Case 17

Test Case ID	USTC017	Tester Name		Pass/Fail	
Test Case Name	Change Avatar in Mobile Application				
Test Case Description	To test the change avatar functionality in mobile application				
Test Case Scenario			Test Data		
1. User taps on profile button 2. System redirects user to profile screen 3. User taps on select avatar button 4. User select an avatar			-		
Expected Result			Actual Result		
- The system updates the selected avatar (in avatar screen, profile screen, and game screen)					

TABLE D-18: Test Case 18

Test Case ID	USTC018	Tester Name		Pass/Fail	
Test Case Name	Unlock Avatar in Mobile Application				
Test Case Description	To test the unlock avatar functionality in mobile application				
Test Case Scenario			Test Data		
1. User taps on profile button 2. System redirects user to profile screen 3. User taps on select avatar button 4. User select a locked avatar 5. User taps on Unlock button 6. User purchase the avatar			-		
Expected Result			Actual Result		
- The system unlocks the avatar and available for user to select					

TABLE D-19: Test Case 19

Test Case ID	USTC019	Tester Name		Pass/Fail	
Test Case Name	View Badge in Mobile Application				
Test Case Description	To test the view badge functionality in mobile application				
Test Case Scenario			Test Data		
1. User taps on profile button 2. System redirects user to profile screen 3. User taps on badge button			-		
Expected Result			Actual Result		
- The system redirects user to badge screen and displays all the badges					

TABLE D-20: Test Case 20

Test Case ID	USTC020	Tester Name		Pass/Fail	
Test Case Name	Send Message in Mobile Application				
Test Case Description	To test the send message functionality in mobile application				
Test Case Scenario			Test Data		
1. User taps on message button 2. User selects the pain level 3. User selects the pain location 4. User press send button			-		
Expected Result			Actual Result		
- The system displays a notification telling that the message has been sent					

TABLE D-21: Test Case 21

Test Case ID	USTC021	Tester Name		Pass/Fail	
Test Case Name	Send Report in Mobile Application				
Test Case Description	To test the send report functionality in mobile application				
Test Case Scenario			Test Data		
1. User taps on report button 2. User selects a body location 3. User taps on next button 4. User selects a pain level 5. User taps on next button 6. User selects a pain description 7. User taps on next button 8. User selects a pain duration 9. User taps on next button 10. User selects a mood 11. User taps on send button			-		
Expected Result			Actual Result		
- The system displays a notification telling that the report has been sent - The system redirects user back to main menu screen					

TABLE D-22: Test Case 22

Test Case ID	USTC022	Tester Name		Pass/Fail	
Test Case Name	Analyse Patient in Web application (With Data)				
Test Case Description	To test the analyse patient's functionality and the process flow when the data is sent from the mobile application				
Test Case Scenario			Test Data		
1. User navigates to view all patient's page 2. User selects a patient to navigate to patient details page 3. User press analyse button			-		
Expected Result			Actual Result		
- The system redirects user to analysis page - Chart is displayed					

TABLE D-23: Test Case 23

Test Case ID	USTC023	Tester Name		Pass/Fail	
Test Case Name	View Notification in Web application (With Data)				
Test Case Description	To test the view notification functionality and the process flow when the data is sent from the mobile application				
Test Case Scenario			Test Data		
1. User navigates to view notifications page			-		
Expected Result			Actual Result		
- The system redirects user to view notifications page - The message sent from mobile application is displayed (with level badge emergency / medium / low)					

TABLE D-24: Test Case 24

Test Case ID	USTC024	Tester Name		Pass/Fail	
Test Case Name	Update Notification Detail in Web application (With Data)				
Test Case Description	To test the update notification detail functionality and the process flow when the data is sent from the mobile application				
Test Case Scenario			Test Data		
1. User navigates to view notifications page 2. User select a notification to update 3. User enter the solution provided 4. User confirm and update the solution			-		
Expected Result			Actual Result		
- The system displays a notification telling that the solution has been updated - The system refreshed and back to notification page - The level badge is changed to solved (green colour)					

APPENDIX E: System Usability Score Questionnaire

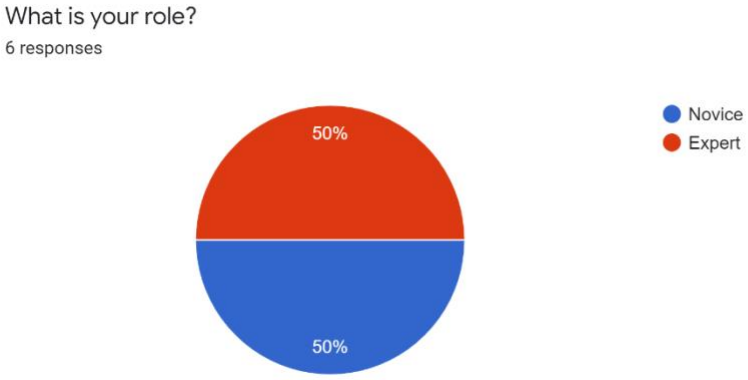


FIGURE E-1: Summary of Role

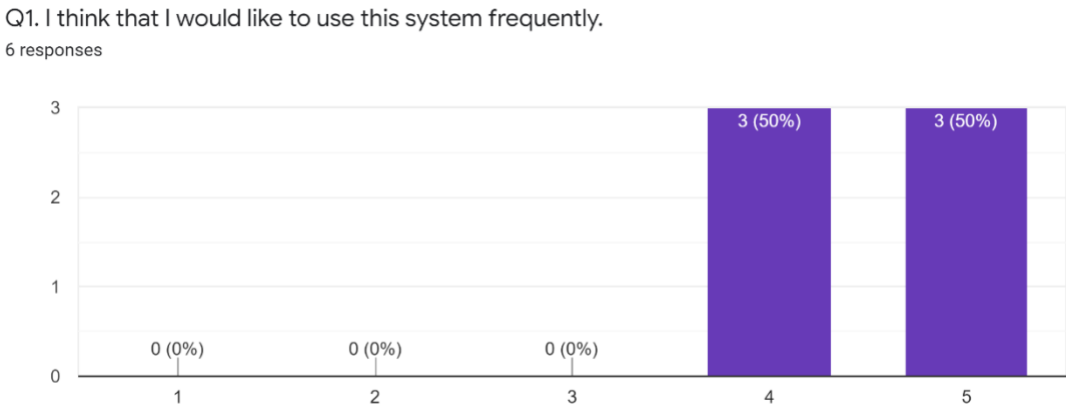


FIGURE E-2: Summary of Q1

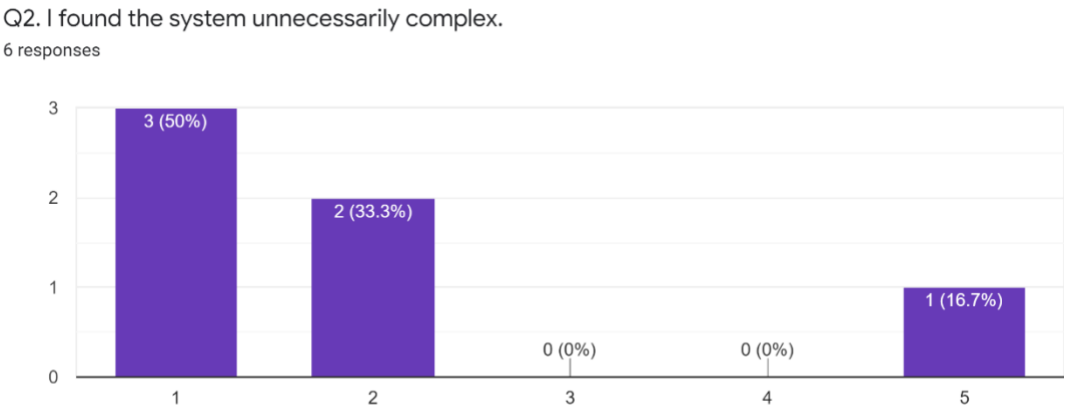


FIGURE E-3: Summary of Q2

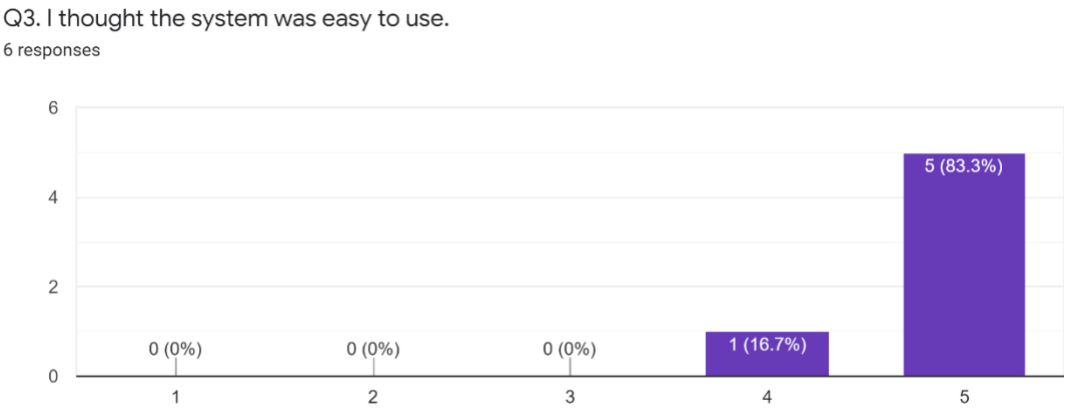


FIGURE E-4: Summary of Q3

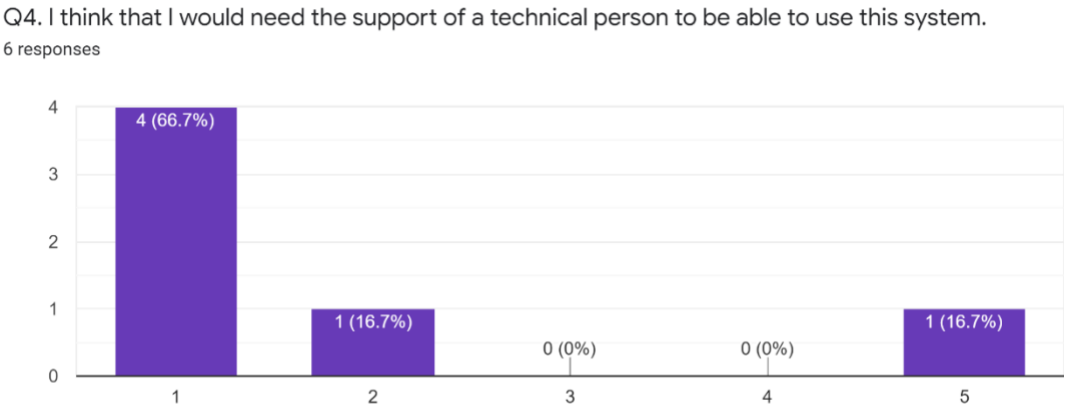


FIGURE E-5: Summary of Q4

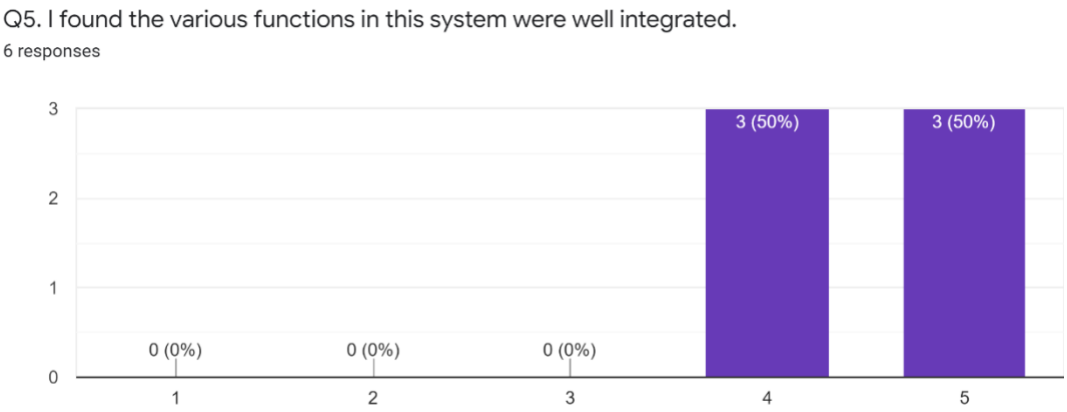


FIGURE E-6: Summary of Q5

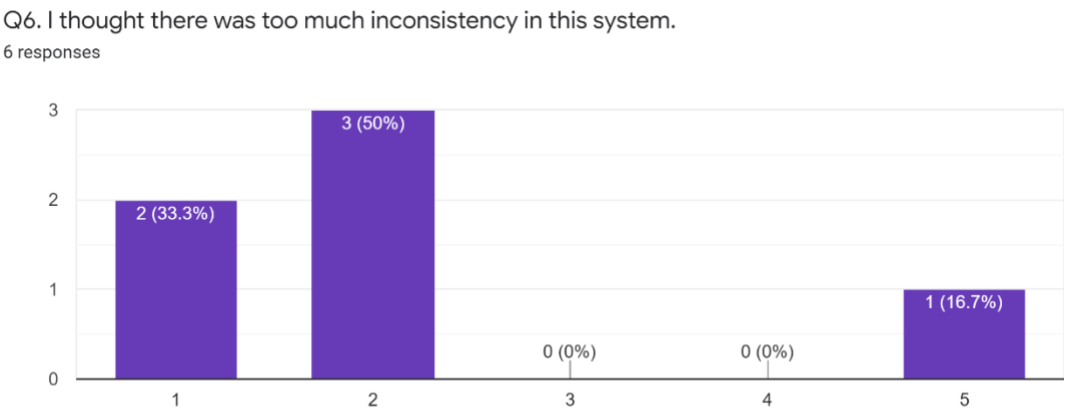


FIGURE E-7: Summary of Q6

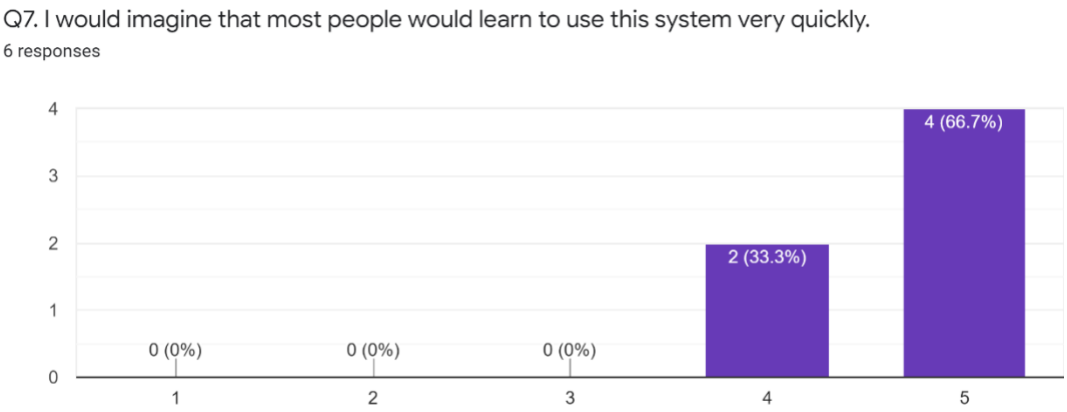


FIGURE E-8: Summary of Q7

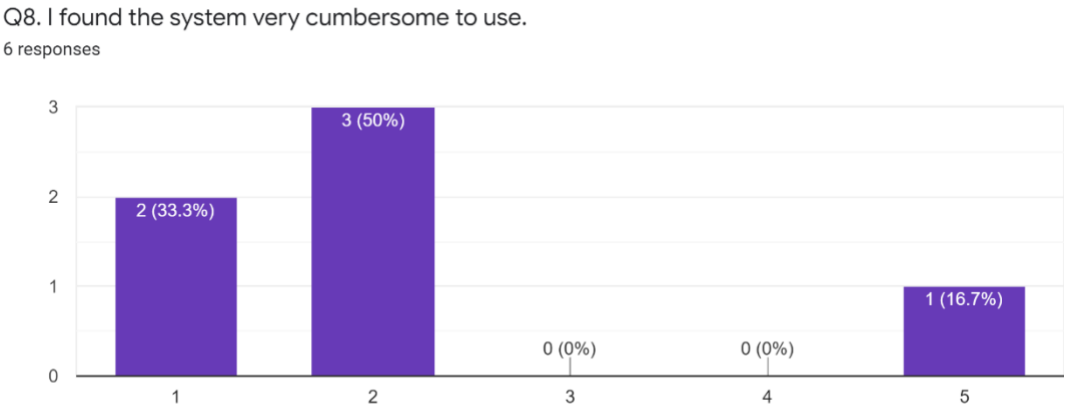


FIGURE E-9: Summary of Q8

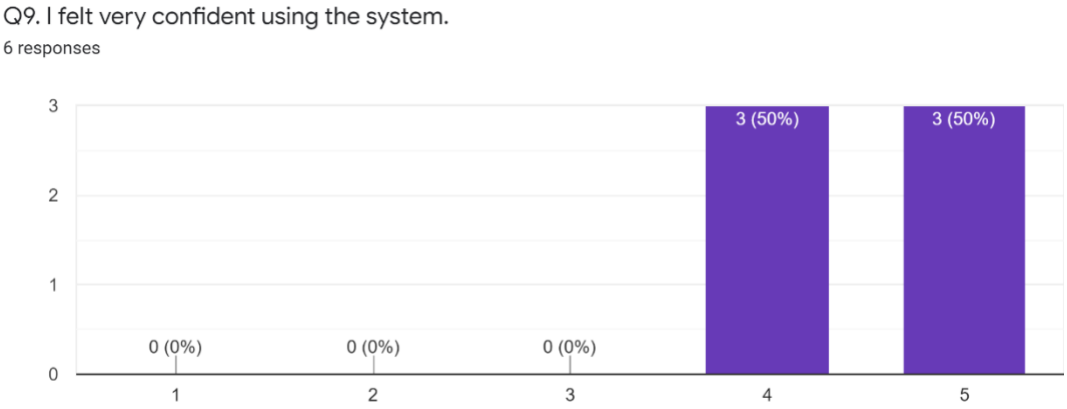


FIGURE E-10: Summary of Q9

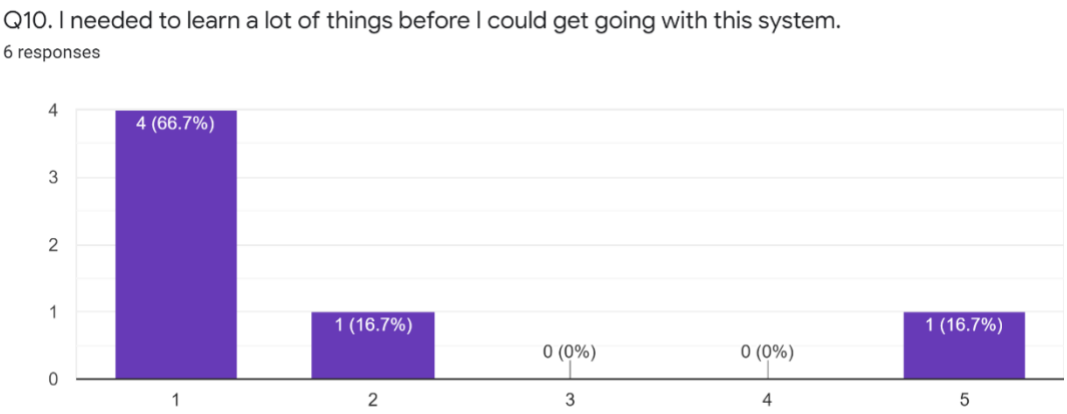


FIGURE E-11: Summary of Q10

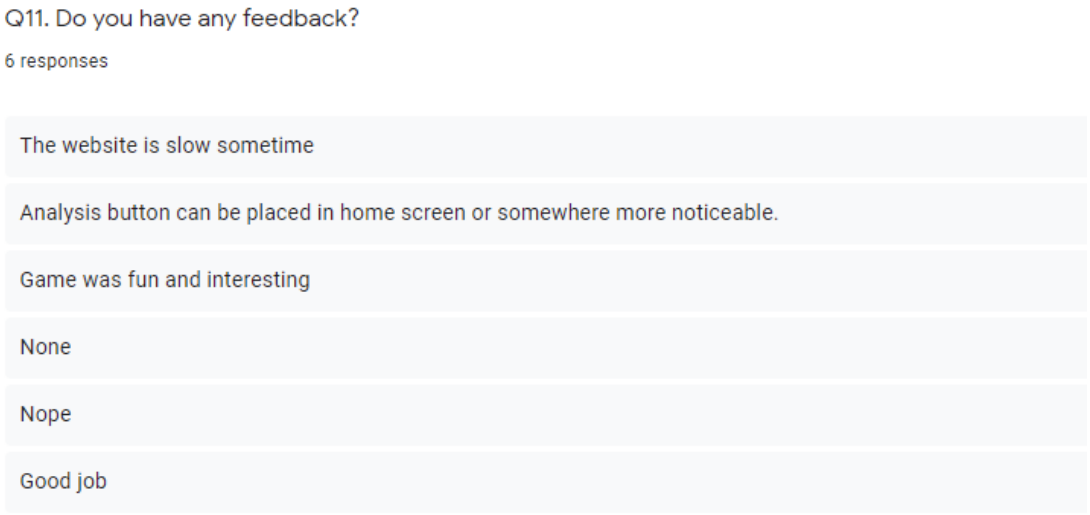
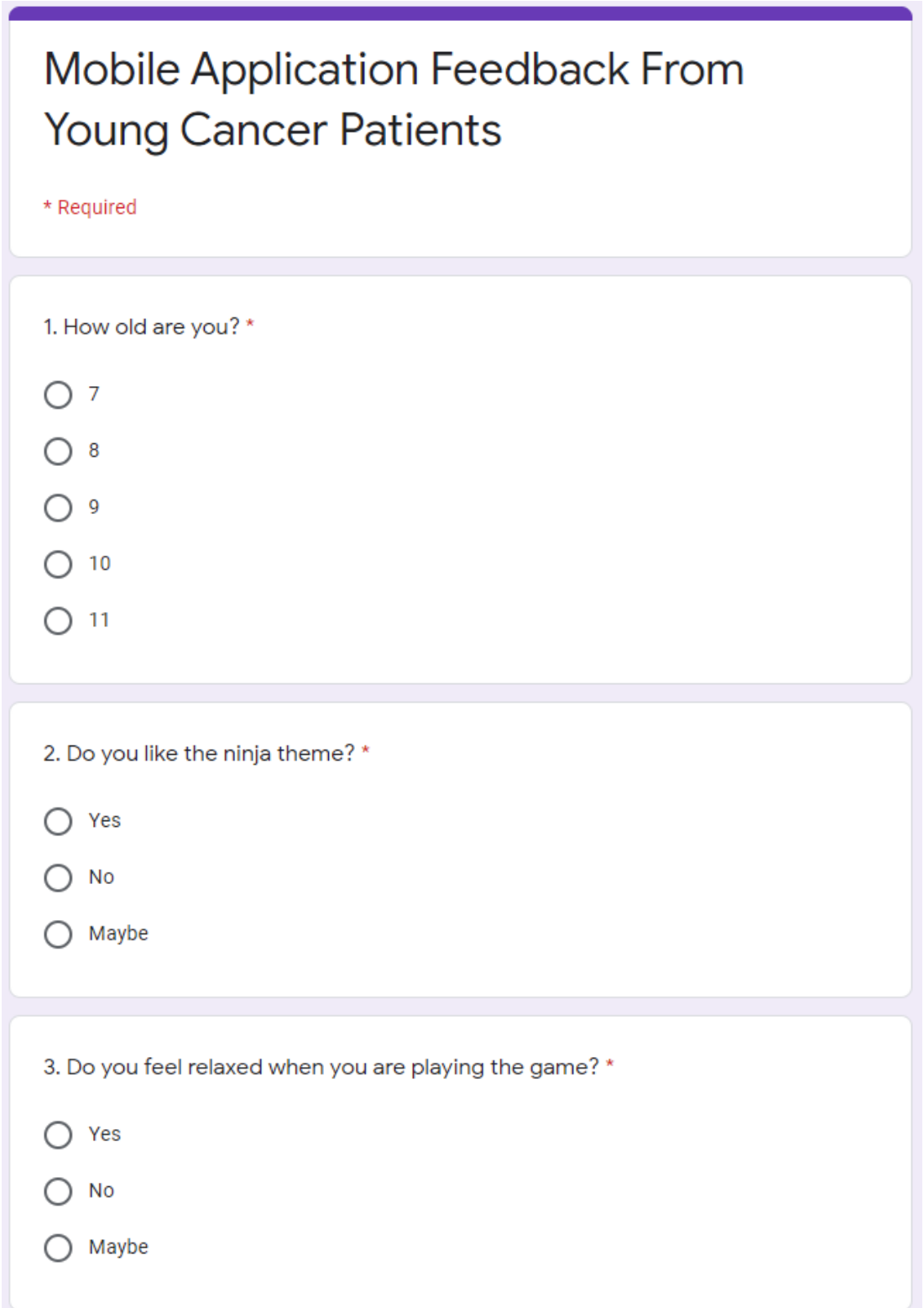


FIGURE E-12: Summary of Q11

APPENDIX F: User Acceptance Test Questionnaire



Mobile Application Feedback From Young Cancer Patients

* Required

1. How old are you? *

- 7
- 8
- 9
- 10
- 11

2. Do you like the ninja theme? *

- Yes
- No
- Maybe

3. Do you feel relaxed when you are playing the game? *

- Yes
- No
- Maybe

FIGURE F-1: User Acceptance Test (Young Cancer Patients)

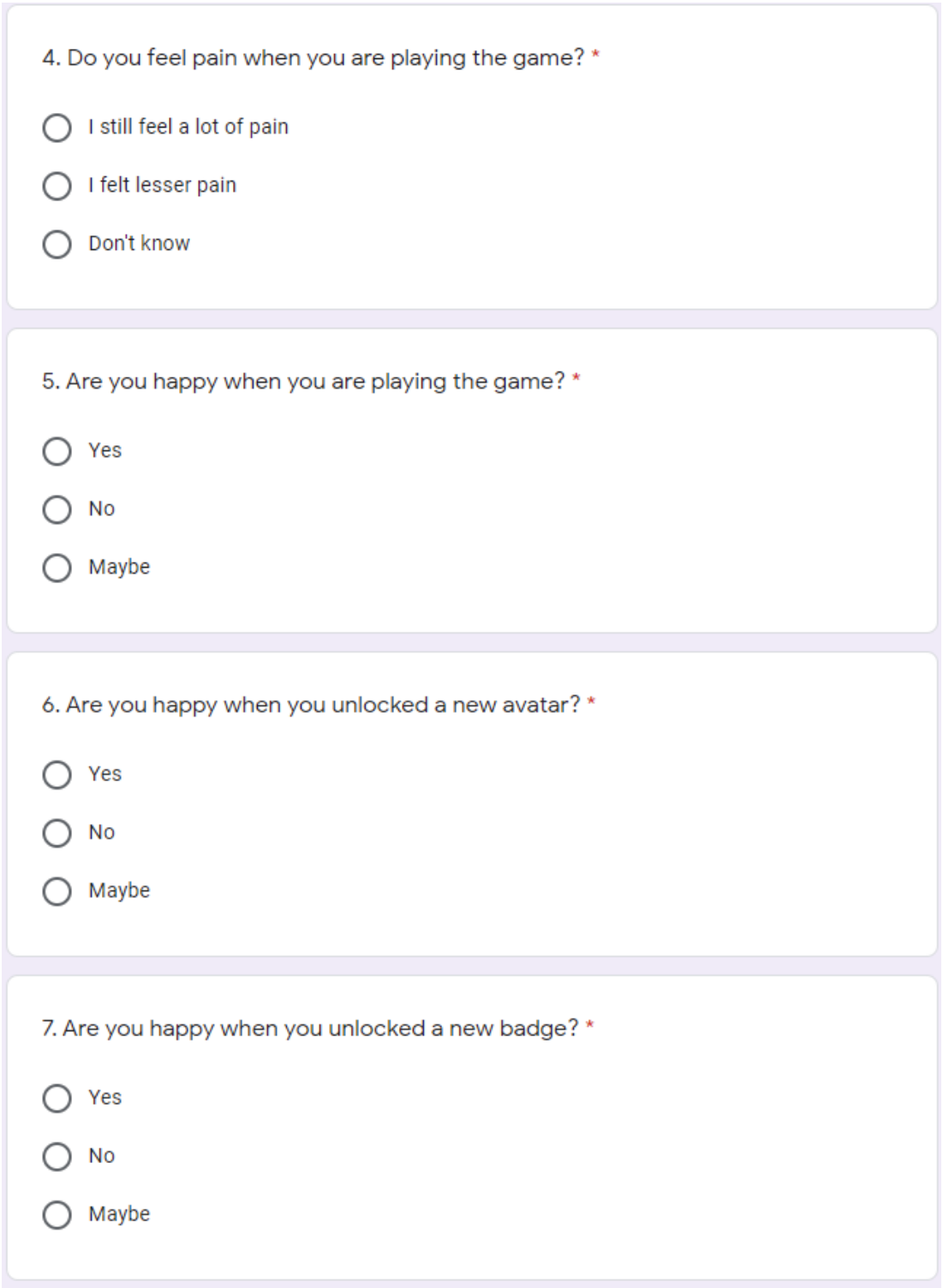


FIGURE F-2: User Acceptance Test (Young Cancer Patients) (Continued)

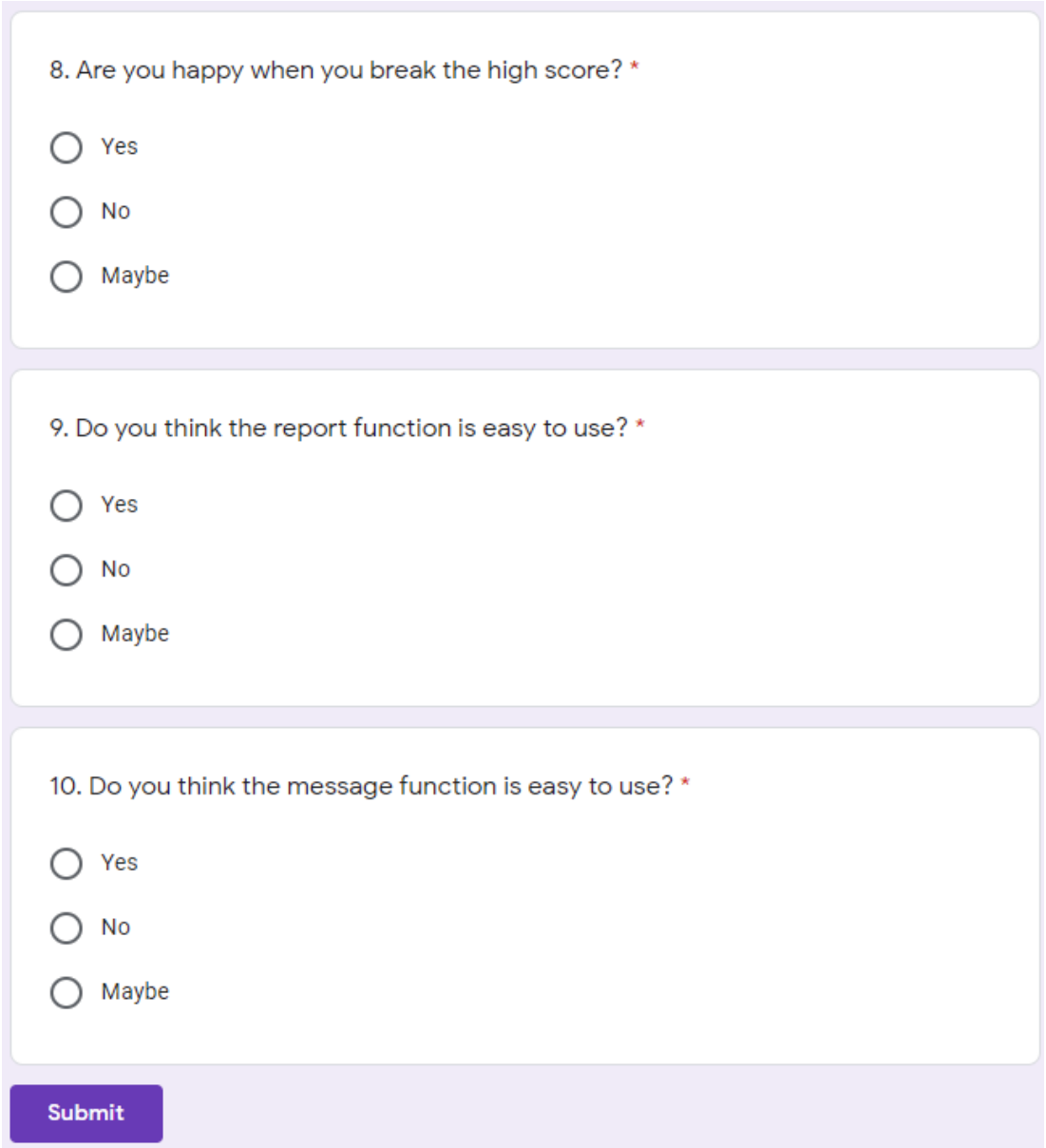


FIGURE F-3: User Acceptance Test (Young Cancer Patients) (Continued)

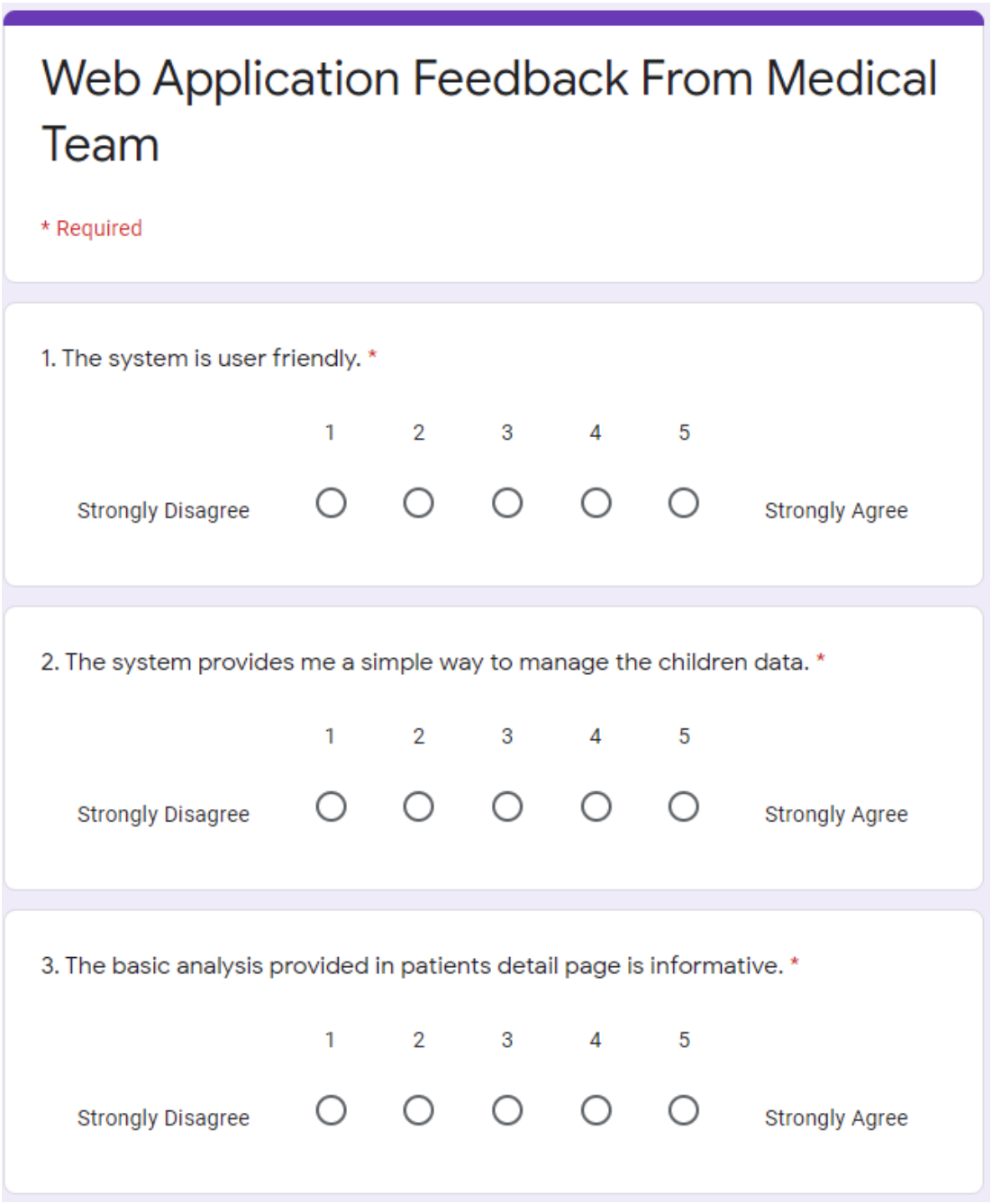


FIGURE F-4: User Acceptance Test (Medical Team) (Continued)

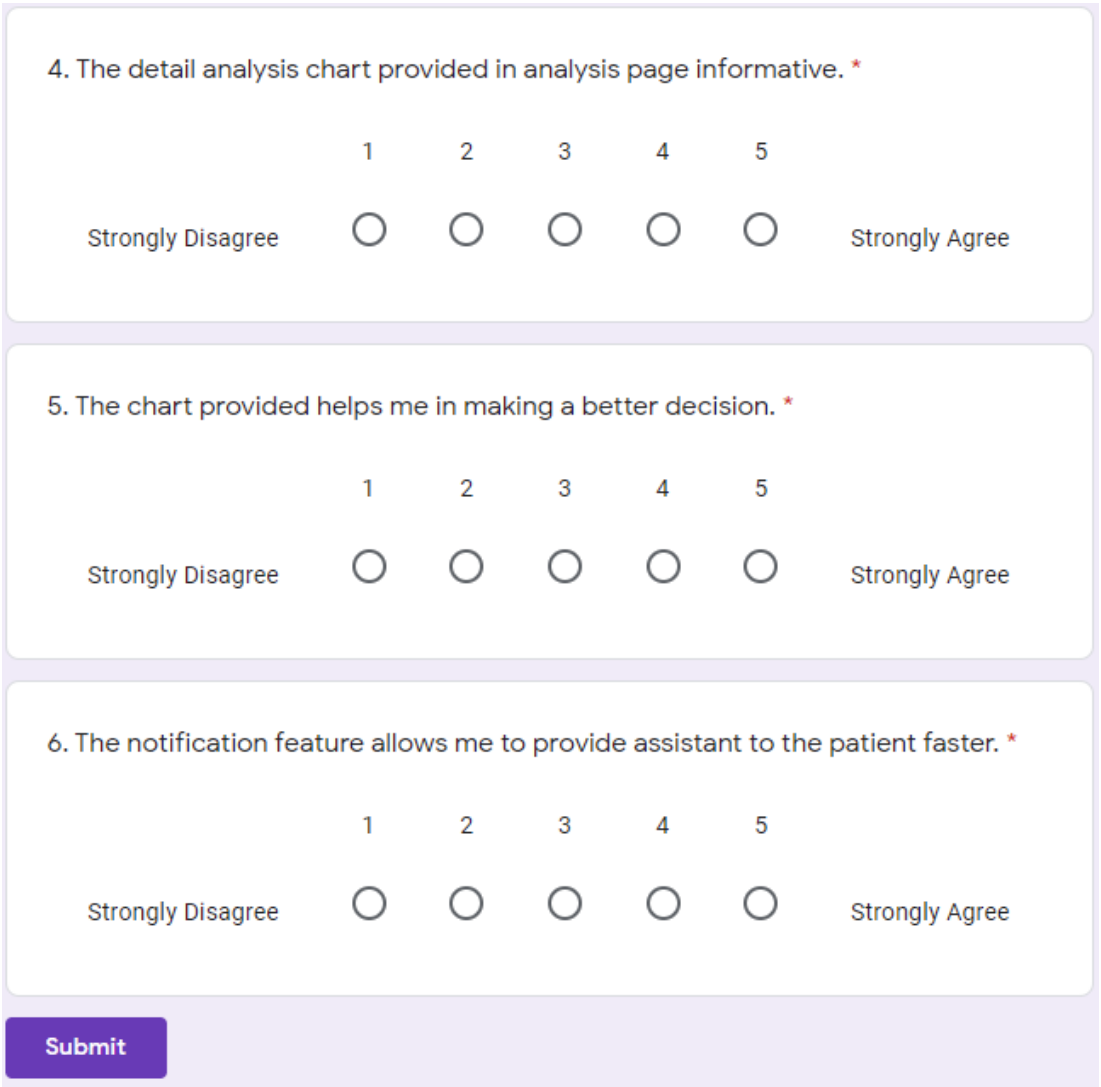


FIGURE F-5: User Acceptance Test (Medical Team) (Continued)