UNIVERSITY OF NAIROBI
COLLEGE OF BIOLOGICAL AND PHYSICAL SCIENCES
SCHOOL OF COMPUTING AND INFORMATICS

Research Final Report

A web-service based Integrated Fitness and Diet Mobile Application for Health Promotion.

MSc Distributed Computing Technologies

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Supervised by

Prof. Robert Oboko

A research project report submitted to the school of Computing and informatics in partial fulfillment of the requirements for the award of the Degree Master of Science in Distributed Computing Technology at the University Of Nairobi, Nairobi Kenya.

DECLARATION

I, Eliud Musumba Ayiro, hereby do state that this research project report is my original work and any contribution of other researchers has been acknowledged accordingly. To the best of my knowledge, this research work has not been previously submitted or presented to any other academic forum or institution.

Signature ……. Date:……

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I, Prof. Robert Obwocha Oboko, do hereby certify that this Masters research has been presented for the award of Master of Science in Distributed Computing Technology with my approval as the University of Nairobi Supervisor

Signature ……. Date:……

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DEDICATION

To my loving parents Duncan and Martha is this thesis dedicated for the precious lessons in life they imparted to me, notably Faith in God, diligence and resilience, being the pillars.

ACKNOWLEDGEMENT

First and foremost I am grateful to God my creator for the gift of life and good heath as well His enabling. It is through His providence that I was able to successfully complete the rigorous studies. I thank my brothers Stephen and Samuel for their relentless encouragement throughout my learning period. I also wish to express my gratitude to my Supervisor Prof Robert Oboko for his invaluable guidance and motivation without which I might not have completed the research. I appreciate the role of the panelists , Prof Elisha Opiyo, Prof Agnes Wausi , Dr Tony Omwansa and Ms Pauline Wambui their positive critiques and insightful comments. Lastly I thank Jacqueline, Abel, Lilian, Debra and others who accorded me help thus making the research a success. May God bless them all.

ABSTRACT

Background: A sedentary lifestyle, unhealthy food and work related stress are part and parcel of the lives of many people thus their wellbeing and consequently their quality of life is adversely affected. Studies show that physical inactivity and improper diet contribute to over 3 million deaths annually. Efforts have been made in different areas to address the problem whereby different technologies such as web services in distributed systems, cloud technologies, internet, Artificial intelligence, mobile technologies have been used in providing solutions as interventions to lifestyle diseases.The emergence and pervasiveness of smartphones and mobile devices has led to an increase in health and fitness applications which possess an assortment of behavior change techniques such as managing and monitoring exercise, diet weight and sleep. The existing mobile apps used to promote healthy lifestyle are inadequate as they are either fitness trackers or dietary applications.

Methods:This research focused on designing and developing an integrated fitness and diet prototype which can comprehensively promote health by having an assortment of exercises and diet plans. The functional requirements were determined by carrying out an expert interview on 12 expert, 8 fitness trainers and 4 dieticians selected through cluster and snowballing sampling respectively. The Application was developed using RAD within the Design Science Research Methodology. The prototype was quantitatively evaluated using a usability test on 197 fitness enthusiasts who were selected using systematic sampling from 8 gyms located in different areas within Nairobi. Links to the APK file and Google Form questionnaire were shared to the prospective subjects through whatsapp groups of the selected gyms.

Results:81% of the users found FitLink to be pleasant to use with over 60% indicating perceived acceptance of the application. Based upon the respondents feedback,

Conclusion: The results demonstrate that a functionality unified mobile application is effective in providing all-inclusive information on exercise and diet to the fitness enthusiasts and by extension the larger population that may require to change their health lifestyle.

Keywords: Mobile Applications, fitness App, Diet, Exercise, health promotion

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List of Acronyms and Abbreviations

AAC	Advanced Audio Coding
ADT	Android Development Tools
AMR	Adaptive Multi Rate Audio Codec
API	Application programmable Interface
APK	Android Application Package
CDMA	Code-Division Multiple Access
C2DM	Cloud to Device messaging
e-Health	Electronic Health
FCM	Firebase Cloud Messaging
HTML	Hypertext Markup Language
IDE	Integrated Development Environment
iOS	iphone Operating System
MCC	Mobile Cloud Computing
m-Health	Mobile Health
MIDI	Musical Instrument Digital Interface
NFC	Near field Communication
GCM	Google cloud messaging
GSM	Global System for Mobile communication
SDK	Studio Development Kit
SDLC	Software development Life cycle
RAD	Rapid Application Development
REST	Representational State Transfer
ROA	Resource Oriented Architecture
SOA	Software oriented architecture
SOAP	Simple Object Access protocol

UI	User Interface
UX	User Experience
WAV	Waveform Audio File
WHO	World Health Organization
WIFI	Wireless Fidelity

CHAPTER 1

1.0 Informational Background

1.1 Introduction

The modern lifestyle is characterized by lack of physical activity, junk food and work related stress which adversely affects people's wellbeing and consequently their quality of life. According to World health organization (WHO, 2017) insufficient physical activity and unhealthy diet contribute to over 3 million deaths annually. Metabolic disorders, some form of cancers, osteoporosis, hypertension and type 2 diabetes are among the diseases associated with lifestyle (Linsay, et al., 2010) To address the problem, it is imperative to embrace a lifestyle of regular exercise and a healthy diet as observed by (Klein, et al., 2014). Nonetheless effective reduction of the global cases of lifestyle related diseases still remains to be a daunting task. With the highly dynamic technological advances, technical interventions are being sought to influence the lifestyle of people by promoting healthy habits. mHealth for instance has been instrumental in promoting behavioral change by creating awareness to mobile phone users on healthy lifestyle such as proper dietary habits and physical activity.

Distributed computing plays a pivotal role in promoting m-health particularly through decentralization of processing and integration of information resources (Saini & Parhi, 2015) A distributed system is defined as an assortment of independent computers that appear to its user as a single coherent system (Tanenbaum & Steen, 2007). The significant design issues in distributed computing namely transparency, heterogeneity, openness, scalability, fault tolerance and task scheduling (Sul, et al., 2016) ensure reliability for any supported applications. Distributed web based systems are increasingly being used in sharing and access of data in form text, images, audio and video using extensible markup Language (XML) and hypertext markup Language (HTML). Service oriented computing is an emerging paradigm which entails merging of several technologies comprising of software development, information systems, distributed computing, web-based computing as well as XML technologies. Web services as defined by (Mironela, 2009) are sectional business application that are self-describing and expose business logic as a service over the internet. Web services are now being used widely because they make use of existing transport internet protocols like SOAP (Simple Object Access protocol) REST (Representational State

Transfer) HTTP and are the common Software Oriented architecture protocols used in exchange of information.

Web services provide a standard and easy way of curbing application integration related problems. Nonetheless, lack of harmonization on the vast numbers of emerging standards and performance issues remain to be a drawback in the use of web services.

Mobile cloud computing is another emerging paradigm where mobile and cloud computing technologies are merged to achieve computational offloading and capabilities extensions such as as storage (Liu, et al., 2013)

The emergence and widespread use of mobile devices such as smartphones has led to a surge in development of mobile applications. In 2017, there were over 318,000 mobile health applications available to clients worldwide (Wayne, et al., 2015). (WHO, 2017) report defines mHealth as a system on a mobile platform which encompasses actions to prevent disease, promote and maintain health. As opined by (Higgins, 2016) health and fitness applications possess an array of behavior change techniques such as managing and monitoring exercise, diet weight and sleep.

According to a survey by (Jospe, et al., 2015) it was established that diet apps are very effective in assisting with dietary assessment. The most commonly perceived limitations of the diet applications under study were nutrient database, incorrect portion and incorrect choice of food type. The benefits of the applications were found to be ease of use, ubiquity, and convenience compared to paper and pen. In a research conducted by (Montagon, et al., 2018) it emerged that internet search is predominantly used to search for health information in comparison to mobile health applications with nutrition , physical activity , sexuality, stress anxiety and depression being the health topics sought after. In the study they hypothized that the limited use of applications is attributed to demanding nature of data entry and limited storage In as much as there is a proliferation of Fitness and Nutrition applications to address physical wellness, many fitness enthusiasts are still yet to benefit optimally by using the synergies of the different available mobile applications. This is echoed by (Montagon, et al., 2018) who recommend that future digital health interventions should be based on mobile applications having an diverse array of health topics. (Rathbone & Prescott, 2017) opine that diet and promotion of regular exercise has been the objective of majority of the mobile applications each having its individual specificities.

The preceding studies show the necessity of development of a unified health intervention for an optimal outcome.

1.2 Problem statement

The leading causes of death in the 20th century has changed from infectious diseases to those related to unhealthy behavior and lifestyle (Walsh & Groarke, 2019). The advent of computers , internet and mobile phones has immensely enhanced the approaches to address e-health issues in the society. There has been a rapid progression in the use of mHealth intervention in disease prevention and self management owing to the the portability, economical feasibility and technical capabilities of mobile phones. Its worth noting that health and fitness awareness has been on the rise globally in tandem with the use of smart phone based applications which according to (Leijdekkers & Gay, 2013) is a step towards ubiquitous healthcare. As observed by (Samma, et al., 2014) most of the popular mobile fitness and health applications dwell on fitness and self-monitoring. According to (Mathias, et al., 2013) despite the great number of mobile fitness and health applications, there are either logging or instructional apps. There are dietary Apps such as LoseIt and MyNetDiary which are predominantly tailored to tracking calories intake and weight loss. (Walsh & Groarke, 2019) opine that features mobile application features that provide for notification and personalization enhanced adherence and thus increased the likelihood of a successful lifestyle behavioral change.

The existing mobile applications used as interventions that promote healthy lifestyle are wanting as they are either fitness trackers or dietary applications. This study sought to bridge the identified gap in addressing the research problem

1.3 Research Objectives

The objectives of the research were classified as general and specific objectives, whereby the specific objectives were developed from the general objectives:

General Objective

The overall objective of the study was to effectively promote fitness and health awareness by providing an integrated fitness and nutrition mobile application to all those who are in quest of a healthy lifestyle

Specific Objectives:.

i. To design and develop an integrated fitness and diet mobile application prototype using web services.
ii. To provide a cost effective and effective health content delivery mechanism.
iii. To evaluate and validate performance of the developed prototype.

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1.4 Justification

The fundamental outcome of the study was an integrated application that is rich in knowledge on exercise regimen and diet plans which are easily accessible to people with android based smartphones.

1.4.1 Societal contribution

Adherence to the exercise and diet plans in the application is expected to help many people exercise correctly and regularly as well as observe dietary rules; consequently, improving their well-being and quality of living.

The cost of controlling and treating non communicable diseases worldwide takes the largest share in the healthcare budget. The financial burden was greatly eased by effectively promoting health by using the proposed comprehensive m-health solution

Corporate employers stand to benefit from the use of this application as the employees productivity at work is relatively optimal as a consequence of reduced hospital visits related absence as well as reduced stressed levels.

Gym proprietors may also cut down on costs of employing many certified gym instructors since the gym members using the application was knowledgeable in terms of the appropriate workouts regimens and diet plans. Gym instructors handling clients using the application will have an easy time as client interaction duration was immensely minimized.

1.4.2 Scientific Contribution

Engagement of professional dieticians and fitness instructors in the development of the prototype is a measure to ensure that the content is evidence based and as a result it is of high quality.

1.5 Scope

This study was limited to development of an android Fitness and diet application consequently the application will not be available to ios mobile users as it was designed to be an android based application. The prototype was tested using an emulator where the functionality and performance of the application are generally the same on different android based devices. The target users were all fitness enthusiasts and individuals seeking to lead a healthy lifestyle by exercising and eating rightly.

The test case audience was limited to the Nairobi population with a purposive sample of eight fitness specialists, four dieticians and a systematic sample of one hundred and ninety seven fitness enthusiasts from different gyms in Nairobi. The population sample provided feedback during the evaluation of the developed prototype.

CHAPTER 2

2.0 Literature Review

2.1 Introduction

This chapter gives an overview of m-Health, distributed computing, web services, Software development life Cycle (SDLC) methodologies and mobile application development. Fitness and diet as well as a review of prior related work on fitness and health applications was conferred in this chapter.

2.2 Exercise and Nutrition

This sub section gives an overview of importance of exercise and proper diet for maintaining a healthy body. Types of exercises and diet are discussed as these will form the data sets in the proposed integrated fitness and diet mobile application.

2.2.1 Importance of exercise and Proper nutrition

According to a study conducted by (WHO, 2016) at least two million of deaths per year are a result of being obese. Metabolic disorders, some form of cancers, osteoporosis, hypertension and type 2 diabetes are among the lifestyle diseases that are associated with increase of body mass and particularly fat mass(Linsay, et al., 2010). Regular exercise and healthy dietary habits have been linked to prevention of the mentioned lifestyle diseases. In their study(Mohamed, et al., 2018) show that dieting combined with exercises greatly improve cardiovascular health compositions, physical fitness and body structure. According to (Skerrett & Willett, 2010) the strategies for preventing some chronic illnesses include regular exercise, limiting caloric intake and avoiding smoking. Other benefits of exercise as per the study conducted by(Ceren, 2015) include increased psychological resilience, enhanced self-discipline and personal efficiency.

2.2.2 Classification of exercises

In the fitness realm there exit myriad exercises which are executed either indoors or outdoor depending on the type of exercise, its functionality, equipments used (if any), environment among other factors. One of the type of exercises is resistance training which is defined by (Hongu, et al., 2015) as any physical activity that causes the muscles to work against an additional force or weight. Also known as strength training it includes use of free weights such as barbells and dumbells, bodyweight exercises such as plank holds and pushups, resistance machines found in the gyms and use of

resistance bands.

Other than strength training, (Havard, 2017) points out balance, aerobics and stretching as being the most important exercises that should be incorporated into any training regimen. Aerobic exercises elevate ones heart rate and breathing thus increasing endurance. These exercises also lower blood sugar levels burn body fat and help relax blood vessel walls. Stretching exercises on the other hand enhance flexibility in muscles and tendons.

2.2.3 Overview of healthy diet fundamentals

There have been numerous studies conducted to establish what constitutes a healthy diet and general good dietary habits and their correlation to prevention of lifestyle diseases.(Willet, 2017) defines a healthy diet as that which optimizes health- complete physical, mental and social well being. A healthy diet as opined by (Skerrett & Willett, 2010) includes whole grains, non-saturated fats, plant protein fruits and vegetables while limiting saturated fats, refined grains and sugar. The same view is echoed in a study called DASH-Dietary approaches to stop hypertension which emphasized on partaking veggies, fruits, low fat dairy products but limiting red meat, saturated fats and sugar. The benefits of the DASH diet were found by (Moore, et al., 2008) to be lowered blood pressure, weight reduction, reduced risks of coronary heart disease and stroke.

Diet quality according to (Childs, 2018) is predominantly characterized by how strictly the diet aligns with either the Mediterranean or western pattern. According to (Brill, 2009) the Mediterranean diet has been regarded as the gold standard of healthy diets owing to its sumptuous nature and its ability to prevent chronic diseases and promote greater longevity. Studies carried out in relation to the Mediterranean diet by (Childs, 2018)(Boucher, 2017) and(Gotsis, et al., 2014) the Mediterranean diet constitutes foods rich in olive oil, fruits, vegetables, legumes, nuts and seafood in contrast to the western diet which is characterized by consumption of refined foods, sugar sweetened soft drinks and processed meat.

The Rockefeller Foundation-Lancet commission on planetary health in 2015 proposed the planetary health plate which should be comprised of half the plate of fruits and vegetables while the other half should contain of whole grains, non animal protein sources and unsaturated plant oils

In a study carried out by the national obesity forum in the United Kingdom, it emerged that the shift in dietary habits to snacking and particularly on refined carbohydrates greatly contributes to the obesity. The study also reveals that sugar has no nutritional value and its ingestion should be shunned

as its excessive consumption is strongly associated with cumulative risk of hypertension, diabetes type II and cardiovascular complications.

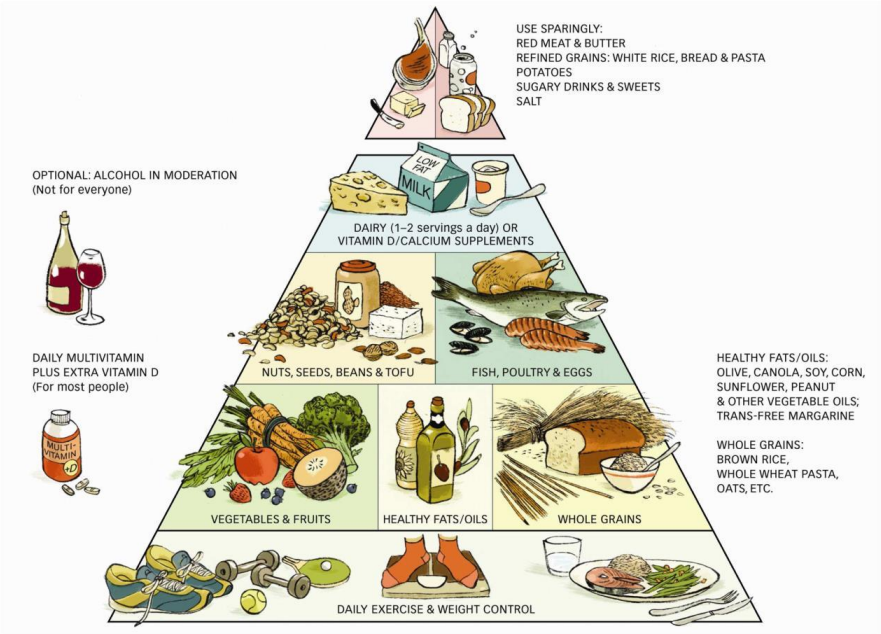


Figure 1: Health Pyramid

2.3 Distributed Computing

A Distributed system is defined as a collection of autonomous computers that seems to its users as a single logical system (Tanenbaum & Steen, 2007). The use of distributed computing technologies is ubiquitous since tasks be executed concurrently on dispersed nodes to achieve a common goal. can

2.3.1 Characteristics Of Distributed Computing

Khaing & Kyaw et .al (2019) identify the main characteristics of a distributed system are as listed:

Resource sharing: This allows system users to access remote resources with ease.

Transparency: The hiding of resources which make the system appear as a single logical system to the user.

Openness: Standard rules define the use of services.

Scalability: This is an attribute that allows for coping with increase of nodes.

Fault tolerance: This is an attribute which allows for availability of resources despite failure of a node.

Heterogeneity which is an attribute that allows for platform independent operations.

The disadvantages attributed to distributed computing include network reliance, security issues, multiple points of failure and management complexities.

2.3.2 Types of Distributed Systems.

Distributed computing systems:

A distributed computing system consists of an assortment of similar terminals for high performance or a association of computer systems which are administered under different domains.

Distributed Information systems:

These are enterprise wide information systems that have been integrated by use of a middleware. An example of such is the Transaction processing System which involves databases.

Distributed Pervasive systems

Pervasive systems comprise of mobile and embedded computing devices which are characteristically small, battery powered and solely rely on wireless connection. Generally the systems are part of the environment and human intervention in their management is not required. An example of these systems is the wireless sensor networks.

2.3.3 Architectures of Distributed Computing

Couloris et. al (2015) identifies the most common distribution computing architectures as follows:

Client- Server Arhitecture

This is an architecture where one device or process has unidirectional control over one or more devices. The clients use the set of services provided by the server and communication is achieved by using reliable connection oriented protocols. The clients know the servers but the servers need not to know the clients

Multi-tier Architecture

In this model the application is divided into user interface, processing computer and data. The client is a dumb terminial as programs run on the user interface while the processing is done at the server.

Peer to peer Architecture:

In this model, the overlay network implementation is achieved by use of distributed hash table to organize processes. Random keys are assigned to data while the nodes have random numbers. Communication is achieved through mapping the random keys to corresponding numbers of the nodes.

Hybrid Architectures

According to Khaing & Kyaw et .al (2019) hybrid architectures are as a result of merging client server solutions with decentralized architectures. An example of this is edge server network where servers are placed at the edge of the network so as to connect to provide clients with a gateway to the internet.

2.4 Web Services

A web service is defined as platform independent loosely coupled, self –contained programmable web enabled application which is self-describing, publishable, discoverable and can be configured for the purpose of realization of distributed interoperable systems. Also defined by (W3C, 2014) as a system designed to support interoperable computers interaction over a network. Generally, web services allow for the exchange of data and information between applications via defined application programming interfaces.According to (Kishor & Ravindra, 2014) web services are based on the concept of service –oriented –architecture (SOA) and resource oriented architecture (ROA). For SOA, software components such as applications, functions and processes are exposed as services while in ROA web services are enabled as web resources. With the proliferation of smart mobile devices as well as the increase of transmission speeds, the combination of smart mobile phones and web services has greatly enhanced the interaction functionalities of mobile devices within their ecosystem with challenges of interoperability and heterogeneity being addressed.

2.4.1 SOAP based web services.

Simple Object access protocol (SOAP) is a W3C standard that permits the exchange of information in a distributed ecosystem. SOAP is an XML-based protocol constituting three parts an envelope which defines the content, message processing procedure, encoding regulations and a guideline for RPC and responses.

The following diagram illustrates the format of a SOAP message;

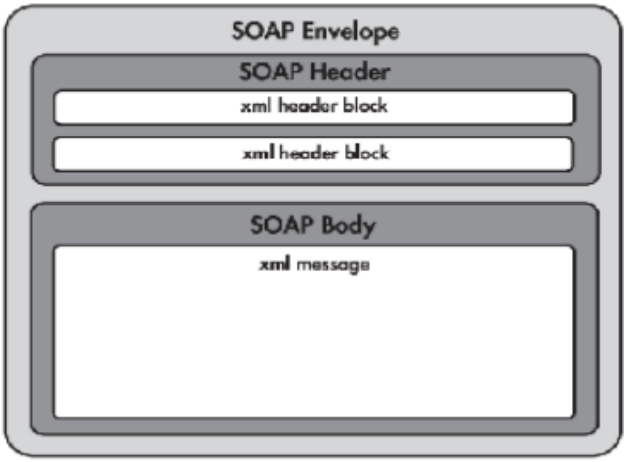


Figure 2A soap message. Adapted from Johal & Singh

2.4.2 RESTful web services.

REST being an acronym for representational state transfer designates an architectural style suitable for distributed applications. According to(Amarpreet & Baljit, 2014) REST utilizes a nonstate server-client protocol to make, retrieve, update and delete resources.

The HTTP methods for RESTful web services are GET, post, PUT AND DELETE with their corresponding CRUD actions being resource retrieval, resource creation, update and deletion of a resource. The use of a Uniform Resource Identifier(URI) in the REST architecture enhances performance in terms of speed.

2.4.3 Differences between SOAP-based and RESTful WebServices

The choice for the web services to be used is based on a combination of different factors as seen in the pros and cons of each type. The table below gives a summarized comparison of SOAP and RESTful webservices.

Feature	SOAP-based	REST-based
Architecture Style	Service-centric	Resource-centric
Coupling	Tightly coupled	Loosely coupled
Transport Protocol	Any	HTTP only
Access Scheme	Single end-point	URI for each resource
QoS	WS specifications	Transport-dependable (HTTP)
Invocation	RPC-like	HTTP methods
Interface	Interface for each Web service	Web browser
Description	WSDL	No standard Exposed
Data Model	Hidden	Exposed
Data Representation	XML	XML, JSON, etc.
Scalability	None	Connected hyperlinks
Security	WS-security-based	HTTP-based

Table 1 Comparison of SOAP-based and REST-based webservices: Adapted from Elgazzar et al

2.5 Overview Software Development Life Cycle Methodologies.

Software development Life Cycle as defined by (Sommerville, 2007) is a set of activities whose goal is the development or evolution of software.

The fundamental phases of a SDLC include requirements definition, application design, Implementation, Integration and testing as illustrated in the diagram that follows.

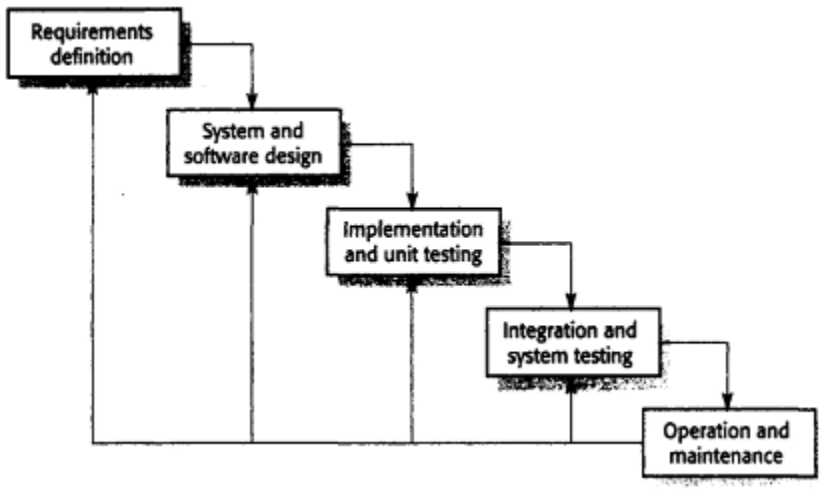


Figure 3:Software Development Life cycle phases: Source Sommerville

There are different software development methodologies employed in development of software systems as discussed in the following sub section.

2.5.1 Waterfall model

This is a methodology with distinct development stages namely the specification phase, the design phase, implementation phase, testing phase and maintenance. It is a requirement that one phase must be completed before proceeding to the subsequent phase. It is highly suitable where user requirements are static over a long period of time.

2.5.2 Evolutionary Model

This is where an initial implementation of the system is done and refined iteratively through the feedback given by customer. It entails interleaving of specification, development and validation with quick feedback given during these phases.

2.5.3 Agile model

A methodology in which the entire process is divided into iterations for incremental delivery. It is also adaptive whereby it provides for accommodating changes in the user requirements.

2.5.4 Spiral model

The development process is depicted in a spiral whereby particular phases are represented by loops. This methodology includes risk assessment, an aspect that explicitly differentiates it from other methodologies.

2.5.5 Extreme Programming

A variant of incremental approach with the main features being development and delivery of very minute increments of functionality, client involvement in the process, continuous code improvement and pair programming.

2.6 Mobile Application Development:

Mobile applications can be defined as applications that run on a mobile device to execute definite tasks. With diffusion of smartphones and increased transmission speeds diverse mobile applications in the field of health, communication, agriculture, entertainment, commerce, education amongst many areas have emerged

In development of mobile applications, there are three application platforms namely native, web and Hybrid application platforms

2.6.1 Native Application Platform

A native application is predominantly developed using a programming language supported by a specific platform such as android, OS or IOS(Marszalek, 2016). Development for a specific platform allows more features to be incorporated in the app

2.6.2 Web Application platform.

Web apps are designed to be accessible through the internet browser and the need not to be down-loaded or installed. Web apps are generally developed using JavaScript, CSS and HTML5.

2.6.3 Hybrid application platform

A hybrid application also known as a cross platform app integrates elements of both native and web applications.

Development of hybrid apps is complex as observed by (Serena, 2014) who opines that greater technical skills base are required when developing applications in a cross platform environment compared to the native platform.

2.7 Android Application Architectures

Software architecture of a system as defined by (Bass, et al., 2007) is the structure of a system encompassing software, external visible entities and the relationships among them.

An architectural design is among the prime factors which greatly determine if development of an application was successful or not; therefore, it is important to choose wisely a design which will harbor if any minimum problems. The common application architectures are discussed in the following subsection

2.7.1 Model View Controller (MVC) Architecture

The MVC is the default architecture for android based applications which according to (Tian, 2016) divides the system into Model, view and controller components. The model component is the repository of data whereby it can either store the data or remotely retrieve it. The view component represents the graphical user interface visible to the users while the controller gets the user interface.

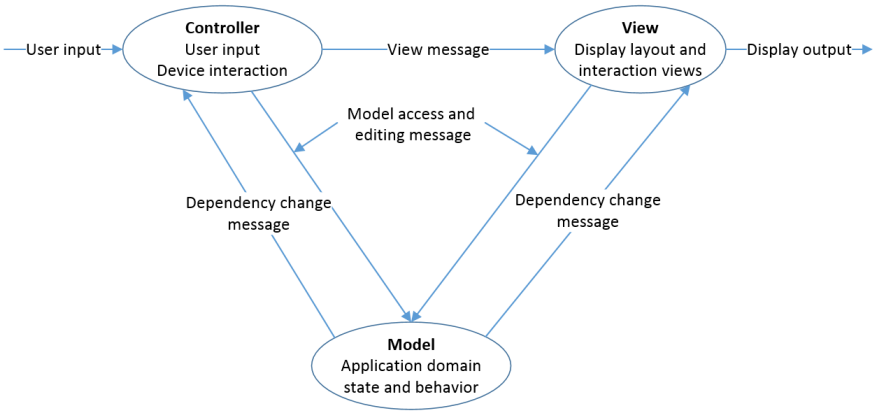


Figure 4: MVC Component interactions

2.7.2 Model View Presenter (MVP) Architecture

The MVP architecture is based on Data management and user Interface whereby emphasis is on how the data is managed and how the users interact with data. The main components of this architecture are model , selection , command , view , interactor and presentor. The model depicts the data in the application, the selection component stipulates the data subsets to operate. The command component shows actions that can be executed. The interacter component gives events that can be invoked by the user. The presenter component is the same as the controller in MVC which primarily systematizes and coordinate intermediate components.

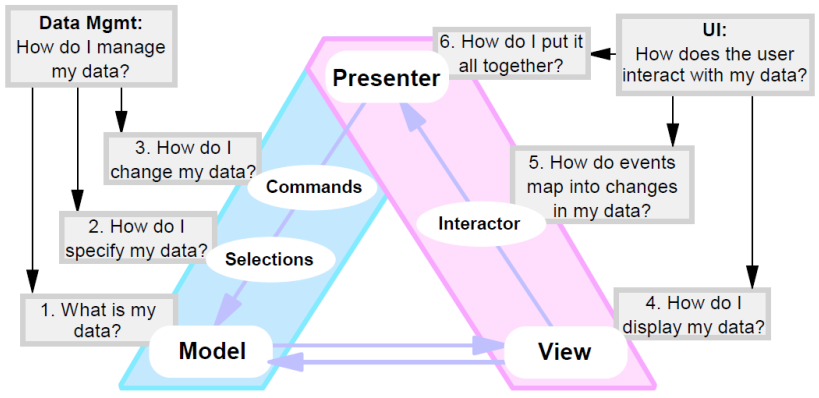


Figure 5: Figure 5 :MVP Components

2.7.3 Model View –View Model (MVVM) Architecture

Model/View/view-Model (MVVM) consists of model, view and view-model with the model representing the data, view user interaction and view model managing the state of view.

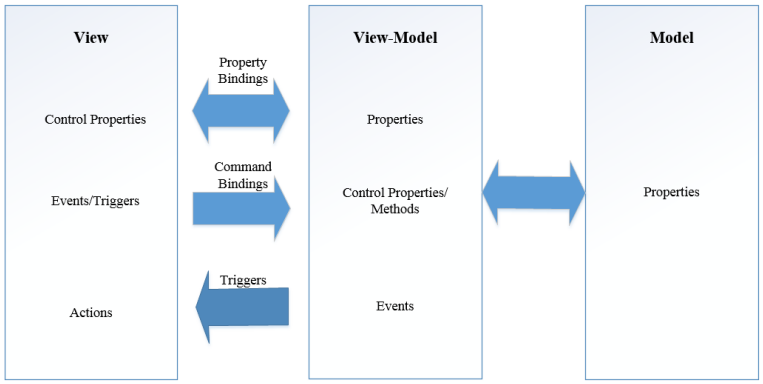


Figure 6: Figure 6:MVVM Interaction

2.9 Android Development

This section discusses the android operating system architecture, android features and development of an android based application.

2.9.1 Architecture of an Android Operating System

Android is an open –source software platform based on the Linux kernel also defined by (Lee, 2011)as a mobile operating system that is based on a modified version of Linux. Its architecture is of a layered nature as illustrated in the diagram below.

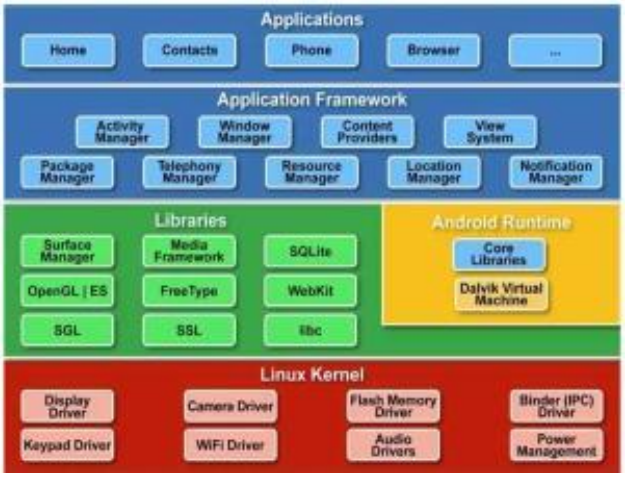


Figure 7: Android Architecture

Application Layer being the residence location for all applications. In the Stack also is the application framework layer which provides APIs and managers to assist in full utilization of the

android functions. The native libraries provide support for different components such as the database, browser, media. Android runtime consists of core libraries and DVM (Dalvik virtual machine) which runs the android application. The Linux Kernel forms the foundation of the Android platform by providing for network stack, memory management, security, process and device management

2.9.2 Features of an Android Platform

The android platform is used by many mobile users worldwide owing to its predominant features which as pointed out by (Rawat, et al., 2014) include Multiple language support, SQLite for data storage, multiple connectivity technologies such as WIFI, bluetooth, GSM, CDMA, lTE, NFC. Android's messaging capabilities such as SMS, MMS, cloud to Device (C2DM) messaging and Android Google cloud Messaging (GCM). Other features include multi touch, java support, tethering, screen capture and web browser.(Lee, 2011) highlights on android features such as hardware support for accelerometer sensor, GPS, camera, digital compass and proximity sensor. Multi-tasking and media support for MP4, MP3, MPEG-4, AAC, AMR, MIDI, WAV, org, vorbis,

2.9.3 Android Devices:

The android operating system powers devices such as smartphones, tablets, e-reader devices such as e-book readers, Net-books, Mp4-players and Internet / smart TVs.

2.9.4 Android Development Tools

Development of android can be done on windows based personal computer, a mac or a computer running a Linux operating system. There are different tools both proprietary and open source that are used for developing an android based application.

(Wolfson, 2013) observes that Java development Kit (JDK) is required since android development platform is built on the standard java framework. The JDK has a compiler and debugger as well as other tools required for developing a software.

Also required is the Android Software Development Kit (SDK) which is a assortment of tools and libraries which are essential in running and developing android applications.

The eclipse, SDK tools, platform tools and an android platform are encapsulated as a single integrated download-ADT bundle which (Wolfson, 2013)suggests that it streamlines the process, minimizes the chances of error and creates a standard directory structure for the tools.

2.9.5 Development Steps

The basic steps for developing an application include setup, development, debugging and testing then finally Publishing.

Setup:

This is the initial step which entails installing and setting up the development environment. As indicated by (Lee, 2011) the first step in developing an application is obtaining of an integrated Development Environment (IDE), which for the case of Android is Eclipse IDE

Development:

This is a stage that includes creation of the source code and associated resource files

Debugging and Testing:

During this stage the project is created in to a debug gable package that can be executed on an emulator

Publishing

This is a phase in which the developed application prepared for release. It entails publicizing and distribution of the final product to the users. A summary of the application development steps is as illustrated in the figure that follows.

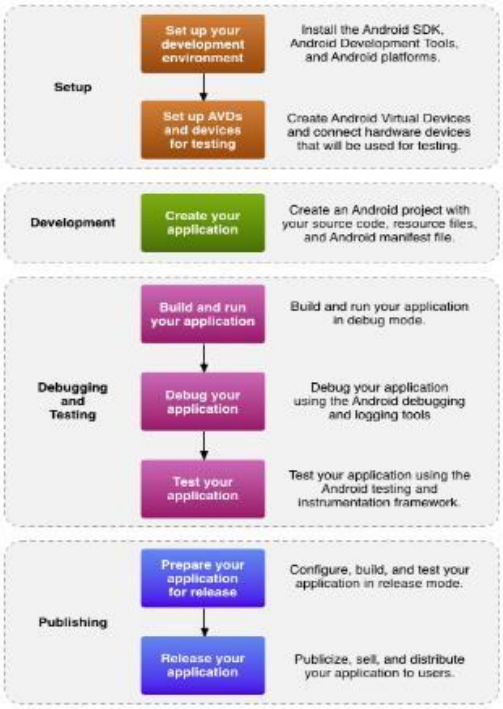


Figure 8: Steps for Application development- Adapted from Pandey

2.10 Mobile Application Development Methodologies

In development of mobile applications, different methodologies with distinct phases may be employed in construction of the software. This section discusses some of the commonly used methodologies in mobile app development.

2.10.1 Mobinex Mobile Application Development Methodology

This methodology was developed by Mobinex a top company that develops applications and offers solutions for devices. The phases constituted in the methodology are as illustrated in the following figure

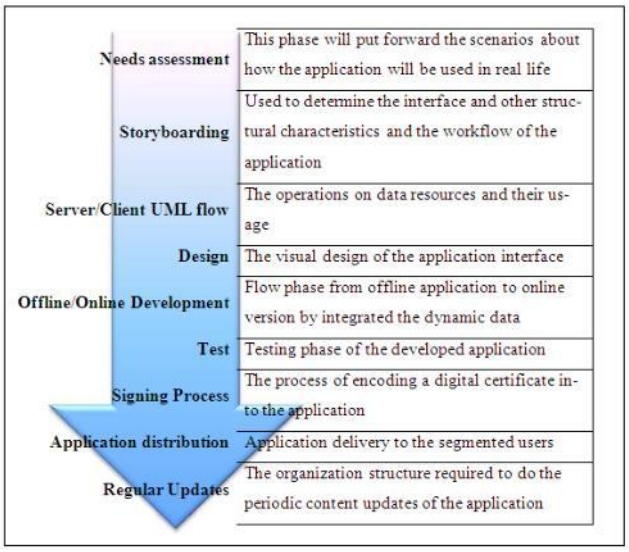


Figure 9: Mobinex mobile application development methodology

2.10.2 Mobile D Methodology

The mobile D methodology according to (Pavaloaia, 2013) is a brainchild of VTT electronics and it constitutes of five phases as illustrated in the figure below.

Figure 10: Mobile D Methodology

2.10.3 Chen M Methodology

This was the first methodology for developing company wide mobile applications suggested by Chen M has the following phases; Developing strategies, analyzing business processes, developing the technical architecture, building the mobile application and finally deploying the mobile applications.

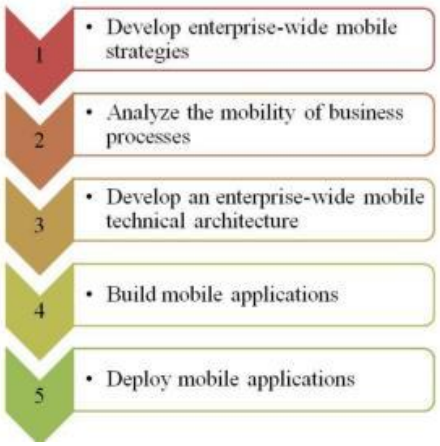


Figure 11: ChenM Methodology

2.11 m-Health.

m-Health is a subsection of electronic health (e-health) which is defined by WHO, (2017) as a cost saving and secure use of ICT in support of health and health related fields as healthcare services, health surveillance, health education and research. The main objectives of e-Health are to improve health literacy, enhance treatment adherence as well as patient empowerment.

According to suggest et . al (2015) some of the channels used to provide e-health education include websites, sms, emails, videos and social support particularly through social networks forums and forums. m-Health is defined 'medical and public health practice supported by mobile devices' WHO (2017). mHealth is categorized into Information and education, health data collection, diagnosis and evaluation.

Previous definitions of mHealth focused on devices connecting via wireless and Bluetooth networks Yu et al. (2006) but the focus shifted to telecommunication with the emergence of voice and text messaging as observed by Fjeldsoe et al (2009). Text messages were employed to disseminate health information while voice communication by phone calls has been used as a communication channel between health care givers and patient Katz et al(2012). The internet acted as a source of information where individuals searched for health information (Chib & Liw, 2018).

Recently , mHealth applications have become ubiquitous as a consequence of the rapid increase in the use of smartphones Pohl M(2019).

A study by Liu & Willoughby (2018) shows a combination of application generated text messages with a fitness application, a paradigm referred to as human-computer interaction by chib & Liw (2018).The Cloud computing technology has emerged in mhealth where computational and storage capabilities are leveraged for effective service delivery.

Estrin D (2010) opines that mHealth has evolved as a result of incompatible applications and that there is demand for interoperable systems whose integration results in improved therapeutic management.

In this study, a convergence of mobile and webservices technology was used integrating fitness and diet content to be disseminated to the application user.

2.12 Empirical studies/Prior related work

This subsection reviews prior related work worldwide on development of fitness and health mobile applications.

2.12.1 Sungye Kim & Carol Boushey

Kim & Boushey (2010) propose an image based dietary assessment system using a server-client architecture. The system entails users capturing images of their meals using their mobile cameras.The images are then forwarded to a server for evaluation in terms of portion sizes and type of food. The results of the evaluation are sent back to the user for confirmation and further advice follows subsequently. While the model is interactive and has provision for self monitoring, the iterative process of getting feedback is tedious; moreover, the proposed solution does not cater for physical activities needs such as exercise. Accuracy of the application's feedback on portion sizes and whether the selected meal is healthy is questionable

2.12.2 Yoga Mobile

Nada (2017) proposes an XML based Yoga mobile application aimed at motivating individuals to workout regularly. The application contains illustrations of yoga workouts in the form of videos and photographs which describe to the user step by step execution of the poses, stretches and breathing techniques. There is provision for its users to engage with yoga instructors by communication through email.

Usability of the application is remarkable as the user interface extremely simple to use. In spite of the positives the Yoga mobile app offers, it lacks certain features such as provision make goals, a variety of exercises other than yoga to break monotony as well as dietery uidelines to users. Incorporation of these features would make them mobile yoga app comprehensive thus being very convenient to many users.

2.12.3 Isala Sports Medical App

This application was developed as a native IOS eHealth system for sports physicians to support employees of firms in enhancing their health and fitness. In their work (Hilco, et al., 2015) The architecture is that of a client –server with the components being a central database, webservices, user application and sensors. The application offers performance tracking functionalities and feedback of sports medical test results maximuheart rate, cholesterol levels and fat percentage. There is a variety of sport related exercises in the application; nonetheless, there is no provision for instructional exercises and diet plans for the users.

2.12.4 GymKit

In a study conducted by Abdulhahamon, (2014) an android based fitness application Gymkit is proposed and developed. The application has customized workout routines aimed at helping its users achieve their fitness goals. the application has provision for its users customizing their workouts and getting advice from a database of trainers. Motivational notifications is a remarkable feature incorporated in the app to engage the users. GymKit has a component of fashion in fitness apparel as well as links to online shops which sale fitness wear. While the application engages the users by interaction with fitness instructors, its drawback is the likelihood of lack of adherence and continual use owing to the monotony of the limited range of exercises provided. The application offers guidelines of exclusively using weight training as the means of exercise. Notably missing is the component of diet which is regarded as being important in helping fitness enthusiasts achieve their goals.

2.12.5 Gym Buddies

This IOS based application was developed by Mark Kirby(2014) with an aim of providing both static and customizable gym workout regimen to its users. Gym Buddies is a mobile cloud computing (MCC) application since its architecture entails use of google firebase database which is hosted on a

cloud platform. The business logic of the app was designed to run on the mobile phone. The app predominantly offers functionalities such as viewing, modifying, submitting programs and locating a gym as well as offering a community utility to link like minded fitness devotees.

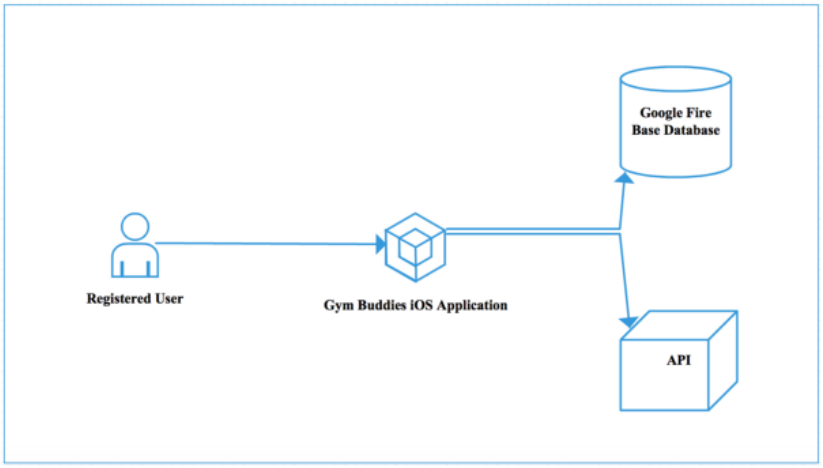


Figure 12: Gym Buddies System Architecture: Adapted from Mrik Kirby

Gym buddies user experience was well thought of with simplicity in navigation being outstanding. The application would however be whole with incorporation of other modules such as diet in order to enhance its uptake and continual use.

2.12.6 MyFitnessPal

MyFitnessPal is a calorie counter and diet tracking mobile and web application developed by underarmour to help users improve their health by tracking , learning and communication.

The app provides for connection to a comprehensive diet database where the users can plan their meals from the assortment of available foods. Input of food taken gives an estimate of ingested calories and the calories to needed to burned in order achieve and or maintain good health. Myfitnesspal also offers a myriad of recepies for users to follow in preparing healthy meals. Another feature which engages the users is the link to dieticians who respond to querries that may be raised by users.

According to Montagon, et al (2018) recommendation, mobile applications in health interventions should have a diverse array of health topics such as nutrition and exercise so as to be effective. MyFitnesspal is comprensive in terms of diet but lacks other modules like exercise and as a result the researcher believes that the solution being offered by the application is deficient.

2.12.7 Recommended Exercise System

Recommended exercise system is an android based system proposed by Vuda & Krishna, (2014) whose objective is to provide its users with advice on the kind of exercise to undertake based on their age and Body Mass Index (BMI). The application has provision for meal planning and tracking daily food requirements in terms of calories. The System is designed to push food tips notifications to users based on whether they are obese or underweight. The server client architecture was used in the systems implementation whereby the main components are web application to access the content, Database server and an android application. The system engages its users to a great degree but it is not exhaustive since the recommendations of the exercises are narrowed down to few exercises such as jogging, bicycle riding which can be done without the use of the application. The diet component of the system is clearly inadequate as tips notification cannot give a comprehensive view on dietary issues.

2.12.8 Healthwise

Shwetha et. al(2014) propose healthwise an android based application for individuals health and nutrition management. The application has a nutrition module which essentially captures information through barcode scanning of packed food products in supermarkets. Evaluation is made by comparison in a repository having details of products and the feedback is sent to the user by use of web services. Healthwise has an exercise module which offers suggestions of the exercises to be done in order to burn the excessive calories consumed. The limitation of the application is it offers a small range of exercises which can be monotonous to the user. Exercise delivery in form of instructional videos would add more value to the offerd solution. The diet component is more of a calorie counter thus nutrinional information passed to the app's user may not be enough for optimal results.

2.12.9 Personal Dietician

In order to promote health and wellness Khiiria (2018) proposes Personal Dietician, an android application which uses food ontology APIs to generate diet plans for its users. The application also has an activity tracker which utilizes accelerometer and gyroscope sensors to track users steps. Another feature worth noting is the health blog, a platform which effectively disseminates information from dietitcians and other application users. The Client-Server architecture is used in the implementation of the system in which RESTful API is used to access data stored in form of tables. Monotony of the activity involved is a drawback that may lead to underutilization of the application.

2.12.10 GoogleFit

Google developed GoogleFit a cloud –based activity tracker platform which integrates data from multiple apps such as Nike running and strava. The application uses embedded sensors to automatically track activities such as running. It can be used to monitor the progress of fitness goals and weight management. Incorporation of diet plans and a variety of instructional exercises would make GoogleFit an ideal fitness anf health application.

2.12.11 Health Promotion

According to WHO (2009) health promotion is the process of enabling people to increase control over and improve their health. Among the channels outlined by the organization, prevention of diseases is one of them whereby the delivery mechanism can be information conveyed through written or audio video resources. In her work Holly Korda(2011) opines that technology and particularly internet provide an opportunity to modify health behavior. This is an effective approach compared to the traditiona field based approach which is faced with very many pitfalls. Health education plays a fundamental role in addressing public health issues and as Sanjir & Preetha (2012) reiterate innovative approaches are highly desired to promote healthy lifestyle and prevent risk factors thus reducing cost of healthcare.

2.13 Synthesis and Gap Identification

The empirical studies present a situation where the existing fitness and diet mobile applications are not comprehensive enough to effectively deliver the required information to people who are in quest of living a healthy lifestyle by exercising rightly and eating healthy food. In order to enhance uptake , adherence and continual use of a fitness application, convergence of a variety of relevant content is key. This study proposes a solution having diet and exercise in the same application. The researcher will seek to include variety of excersises such as weight training, body weight exercises and yoga in the prototype. Other features to engage the app users such as advice from fitness trainers and dieticians as well as motivation quotes and diet tips in form notifications was explored.

2.14 Conceptual Model

(Whitten, et al., 2012) posist that a conceptual model helps in establishing a project scope by giving a visualization of the fundamental business entities and their natural relationships. The entities encompassed in this study are mobile user, Fitness trainer, system Administrator, the application and a database as illustrated in the following figure.

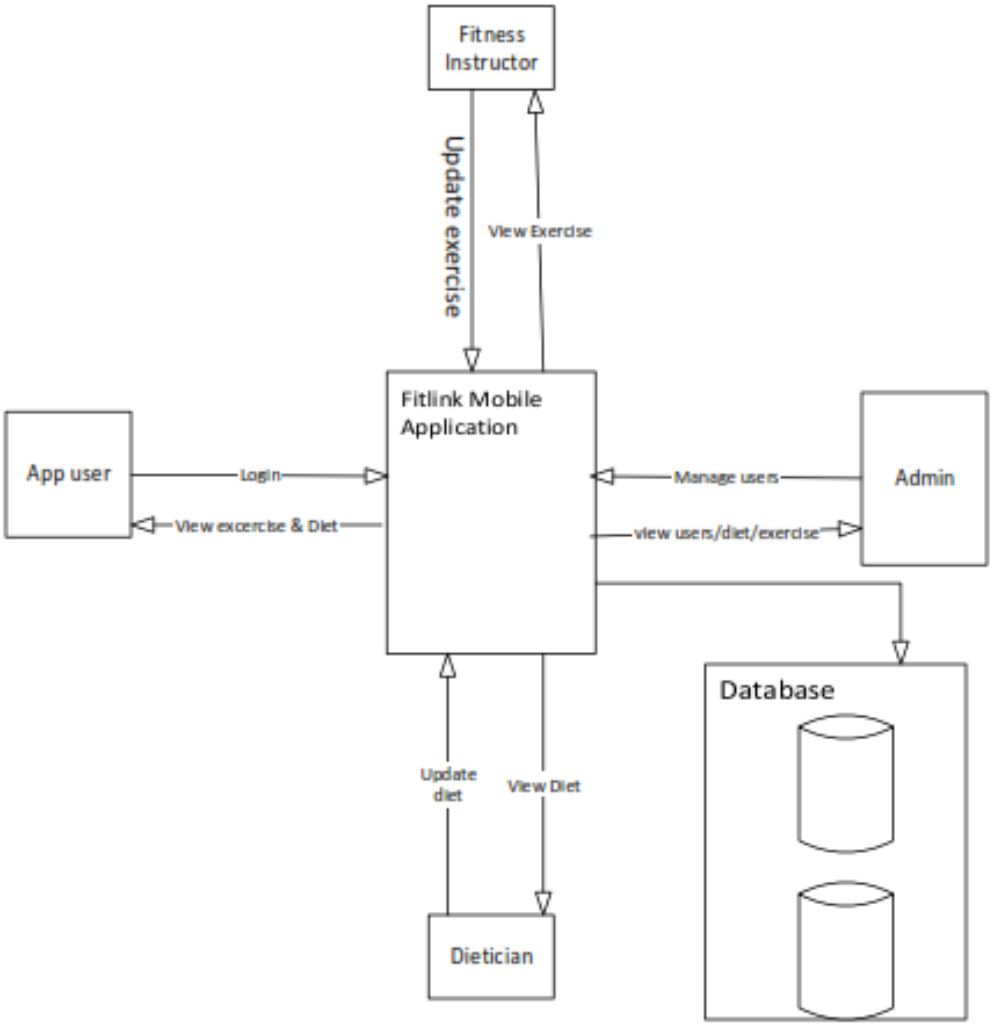


Figure 13: proposed Conceptual Model: Source Author

CHAPTER 3

3.0 Research Methodology

3.1 Introduction

This chapter gives an insight on the methodology adopted in the design, development and testing of a mobile application-FitLink. The study sought to achieve the following objectives:

i. To design and develop an integrated fitness and diet mobile application prototype using the appropriate technologies.
ii. To provide a cost effective and effective health content delivery mechanism.
iii. To evaluate and validate performance of the developed prototype.

The research design and approach presented with focus being on population of the study, sampling procedure, data collection procedures, data analysis and prototype evaluation. The design science research methodology (DSRM) will also be conferred in this section.

3.2 Research Design and Approach

Research design is defined by (Bryman, 2016) as a framework for generation of evidence that is chosen to answer the research questions that are of interest to the investigator. According to (Rosen, 2019) research design encompasses a comprehensive approach to research and specific components of how it was executed. Generally,the cross sectional research design was employed as it entailed collection of data on a sample of cases at a single point in time in order to detect patterns of association. Since the research model will necessitate eliciting of user requirements, development of a prototype and eventually evaluation of the developed prototype, a qualitative and quantitative approach was used. Bryman, (2016) identifies the design as the exploratory sequential design, a mixed methods design whereby collection of qualitative data is performed prior to the collection of quantitative data.

The research model used was adapted from the research method by Verschuren & Doorewaard (2007). It is comprised of literature study, expert and validation interviews as well as Design science.

3.3 Design Science Research Methodology (DSRM)

The approach in this study is based on design science research methodology (DSRM) which is defined by (Dresch, et al., 2016) as a method that establishes and operationalizes research when the desired goal is an artifact or a recommendation. The approach was followed to develop a fitness and diet

mobile application artifact with an aim of enabling individuals to self manage exercise and diet in order to lead a healthy life.

The design science framework is illustrated in figure 16. The study was conducted in an environment consisting of fitness instructors, dietiticians and fitness enthusiastswho will interact through the fitness and diet mobile app.

Existing theories on mobile technologies as well as fitness and diet apps form the basis of this study's knowledgebase. Application of design science, expert interviews and literature study in the development of the artifact and consequently realizing the objectives of the study.

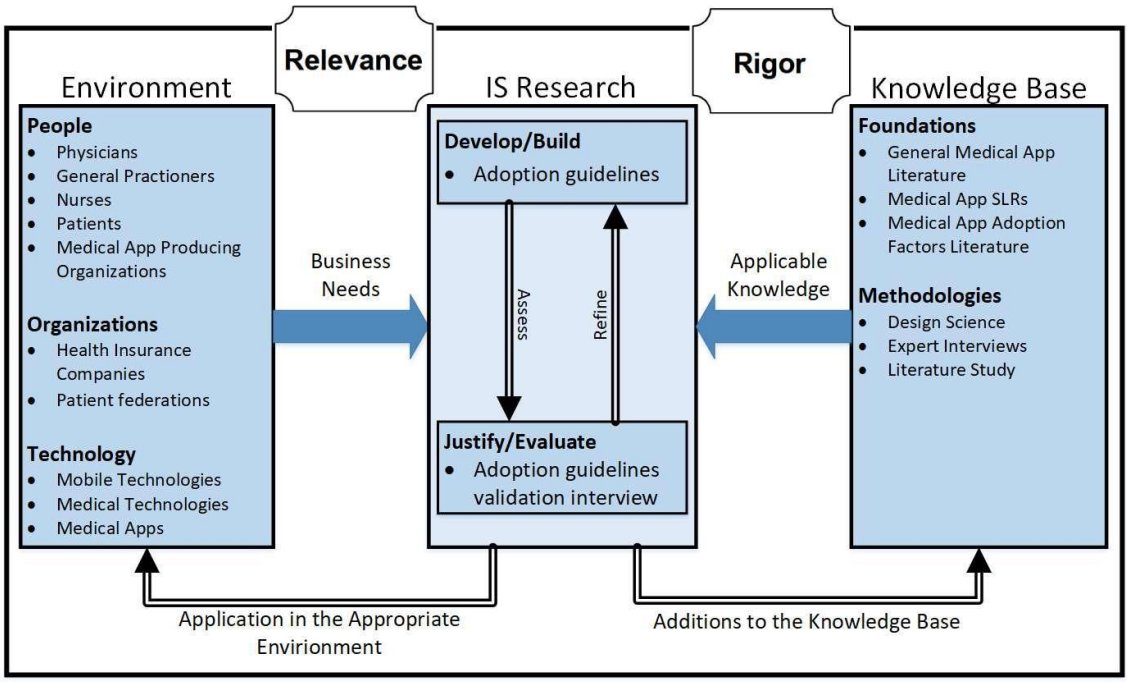


Figure 14: Design Science framework to for development of fitness and diet app artifact

The 7 design science research methodology guidelines as provided by Dresch, et al., (2016) was applied in this study as discussed in sections 3.3.1 to 3.3.7

3.3.1 Design as Artifact

This study sough to develop an integrated android based fitness and diet application as the artifact based on the requirements gathered from literature study, empirical data and expert interviews.

3.3.2 Problem relevance

The problem in the study was that mobile applications intervention in lifestyle diseases is not comprehensive to effectively help people live healthy lives by exercising and eating properly. The solution offered by this study would undoubtedly bridge the identified gap by enhancing health promotion through mobile technology.

3.3.3 Design evaluation.

An evaluation of the artifact was conducted by performing usability and performance tests then eliciting feedback from fitness enthusiasts, fitness trainers and dieticians by use of an online administered questionnaire to determine its quality.

3.3.4 Research contribution.

The literature review presented in the preceding chapter gave an insight on fitness and diet, m-Health, distributed computing technologies and mobile applications. It emerges from the empirical data that there exists a gap in the current fitness and diet mobile applications. This study therefore contributes to the research fraternity by seeking to integrating exercise and diet in a single application as an effective intervention.

3.3.5 Research Rigor

Rigorous methods was employed in both the development and evaluation of the application. An extensive literature review to identify the gap and gather user requirements form the foundation of the design and implementation of the system. This is done so as to avoid replication of an existing research work.

3.3.6 Design as a research process

In this study the development of the artifact will performed using proven software development cycles as well as mobile development tools and techniques.

3.3.7 Communication of the research

The final report of this study was presented to an academic panel comprised of technology oriented members as well as management representatives. The researcher will also seek to publish a scientific paper from this thesis as a way of disseminating information.

3.4 Population and Sampling Design

This study was be conducted within the Nairobi county where the participants were drawn from eight gyms located within the four quadrants of the City-(Northern zone, eastern Zone, western Zone and Southern zone) whereby two gyms were randomly selected from the each zone.

3.4.1 Purposive sampling

For the qualitative part of the research, sampling of the area was carried done followed by that of the participants. The target population was predominantly homogenous as it comprised of fitness instructors and dieticians who are experts in their areas of specialization within Nairobi county. Consequently, the sample size was relatively small where 10 fitness instructors and 6 dieticians was interviewed. According to Adler (2012) a sample size should be in the range of 12 to 60 though it is to vary from one situation to another. A non probability form of sampling, the purposive sampling was employed since the subjects are to be individuals within subgroups of interest in this case fitness and health enthusiasts.

3.4.2 Snowballing Sampling

This method of sampling was employed to get dieticians as expert interviewees. The first identified dietician provided leads to fellow dieticians who were willing to be interviewed in regard to the survey.

3.4.3 Multistage Cluster Sampling

For the quantitative part of research a multi stage cluster was used where the county was divided into four quadrants. 240 prospective participants who are gym patrons were randomly sampled from the eight selected gyms to answer an online administered questionnaire.

3.5 Data Collection

3.5.1 Interviews

The use of interviews is based on the fact that they are flexible and are able to acquire details of the concepts under study. (Walliman, 2011) posits that interviews are instrumental in the gathering of qualitative data. After the literature study, 45 minutes face to face expert interviews were conducted to determine the kind of effective exercise regimens for different objectives such as muscle hypertrophy or weight loss as well as the right diet plans to be followed in order to live a health life. It is through the use of semi structured interviews that the study established the factors which impede people from adhering to prescribed workout and diet plans.

3.5.2 Questionnaires

In this study evaluation of the developed artifact was carried out quantitatively by the use of an online administered questionnaire which was formulated using google forms. A link to the form was then shared to prospective study subjects via whatsap platform in the various gym whatsapp groups.

Questionnaire was used as it is cheaper to administer and the response rate is comparatively higher than other methods of collecting quantitative data.

The question categories included perceived usefulness, perceived ease of use and personal attitude.The Likert scale scale was predominantly used in getting feedback from the subjects on functionality and usability of the prototype.

3.6 Data Analysis

A mixed methods analysis was employed to evaluate prioritise user requirements in the development of the prototype as well its evaluation.

3.6.2 Thematic Analysis

Qualitative data gathered from the first respondents was analysed so as to establish the user requirements of the proposed system.The data was categorized by breaking it down into components –themes and subthemes. Indexed on a framework matrix was then carried out with efforts made not to lose context of what the respondents will have said.

3.6.3 Statistical Analysis

The quantitative data collected during the evaluation phase was processed by being edited, coded and entered for analysis. Data analysis was executed using excel by descriptive analysis measures such as frequencies and measures of central tendency so as to determine the usability of the developed artifact.

3.7 System Modeling

System modeling is a process of creating abstract models of the system to present a view of the system according to some perspective Sommerville,(2007). In this study use-case modeling and dataflow modeling was employed to illustrate system actors and the flow of data in the system. Use-case diagrams and Data flow diagrams was discussed in detail in the chapter "Systems Analysis and Design".

3.8 Architectural design:

Architectural design as defined by Sommerville, 2007 is the subsystems constituting the entire system. In this study, the proposed architectural design was a 3 tier architecture comprising of a User Interface or presentation tier, mobile application (API) and Database.

The choice of this architecture was because of its flexibility when making changes on the business logic without affecting other system components.

Server : Application services processed and managed on the server.

Client : User interface running on the mobile phone.

Database: A repository of exercise programs and diet plans.

Network: Internet for this case to allow client to access the services on the server.

A thin client model was adopted so that all the application processing is executed solely on the server. The overall system architectural model is depicted in figure 15.

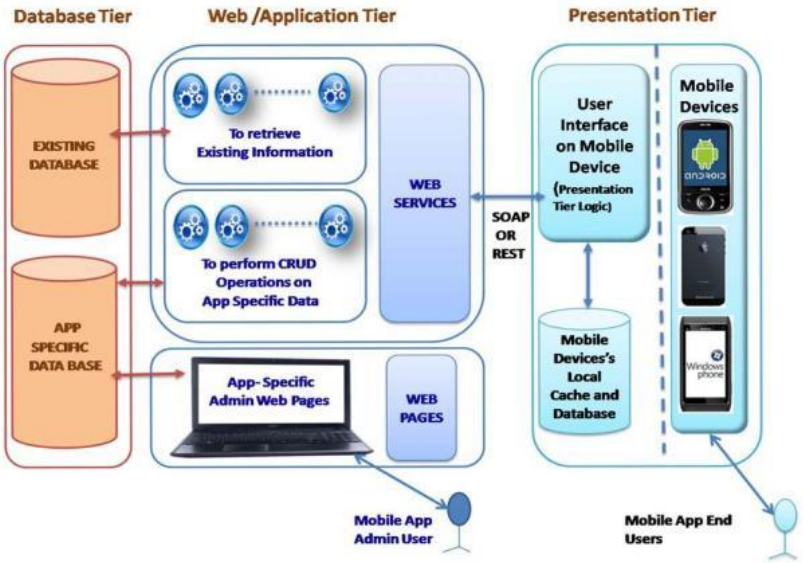


Figure 15:Three Tier Architectural model

3.9 Rapid Application Development(RAD)

In order to implement the proposed application, the agile process method to be used was Rapid Application Development (RAD) because as opined by Sommerville (2007) it supports simplicity of design and involves incremental delivery whereby the software is developed in increments with continuous integration.The RAD lifecycle encompasses requirement preparation, design, development and cutover.

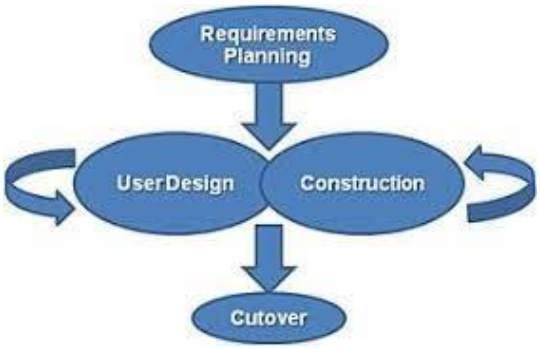


Figure 15: RAD process

3.9.1 Requirement Planning.

In this phase eliciting of user requirements is conducted so as to establish the business functions as jwell as the scope of the system to be developed. Requirements definition is carried out to determine what the system should do- its functions and the constraints upon it. Functional and Non functional requirements as well as characteristics that the system must not exhibit was determined during this phase by identifying and prioritizing the system requirements. Functional requirements depict what the system should do in response to specific inputs and the services it should offer.The acquisition of specifications was achieved through expert interviews as discussed in section 3.5.1.

3.9.2 User Design

After the identification and prioritizing of system requirements has been carried out, user design which entails modeling of systems requirements, data modeling and process modeling will ensue.

Modeling of system requirements was achieved by use case modeling where use cases and use case narratives was employed. For data modeling, entity relationship diagrams was used while context and data flow diagrams was utilized in process modeling. Details of user design was discussed in the chapter Systems Design and analysis.

3.9.3 Development

Construction of the artifact then follows so as to realize the product according to the established user requirements and design considerations. The system implementation was carried out in an iterative manner as illustrated in the diagram that follows.

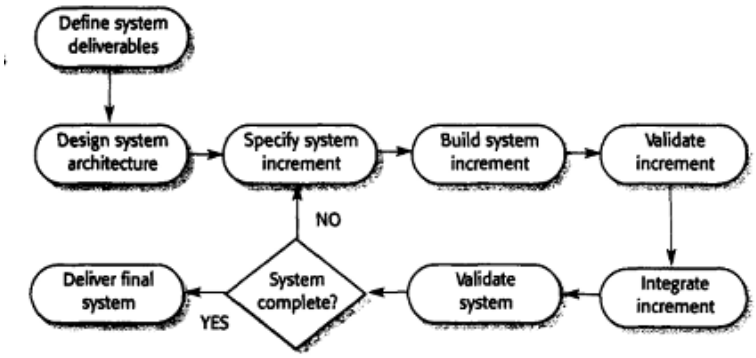


Figure 16: An Iterative development process

The system's component units to be implemented are the mobile user interface UIX, the applications business logic, database, webservices and their integration.

User Interface

Sketches and Sketch mock ups will precede the actual development of the user interface. Use of pen and paper as well as a PDF file with clickable buttons was used to create a visualization of the interface. The actual user interface was developed using Android Studio Development Kit (SDK) with the eclipse IDE to develop the screen layout structure as well as navigation and controls.

The Android SDK was is convenient and comparatively easy to use since it has the required libraries debugger and an emulator.

Application Programmable Interface.

The application is to be developed using Java- an object oriented programming language and platform that supports numerous applications. In this study, Java is the preferred since it is fast secure and reliable. The language supports such concepts as data abstraction, encapsulation, inheritance and polymorphism thus resusability of methods and variables can be achieved.

Database

The database to be used was MySQL which is a database system that runs on a server using standard structured query language. MySQL is renown for its high performance, reliability and platform flexibility. Its high availability is as a result of provision for master/slave replication.

Data security is achieved Secure shell connections (SSH) and secure sockets layer (SSL). MySQL provides for authorization of users before they can access the database. Data in form of text images and video was stored in JSON (JavaScript Object Notation) format.

Webservices

RESTful webservices were created using the Java development kit (JDK) and Eclipse Oxygen as the development environment. RESTful webservices was used in this study pwing to their attributes of being lightweight and scalable in nature.

3.9.4 Cutover

Cut over usually encompasses testing, training of stakeholders and rolling out of the developed system. In this study cutover will only entail testing as discussed in section 3.9

3.10 Testing

Testing is important in systems development as it identifies the defects and errors that emerge during the development phase. This is done to ensure that quality is achieved and the user requirements are met satisfactorily. Testing was an integral part of the core application development process which is iterative in nature. The Test levels were conducted in this study are Unit Testing, functional testing, usability Testing, and Security Testing.

3.10.1 Unit Testing

Unit Testing was conducted during development to find and eradicate errors in the code and ensure the each component of the system

3.10.2 Functional Testing

Functional tests were conducted during and after the development stage to confirm that the application functionalities are in harmony with the user requirements.

3.10.3 Usability Testing

The usability Test was be conducted to determine the users ease in using the application and thereupon exposing usability defects.

3.10.4 Security Testing

Security of data in applications and particularly health related applications is essential thus necessitating security Testing. User authentication is the main component to to be tested in this study.

3.11 Evaluation.

A triangulation approach was employed in evaluation-Evaluating with users and expert review of the developed prototype where fitness enthusiasts, professional fitness trainers and dieticians was involved in the evaluation.

3.11.1 Summative Users Evaluation

In order to validate the implemented application, a summative evaluation was conducted so as to determine the user acceptance in the context of functionality, usability and general performance. A group of 20 randomly selected fitness enthusiasts give their opinions using a self administered questionnaire in the form of a system usability scale on the application and thus determine if the study's formulated objectives will have been achieved.

3.11.2 Expert Review

Cognitive walkthrough evaluation which is a usability inspection method for identifying usability issues in interactive systems was employed whereby 2 Expert fitness trainers and 2 dieticians was involved in the cognitive walkthrough sessions in order to evaluate the developed prototype. This method was chosen as it is task specific and it generates results faster at a low cost.

3.12 Ethical Considerations

The researcher earnestly sought to adhere to the principles of ethical research identified by (Walliman, 2011) while conducting this study.

3.12.1 Participants' Informed consent

The subjects of the research will briefed on the purpose of the study and their roles in it. They was treated courteously and assured of confidentiality regarding the information which they will provide.

3.12.2 Participants' Protection from harm

The nature of this study will not subject the participants to any form of physical or psychological harm in the context of location, time of study and the nature of questions which was asked.

3.12.3 Honesty and Integrity.

In any study it is prudent to have thoughts and ideas from other researchers being acknowledged through citation to avoid plagiarism. Trustworthiness was sought and upheld by the researcher during this research.

3.12.4 Responsibility and Accountability

The researcher is accountable to fellow researchers and the community at large. Consequently, the researcher endeavored to provide an accurate account of what has been done without distorting data and the results

3.13 Project Schedule

The Project was scheduled to take four months from its inception to its closure. The schedule with the component tasks is as depicted in the following figure.

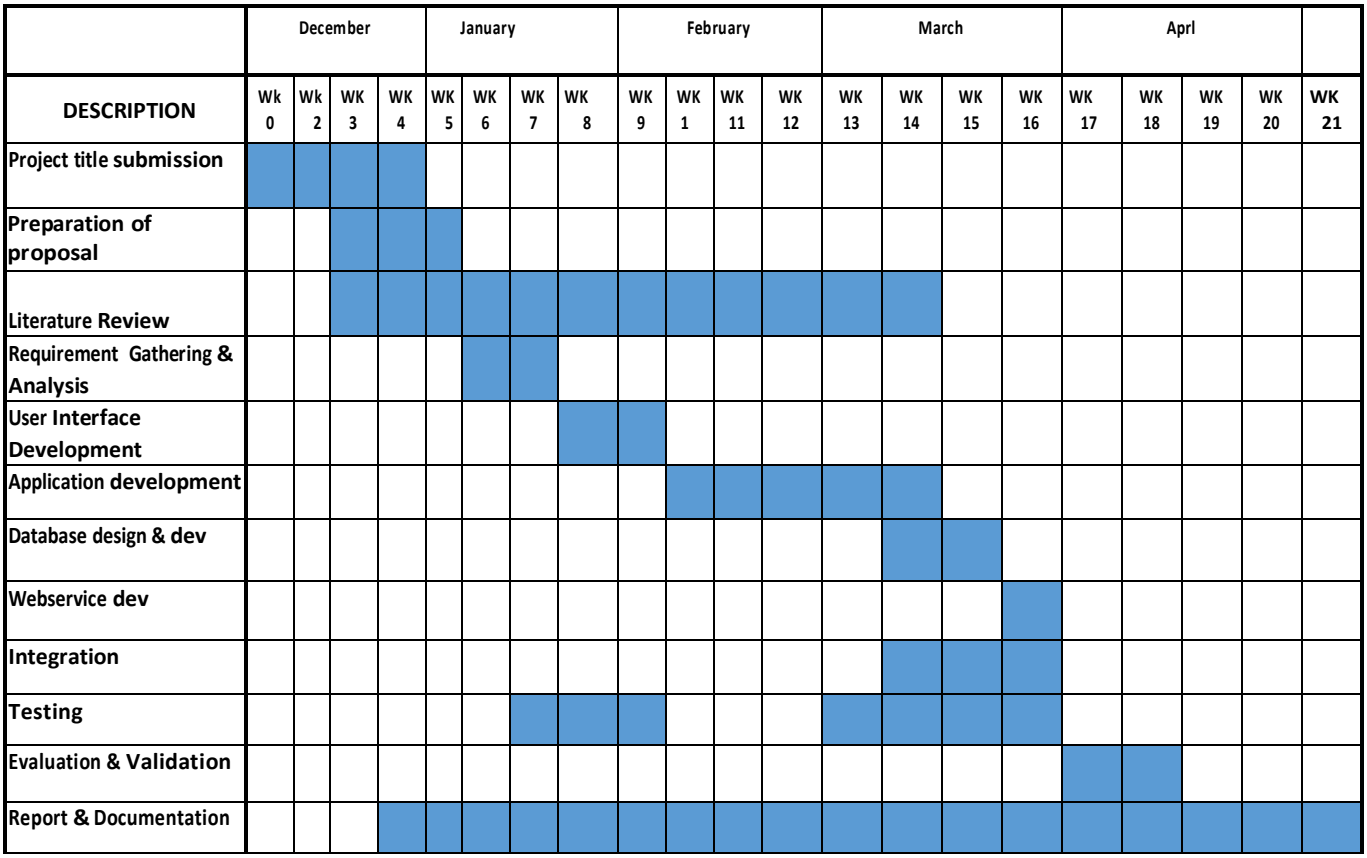


Figure 17: Project schedule

CHAPTER 4

4.0 Analysis and Design

4.1 Introduction

This chapter confers the system investigation carried out to establish the user and system requirements of the proposed application. The system design undertaken as a prerequisite for the mobile app implementation is also conferred in this section.

4.2 Analysis

Following the expert interviews with fitness instructors and dieticians as a requirements discovery process, an analysis was executed by decomposing the system into component pieces. In this study a modeling approach was employed, which according to (Whitten, et al., 2012) is a pictorial approach for documentation and validation of systems

4.2.1 Feasibility Analysis

The feasibility study conducted in this research entailed scope definition to warrant the development of an application prototype as a solution to the identified problem. The scope and schedule were found to be feasible after prioritizing the identified functional requirements.

An evaluation of the technical solution in offering unified fitness and diet information to clients, the availability of technical resources and expertise confirmed that this study is indeed technically feasible.

Implementation and use of an integrated fitness and diet application is economically feasible considering the cost of developing the system is way lower compared to potential users seeking personalized services of fitness instructors and dieticians.

4.2.2 Functional Requirements

As defined by (Whitten, et al., 2014) functional requirements is an account of actions and services a system must provide. The system has both mandatory and desirable requirements whereby mandatory requirements are those that must be fulfilled by the minimal system while desirable requirements are not absolutely essential to the initial version of the system.

In this study a total of 12 experts were interviewed with 8 being fitness instructors and 4 dieticians as detailed in the research methodology. Following is a select list of expert interview questions formulated within the study objective's framework that were used to elicit the application's user requirements.

No	Expert Interview Question
EIQ1	**What are the main goals the people in quest for a healthy lifestyle** weight loss, Muscle hypertrophy, general wellness, strength training, rehabilitation
EIQ2	**What is your view on why people do not not adhere to a proposed exercise regimen or diet plan?** Lack of motivation, unrealistic goals not being achieved, busy schedules, influence
EIQ3	**What are the outstanding hurdlesthat fitness enthusiasts face in meeting their objectives?** Bad nutrition/eating habits-overeating, eating hurriedly, poor mastication, misinformation, Bad workout regimens, overtraining,stress, injuries
EIQ4	**What are the most effective exercises/diet for muscle hypertrophy and weight loss?** Weight training, body workouts, stretching, cardio exercises, yoga, spin bikes, swimming ,power walks. High fibre food, wholesome foods – avoid sugar, and other refined foods, balanced macros from protein sources, vitamins and carbohydrates. Diets rich in seeds, nuts, fruits, vegetables.
EIQ5	**How do you continually motivate your clientele?** Constant communication, motivational quotes, group discussions, reminders, reference for personal reading, music
EIQ6	**How do you keep track of your clients' progress record** Client Progress files, databases, personal journals

Figure 18: Expert Interview questions

The outlined functional requirements were derived from literature review on prior related work and expert interviews of fitness instructors and dieticians.

No	**Functional Requirement**	
FR1	Ability to open the app and input the required data.	LR
FR2	Ability to easily navigate through the application.	
FR3	User's ability to come up with a plan based on their objectives	
FR4	The ability to access relevant detailed Diet plan.	
FR5	User's ability to access relevant detailed exercise regimen.	
FR6	Motivational notification messages will periodically be pushed to the users.	
FR7	Provision for video file format of exercise demos	
FR8	Provision for a communication channel for human expert consultation.	
FR9	The system shall provide for goal setting and progress monitoring.	
FR10		

4.2.2 Non Functional Requirements

Though regarded as non essential , the non functional requirements provide for a way to evaluate the prototype's performance. In this study the prioritized non functional requirements include the following.

No	Non Functional Requirements
NFR1	System Security
NFR2	reliable-high availability
NFR3	easy to use by being self intuitive
NFR4	The system shall have minimized latency by having a scalable database which would cater for an increased load
NFR5	The system shall be scalable

4.2.3 Database Requirements

In this study MySQL is the database that was chosen owing to it being an open source relational database which is highly scalable, which is fast and comparatively easy to use

4.2.4 Hardware Requirements

The proposed system encompasses different modules for its implementation. The components used include the following:

1. Computer for code development
2. Server Computer for Application running
3. Computer for database
4. Android phone for application installation and testing

4.2.5 API Requirements

The middleware provides for communication within the system whereby data is sent to and retrieved from the database with JavaScript Object Notation (JASON) being the messaging framework. REST is the architectural API style to be used owing to it being flexible to allow the use of XML, HTML, JSON. The lightweight nature makes the performance of RESTful web services comparatively better than SOAP.

4.3 Design

After the requirements have been elicited and analyzed, designing of the proposed prototype ensues. The fitness and Diet application FitLink is

4.3.1 Application Architecture and Modeling

According to (Whitten, et al., 2012)an application architecture is a specification of the technologies to be employed in implementing a system. A distributed data and application architecture also known as a multi-tiered layer architecture was settled upon since data, the application logic and the presentation are placed remotely from one another. The architecture is depicted as a DFD in figure

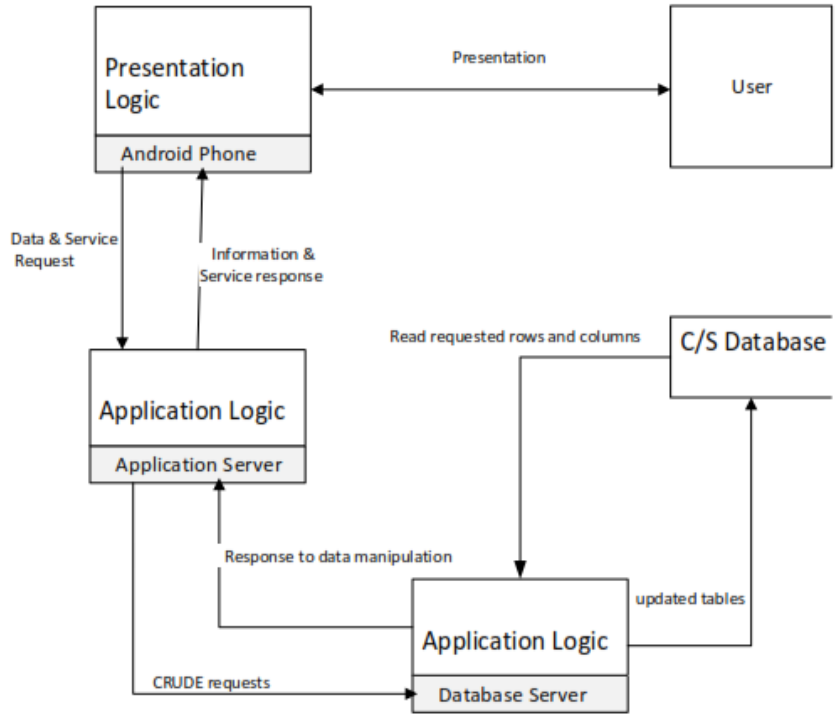


Fig 19: Three Tier Architecture

4.3.1.1 Process modeling using use case diagrams

A usecase diagram graphically depicts how the system interacts with users and external systems

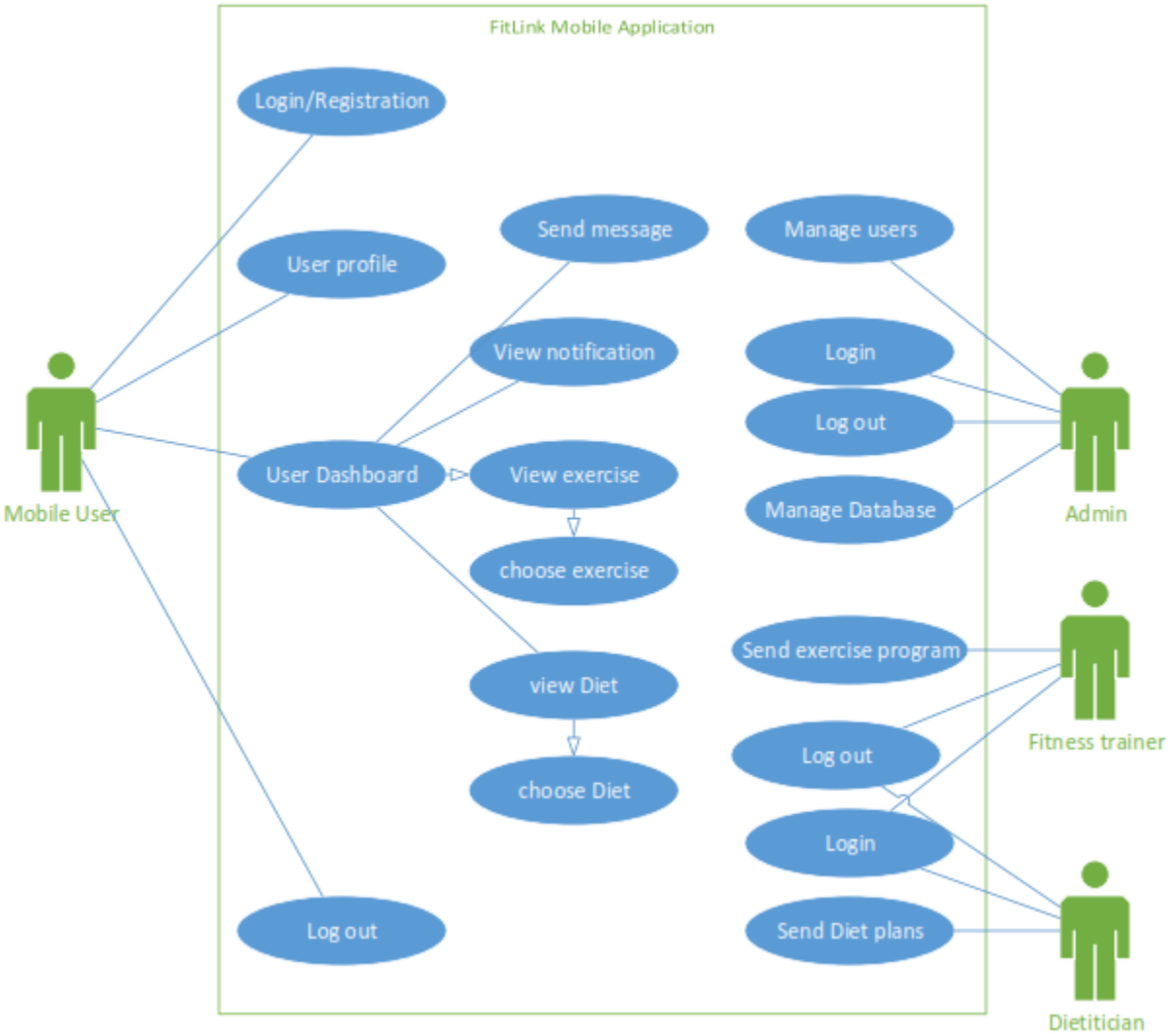


Figure 20: Usecase Diagram

4.3.1.2 Use Case narrative

A use case narrative describes what a system ought to do in an ordered manner in response to a particular event. The following select diagrams in this sub section illustrate some of the use case narratives generated during the requirements modeling.

Use-Case Name	Login	Requirements
Actor	Registered User	
Precondition	Client must be registered to the app	
Trigger	Initiated when client clicks on login button	
Chain of events	Action Enter username and password If successful client accesses application	Response If unsuccessful an error message is generated
Conclusion	Terminates when user logs in successfully or error message is displayed	
Post condition	Client accesses app upon successful validation	

Figure 21: Usecase Narrative for login

Unified Modeling Language (UML) Sequence Diagrams

Sequence Diagrams are interaction diagrams which depict message interchange between actors or participants who are usually arranged in a a chronological order of activation. These diagrams enhance comprehension of the modelled functional requirements.

Some of the sequence diagrams used in the requirements modelling in this study are as illustrated in the following figures. Figure xv is a generalized sequence diagram where the Android user requests are sent to the server and the feedback sent back to the client. Automated, scheduled motivational notifications are pushed to registered clients using the firebase.

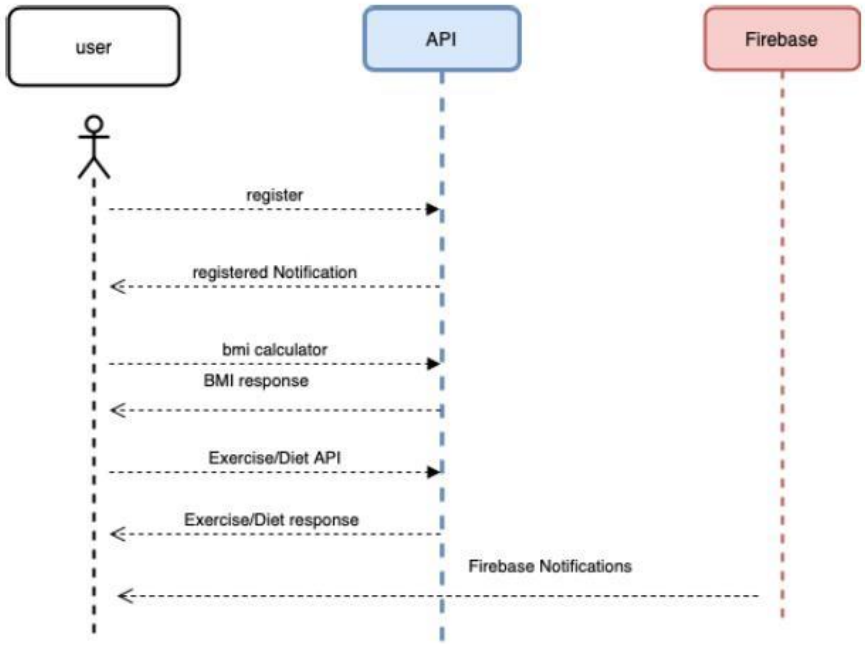


Figure 22: Sequence diagram a

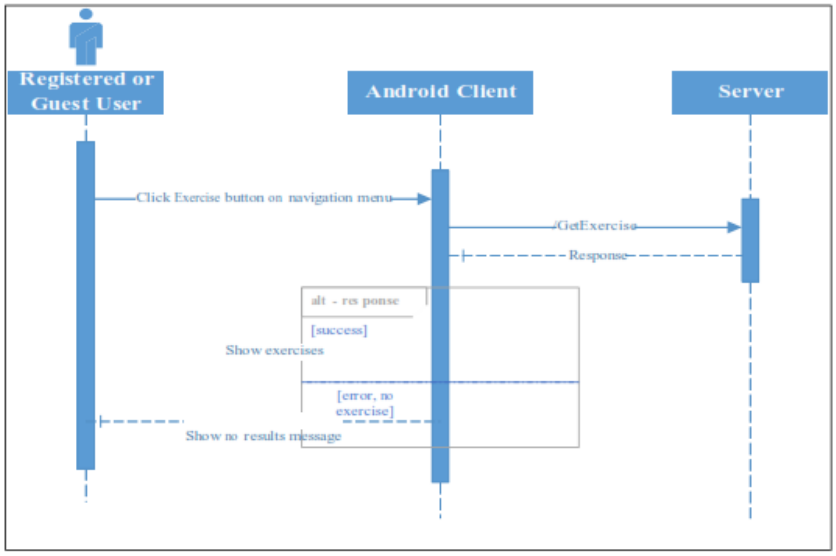


Figure 23: Sequence diagram for registered user

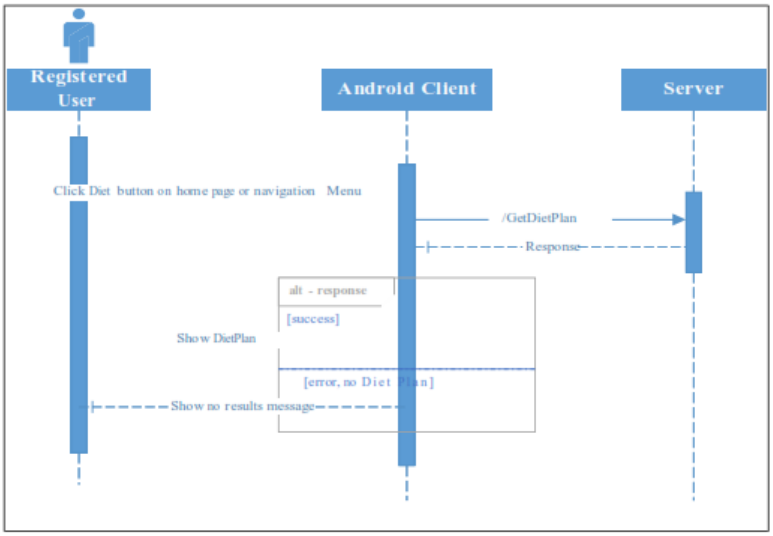


Figure 24: sequence diagram for registered user 2

Context Diagram

A Context diagram defines the boundaries of a system and illustrates the high level flow of information. In this study the basic information flow was between the application user and the business logic server as illustrated in the following diagram.

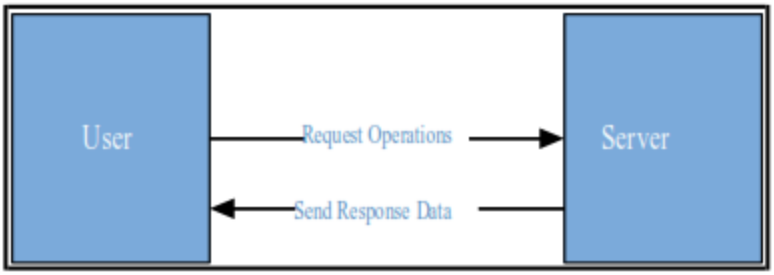


Figure 25: Context diagram

4.3.2 System Database Design

Database design is carried out to produce physical and logical design models of the system to be implemented. This is a crucial stage as it determines the overall performance of the developed application. Data consistency and preclusion of redundancy are achieved as a result of a good database design.

In this study type of data used in implementation of the proposed application is both in textual and video form. The types of exercises and diet are in textual form while a demonstration of the exercises was in video format.

4.3.3 User Interface Design

Design of the mobile application's user interface was done with the focus being user experience and interaction. In order to develop a widely acceptable application, the user interface was designed considering human engineering guidelines which address issues to do with navigation, validation of entered data, errors and screen formatting. A good user experience interface is easy to use and engages the user more thus enhancing the chances of the application uptake and continual use.

A menu driven interface was chosen where the user is to select appropriate exercise regimens and diet plans from the available menus.

4.3.4 API/ RESTful Web services Design

Data exchange between the application users and the repository is achieved through the Application programmable Interface (API). The dissimilar application components (data and functionalities) also known as resources are exposed as web services; consequently, these resources can efficiently be shared concurrently across multiple users. The user invokes the server which in turns responds to the request. Usually the request is in form of CRUD (create, Read, Update, Delete) actions while the response from the API is in JSON format as depicted in the following diagram.

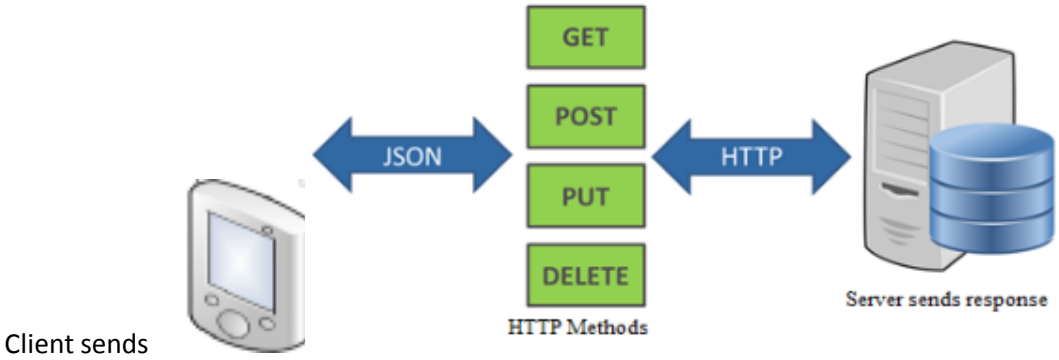


Fig 26; RESTfulweb services design

In their work, (Thu & Aung, 2015) point out RESTful web services as being simple, light and of high performance and thus the preferred architecture especially in mobile applications.Javascript Object Notation (JSON) was considered to be ideal compared to XML since JSON's representation of data is easier.

CHAPTER 5

5.0 Implementation

5.1 Introduction

This chapter discusses implementation of the system, the database, user interface and the messaging solution as per the established user requirements.

5.2 System Development

This study's application prototype was developed using the following outlined business logic in accordance to the established functional requirements.

i. The app requires a user to be a registered user and once the user logs in the following steps can be undertaken.
ii. The user is enabledeto create a fitness objective based on preference.
iii. They can then be able to proceed to calculate the BMI and then send the information to an API to select the best diet and exercise plan for the user.
iv. Once the plan is created using the backend API the information is then persisted in the database and can then be available in the "My plans" selection option on the homepage.
v. Once this is selected, one can be able to view the various different plans this then leads to selection of two options either the diets or the exercises.
vi. When this is selected then one can be able to select the day of the exercise or diet to be able to know what exercise is being undertaken.
vii. For the YOGA videos, on can be able to see the yoga exercise in video form and this can be updated from the database.

5.3 Database Development.

The database used was MySQL database which was hosted on an Apache server that having various tables to ensure that the required data for the application is stored. The tables used in this study include:

i. Users table : the table stores the information of those who have registered.
ii. Fitness plan table : this stores the data regarding the fitness plans that users create.
iii. Exercise plan table : this stores the exercises plan that is linked to the users.
iv. Diet plan table : this stores the diet plan that is linked to the plan created and the specific user.
v. Weight loss diet table : this stores the data that has been entered that includes the diet.
vi. Body building diet table : this stores the diet data linked with body building objectives.
vii. Body building exercise table : this table stores the various exercises linked to the body building objective.
viii. Weight loss exercise table : this table stores the various exercises linked to the weight loss objective.
ix. General wellness exercise table : this table stores the various exercises linked to the general wellness objective.

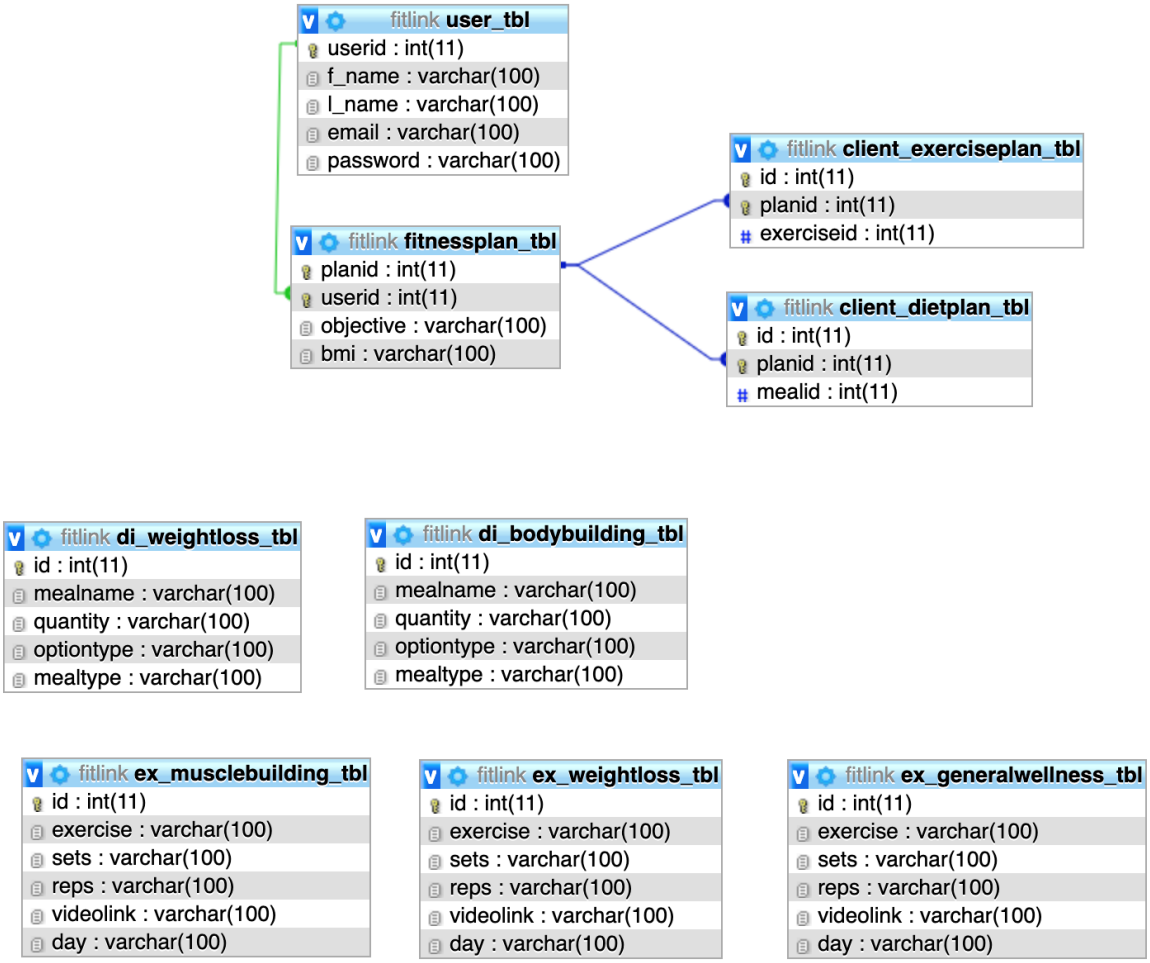


Figure 27: Database design

One to many

i. The user table(user_tbl) has one to many relations with fitness plan(fitnessplan_tbl) : one user can have many fitness plans.

One to one

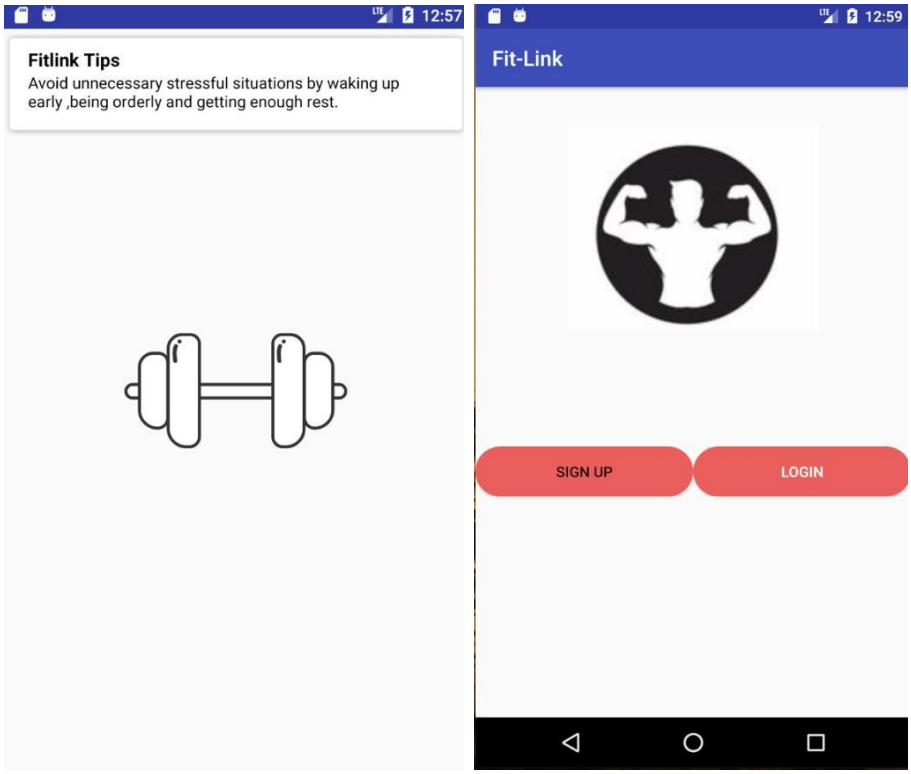
ii. One fitness plan has one exercise plan linked to it, once a fitness plan is created one can only have one exercise plan.

iii. One fitness plan has one diet plan linked to the fitness plan and to a specific user.

The rest of the tables only store content that can be updated directly.

5.3 GUI Implementation.

The android mobile application was developed using the android studio 3.6.1. The following screenshots illustrate the user's navigation from the splash when using the app.



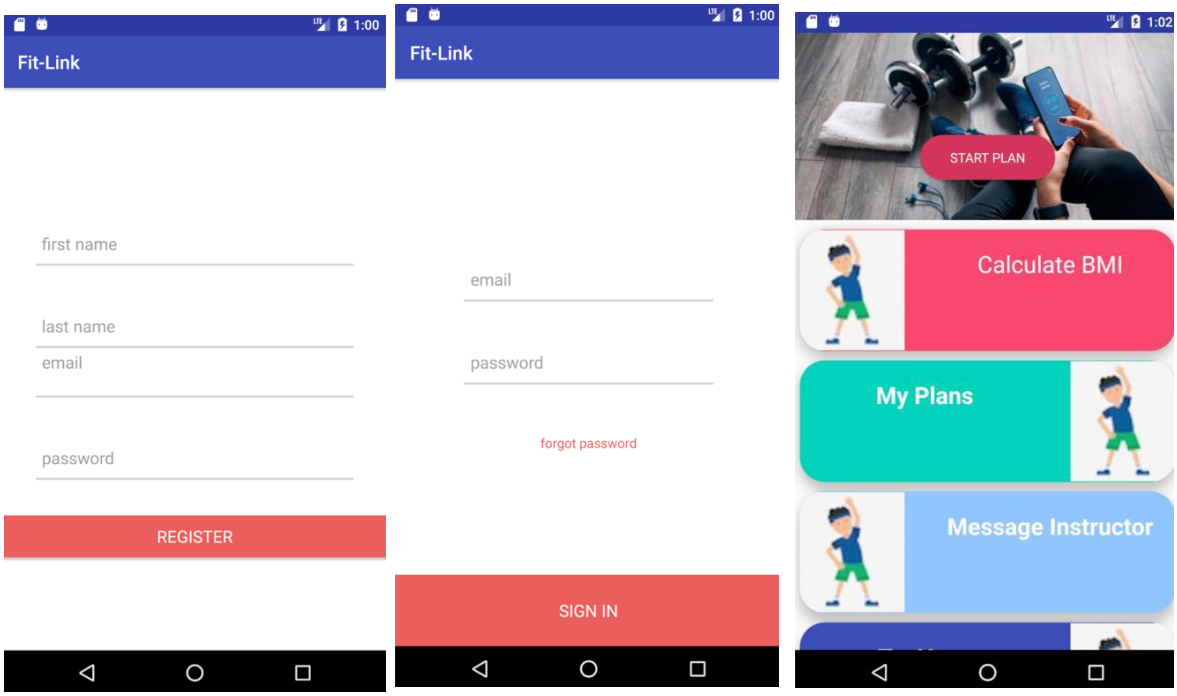
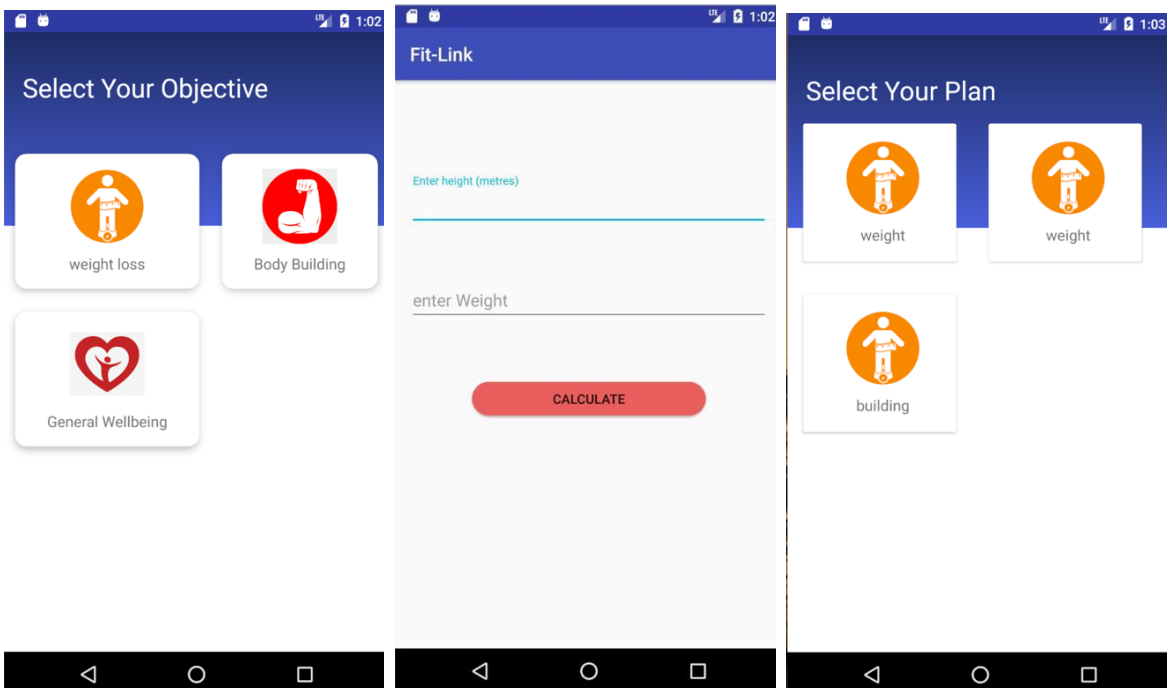
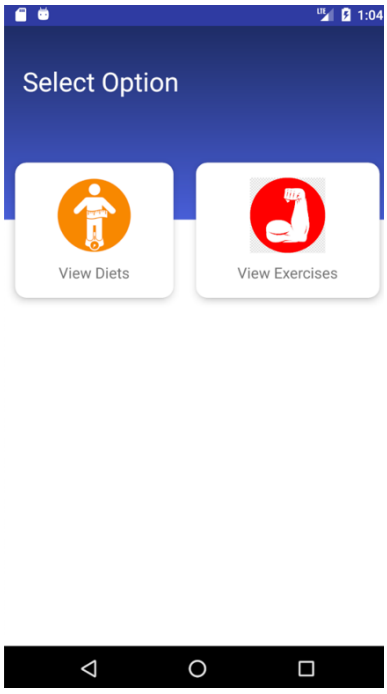
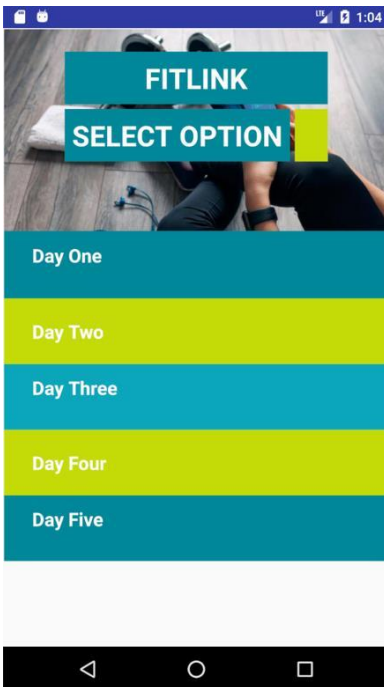
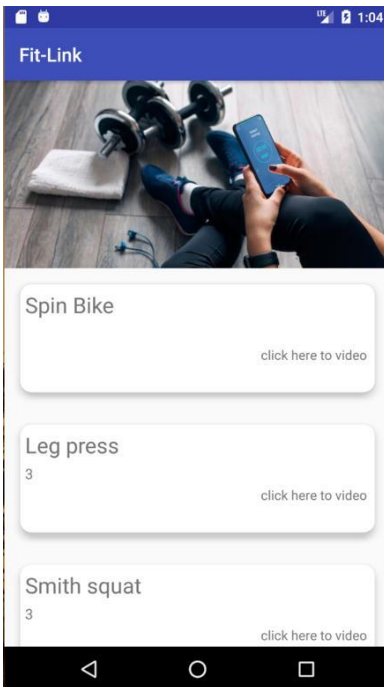


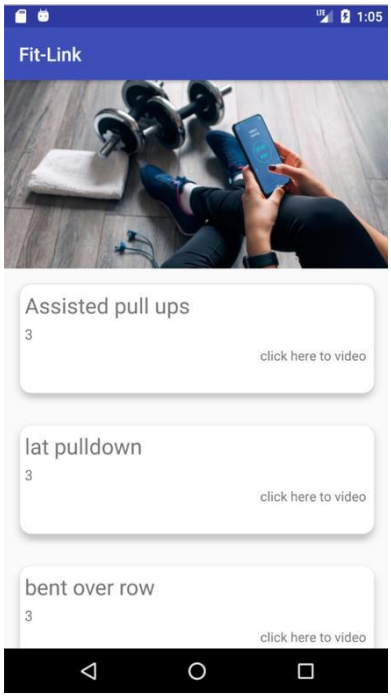
Figure 30: Register screen

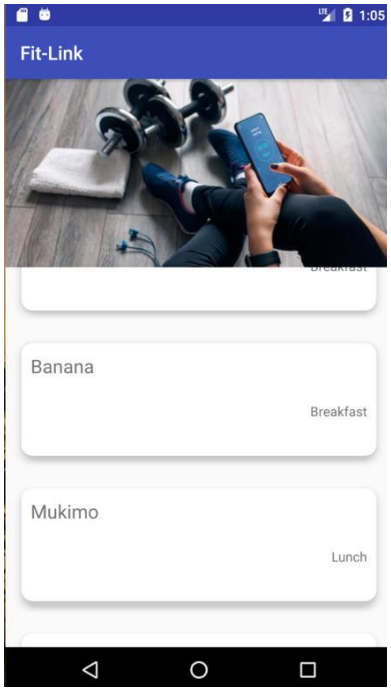



1:04
Select Option
View Diets
View Exercises


1:04
FITLINK
SELECT OPTION
Day One
Day Two
Day Three
Day Four
Day Five


1:04
Fit-Link
Spin Bike
click here to video
Leg press
3
click here to video
Smith squat
3
click here to video


1:05
Fit-Link
Assisted pull ups
3
click here to video
lat pulldown
3
click here to video
bent over row
3
click here to video


1:05
Fit-Link
Banana
Breakfast
Mukimo
Lunch

5.4 Web Services/ API Implementation.

The request made to the API are a combination of GET and POST requests. The mobile application makes request to the API so as to access and parse data to the database. The API sits on a server that handles request from a mobile application client and performs the business logic and communicates with the persistent layer which is the database that hosts the data.

The table below illustrates the requests that have been made and the various API calls

a) REGISTER

The purpose is to register the user and persist in the database.

a. REQUEST

METHOD	ENDPOINT	REQUEST PARAMETERS
POST	/register.php	Fname, lname,email, password

b. RESPONSE

Response is through json and the response is as follows

{[

“Success” :” true”

]

}

b) LOGIN

The purpose of the app is to login the user.

a. REQUEST

METHOD	ENDPOINT	REQUEST PARAMETERS
POST	/login.php	email, password

b. RESPONSE

Response is through json and the response is as follows

[

{"name":"test",

"lname":"test",

"emai":"test@gmail.com",

"userid":"3"}]

c) CREATE PLAN

The purpose is to create plans for the user so as to set objectives.

a. REQUEST

METHOD	ENDPOINT	REQUEST PARAMETERS
POST	/createplan.php	objective, bmi

b. RESPONSE

Response is through json and the response is as follows

[{

“Success” :” true”

}}

d) GET PLAN

The purpose is to get the plans that is associated with the user.

a. REQUEST

METHOD	ENDPOINT	REQUEST PARAMETERS
GET	/getplans.php	Email

b. RESPONSE

Response is through json and the sample response is as follows

[{"planid":"1","objective":"weight","bmi":"normal"},{"planid":"2","objective":"weight","bmi":"normal"},{"planid":"3","objective":"building","bmi":"normal"}]

e) GET PLAN DIET

The purpose is to get the specific date and diet that is associated with the user plan.

a. REQUEST

METHOD	ENDPOINT	REQUEST PARAMETERS
GET	/ getplancontentsdiet.php	Planid, day

b. RESPONSE

Response is through json and the sample response is as follows

[{"mealname":"Oatmeal","quantity":"small bowl","optiontype":"1","mealtype":"1"},{"mealname":"eggwhites","quantity":"4","optiontype":"1","mealtype":"1"},{"mealname":"Apple","quantity":"1","optiontype":"1","mealtype":"1"},{"mealname":"Almonds","quantity":"","optiontype":"1","mealtype":"1"},{"mealname":"Ugali","quantity":"","optiontype":"1","mealtype

":"2"},{"mealname":"Chicken","quantity":"","optiontype":"1","mealtype":"2"},{"mealname":"Kale","quantity":"","optiontype":"1","mealtype":"2"},{"mealname":"Banana","quantity":"","optiontype":"1","mealtype":"2"},{"mealname":"Brown rice","quantity":"","optiontype":"1","mealtype":"3"},{"mealname":"Salmon \/fish fillet","quantity":"","optiontype":"1","mealtype":"3"},{"mealname":"Chia seeds","quantity":"","optiontype":"1","mealtype":"3"},{"mealname":"cucumber","quantity":"","optiontype":"1","mealtype":"3"}]

f) GET PLAN EXERCISE

The purpose is to get the specific date and exercise plan that is associated with the user plan.

c. REQUEST

METHOD	ENDPOINT	REQUEST PARAMETERS
GET	/ getplancontentsdiet.php	Planid, day

d. RESPONSE

Response is through json and the sample response is as follows

[{"exercise":"Leg Extension","sets":"3","reps":"15","videolink":"","day":"1"},{"exercise":"Leg Extension","sets":"3","reps":"15","videolink":"","day":"1"},{"exercise":"Leg Press","sets":"3","reps":"12","videolink":"","day":"1"},{"exercise":"Barbell Squat","sets":"3","reps":"10","videolink":"","day":"1"},{"exercise":"Stiff Legged Deadlift","sets":"3","reps":"10","videolink":"","day":"1"},{"exercise":"Lunges","sets":"3","reps":"12","videolink":"","day":"1"},{"exercise":"Leg curls","sets":"3","reps":"15","videolink":"","day":"1"},{"exercise":"Seated calf raise","sets":"3","reps":"15","videolink":"","day":"1"}]

g) GET BMI

The purpose is to get the specific BMI result.

e. REQUEST

METHOD	ENDPOINT	REQUEST PARAMETERS
GET	/ bmicalculator.php	Weight, height

f. RESPONSE

Response is through json and the sample response is as follows

[{"result":"1"}]

5.5 FireBase Implementation

To fulfill the requirement of messaging with the users of the mobile application and the motivational messaging firebase tool by google was used. The firebase tool allows for messaging to be set from the firebase portal and the messages sent to installed mobile applications. Once the message is set in the portal as shown below.

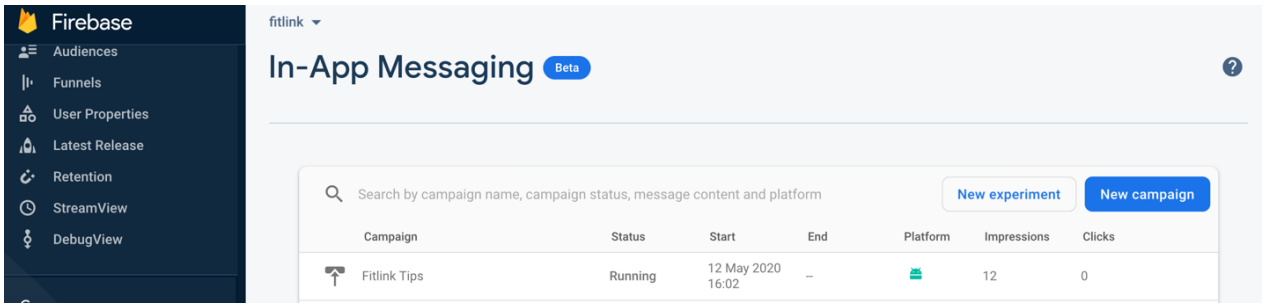
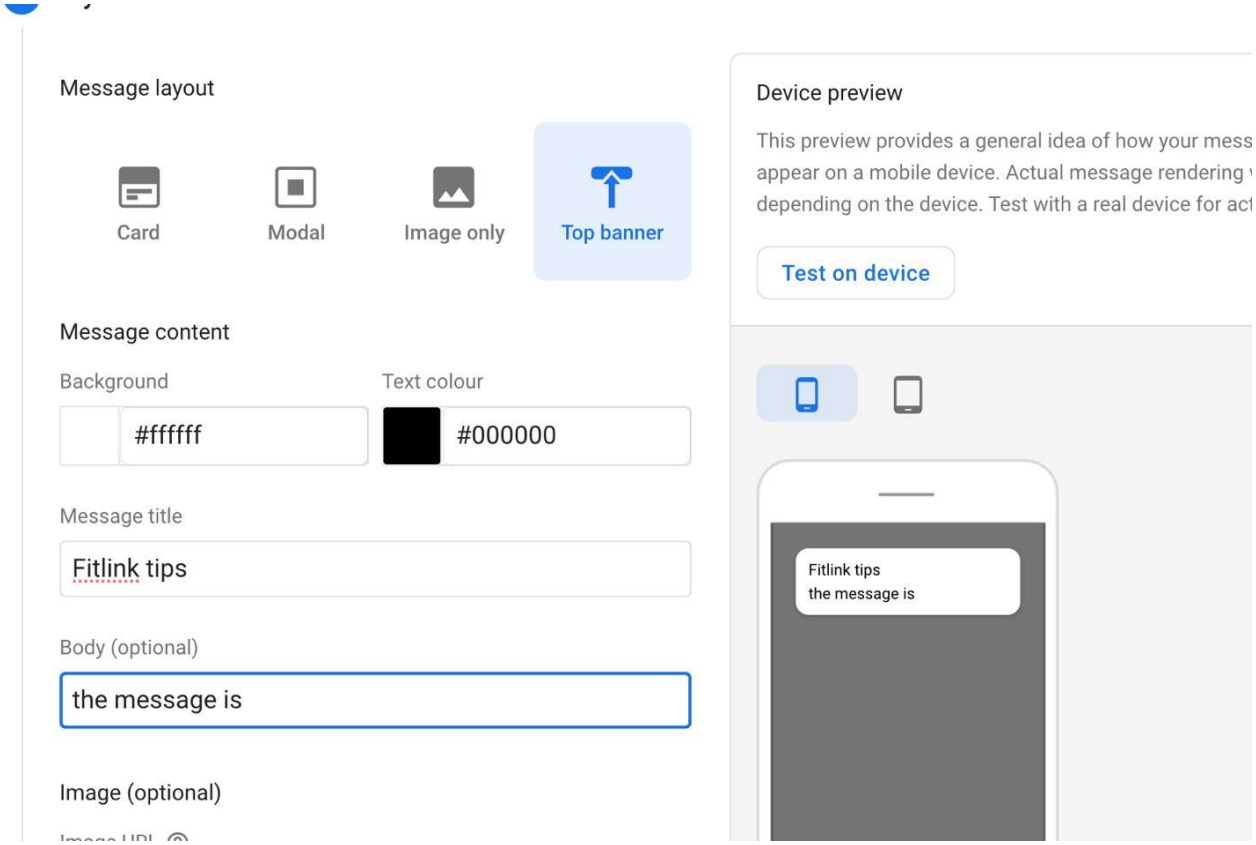


Figure 31: Firebase Messaging console

Once the message text is entered as shown below the portal can set the number of times the messaging is to be shown on users phones and devices.



And it appears on the user's application as depicted above.

5.6 Testing and Evaluation.

Testing of developed software applications is important in ensuring functionality and quality of the system is achieved . In this study, several tests were conducted on the developed prototype at different stages of the development cycle.

5.6.1 Unit testing

This test was conducted during the development of the business logic code. The constituent fragments of codes were tested separately to ensure that they worked as expected with no errors. The results of the code fragments written during the development were successful.

5.6.2 Functional Testing

Functional tests were conducted after the developed prototype had been completed with an aim of validating that the application behaves as expected and thus meets the functional requirements. Following is a sample of select test cases that were conducted to test the different functionalities of FitLink.

Case Identity:	**Client Registration**	**Test serial Number:**	001
Test Narrative	Testing the process of registering a new user		
Pre-conditions	The client has downloaded and installed the mobile application to their android cellphone		
Procedure	Action	Anticipated Response	Result
A	User clicks on sign up button	Client is directed to Sign up page	Passed
B	Client enters required details	Button becomes active	Passed
C	upon successful registration user is notified	The application navigates to the logging page	Passed
Post Condition	Registered User		

Figure 32: Test case

The functional tests that were successfully conducted included user Registration, User Login, Exercise view as well as Diet View.

5.6.3 Usability Test

In this study a usability test was carried out upon the completion of the developed prototype. A quantitative survey was conducted using different metrics to determine the usability of Fitlink. The details of the test are discussed in section 6.2 of chapter six

CHAPTER 6

6.0 Results, Data Analysis and Interpretation

6.1 Introduction

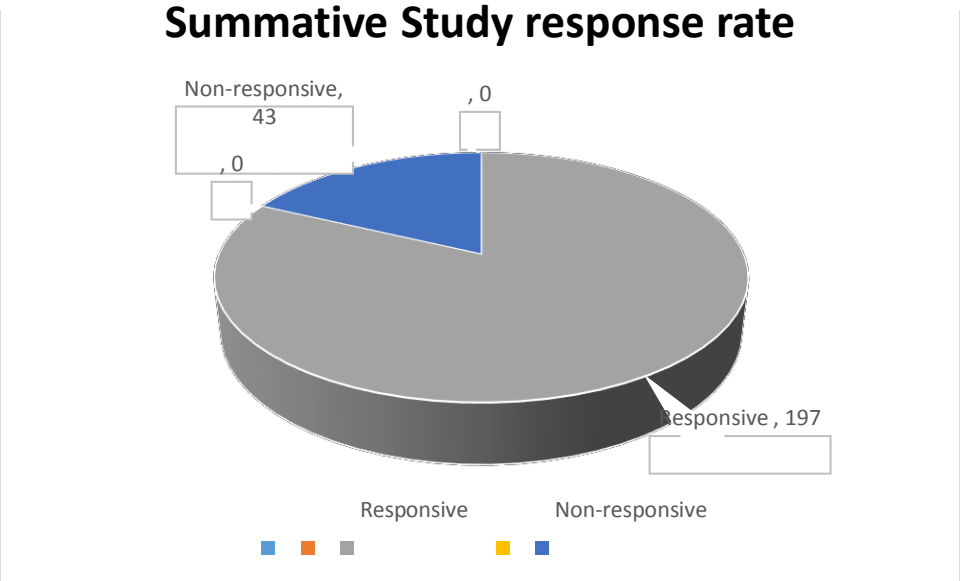
This chapter confers the results of a summative evaluation study of the developed application prototype. The objectives of the study were to develop a fitness and diet mobile application, to provide a cost effective health content delivery mechanism and to evaluate the developed prototype. Data was collected from respondents who are fitness and health enthusiasts from eight gymnasiums located in Nairobi as discussed in the research methodology section. Also presented in this section is a statistical analysis of the data and how it correlates with the objectives and conceptual model of this study.

6.2 Research findings

A summative survey to evaluate the developed prototype had its basis on the Nielsen's usability model which encompasses user satisfaction, learnability, efficiency, error detection and memorability

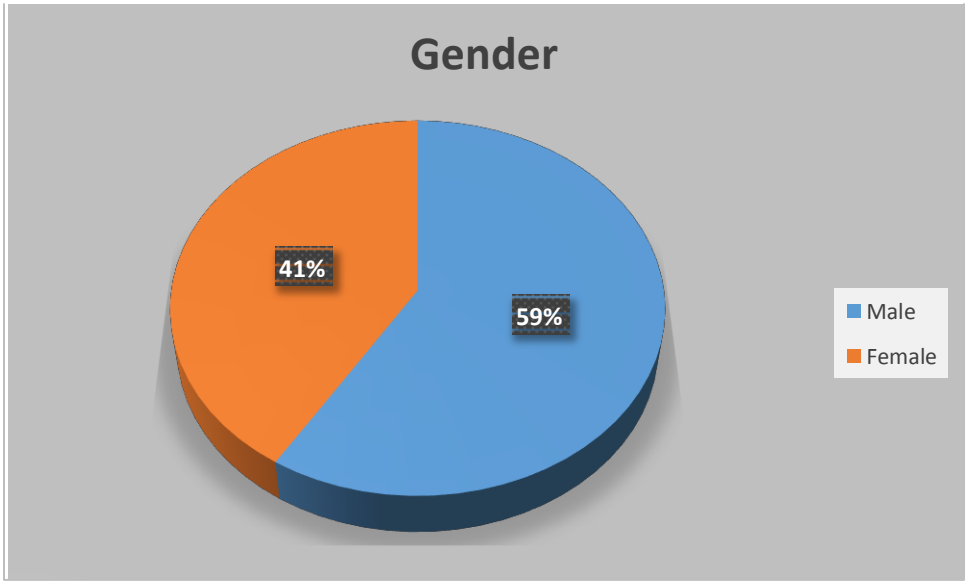
6.2.1 Response Profile

A total of 240 invitations to the survey were sent whereby links to the prototype and the google form based questionnaire were shared with the prospective study subjects. 197 responses were achieved giving a response rate of 82% which according to mugenda and mugenda (2003) is very good as it is above 70%.



The good response rate is attributed to the study's target population being homogenous in nature as well as the rise in quest for remote fitness and health consultation which has been occasioned by the current covid-19 pandemic.

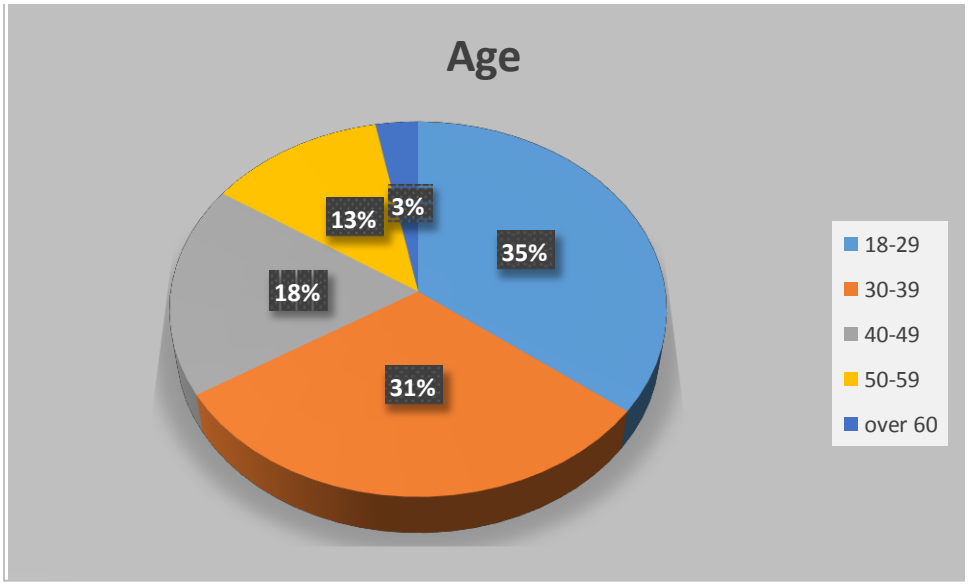
Gender Distribution:



In the study 59% of the respondents were male compared to 41% female.

Age Distribution:

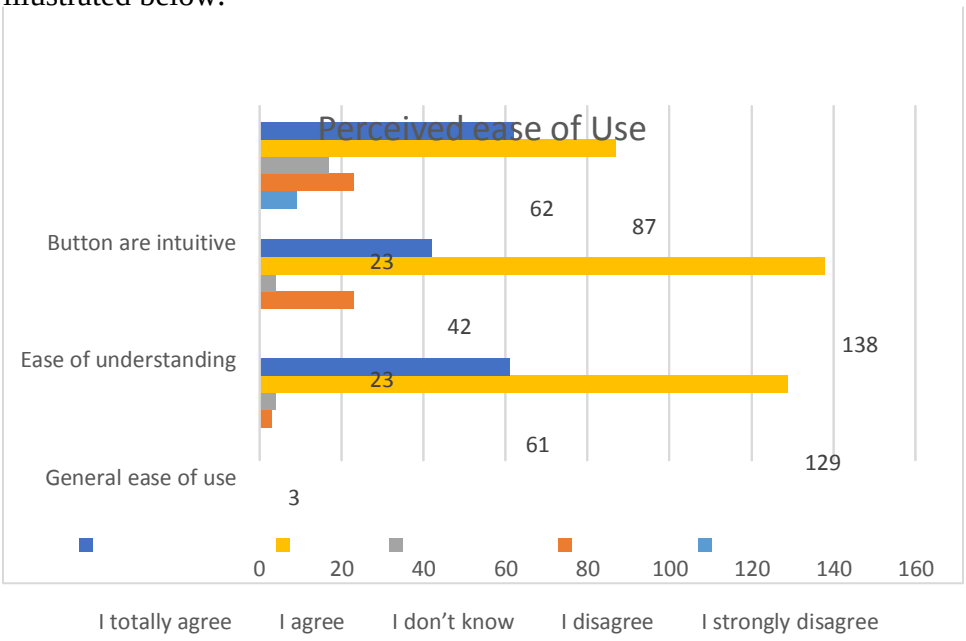
The age range of the respondents is as illustrated in the figure below.



6.2.2 Perceived ease of use

The respondents' opinion on the prototype's learnability was sought through questions on general ease of use, ease of understanding the application and navigation in the application. The results were as

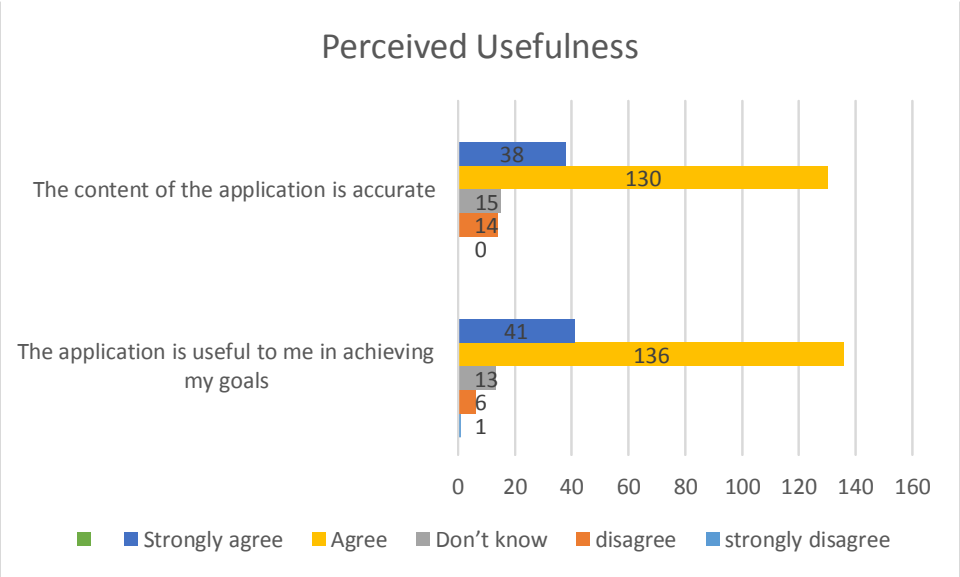
illustrated below.



From the depicted presentation, the three metrics chosen being buttons being intuitive for navigation, ease of understanding it is clear that majority of the users found the application to be easy to use.

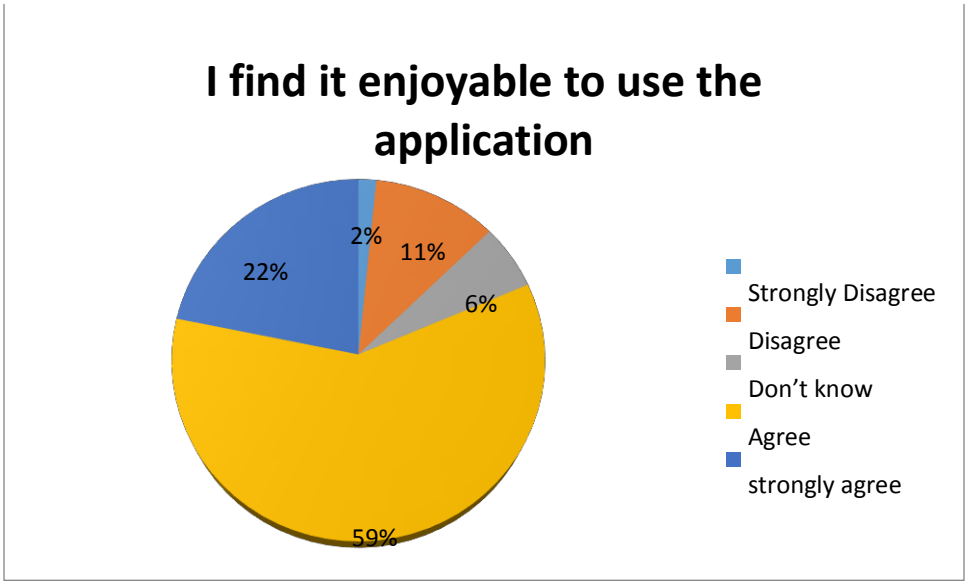
6.2.3 Perceived usefulness

The perceived usefulness of the application was captured by soliciting responses on relevance of the application and perceived accuracy of the content. The general opinion of this survey's subjects was that the developed application is useful as depicted below.

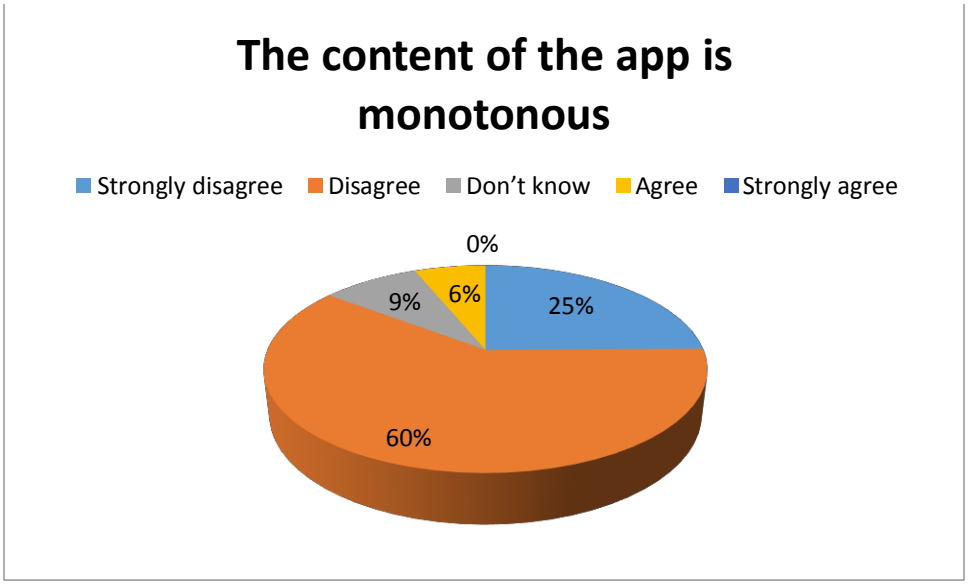


6.2.4 Perceived User satisfaction.

The metrics for measuring user satisfaction were the users' delight in using the application and their perception of monotony of the applications content. The results are as illustrated in the following figures.



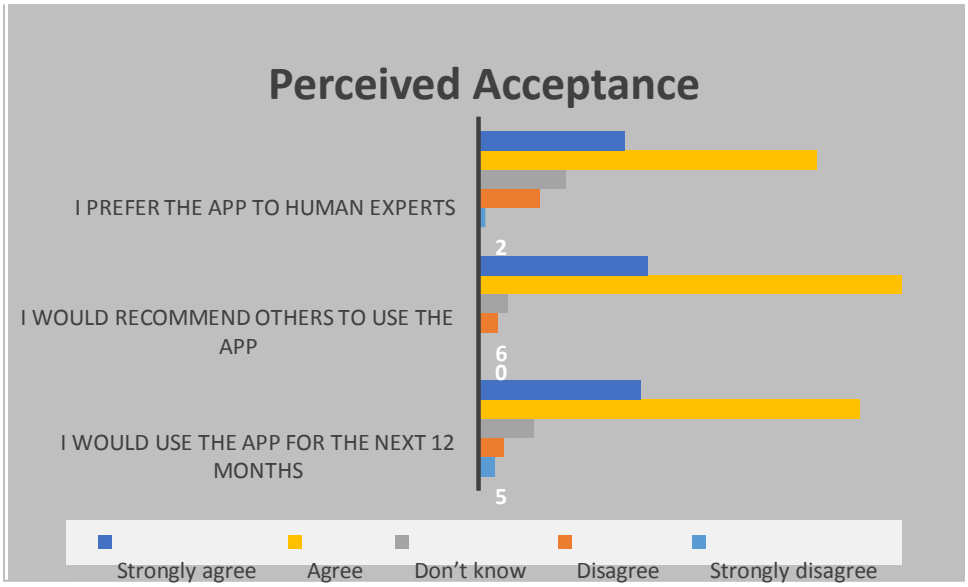
Over 80% of the respondents found using the application to be enjoyable, an indication of satisfaction according to Nielsen's usability model.



According to the survey only 6% of the respondents found the application to be monotous implying that the majority formed by 85% of the total respondents were satisfied.

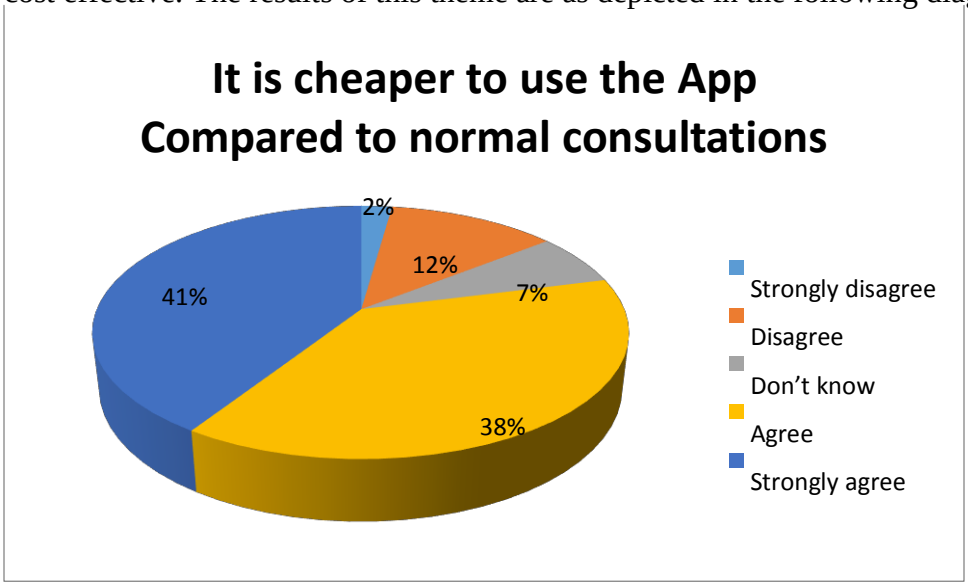
6.2.5 Perceived Acceptance

In determining the perceived acceptance of the developed prototype, questions on intent to use the application for 12 months, recommending the application to others and preference of the App to human experts were posed. The outcome of the study shows a general acceptance of the application as evidenced by the figure below.



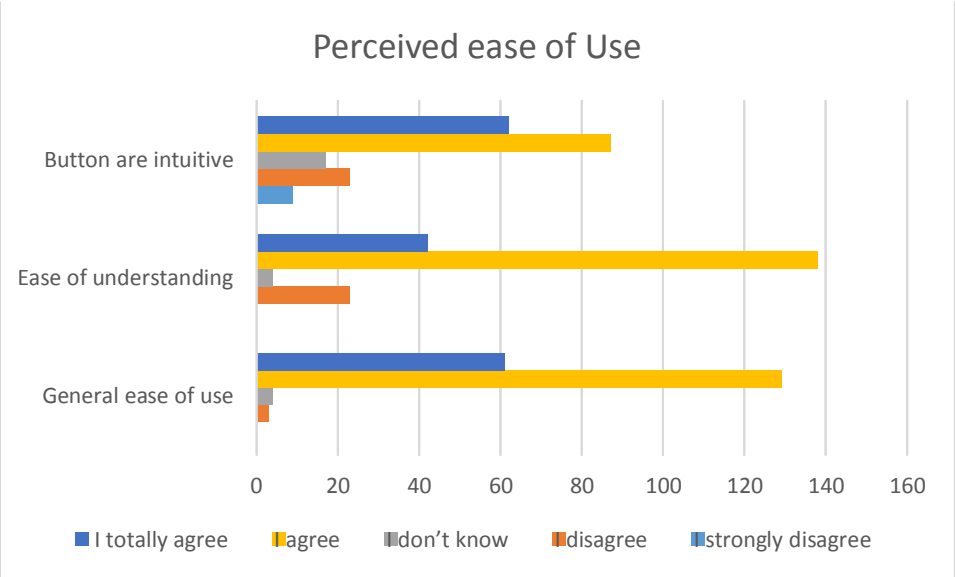
6.2.6 Perceived Cost effectiveness

The respondents were asked for view on whether they find the developed application as being comparatively cheaper to seeking physically seeking human experts services. The responses were overwhelmingly positive with a very small percentage of the respondents disagreeing that the App is cost effective. The results of this theme are as depicted in the following diagram.

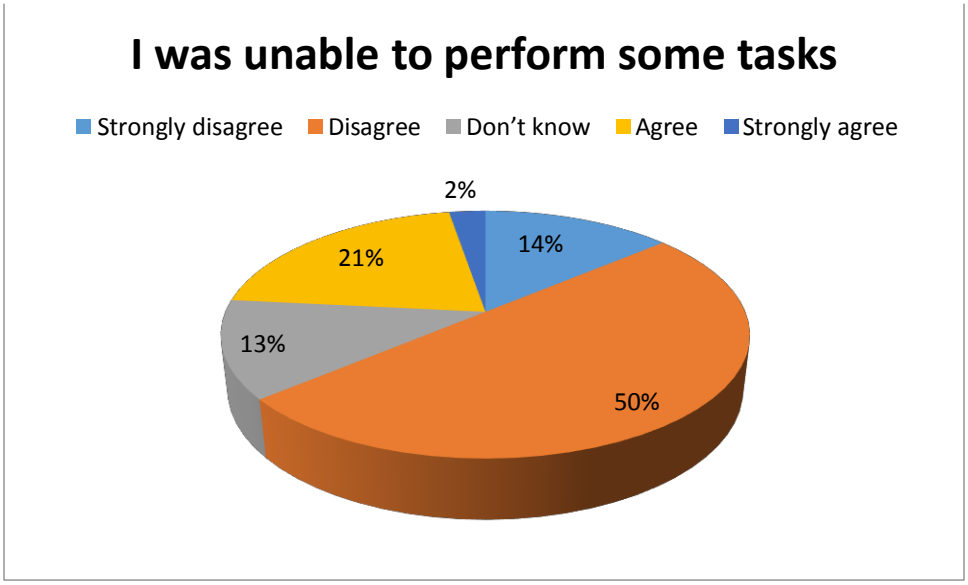


6.2.7 Overall Performance.

The overall performance of the prototype was determined by comparing the following parameters; ease of use, responsiveness, Navigation, completion of a task and enjoyabilty of the user interface. The results as presented below indicate that the overall performance of the developed application is satisfactory.



The metrics used were button being intuitive, ease of understanding and general ease of use of the application.



About 22% of the respondents were unable to perform some tasks on the application, while 50% of the total number of respondents disagreed with the claim.

6.2.8 Respondents recommendations

This study's online questionnaire had a provision for remarks from the respondents in regard to the developed prototype. Following is a select listing of the commendations that emerged from the respondents summative study.

Rec	**Recommendation / Comment**
Rc1	”There seems to be an error in accessing the exercises,yoga or the message instructor.”
Rc2	“I think it would be better for the user if there were workouts they can do at home, with minimal to zero equipment”
Rc3	“home exercises especially during this covid-19 period would go a long way to help many”
Rc4	“consider incorporating music playlist and nutritional supplements links”
Rc5	“It would be best to have more instructional videos”
Rc6	“Why not add levels so that you can accomodate begginers intermediate levels and advanced levels including trainers”
Rc7	” consider extending the same app to iPhone users”
Rc8	“Get and use more of the local content in terms of exercise and a wider variety of foods”
Rc9	“ Technique in power lifting is not there otherwise it is a good app”
Rc10	“A we ll thought idea if implemented fully. Can you include healthy food recipes alongside the diet plans?”
Rc11	“ Add more features like shopping for sports wear and supplements”
Rc12	” thank you for the amazing application”
Rc13	“When is thefull app being released to consumers?”

6.3 Data Interpretation.

6.3.1 Assessment of research Objectives in relation to the Developed Prototype

The stated research objectives provided a framework within which the development of the prototype took place.

The first objective was to design and develop an integrated fitness and diet mobile application prototype using the appropriate technologies. This objective was achieved by conducting an expert interview to gather user requirements in line with the objectives, modeling the conceptual model, designing the architecture and finally implementing the design using design science research metholodology. The developed artefact demonstrated a unified system to address the identified research problem of the study.

The second objective was to provide a cost effective and effecient health content delivery mechanism to the users of the application. This objective was to a great extent achieved through the integration of a firebase cloud messaging (FCM) solution to the mobile application. FCM provided for health tips push notifications which were received on the registered users' mobile devices. The second channel of communication between users and human experts was not fully realized as a result of underestimated project schedule in relation to the scope.

The third objective of the study which was to evaluate and validate performance of the developed prototype was successfully achieved. Unit tests, functional test and usability tests were conducted to evaluate the application. Performance of FitLink was satisfactory and user acceptance metrics from the usability test carried out indicate that solution was by generalization accepted in fitness spheres

CHAPTER 7

7.0 Discussion, Recommendations and Conclusions

7.1 Introduction

This chapter discusses the results of the survey in summary, recommendations and conclusion based on the objectives of the study. Challenges that emerged during the research and their mitigations where possible are also be presented in this section

7.2 Discussion

This study sought to develop an integrated fitness and diet application as an enhanced intervention for lifestyle related diseases. The specific objectives were to develop an integrated fitness and diet mobile application, to provide a cost effective means of health promotion and to evaluate the developed prototype.

Lately, Increase in internet speed, pervasive nature of smartphones and the proliferation of mobile applications intended for a diverse array of uses all have led to the development of fitness and diet apps. Of the developed applications, very few are unified to provide a comprehensive solution to those who are in quest for fitness and health lifestyles.

The proposed solution was aimed at bridging the aforementioned gap whereby an integrated application with a wide range of exercises and diet plans was to be developed. This approach was used as a means to enhance acceptance and eventually adherence on the use of the application. The prototype was developed using design science research methodology which requires a problem to b addressed by providing a recommendation or developing an artifact. Considering the conducted application's survey, it is evident that the study's objectives were achieved.

7.2.1 Challenges encountered

The study was conducted during the period of covid -19 pandemic and with the government's directives to observe social distancing and a ban on sporting activities, it was difficult to access the target subjects of the study since the gymnasiums were closed to the public. This was however mitigated by the use of whatsap communication whereby the gym members in various whatsap groups for different gyms were reached.

Generation of local content for the app in form of instructional videos was not achieved as the health club facilities were not accessible.

The subjects in this study were individuals who are already fitness conscious and are active in their quest for a healthy lifestyle thus their opinion could have a different perception on the research topic compared to the broader population. In mitigation a large sample size of 197 respondents was used in evaluation of the developed prototype.

In spite of the aforementioned limitations, this study provides a framework for future research on amalgamated fitness and diet mobile applications in an effort to curb lifestyle diseases specifically by inspiring the app users to change their sedentary and improper eating habits.

7.3 Recommendations

The main objective of the study was to design and develop an integrated fitness and diet application. The following findings are based on the findings of the summative quantitative study and the literature review.

7.3.1 Inclusion of e-commerce module

The general feeling of the respondents is that the majority were satisfied with the solution, nonetheless, the prototype can be enhanced by incorporating an e-commerce module to cater for the sporting needs of the users such as apparel and sports supplements.

7.3.2 Integration of barcode scanner

Another feature to be incorporated in improving the presented prototype would be incorporation of a barcode reader functionality to enable users shop for healthy foodstuff in the convenient stores. This would involve gathering and populating a database of foodstuff sold in convenient stores where the

application indicates whether the scanned foodstuff is healthy or not.

7.3.3 Mobile health applications and health promotion

For future consideration, a broad spectrum of studies can be drawn from this research depending on areas of interest. Recommendations are made for a study to be carried out on the effect of exercise and improved diet on public officers' productivity and the economy. A nationwide or regional comprehensive study to be carried out in determining the influence of mobile health applications on health promotion.

7.3.4 Exploration of emerging Technologies

The emergence of Artificial Intelligence (AI) presents myriad of opportunities in research on health and fitness related applications or systems. Future research based on this study would enhance the capabilities and efficiency of the prototype to a great extent if a balance of functionality and simplicity is upheld.

7.3.5 Gamification in health behavior change

Prior research has revealed that gamification greatly motivates app users especially the youth as evidenced by the use of avators in Apps like Nike app to invoke behavior change and subsequently achieving and maintain health.

7.3.6 Upholding of Apps Quality

Lately, mHealth applications have been mushrooming at an alarming rate as developers try to outdo each other in tapping into the multimillion fitness industry; consequently, quality in many instances is compromised. It is recommended that inclusion of fitness and diet experts in the development process be adhered to so as to ensure authenticity of content. A balance in additional functionality and simplistic design principles should be observed while developing the fitness and diet applications.

7.4 Conclusions

The focus of the study was on a unified fitness and diet application which was developed following a design Science and research methodology. The study was founded upon prior studies on fitness and diet mobile applications, exercise and diet, health promotion all within the context of lifestyle disease intervention. The DSRM being rigorous in nature addressed the identified problem by offering an artefact as a solution as well as contributing to the knowledgebase of helping curb lifestyle diseases.

Considering the study's objectives and the conceptual model, It would be suffice to state that this study successfully presented a clear picture of leveraging mobile applications, pervasive distributed technologies, web-services, exercise and nutrition content in effectively promoting health. Comprehensive diet and fitness applications can play an immense role in effectively promoting health to a wider population by helping users achieve their individual objectives such as weight loss, general well-being or muscle building.

With Information Technology being highly dynamic it is clear that numerous opportunities exist for future research on fitness and diet mobile applications as a globally accepted intervention mechanism for lifestyle related diseases.

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APPENDIX A

User Requirements/Expert Interview

Interviewer: Eliud Ayiro

Interviewee:_____

Date:_____

Questions

1. What is your area of expertise?
2. For how long have you worked in your field of profession?
3. What are the main goals for the people in quest for a healthy lifestyle?
4. What are the main challenges that fitness enthusiasts face in meeting their objectives?
5. What is your view on why people do not not adhere to a proposed exercise regimen or diet plan?
6. What are the most effective exercises/diet for muscle hypertrophy and weight loss?
7. How do you continually motivate your clientele?
8. How do you keep track of your clients' progress record?
9. When and how often do you find it appropriate to change your exercise/diet plan?
10. Have you ever used a fitness or diet mobile application? If so what challenges did you observe?
11. Can you recommend your clients to use a mobile application as a secondary source of guidance?
12. Many people are not able to afford regular fitness and diet consultations, what is your view in making it affordable to a bigger population?

APPENDIX B

Summative Evaluation Survey

Integrated Fitness and Diet App-FitLink

You are invited to fill this survey for the purpose of evaluating a fitness and diet mobile application prototype which is aimed at preventing lifestyle diseases and thus promoting health. Your Valuable feedback will contribute in improving the application.

Gender

- Female
- Male

Age

- 18 - 29
- 30 - 39
- 40 - 49
- 50 - 59
- above 60

My Fitness Objective

- Weight Loss
- Bodybuilding
- Strength Training/power-lifting
- General wellness
- Rehabilitation/Physiotherapy

Gym Location

- Northern Zone (Parklands, muthaiga, thika road , westlands)
- Eastern Zone (eastlands Embakasi)
- Southern Zone (mombasa road, South B/C, Lang'ata)
- Western Zone (Karen, Ngong rd, kawangware, Kilimani)
- Other Zone

App Experience

The application is useful to me in achieving my goals

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

The content of the application is accurate

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

The provided information by the app is easy to understand.

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

The Application is generally easy to use

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

I find it enjoyable to use the application

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

I was unable to perform some tasks

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

The application was slow

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

The content of the app is monotonous

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

The functional buttons were intuitive

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

Influence

I would use the App for the next 12 months

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

I would recommend others to use the App

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

I prefer the App to human experts

- I totally disagree
- I disagree

- I dont know
- I agree
- I totally agree

It is cheaper to use the App compared to normal consultations,

- I totally disagree
- I disagree
- I dont know
- I agree
- I totally agree

Please make your comments (if any)

Your answer

APPENDIX C

Sample Codes

Register:

```
/**
 * Created by PhpStorm.
 * User: mac
 * Date: 2/29/20
 * Time: 1:32 PM
 */


if($_SERVER['REQUEST_METHOD']=='POST'){
    $name = $_POST['fname'];
    $lname = $_POST['lname'];
    $password = $_POST['password'];
    $email = $_POST['email'];

    require_once('dbConnect.php');


    $sql3 = "SELECT * FROM user_tbl where email = '$email'";
    $mpy = mysqli_query($con, $sql3);
    $count = mysqli_num_rows($mpy);

    if($count!=0)
    {
        echo 'error';

    }
    else {
        $sql = "INSERT INTO user_tbl(userid, f_name, l_name, email, password)
VALUES
      ('', '$name', '$lname', '$email', '$password')";


        if(mysqli_query($con, $sql)){
            $sql4 = "SELECT * from user_tbl where email='$email'";
            $test = mysqli_query($con, $sql4);
            $res = mysqli_fetch_array($test);
            $result = array();

            array_push($result,array(
                    "name"=>$res['f_name'],
                    "lname"=>$res['l_name'],
                    "emai"=>$res['email']

                )
            );

            try{
                $subjectmail = "MESSAGE RECEIVED";
```

```
                $messagemail = "Hello ,\n\n Welcome fitlink \n\n  Regards,\nfitlink
Team.";
                $frommail = "support@fitlink.com";
                $headersmail = "From:" . $from;

                mail($email,$subjectmail,$messagemail,$headersmail);
            }catch(Exception $e){

            }

          //  echo "success";
            echo json_encode(array("success"=>"true"));


        }else{

            echo 'error';
        }

        mysqli_close($con);

    }
}else{
    echo "Error";
}
```

Get Plans

```
<?php
/**
 * Created by PhpStorm.
 * User: mac
 * Date: 5/6/20
 * Time: 8:48 PM
 */

//importing dbConnect.php script
require_once('dbConnect.php');

//Getting values
$username = $_GET['email'];

$sql = "SELECT userid FROM user_tbl where email = '$username'";
$result = mysqli_query($con, $sql);
$tibim=mysqli_fetch_assoc($result);
$id = $tibim['userid'];

$sql3 = "SELECT * FROM fitnessplan_tbl where userid = '$id'";
$mpy1 = mysqli_query($con, $sql3);

$res = array();
//$isset = mysqli_fetch_array($mpy1) or die(mysqli_error($con));

while($row = mysqli_fetch_array($mpy1)) {

    array_push($res, array(
            "planid"=>$row['planid'],
            "objective"=>$row['objective'],
            "bmi"=>$row['bmi']
        )
```

```
    );

}
echo json_encode($res);


//****check the data from other get cards functions

mysqli_close($con);

//*******************************************//
```

Get plan contents-Diet

```
<?php
/**
 * Created by PhpStorm.
 * User: mac
 * Date: 5/6/20
 * Time: 8:48 PM
 */

//importing dbConnect.php script
require_once('dbConnect.php');

//Getting values
$username = $_GET['email'];

$sql = "SELECT userid FROM user_tbl where email = '$username'";
$result = mysqli_query($con, $sql);
$tibim=mysqli_fetch_assoc($result);
$id = $tibim['userid'];

$sql3 = "SELECT * FROM fitnessplan_tbl where userid = '$id'";
$mpy1 = mysqli_query($con, $sql3);

$res = array();
//$isset = mysqli_fetch_array($mpy1) or die(mysqli_error($con));

while($row = mysqli_fetch_array($mpy1)) {

    array_push($res, array(
            "planid"=>$row['planid'],
            "objective"=>$row['objective'],
            "bmi"=>$row['bmi']
        )
    );

}
echo json_encode($res);


//****check the data from other get cards functions

mysqli_close($con);

//*******************************************//
```