



ASHESI UNIVERSITY COLLEGE

**COMMUNICATING PRESCRIPTION INFORMATION TO NON
LITERATE PATIENTS USING VISUAL AIDS**

APPLIED

B.Sc. Computer Science

Ebenezer Elom Dzobo

2017

ASHESI UNIVERSITY COLLEGE

**Communicating prescription information to non-literate patients using
visual aids.**

APPLIED PROJECT

Applied project submitted to the Department of Computer Science, Ashesi
University College in partial fulfilment of the requirements for the award of
Bachelor of Science degree in Computer Science

Ebenezer Dzobo

April 2017

DECLARATION

I hereby declare that this [capstone type] is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature:

EBENEZER ELOM DZOBO

Candidate's Name:

EBENEZER ELOM DZOBO

Date:

17th April 2017

I hereby declare that preparation and presentation of this [capstone type] were supervised in accordance with the guidelines on supervision of [capstone type] laid down by Ashesi University College.

Supervisor's Signature:

.....

Supervisor's Name:

.....

Date:

.....

Acknowledgement

To my supervisor, Mr Aelaf Dafla and the computer science department, for your immense support and guidance throughout the project.

To Mr Albert Nettey, for your insights in the pharmaceutical industry

Abstract

Health literacy has always been a challenge to 100 percent user absorption rate of medicines. The sad truth is that literacy does not always translate into health literacy. And despite the education levels of people, they do not always understand their medical prescriptions. Worst of all is non-literate patients who do not have the luxury of reading their prescription information off the package of drugs especially when they have more than 3 medications with distinct prescription doses.

In this project, I seek to use computer science to communicate prescription information to literate and non-literate patients using visual aids primarily.

Table of Contents

DECLARATION.....	IV
ACKNOWLEDGEMENT	VI
ABSTRACT.....	VII
CHAPTER 1: INTRODUCTION	1
1.1 BACKGROUND.....	1
1.2 MOTIVATION.....	2
1.3 REVIEWS OF RELATED LITERATURE AND STUDIES.....	3
1.3.1 <i>Visual Aids</i>	3
1.3.2 <i>Notification/Reminders</i>	4
1.3.3 <i>Farmerline</i>	4
1.4 ANALYSIS OF RELATED RESEARCH WORK.....	4
CHAPTER 2: REQUIREMENTS.....	7
2.1 PLAN FOR REQUIREMENT.....	7
2.1.1 <i>My Requirement and Data Gathering</i>	7
2.2 SCOPE OF SOLUTION.....	7
2.2.1 <i>Literacy Level</i>	7
2.2.2 <i>Technological Competence</i>	8
2.2.3 <i>Platform Type</i>	8
2.3 REQUIREMENT DISCOVERY.....	9
2.3.1 <i>Patient Scenario</i>	9
2.3.2 <i>Pharmacist Scenario</i>	9
2.3.4 <i>Patient Scenario with web Application</i>	10
2.4 ANALYSIS OF SCENARIOS.....	10
2.4.1 <i>Pharmacist Functional Requirements</i>	11
2.4.2 <i>Patient Function Requirement</i>	11
2.4.3 <i>Non Functional Requirement</i>	12
2.4 USE CASE DIAGRAM FOR PHARMACIST AND PATIENT.....	12
CHAPTER 3: ARCHITECTURE AND DESIGN.....	14
3.1 HIGH LEVEL ARCHITECTURE.....	14
3.1.1 <i>Client Side User Interface</i>	14
3.1.2 <i>Client Side Backend</i>	14
3.2.....	15
COMPONENT DIAGRAM.....	15
3.2.1 <i>Web Application</i>	15
3.2.2 <i>Database</i>	16
3.3.....	17
SEQUENCE DIAGRAM.....	17
3.4 CLASS DIAGRAM.....	18
3.5: IMPLEMENTATION RESOURCES AND SETUP.....	19
3.5.1 WEB APPLICATION.....	19
3.5.2 BACKEND.....	19
CHAPTER 4: IMPLEMENTATION.....	20
4.1.1 DRUG PACKAGE REDESIGN.....	20
4.1.2 FRONT-END USER INTERFACE DESIGN.....	22
4.2 BACK END DEVELOPMENT.....	25
4.2.1 <i>Database Design</i>	25
4.2.2 <i>Algorithms</i>	27

4.3 DEVELOPMENT.	28
CHAPTER 5: TESTING AND RESULTS.....	29
5.1 COMPONENT TESTING.....	29
5.2 MODEL AND CONTROLLER TESTS	29
5.3 SYSTEM LEVEL TESTING.....	30
5.4 USER TESTING.....	31
5.4.1 <i>Analysis of User Test</i>	31
5.5. TEST SUMMARY	33
CHAPTER 6: CONCLUSION AND RECOMMENDATIONS	34
6.1 DEGREE TO WHICH PROJECT MEETS FUNCTIONAL REQUIREMENTS.....	34
6.2 LIMITATIONS	34
6.3 FUTURE WORK	34
6.4 CONCLUSION	35
BIBLIOGRAPHY.....	36

Chapter 1: Introduction

1.1 Background.

No matter how much technology and new information available to the medical discipline, the problem of health literacy and patient understanding always serves as a bottleneck to a hundred percent user absorption success. Health Literacy is defined as “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” (U.S. Department of Health and Human Services, n.d.). Health literacy is important because low health literacy directly translates to poor health outcomes such as higher rates of hospitalization and less frequent use of preventive services (U.S. Department of Health and Human Services, n.d.).

According to the U.S. Department of Health and Human Services, a survey of the National Assessment of Adult Literacy showed that only 12 percent of adults in US have proficient health (U.S. Department of Health and Human Services, n.d.). In other words, nearly nine out of ten adults may lack the skills needed to manage their health and prevent disease. Fourteen percent of adults (30 million people) have Below Basic health literacy.

The situation is not any different in Ghana. Dr Christina Osei-Yeboah, a Consultant Paediatrician and a Public Health Specialist, described health literacy in Ghana as poor. She asserted that “the country’s health system is fragmented with different cadres of people providing health services and information they often do not have requisite training or qualification to provide” (Ghana News Agency, 2016). In addition, the few professionals are too busy diagnosing and providing treatments with little attention to communicating drug and health information to clients.

According to research conducted by the Minnesota Health Literacy Partnership, communicating drug information to patients often have the following problems:

1. Doctors and even nurses must rush through most encounters with patients.
2. Patients “don’t ask, don’t tell.” For their part, patients often keep silent when they should speak up.
3. Poor package design leads to confusion. Perhaps the largest and most visible problem with prescription medications is their packaging
(Minnesota Health Literacy Partnership, 2007).

Drawing from these, I seek to use Computer Science to design, develop and evaluate aids for communicating prescription drug instructions to non-literate patients via visual aids and must be available round the clock.

1.2 Motivation.

My grandmother lives in Tokurano, a village in the Volta Region of Ghana. She often visits my house when she is ill so she can gain good medical care in the city. After one of such visits to the hospital, she called me and asked me to read to her what the doctor had written on each of the drugs.

After reading and explaining her prescription to her, I asked what she normally did back in the village when no one was around to read her prescription to her at home. She said she didn’t take the drugs anymore since she could not remember her prescription.

From research, other solutions were that patients put small stones or rocks into the Ziploc package of drugs to represent the doses they had to take a day.

The challenge with this is that even though it was an ingenious solution to their

problem, it did not take into consideration the intervals between prescriptions or the mode of administration (with or without food). The stones could contaminate the drugs or even introduce new diseases.

1.3 Reviews of Related Literature and Studies.

1.3.1 Visual Aids.

In communicating prescription information to non-literate patients, several researchers explored visual aids. Researchers came up with culturally responsive pictograms and images which communicated prescription information to the community. In one study, Seventy-eight female ambulatory patients were evaluated for comprehension and compliance with antibiotic prescription instructions. A comparison of the three groups showed that subjects in the experimental groups scored significantly higher than the control group in both the comprehension and compliance measures. In the second research, twenty-three pictograms from the USP-DI and a corresponding set of 23 locally developed, culturally sensitive pictograms for conveying medication instructions were evaluated in 46 Xhosa respondents who had attended school for a maximum of 7 years. Preference for either the Local or USP pictograms was determined. In the group of 25 respondents who had completed between 5 and 7 years of schooling, a quarter (five respondents) were categorised as having had no understanding of the label at all, with the majority (17 of the 25 respondents) partly understanding the label. These findings imply that even after having completed between 5 and 7 years of schooling, there is a strong likelihood that comprehension of written instructions will be incomplete.

Essentially, the results confirmed my assumption that basic literacy did not guarantee health literacy. If people received tailored information about their prescription,

there was a high chance that they followed the prescription accurately.

1.3.2 Notification/Reminders.

Medisafe is a mobile application which reminds users to take their medicines at regular intervals. The app allows users to create a new drug collection with their prescription. At the stipulated time, a push notification is received reminding users to take their medications. A report is generated at the end of the day to show user progress. The drawback of the application is that it is very literate intensive. Non literate patients would have a hard time using the application. It can be compared to the USP-DI pictograms which did not respond culturally to the patients from Xhosa. The application is a step in solving the problem yet it is still disconnected from rural communities such as Berekuso.

1.3.3 Farmerline.

Farmerline is an online platform that seeks to help small scale farmers in Ghana by communicating information to farmer. Farmerline has a tool for communicating weather forecast information to the local farmers. They have a platform known as merge data which allows bulk calls and messages to groups of people in any language anywhere in the world.

1.4 Analysis of Related Research Work.

Drawing from the above research papers, I propose a solution of using a web application which will communicate prescription information to non-literate patients using culturally responsive visual aids.

From the research conducted in Xhosa, using pictograms which were culturally responsive had a higher likelihood of understanding and thus, adherence than employing international symbols. For my proposed solution, I suggest using coloured pictograms of

day to day objects that people of a particular demographic and geographical location are accustomed to. For instance, using a plate with a fork and knife to represent meals may be prescribed as an international symbol but may not particularly work well in a society that predominantly eats without a fork or knife.

The desired platform for my solution is a web application. I propose this platform because:

1. Building a web application is cost effective for development: With web-based applications, users access the system via a uniform environment—the web browser. While the user interaction with the application will need to be thoroughly tested on different web browsers, the application itself needs only be developed for a single operating system. There's no need to develop and test it on all possible operating system versions and configurations. This will make development and troubleshooting much easier (Magic Web Solutions, n.d.).
2. Ubiquitous: Unlike traditional applications, web systems are accessible anytime, anywhere, via a PC with an Internet connection, putting the user in charge of where and when they access the application. (Magic Web Solutions, n.d.).
3. Accessible for a range of devices: In addition to customising content for user groups, content can also be customised for presentation on any device connected to the internet, including PDAs, mobile phones, etc., further extending the patient's ability to receive and interact with information (Magic Web Solutions, n.d.).

Also, recent statistics from the Ghana National Communications Authority, mobile phone penetration has risen to 127.63 percent as a result of voice subscriber base climbing to from 34 million in November 2015 to over 35 million in December 2015 (Laary, 2016). According to the same statics released, the number of mobile data subscribers rose from

17.73 million to 18.03 million resulting in an access rate of 65.74% (Laary, 2016). Essentially, the number of low-end smartphones from brands such as Infinix and Tecno have become so popular that the average mobile phone owner uses a smart phone and hence would support the web application.

It is important to note that literacy or the ability to read and write differs somewhat from health literacy such that the ability to read or write doesn't necessarily guarantee health literacy. Improving people's access to health information and their capacity to use it effectively is what empowers health literacy (World Health Organization, n.d.). My solution aims to target people who can use a mobile phone to an extent thus, a user base who have some form of literacy.

Chapter 2: Requirements.

2.1 Plan for Requirement.

The web application shows visual aids to patients upon signing in. The purpose of the system is to provide patients with bespoke visual aids and audio, educating patients on how to take their drugs at the right time. The system focuses on communicating prescription information to health illiterate patients.

2.1.1 My Requirement and Data Gathering.

1. Research on the prescription guidelines by speaking to pharmacist and simulating a prescription / drug purchase process.
2. Research on how pharmacist solve misinterpretation of prescription information by speaking to pharmacist.
3. Check online for existing standards and guidelines for communicating prescription information to patients.
4. Available hardware technology that would allow the platform to be built.
5. How much the proposed solution will cost

2.2 Scope of Solution.

The user base the solution addresses can be classified into the literacy level, the technological competence and platform.

2.2.1 Literacy Level.

As described earlier, the ability to read pamphlets and successfully make appointments does not constitute to health literacy. Essentially reading and writing helps but does not mean a person has health literacy.

The web application comes with certain basic functionalities like signing up and

signing in to ensure security. Due to this, the application defines its users as people with some basic literacy skills such as being able to remember and type a username and password. Given that a user has the skills to log in, they can easily use the web application.

2.2.2 Technological Competence.

Technological competence and literacy almost go hand in hand. The application does not require any extreme skills in using technology.

A novice user should be able to sign up and log in to the application. Beyond this, the application does not require any further complications.

In addition, it is the duty of the pharmacists to educate the users on how to use the web app and what the visual aids mean. These are already duties of pharmacists to patients.

The pharmacist who manages the admin side of the application will require novice expertise since the application does not require anything beyond adding users, editing, deleting and managing prescriptions. All of which can be achieved through education.

2.2.3 Platform Type.

As defined earlier, web applications require a web browser to run. Thus, the device required should be a personal computer or a smartphone with web capabilities.

The application is responsive such that a smaller screen would not compromise the conveyance of information to a user.

2.3 Requirement Discovery.

Functional requirement discovery was done by writing different scenarios based on information gathered and documents reviewed. The scenario is analysed to identify user requirements.

2.3.1 Patient Scenario.

Mrs Angela Narh is a 50-year-old farmer living in Berekuso in the Eastern Region of Ghana. Mrs Narh is non literate and often relies on her family to read and translate any piece writing given to her. She falls ill and visits the hospital. After meeting with the doctor she is diagnosed with malaria and given drug prescriptions. Her prescription consists of 4 different drugs with distinct prescriptions.

1. Drug A: 1 should be taken 3 times daily (before meals).
2. Drug B: 2 in the morning, 2 after 4 hours then one in the evening. 1 each day for five days
3. Drug C: 1 each day for 5 days
4. Drug D: 2 tablets the first 2 days, 1 daily afterwards.

Due to the distinction and number of drugs, Mrs Narh cannot keep all the instructions in memory. Since her family members are not always at home, Mrs Narh does not know how to remember the prescription.

2.3.2 Pharmacist Scenario.

Mr John is a pharmacist. Since he is the only pharmacist that attends to the village, he is quite popular. Due to this, he has a bond with the townsfolk and sometimes checks on his customers to see if they follow their medication. He has been given a new application to aid communicating prescription drug information to patients. When Mrs

Narh visits him with her prescription, he enters her name, age, sex, phone number and next of kin information into the application which adds to a database. He then assigns:

1. A red places a red sticker on drug A's package.
2. A white sticker to drug B.
3. A black sticker to drug C.
4. A yellow sticker to drug D

Mr John again enters the drug name, assigned colour and dosage information into the application. This information entered is tied to Mrs Narh's information. He then teaches Mrs Narh the dosage and ensures full comprehension. He bids her farewell.

2.3.4 Patient Scenario with web Application.

In the morning Mrs. Narh takes her mobile phone and visits the prescription information web application. She has to sign in in order to see her prescription and modes of administration.

When she signs in, she sees her prescription page which is culturally responsive and can communicate the prescription to her effectively.

According to her medicine packaging, the pharmacist colour coded paracetamol as red, vitamin C as black and her multivitamins as blue. The page indicates that she takes 2 of the red package (paracetamol) in the morning and two at night after meals. Vitamin C (Black) must be taken once a day after meals. Multivitamins should be taken one in the morning, afternoon and evening.

2.4 Analysis of Scenarios.

From reading the various scenarios, I gathered the necessary user requirements a

web application communicating prescription information should have. They are classified into pharmacist and patient functional requirement.

2.4.1 Pharmacist Functional Requirements:

1. Sign up as new pharmacist
2. Create new patient
3. Edit details of existing patient
4. Delete patient
5. Add new prescription for a patient.
6. Edit, delete prescription of a patient

2.4.2 Patient Function Requirement.

1. Login as a patient
2. View prescription visual aids
3. Indicate if drug has been taken

Drug prescriptions can be generally classified into 2 major categories. Repetitive Prescriptions and Non Repetitive prescriptions. Repetitive prescriptions involve taking the same sequence of medication every day for the stipulated number of days.

Non repetitive involves taking drugs at irregular intervals especially hourly based. The challenge with this is keeping such information in a database.

Two tables were created, one to store repetitive prescription whilst the other stored non repetitive prescription. The repetitive prescriptions were classified by time of day to be taken such as morning, afternoon and evening whilst the non-repetitive was managed based on the hours between intervals.

The critical feature for the project was to represent patient descriptions in a culturally responsive visual aid which teaches patients when and how to take their drugs.

2.4.3 Non Functional Requirement.

Reliability: Components of the project code will be tested alongside the implementation phase to ensure that they are functional.

Performance: Adding, searching and deleting user must be without any glitches whatsoever. The app must be up and running at all times when requested by the pharmacist.

Supportability: The application must not be platform dependent, i.e., it should be able to run on any platform with a web browser.

Implementation: Project will be implemented in php and html. All project graphical user interfaces will be created using a CSS and html.

2.4 Use Case Diagram for Pharmacist and Patient.

The diagram in figure 2.2 and figure 2.3 shows the respective use case instance of a pharmacist and a patient using the application from the scenarios detailed above. For the pharmacist use case (figure 2.2), a pharmacist logs into the application and the pharmacist is authenticated. He then proceeds from the menu to add a new patient. After adding a patient, he goes on to add a prescription for the patient. He can then have a preview of how the patient is going to see the prescription information, where he can explain the pictograms to the patient.

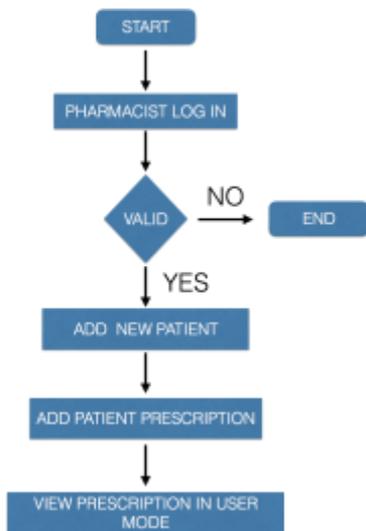


Figure 2.2 Pharmacist Use Case Diagram

For the patient use case in figure 2.3, the patient signs in with the username and password the pharmacist signs them up with, their credentials are authenticated and then they have access to view their prescription.

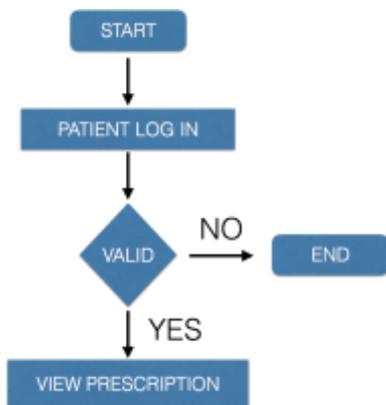


Figure 2.3 Patient Use Case Diagram

Chapter 3: Architecture and Design.

3.1 High Level Architecture.

3.1.1 Client Side User Interface.

The client side of the application (also the pharmacist side) manages how information is going to be recorded. The pharmacist needs a simple user interface to record new patients and their prescriptions. This with in accordance with the backend makes the application usable. Figure 3.1 is an example the add new prescription page.

The screenshot shows a web form for entering prescription details. At the top, there are two tabs: 'Everyday' (which is selected) and 'Specific days'. Below the tabs is a heading: 'memory is not always reliable. Please tell us your prescription so we can remind you'. The form consists of several input fields and a color selection section. The fields are: 'drug name', 'how many doses in the morning', 'how many doses in the afternoon', 'how many doses in the evening', and 'how many days are you stuck on this medication'. There is also a section for 'associated colour' with four colored dots (red, blue, black, yellow). A checkbox for 'to take before or after meals?' is present. A 'sign up' button is at the bottom.

Figure 3.1 Enter Prescription Details form

The user interface will be written in standard web Hypertext Transfer Markup Language (HTML) and formatted using in Cascading Style Sheet (CSS).

3.1.2 Client Side Backend.

The backend of the client side will be written using php and ajax. Php is generally suited to server side web development and hence is the chosen language. Ajax has the advantage of communicating with the server and updating the page without reloading the

whole page.

3.2 Component Diagram.

Figure 3.2 is a component diagram showing the major components that make up the functionality of the web app. There is a pharmacist side web application where the pharmacist enters the details of the patient. This updates the database. The user then logs in and their prescription is pulled up using visual aids. The web app can pull the data from the database and alert the patient with information with the stipulated time and mode of administration.



Figure 3.2 Component Diagram

The major components include the web application, a database and a mobile client.

3.2.1 Web Application.

The web application has all user interfaces and is the primary medium of interaction all users of the application will have with the system. It will have a pharmacist administrator side which manages all prescriptions and entering patient information.

The patient also interacts with the web application component via a mobile device (any device of their choice) and has a patient sign in where they see prescriptions.

3.2.2 Database.

The database component deals with storage manipulation and management of all user information for the application. As shown in the diagram figure 3.3, patient information, prescription information and user management information is all stored in a database. When users log in the relevant details are pulled from the database based on their privileges.

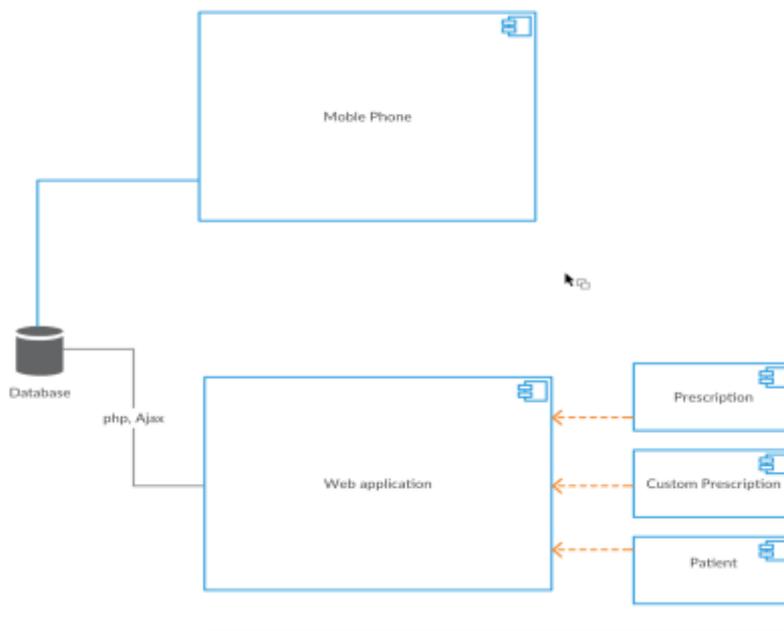


Figure 3.3 Database Architecture

The web application involves some form of keeping and managing information about patients and their prescriptions. In order to structurally store and manipulate this data, a database using MySQL relational database management system. This database will be queried using standard SQL scripts.

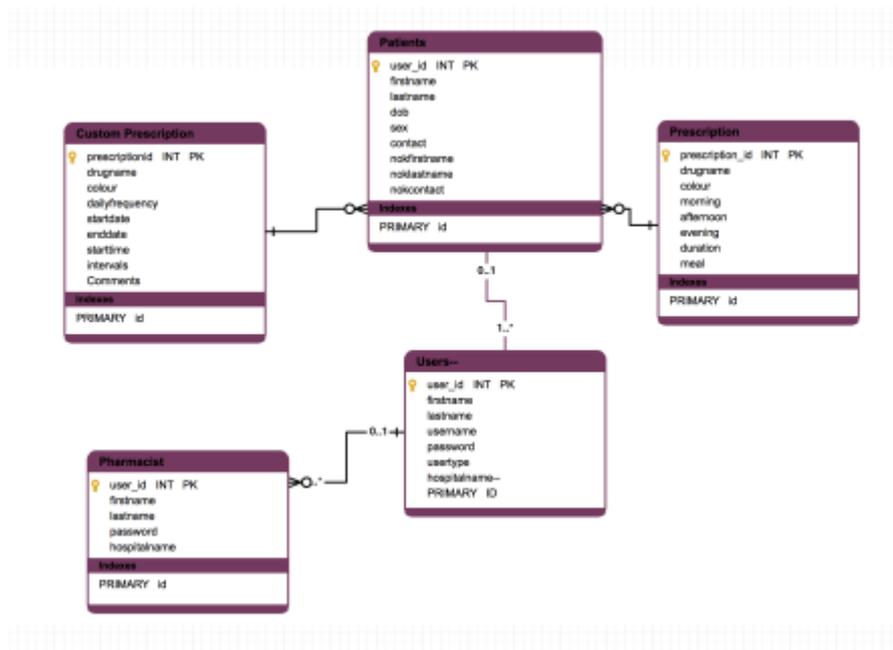


Figure 3.4 Entity Relation Diagram

3.3 Sequence Diagram.

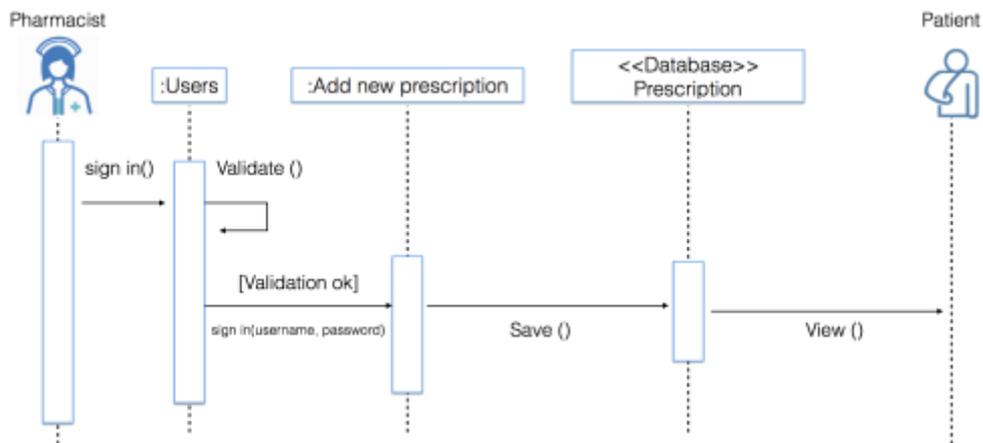


Figure 3.5 Sequence Diagram

The Sequence diagram in figure 3.5 highlights one activity of adding a new patient prescription. The pharmacist signs in, authenticates his credentials and then proceeds to enter a new prescription through the user interface. When the save button is hit, it calls the function `enterNewPrescription()` which saves to the prescription table in the database. The pharmacist then views the prescription as the user would see it as seen in figure 3.6.

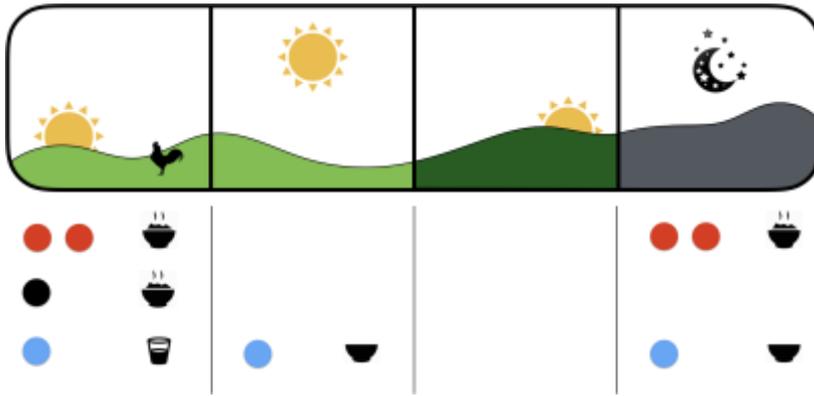


Figure 3.6 Culturally Responsive Visual Aid

Figure 3.7 is an activity diagram showing how a patient views their prescription. The patient signs in, the credentials are authenticated, using the same username their prescription is fetched from the database and displayed to the user.

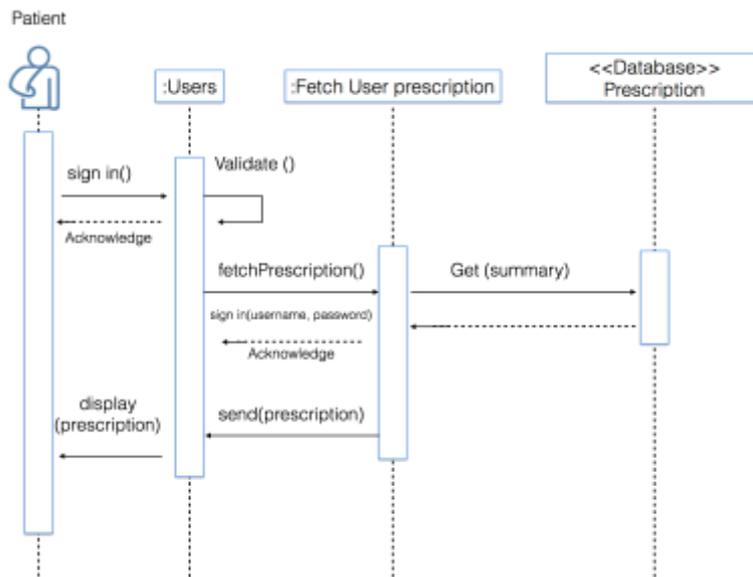


Figure 3.7

3.4 Class Diagram.

This simple class diagram shows the different classes going to be used in the system.



Figure 3.8 Class Diagram

3.5: Implementation Resources And Setup.

3.5.1 Web Application.

Front end The web application on the pharmacist side will be written in HTML and styled in CSS to take advantage of the multi-platform capabilities.

3.5.2 Backend.

The backend and database handling will be done in php while MySQL server will be used as the database to keep patient information.

Chapter 4: Implementation.

The implementation stage of the project has been the most time consuming and challenging phase of the project. Below is a list of the functions implemented and their descriptions.

4.1.1 Drug Package Redesign.

My proposed solution makes the use of design thinking as well as computer science. A major problem with drug packaging is the overload of information on the exterior packages. The reason being that it essential that all the information is published for the patient to know what they are administering.

Due to this, I sought to simplify the packaging of drugs in order to differentiate between various drugs regardless of patient literacy level.

Figure 4.1 and 4.2 show an example of the standard packaging of drugs after a visit to the pharmacy or hospital. This is from a personal experience which occurred in March 2017.



Figure 4.1



Figure 4.2

For my proposed solution, I added a simple yet powerful distinction between the drugs. I achieved this by colour coding the exterior packaging of drugs via coloured stickers. Figure 4.3 to 4.5 shows that the medicine are colour coded. The colour distinction is left to the sole peorative of the pharmacist. There is no standard which suggests which drug should have a particular colour. The pharmacist just needs to ensure that the chosen colour corresponds to what he enters into the web application to prevent wrong prescription.



Figure 4.3



Figure 4.4



Figure 4.5

These stickers clearly identify which drug is which without the patient necessarily knowing the name of the drug. This case is essential for catering for an extreme patient who is has no literacy.

Based on these colour coded distinctions, a patient can be directed to take 2 pills of the red drug or the blue drug in accordance with the patient's prescription.

4.1.2 Front-End User Interface Design

From the research work of Lucy Ngoh and Marvin D. Shepherd it was concluded that low literacy impaired the understanding of prescription information, drug warning labels and standardized drug pictograms (Ngoh & Shepherd, 1997). It was also concluded that pictograms which were culturally responsive and developed with the people of a certain geographical location and demographic proved better comprehension and adherence results (Dowse & Ehlers, n.d.). With this information I sought to create a user interface which was responsive to the Ghanaian culture.

Using the keynote application, I designed the look and feel of the web application taking into consideration key Human Computer Interaction concepts.

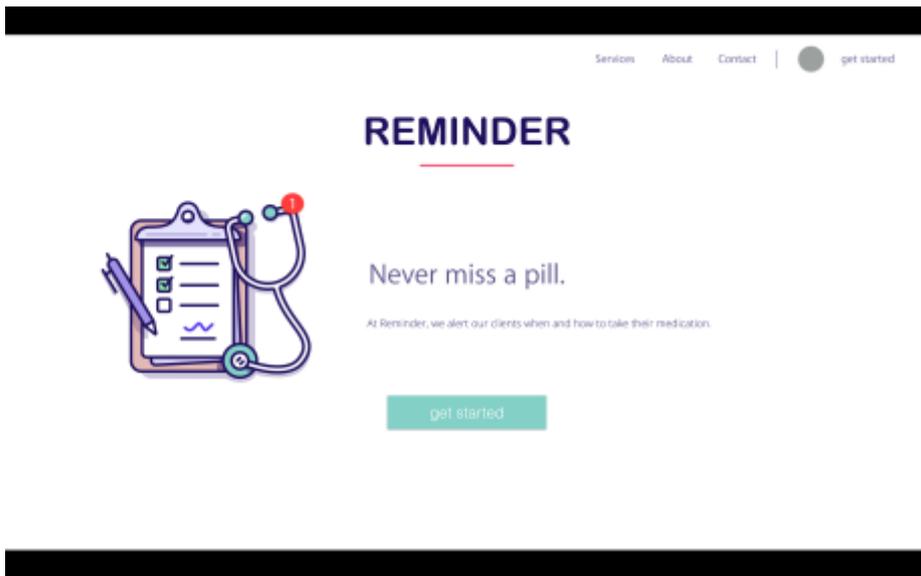


Figure 4.6

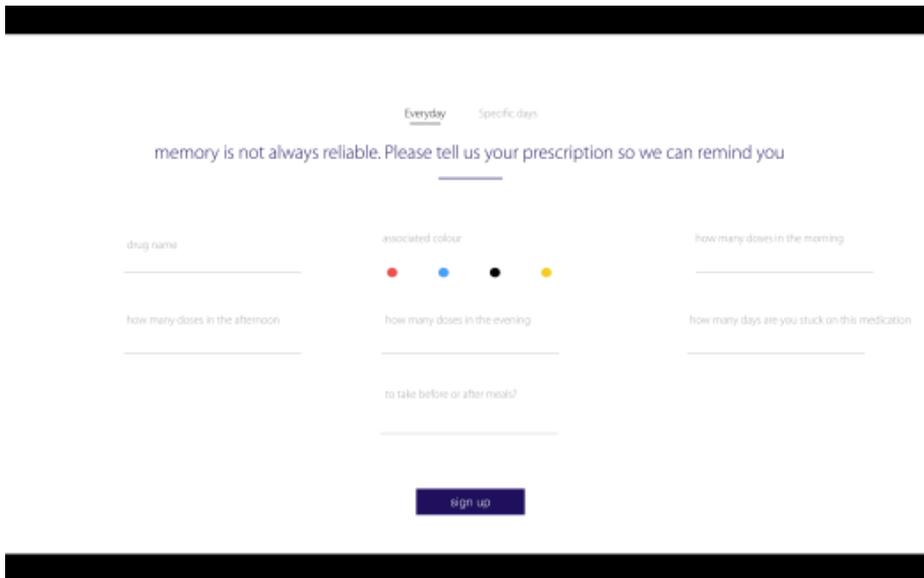


Figure 4.7

Using black text on white background as seen in figure 4.6 and 4.7 ensures maximum readability. Implementation involved the user of large fonts and using colour where possible to guide the users while using the application.

For the prescription information page, I designed the various times of the day in Keynote and using bright colours and positioning the sun at different heights to aid intuition while reading the time. The figure below shows the sun at different times

representing morning, afternoon, late afternoon or dusk and night.

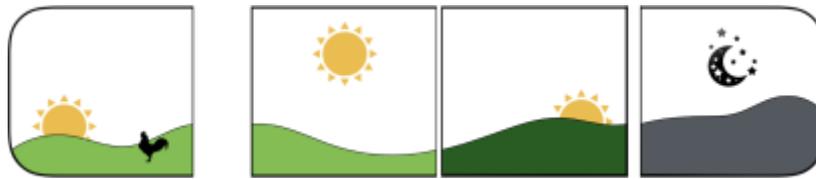


Figure 4.8

The choice of medicine colour was based on the primary colours and a few secondary colours which were very distinct from each other. These colours would be represented as stickers to colour code the exterior packaging of drugs to distinguish each from the other.



Figure 4.9

To indicate whether a drug needed to be taken before or after meals, I chose to represent a glass of water as before meals and a bowl of food for after meals.



Figure 4.10

Combining these components of the user interface, the final prescription information page looks like the figure 4.11 to show patients when to take their drugs, how to take the drugs and the frequency. In addition, there is a text description to cater for literate patients.

It is important to note that pharmacists have the responsibility to explain how to read the prescription to the patients. As much as the display is intuitive, education still needs to be done to users so as to ensure full compliance.

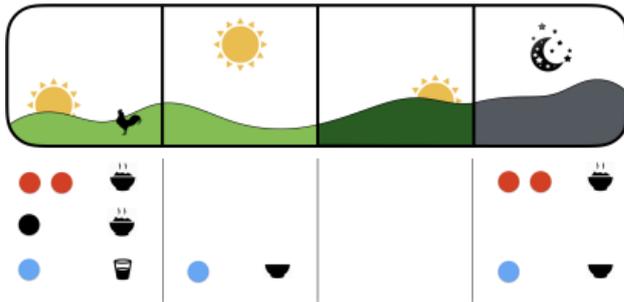


Figure 4.11

4.2 Back End Development.

4.2.1 Database Design.

In chapter 2 the plan for requirements highlighted the functional requirements. A few of them were the ability to add a patient, add a prescription, edit a patient's details, delete a patient etc. All these functional requirements have something in common, they require management of data in a structured way. The way to achieve this is by using a Database Management System to cater for all data manipulation and storage.

For the web application, I used an SQL relational database management system phpMyAdmin. I used phpMyAdmin because it is a free tool written in PHP which is intended to handle MySQL with the use of a web browser.

I created a database called 'user' with 6 tables:

1. Customprescription
2. Images
3. Patient
4. Pharmacist
5. Prescription
6. Users

The users table stores information about all registered users of the web application and classifying them as pharmacists versus patients. The passwords are encrypted using the built in MD5 algorithm.

There is an image table which holds the image id, image name and image location in the file system. An image table is necessary because of the nuanced nature of prescriptions, each user sees a different prescription from one another and these come with different sets of icons and pictograms. Hence, the database holds a location reference in the file structure.

The most challenging part of the database architecture was storing and manipulating prescription information about users. This is because, prescriptions can be repetitive or taken as and when needed. My solution did not tackle the latter however the challenge was in storing repetitive prescriptions. This is because repetitive doses can be based on 8 hour bases which often translates into morning, afternoon and evening. The challenge arises when prescriptions have an irregular interval such as 2 hours first, then 6 hours later.

To do this, I separated the prescriptions and handled them in two separate databases, the first one classifying doses by the time of day (morning, afternoon, evening and night). The second table classified medication based on the hourly intervals. These hourly intervals then rely mostly on text and audio to effectively communicate to the patient. The figure 4.12 shows a screenshot of the database and associated tables.

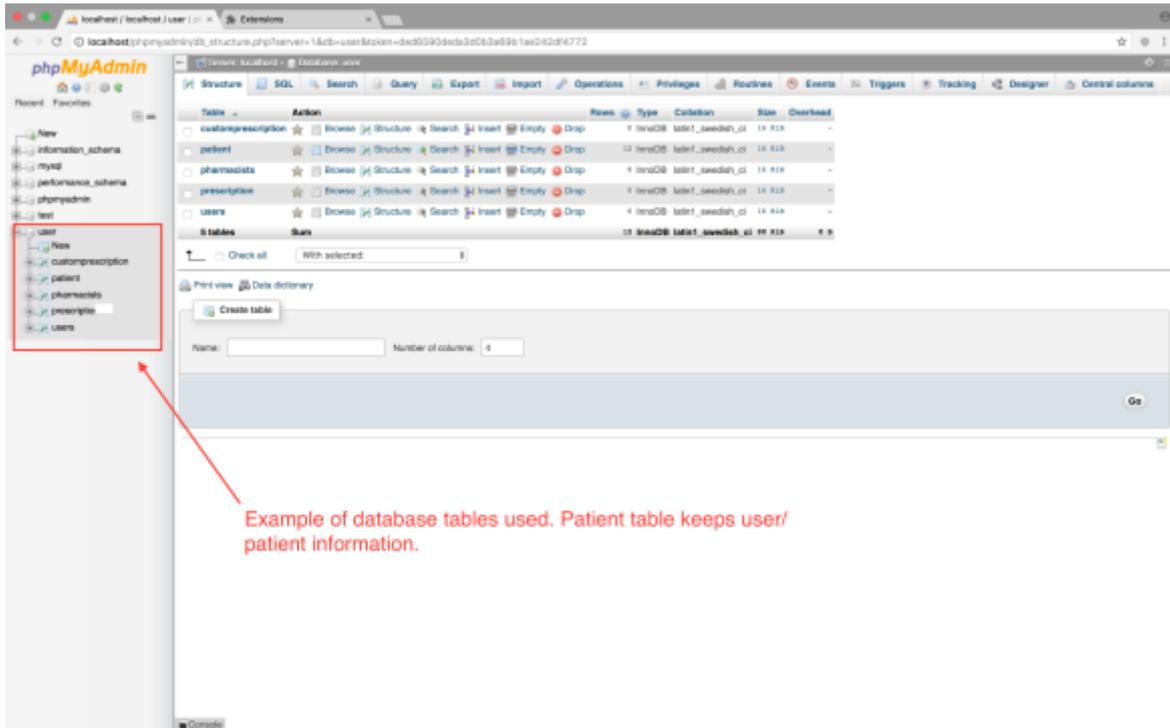


Figure 4.12

4.2.2 Algorithms

I implanted primarily algorithms which interacted with the database such as an `addUser()`, `addPrescription()`, `searchPrescription()` etc. which have the respective SQL statements to help perform the action.

In displaying the prescription such that it would be responsive on a smaller screen, I first divided the time of day image into separate individual images (figure 4.13) even though it displays as one long continuous image (4.14).

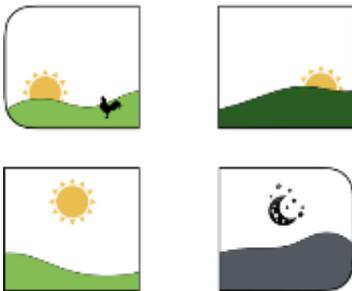


Figure 4.13

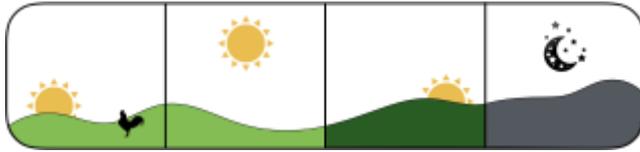


Figure 4.14

The images are printed in a table with the time of day as the first row (figure 4.15). When the first time of day is printed in row 1, column 1, the first dose is printed in row 2, column 1, the next in row 3, column 1. When that time of day is completed, the next time is printed in row 1, column 2. This continues until the loop is completed and a patient can see their prescription. The advantage of printing with this algorithm is that it is optimised for a smaller display.

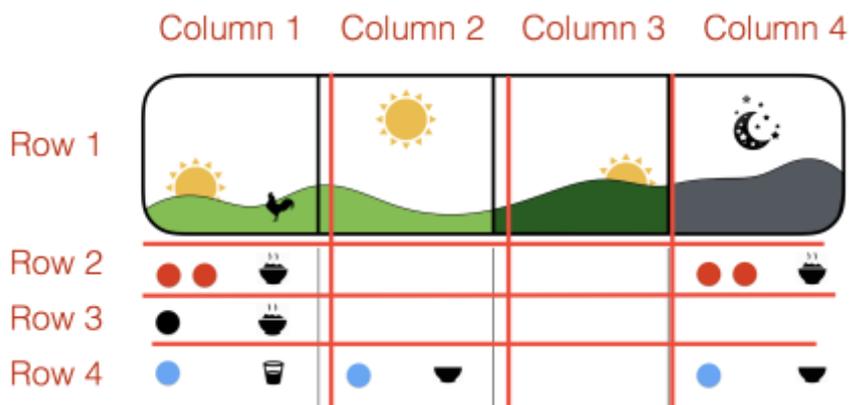


Figure 4.15

4.3 Development.

The web application was developed in php, HTML (Hyper Text Mark-up Language) and CSS (Cascading Style Sheet) is used to style the web application. The architectural pattern I used for the application is the MVC (Model View Controller) architecture. Just like MVC, the data handling and connection to database which is the Model was separated in a one php document. The controller contains all the php functions whilst the View handles all user interface logic.

Chapter 5: Testing and Results.

5.1 Component Testing.

The web application is divided into 3 components, the model view and controller.

The model test involves testing the SQL scripts associated with the functional requirements, the expected results and the actual results.

The Controller test encompasses testing all php functions, providing their expected results and finally, the end result.

The view test includes testing the various user interface logic.

5.2 Model and Controller tests

PHP functions	Description	SQL Command	Expected Result	Final Result
getPrescription()	Fetch user prescription	Select USERNAME, DRUGNAME, COLOUR, MORNING, AFTERNOON, EVENING, NIGHT, DURATION, MEAL from prescription where USERNAME = "username"	rows + response time	Showing rows 0 - 0 (1 total, Query took 0.0006 seconds.)
editUser()	Edit a user	UPDATE users SET USERNAME = '\$username', FIRSTNAME= '\$firstname', LASTNAME= '\$lastname', USERNAME = '\$username', DOB= '\$dob', SEX= '\$sex', CONTACT= '\$contact', NOKFIRSTNAME = '\$nokfirstname', NOKLASTNAME= '\$noklastname', NOKCONTACT= '\$nokcontact', WHERE USERID = '\$userid';	row affected + time	1 row affected. (Query took 0.0108 seconds.)
getUsers()	Fetch all users	select USERNAME, FIRSTNAME, LASTNAME, DOB, SEX, CONTACT, NOKFIRSTNAME, NOKLASTNAME, NOKCONTACT from patient	row + time	Showing rows 0 - 11 (12 total, Query took 0.0004 seconds.)

addPatient()	Add new patient	insert into patient set USERNAME='\$username', FIRSTNAME='\$firstname', LASTNAME='\$lastname', DOB='\$dob', SEX='\$sex', CONTACT='\$patientcontact', NOKFIRSTNAME='\$nokfirstname', NOKLASTNAME='\$noklastname', NOKCONTACT='\$nokcontact'	row + row insert id	1 row inserted. Inserted row id: 23
addPrescription()	add a new prescription to a patient	insert into patient set USERNAME = '\$username', FIRSTNAME = '\$firstname', LASTNAME = '\$lastname', DOB = '\$dob', SEX = '\$sex', CONTACT = '\$patientcontact', NOKFIRSTNAME = '\$nokfirstname', NOKLASTNAME = '\$noklastname', NOKCONTACT = '\$nokcontact'	row +row id	1 row inserted. Inserted row id: 15
getImage()	Fetch file location of an image	select LOCATION from images where IMAGENAME= '\$filter'	Rows + time	Showing rows 0 - 12 (13 total, Query took 0.0010 seconds.)
deleteUser()	Delete a patient	Delete from patient where USERCODE = \$usercode	Rows + time	1 row affected. (Query took 0.0008 seconds.)

5.3 System level testing

For system level testing, the various pages on the and user inputs were tested for bad user inputs such as entering alphabetical characters where a number was expected. All bad user inputs were handled such that the application was did not crash.

Also, the app was tested to make sure that the same colour could not be applied to more than one drug. This would cause a fatal problem in the logic of the application since users would then take a wrong prescription.

5.4 User Testing

After the web application was built to the point where user prescription could be displayed to the user. I asked a few users to conduct a black box test by using the application. Arbitrary prescriptions were given to users and their prescription displayed to them. Test subjects were then asked to explain what the visual aids represented in relation to their prescription. The test recorded a 100 % success as all patients were able to explain their prescription in their preferred language of choice. They were then asked to answer a few questions. The questions included:

Ranking from 1 (less effective), 2 (moderately effective) and 3 (very effective) how effective does this tool communicate prescription information to you.

Would you rely on the use such a system to communicate prescription information to you?

If you decide to use the app would you prefer an accompanying print out of the prescription? Tick print only, web and print only and web only.

5.4.1 Analysis of User Test

The user base was stratified based on the level of education. Namely, non-literate (cannot read and write), Secondary level education and Tertiary level education. The users were taken from Ashesi University campus and Berekuso township. The sample was purposive and capitalised on the characteristics of a population and the objective of the study. 30 people partook in the test.

Of the 8 non-literate patients who chose to use the application, 7 of them preferred to use both the web application and a printed copy of the prescription information. 4 out of

the 11 Secondary school education responders, 3 preferred to use the web app, 4 preferred only web and 4 preferred both. 1 tertiary educated person chose not to use the application out of the 8 people tested.

From the results of this test, I can tell that despite the varying literacy levels, people still found the application relevant in communicating prescription information and also wanted a print out from the drug dispensary of their prescription.

Level of Education	People who would use the app	Number of people of who will not use the app	People who prefer print only	People who prefer web only	People who prefer both
Non-literate	8	2	1	0	7
Secondary	11	0	3	4	4
tertiary	8	1	4	0	4
Total	27	3	8	4	15

Of the 30 users tested, 3 non literate people found it least effective whilst 6 people found the application very effective. No tertiary person found the application ineffective in communicating prescription information. 1 Secondary school educated person found the application ineffective as well.

The probable reason for these numbers and demographic finding the application somewhat ineffective is probably because of the sign in and log in issues. It is important to note that majority of this demographic wanted print outs too.

Row Labels	Number of people who found the application to be ineffective	Number of people who found the application to be moderately effective	Number of people who found the application to very effective
non literate	3	1	6
Secondary	1	3	7
Tertiary	0	2	7
Grand Total	4	6	20

5.5. Test summary

The final test proves that the solution meets the functional requirements and has been able to communicate prescription information to non-literate patients. This is because, after education on what the pictograms represented and how to read the prescription information page, all test subjects were able to recite the correct prescription and point out the different drugs they needed to take based on the colour code.

Chapter 6: Conclusion and Recommendations

6.1 Degree to which Project Meets Functional Requirements

The final implemented solution meets all functional requirements stated in chapter 2 of this report. As seen from the results and tests, non-literate patients have been able to tell prescriptions and point out which drug based on their colour code. Majority of all test subjects also reported that the solution was effective in communicating prescription information to them and would like to use an app like this to help with their prescriptions.

6.2 Limitations

The main challenge with this application is that people who cannot read or write or people who have no education at all cannot sign in to the application because of their illiteracy.

Also like any web application, internet connectivity is necessary in order to access prescription information and also to enter in patient information. This is a major challenge because of the project is aimed for close knit community or village which is often rural.

6.3 Future Work

To solve the problem of extreme non literacy, the system needs a lot more work to be done. Since prescription has been translated into visual aids, the same data can be mapped on to voice in a voice response system. This system can then call patients at stipulated times to speak a local language of their choice with their respective prescription information.

Also, a reminder can be implemented where mobile devices alert users at regular intervals to take their medication.

6.4 Conclusion

Technology is constantly making the world a better place to live in. Advances in medicine as well as technology has prevented people from dying from diseases which were fatal a few years back. The case of my grandmother I mention in the motivation for this project is still a growing concern despite our advances in technology. My simple solution has proven to counter the miscommunication of prescription information to low health literate patients. I believe this is a start of a future where literates and non-literates can achieve full health literacy.

Bibliography

- Abroso, A. (2013). *Health Literacy and Sexually Transmitted Infections amongst University of Ghana Female Students*. University of Ghana, Business Administration. Accra: University of Ghana.
- Davis, T. C., Wolf, M. S., Bass III, P. F., Middlebrooks, M., Kennen, E., Baker, D. W., . . . Parker, R. (2006). *Low Literacy Impairs Comprehension of Prescription Drug Warning Labels*. Louisiana State University Health Sciences Centre, Departments of Medicine, Paediatrics and Pharmacy, Los Angeles.
- Dowse, R., & Ehlers, M. S. (n.d.). *The Evaluation of Pharmaceutical Pictograms in a Low literate South African Population*. Rhodes University, Faculty of Pharmacy. South Africa: Rhodes University.
- Minnesota Health Literacy Partnership. (2007). *Prescription Literacy*. Minnesota Literacy Council, Minnesota.
- Ngoh, L., & Shepherd, M. (1997). Design, Development and Evaluation of Visual Aids for Communicating Prescription Drug Instructions to Non-Literate Patients in Rural Cameroon. *Patient Education and Counselling* (30), 245-261.
- Ch.ChakradharaRao, P.Pushpalatha, N.AdityaSundar. (2013). GPS Based Vehicle Navigation System Using Google Maps. *International Journal of Computer Science and Information Technologies*, IV(6), 979-982.
- Emerson, J. (2010). Visualizing Information Design. *Americas Conference on Information Systems(AMCIS)*.
- Environmental Systems Research Institute, Inc. (1996). Retrieved from [www.esri.com: http://www.esri.com/industries/k-12/education/~media/Files/Pdfs/industries/k-12/pdfs/intrcart.pdf](http://www.esri.com/industries/k-12/education/~media/Files/Pdfs/industries/k-12/pdfs/intrcart.pdf)
- Ghana News Agency. (2016, August 3). *Literacy Is Poor In Ghana - Specialist*. Retrieved April 14, 2017, from Ghana News Agency: <http://www.ghananewsagency.org/health/health-literacy-is-poor-in-ghana-specialist-106389>
- Google. (n.d.). Retrieved from Google Developers: <https://developers.google.com/maps/>
- Laary, D. (2016, March 9). *Ghana: Mobile Phone Penetration Soars to 128%*. Retrieved April 14, 2017, from The Africa Report: <http://www.theafricareport.com/West-Africa/ghana-mobile-phone-penetration-soars-to-128.html>
- Leon Stenneth, W. S. (2002). Reducing Travel Time by Incident Reporting via CrowdSourcing. *Americas Conference on Incident Reporting*, (pp. 257-289).
- Magic Web Solutions. (n.d.). *The Benefits Of Web-based Applications*. Retrieved April 14th, 2017, from Magic Web Solutions:

- <http://www.magicwebsolutions.co.uk/blog/the-benefits-of-web-based-applications.htm>
- Ministry Of Roads And Highways. (2013). Retrieved from Pilot Program Based Budget(PBB):
<http://www.mofep.gov.gh/sites/default/files/pbb/1%20GHANA%20MINISTRY%20OF%20ROADS%20AND%20HIGHWAYS%202013.pdf>
- Minnesota Health Literacy Partnership. (2007). *Prescription Literacy*. Minnesota Literacy Council.
- Mohd Zulkifli B. Mohd Yunus, Hamidah Bt. Hassan. (2010). Managing Road Maintenance Using Geographic Information System Application. *Journal of Geographic Information System, IV*(6), 215-219.
- National Road Safety Commission. (2013). *Provisional Review of Road Crashes*.
<http://www.rsa.ie/Documents/Road%20Safety/Crash%20Stats/Provisional%20Review%20of%20Road%20Crash%202013.pdf>, Road Safety Authority , Accra. Retrieved from Road Safety Authority:
<http://www.rsa.ie/Documents/Road%20Safety/Crash%20Stats/Provisional%20Review%20of%20Road%20Crash%202013.pdf>
- Pick, J. (2004). Geographical Information Systems. *AMCIS 2004 Proceedings*.
<http://aisel.aisnet.org/amcis2004/568>, (pp. 1-11). New York.
- Stefano Burigat, Luca Chittaro. (2012). Retrieved from citeseerx.ist.psu.edu:
http://hclilab.uniud.it/publications/2007-01/GeographicDataVisualization_BookChapter07.pdf
- Thao Nguyen, N. P. (2009). *Gathering and Utilizing Crowdsourced Pedestrian Flow Data from Mobile Devices*.
- U.S. Department of Health and Human Services. (n.d.). *Health Literacy - Fact Sheet: Health Literacy Basics*. Retrieved April 14, 2017, from U.S. Department of Health and Human Services:
<https://health.gov/communication/literacy/quickguide/factsbasic.htm>
- Westminster College. (2012). Retrieved from
<http://www.westminster.edu/staff/athrock/GIS/GIS.pdf>
- World Health Organization. (2002). Retrieved from
http://www.who.int/occupational_health/publications/en/oehairbornedust.pdf
- World Health Organization. (n.d.). *Health Literacy and Health Behaviour*. Retrieved April 14, 2017, from World Health Organization:
<http://www.who.int/healthpromotion/conferences/7gchp/track2/en/>