

Evaluation of a Cross Platform Persuasive M-Health App for Body Fitness using Analytic Hierarchy Process.

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Abstract

Persuasive mobile health apps are types of information systems that are aimed at motivating or encouraging people towards a pragmatic approach at an improved quality of life. The app store market is gradually becoming saturated with numerous types of mobile apps and designing apps to be persuasive in nature is a novel way of attracting and encouraging more users to access and use such apps. Hence the main aim of this work is to design a cross platform persuasive mobile health application called StayFit. The app was designed from the extended Persuasive System Design (PSD) model and evaluated using the same model qualitatively. The app was also developed using Cordova platform, Windows Operating System, Android studio, MySQL database, Apache Server, Node.js, PHP, Bootstrap, Phonegap, Apache ANT and jQuery. The work provides an approach for developing cross-platform applications in order to target a wider range of platforms and the mHealth persuasive app developed is able to assist users maintain a healthier lifestyle. The usability of the developed app was compared with existing apps using the Analytic Hierarchy Process (AHP) model. Comparison was done using a group of 5 users with a usability model and evaluated with the AHP-OS. Results of analysis showed that StayFit ranked the highest with 48.4%, MyFitnesPal with 28.7% and Lose It with 23.0% while consolidated group Consistency Ratio was 4.9%. It is recommended for further studies that the app be compared with more apps in its category and evaluated using other Multi Criteria Decision Making (MCDM) techniques. The usability of the app can also be determined using appropriate usability models and techniques.

Keywords: *Persuasive applications, mobile health apps, Analytic Hierarch Process (AHP)*

1.0 Introduction

The influence of technology on humanity is affecting all sectors of human life both public and private, on-line and off-line (Deragon, 2011). The word influence comes under the umbrella of the word persuasion which is an effort to motivate or inspire people's beliefs, thoughts, actions, feelings, motivations, intentions or behaviours (Seiter, Robert & John, 2010). In a scenario where software systems are designed to achieve such purpose, it is termed persuasive technology.

The current upsurge in untimely death and human ravishing sickness as a result of different diseases that can be prevented warrant urgent attention and behavioural change towards a healthier lifestyle by using a more technological and pragmatic approach towards preventing such diseases. Currently, there have been various information systems that have been designed in an attempt at using technology to either control, prevent, monitor or treat diseases such as expert systems, decision support systems and persuasive systems that are aimed at changing people's attitude towards a healthier lifestyle (Chittaro, 2015).

The rise of social web and the use of mobile applications has led to an increase in the way information and knowledge is being shared in innovative ways and this has accelerated the chances

for introducing novel Information Systems (IS) that are aimed at impacting or inspiring potential users (Oinas-Kukkonen, 2010). The benefits of using computers or software as persuasion tools over human-human persuasion has already been highlighted by Fogg (2003) but developing persuasive systems usually put a heavy strain on developers, so design problems ought to be given more care as they pose a major threat, hence, they have real implications because if the systems are not properly designed then the persuasion potential cannot really be achieved. Hence, the focus of this work is to design a persuasive mobile health fitness app called Stayfit and compare its usability with existing apps using the Analytic Hierarchy Process technique, a Multi Criteria Decision Making (MCDM) technique developed by Saaty in the 70's based on mathematical and psychological principles (Saaty, 2008).

2.0 Literature Review

2.1 Conceptual Model for the Mobile Health Application Design

The theoretical framework used in the design of StayFit is an extension of the Persuasive System Design (PSD) model because it is believed that all the 28 design features in the model is essential to the eventual acceptability and usability of PT. The features were embedded in the model as they all aid in the easy identification and categorization of persuasive technologies since it is widely claimed that an element of persuasiveness exist in many application domains.

Oinas-Kukkonen and Harjumaa (2009) analyzed the PSD framework thoroughly in their article on persuasive designs. The seven theories they came up with in other to have a profound idea on the real factors affecting persuasive applications is as a result of their empirical and conceptual analysis and these postulates can as well be applied to other major IS.

The schematic model in Figure 1 gives an extension of the PSD model and proposes how all the concepts involved during the development and effective assessment of persuasive systems are related. The theoretical models imbedded in the extended PSD framework includes the Elaboration Likelihood Model (ELM) which is already in the PSD model, the iterative requirement engineering process model and the MCDM approach for evaluation purposes.

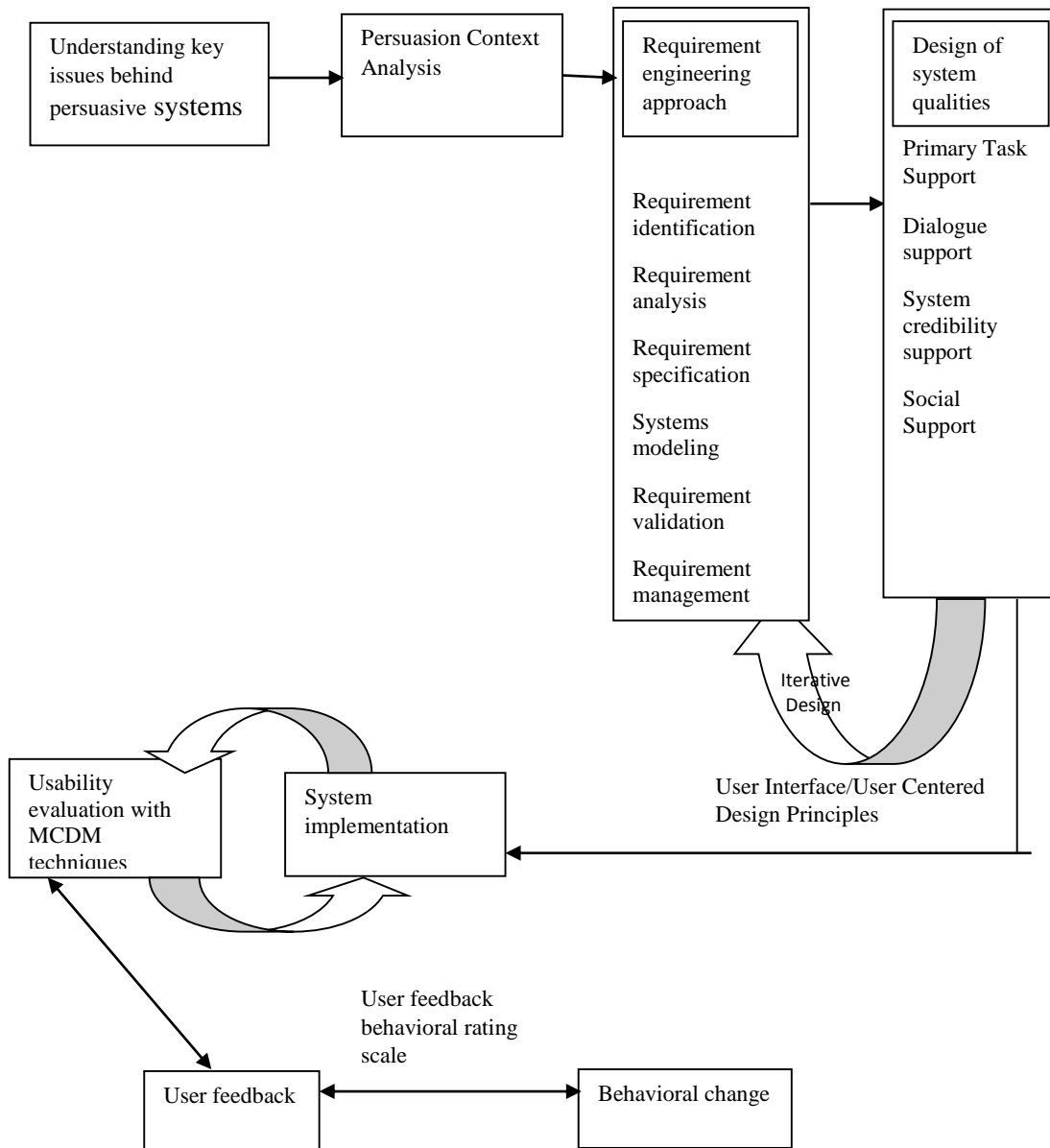


Figure 1: Conceptual Framework for Persuasive Design and Evaluation (Kasali, Awodele, Kuyoro, Akinsanya & Eze, 2017)

In analyzing the persuasion context, users need to have a thorough understanding of what the system is intended to do, what it was designed for, understand the persuasion event and be able to explain or identify the strategy.

Pandey, Suman and Ramani (2010) explained what Requirement Engineering is all about and they gave a detailed summary of each process in their work. They termed Requirement Engineering as “a systematic approach through which the software engineer collects requirements from different sources and implements them into the software development processes”. In trying to design the system requirement, requirement engineering steps should be adhered to as requirement has been identified by various researchers as an important concept for developing high quality software

products (Pandey, 2013). It is also an important phase in any software development (Pandey & Ramani, 2009).

In designing Persuasive Technologies that are meant to be effective, usable and acceptable, users need to be involved at every phase of the developmental process. The suitable way in which such method can be achieved between users and developers is by using the iterative process which allows developers to show results earlier on in the process and obtain essential feedback from system users (Munassar & Govardhan, 2010).

In designing PT design qualities, the persuasive features suggested in the PSD model is of four categories which are primary task, dialogue, system credibility and social support with each one of them having seven design features each making the total design features specified by the PSD model to be twenty eight. It is not mandatory to use all the identified principles but features should be chosen based on the domain of application, criticality of the intent behind the design and the inherent extent of persuasiveness intended by designers.

User interface design principles should be put into consideration at the design phase of PT since the interface is a very vital component in any software design. The interface is the first point of connection for any PT user. This is necessary for increased acceptability and usability by prospective users. In choosing any design principle, it is expedient that it is simple and consistent (Valverde, 2011).

After the first prototype of a persuasive system is designed and implemented, the next is the installation process and an organized set of users to have an initial encounter with using, assessing and identifying all design faults that could be associated with the system and suggestions for improvement in the next prototype design.

Based on users' feedback, extensive usability evaluation in terms of the system effectiveness can be done to further intimate designers on which user friendly and/or usability factors to emphasize more at subsequent prototypes design. In order for persuasive applications usability to be assessed, researchers and persuasive apps enthusiasts make use of various usability models and techniques as widely reviewed by Kasali *et al.* (2019).

2.2 Analytic Hierarchy Process (AHP)

AHP is a useful mathematical technique that is used to solve MCDM problems, where a choice has to be made from a number of alternatives based on their relative importance (Asuquo & Onuodu, 2016). It relies on the judgments of experts to derive priority scales through pairwise comparison of decision elements at each level as shown in Figure 2.

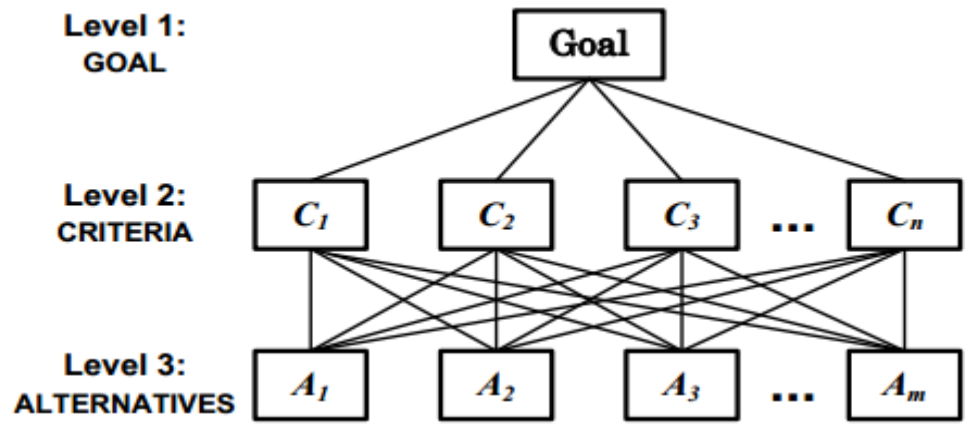


Figure 2: Hierarchical Decision Structure (Bacudio, Esmeria & Promentilla 2016)

It is easy to apply, popular, scalable since it allows for problems to be represented hierarchically. Weighing and comparing alternatives is done easily by decision makers using this approach (Banwet & Majumdar, 2014).

Highlighted are the major procedures involved in AHP technique according to its proponent, Saaty (1980; 2008):

- i. Define the unstructured problem shown in Figure 2.11 which indicates i alternatives and j criteria.
- ii. Construct a set of pair-wise comparison matrices among decision elements i and j by establishing priorities among them based on a preference scale.

Let a_{ij} ($i, j=1, \dots, n$) denote the relative weight of alternative i to j , and $a_{ji} = 1/a_{ij}$, then the corresponding matrix is $n \times n$ matrix (a_{ij}) , where $a_{ii} = 1$ for all $i=1, \dots, n$.

$$A' = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ a_{21} & \dots & a_{ij} & \dots \\ \dots & a_{ji} = 1/a_{ij} & \dots & \dots \\ a_{n1} & \dots & \dots & 1 \end{bmatrix} \quad \text{Equation (2.2)}$$

where a_{ij} is the comparison between element i and j

In forming the pairwise matrix, if a certain criteria or alternative is compared with itself, then the weight given to such comparison will be 1.

Table 1 gives Saaty's 9-point scale for pairwise comparison which is used by experts to explain how an alternative is ranked over the other.

Table 1: Pairwise Comparison Scale (Saaty, 2008)

Saaty's scale	Definiton
1	Two criteria or alternatives have the same level of importance or the same weight
3	A criteria or alternative has a fair chance of being preferred over the other based on decision makers opinion i.e. reasonably important.
5	A decision maker is highly convinced that a criteria or alternative is preferred over the other
7	It is obvious that a criteria clearly dominates the other based on practice and decision makers opinion
9	The proof that a criteria or alternative is favored over the other is of topmost imaginable order and assertion.
2,4,6,8	These are chosen in situations when decision makers opinion about a criteria or alternative being preferred over the other are of average values i. e. when they need to find a middle ground between two criteria or alternatives.
Reciprocals	If a criteria a for example, already has a value ascribed to it when compared with another criteria b, then b automatically has the inverse or reciprocal value when judged with a.
Rational (1.1 – 1.9)	These values are chosen when decision makers find it cumbersome to ascribe the best values in a certain situation but when assessed with criteria that differs, it will not be too obvious to notice the magnitude of the small value but the significant of such criteria can still be known.

A reciprocal matrix A can be developed as shown in equation 1 whose values represent the dominance of *i*th element on *j*th element as shown in equation 1

1. $a_{ij} = 1/a_{ji}$, for $a_{ij} \neq 0$
2. $a_{ij} = 1$ for $i = j$ and $i, j = 1, 2, \dots, n$

- iii. Compute the consistency ratio to determine the acceptability or otherwise of the chosen criteria or alternative. This is given in equation 2.3

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad \text{Equation (2.3)}$$

where *n* is the dimension of the matrix, λ_{\max} is the maximal eigenvalue and *CI* is the Consistency Index. Hence, Consistency Ration $CR = CI/RI$ where *RI* is the Random Index (the average *CI* of 500 randomly filled matrices).

If *CR* is less than 10%, then the matrix can be considered as having an acceptable consistency. Saaty (1977) calculated the random indices as shown in Table 2 for $n \leq 10$ and it is still the most acceptable and widely utilized *RI* Table among AHP researchers.

Table 2: Random Indices (Saaty, 1977)

N	3	4	5	6	7	8	9	10
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

- iv. Estimate the relative weights of the decision elements using eigenvector method. Saaty developed the eigenvalue method in order to synthesize a pairwise comparison matrix A and to obtain a priority vector for several decision criteria and alternatives. Vector of weights is generated as normalized eigen-vector using equation 2.4

$$Aw = \lambda_{\max}w \quad \text{Equation (2.4)}$$
 where λ_{\max} denotes the eigenvalues and relative vector weight is given in equation 2.5

$$w = [w_1 w_2 \dots w_n]^T \quad \text{Equation (2.5)}$$
- v. Aggregate the relative weights: For group decision, numerous researchers usually recommend geometric mean techniques instead of the arithmetic mean (Kardi, 2006) but Wu, Chiang and Lin (2008) also confirmed in their study that using geometric mean for aggregate calculation could be difficult for large number of experts and in this case, the arithmetic mean is suitable.
- vi. Model Synthesis: After the local priorities have been gotten which signifies the preferred choice with respect to each criterion, the overall priority otherwise known as the final priority for each alternative has to be calculated i.e. priorities that takes into consideration not only the preferred choice for each criterion but also the fact that each criterion has a different weight (Mu & Pereyra-Rojas, 2017).
- vii. Sensitivity analysis: This is done to understand how robust, reliable and implementable the final model is (Saaty & Vargas, 2013; Saaty & Daji, 2015). It is achieved by making some changes to the weights of the criterion and determine how they affect the overall priorities of the alternatives.
- viii. Make a final decision after all the steps have been rigorously done by comparing the overall priorities gotten and whether there is any significant difference for a clear choice to be made. It is also required to analyze the result of the sensitivity analysis.

AHP as a MCDM technique is a powerful tool for solving, ranking, selection and comparison problems especially when it relates to decision making but it can only deal with crisp numbers but in reality, decisions take place in situations that cannot be precisely ascertained because of their complex nature.

3.0 Methodology

3.1 Persuasive mHealth Application Architecture Design and Tools

A persuasive mHealth app called StayFit which can promote a healthier lifestyle amongst users was designed using the conceptual framework of the extended PSD model. The major technologies that was used in designing the prototype of the system is the Apache-Cordova; an open source mobile development framework for building cross-platform applications. Other tools used include Node.js; an open source, cross-platform runtime environment for executing JavaScript code server-side and also the platform needed for Cordova development, Cordova is the engine required to convert HTML and Javascript to cross-platform applications, Phonegap; the platform developed

by Adobe for designing cross applications with HTML and Javascript, Android Software Development Kit (SDK); for android platform, Apache ANT; the software tool required for Cordova to run, Bootstrap; framework for designing intuitive web interface and for the backend, MySQL was used for database storage, phpMyadmin serves as the database manager, google Chrome serves the need for web browser and Apache was used as the host server.

Figure 3 depicts the proposed persuasive mHealth application architecture. The web app is the administrator's interface that enables interaction between the administrator and app users. Information which includes users update, feedback information and software upgrade are stored in the online database. If permission is granted by the administrator, some of the information can automatically be synchronized and updated to the mobile app when online.

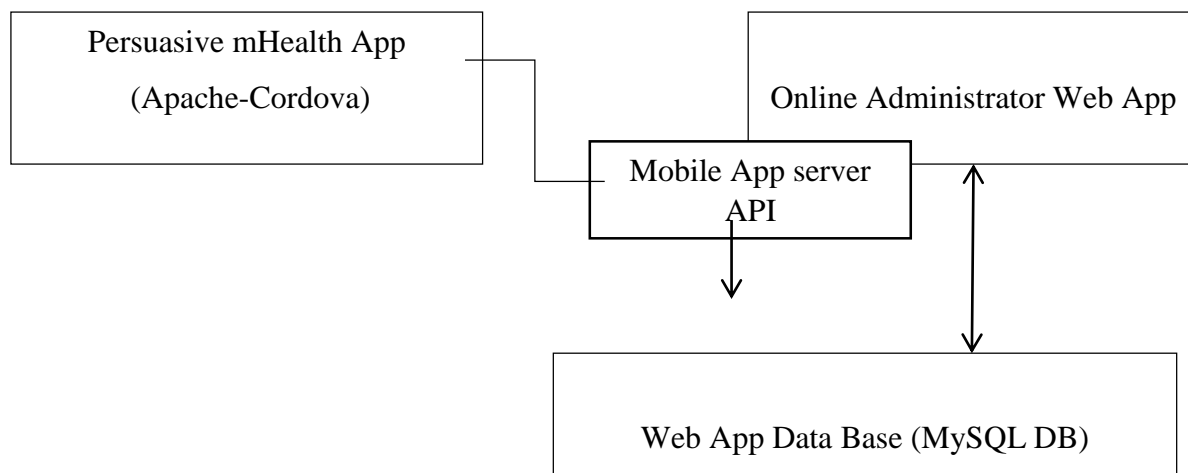


Figure 3: System Architecture for Persuasive mHealth Application

All attributes specified in the usability hierarchical model developed by Kasali et al. (2019) were considered during the app design.

The designed application was compared with MyFitnessPal and Lose It; android mHealth apps found on the Google play store. The apps were selected purposively based on their user ratings and popularity. Both apps were tested using the usability hierarchical model and the alternative with the highest usability score after evaluation was chosen as the app that performed optimally.

3.2 Persuasive Mobile Application Design

StayFit was designed using the extended PSD framework. The iterative software engineering development approach which entails that a part of the application should be specified, implemented and reviewed to identify future needs was also be applied to get reliable feedbacks from users and also detect design faults early (Bhuvaneswari & Prabakaran, 2013).

3.2.1 Functional Requirements

This is used to describe the precise functions or actions of StayFit. The functional requirements for the app are as follows:

- i. The app has a general page in which users can access to get health tips, health check reminders and success stories of former mHealth application users once they download, install it on their mobile devices and are connected to the internet.
- ii. The app has a register page where authorized users can enter their demographic data, check their Body Mass Index (BMI) and Basal Metabolic Rate (BMR) and Total Daily Energy Expenditure (TDEE) values by inputting their body weight (kilogram), height (meters), age (years) and gender.
- iii. The app is able to get feedback from users and automatically generate how many users access the system within a specified period of time.
- iv. The app is able to allow the administrator have unlimited access to the database, send health tips, send latest updates, upgrade the app, update exercises and other necessary information.
- v. The app is able to suggest adequate activity and food choices for users based on their BMI, MBR and TDEE values.

3.2.2 Non-functional Requirements

This describes the app's behaviour as it relates to its functionality. It elaborates the performance characteristics of the app. Most of the non-functional requirements of the system were integrated at each level of the software developmental process. The major non-functional requirement that this work addressed is usability.

3.2.3 User Requirements

The need to know the user requirements is a vital and integral part of information system design which is essential to the success of any persuasive mHealth app. Users need a persuasive mHealth app that will motivate them to exercise more, check their Body Mass Index (BMI), check their Basal Metabolic Rate (BMR), get health tips and basically improve their quality of life without adding any complexity to it. The system was designed to be user centered i.e. factoring users' needs and integrating them at the design phase of the system design process for increased usability. The app was designed to be persuasive and unilingual, English being the language of choice.

3.2.4 Software and Hardware requirements

A smart phone running on any operating system platform is required since the app was designed to be cross-platform. An internet connection is also necessary for the functions of the app to be utilized maximally.

3.3 System Model

The system model was designed to show an abstract representation of how the developed system will look like after implementation. It shows the graphical representation of the functionality of the system which plays a vital role in software development. The system was modelled using flow chart, use case diagram and entity-relation diagram.

3.3.1 Process Flow Chart

The flowchart depicts the algorithmic representation that illustrates a solution model to a given problem. It is mostly used in analysing, designing, documenting or managing a process or programs in various field

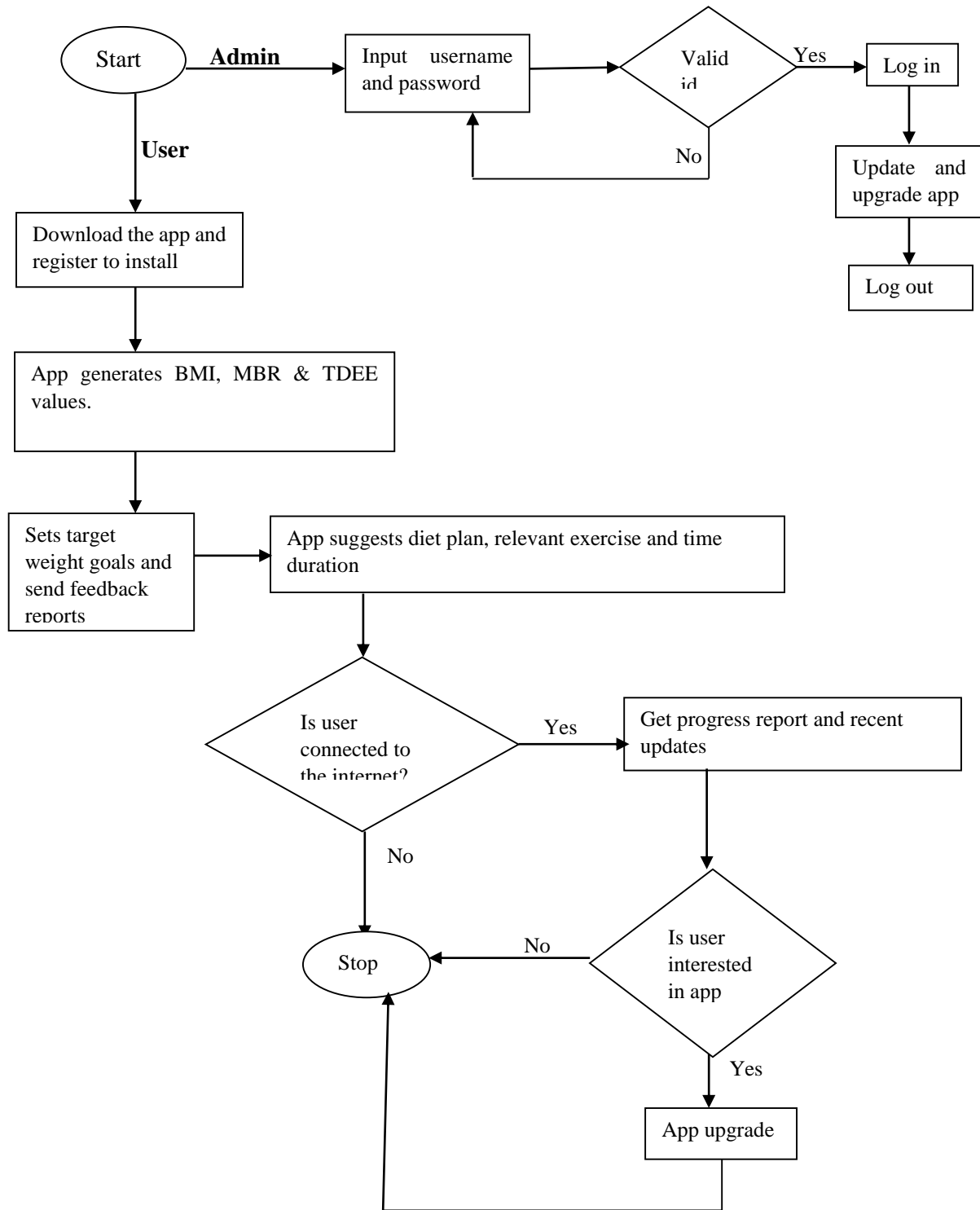


Figure 4: Persuasive mobile app flow chart

Use Case Diagrams

These are diagrams that are used to represent user's interaction with the system. In StayFit, Figure 3.5 and Figure 3.6 depicts the use case diagrams for users and the administrator that has sole access to the database.

Use Case Diagram for User

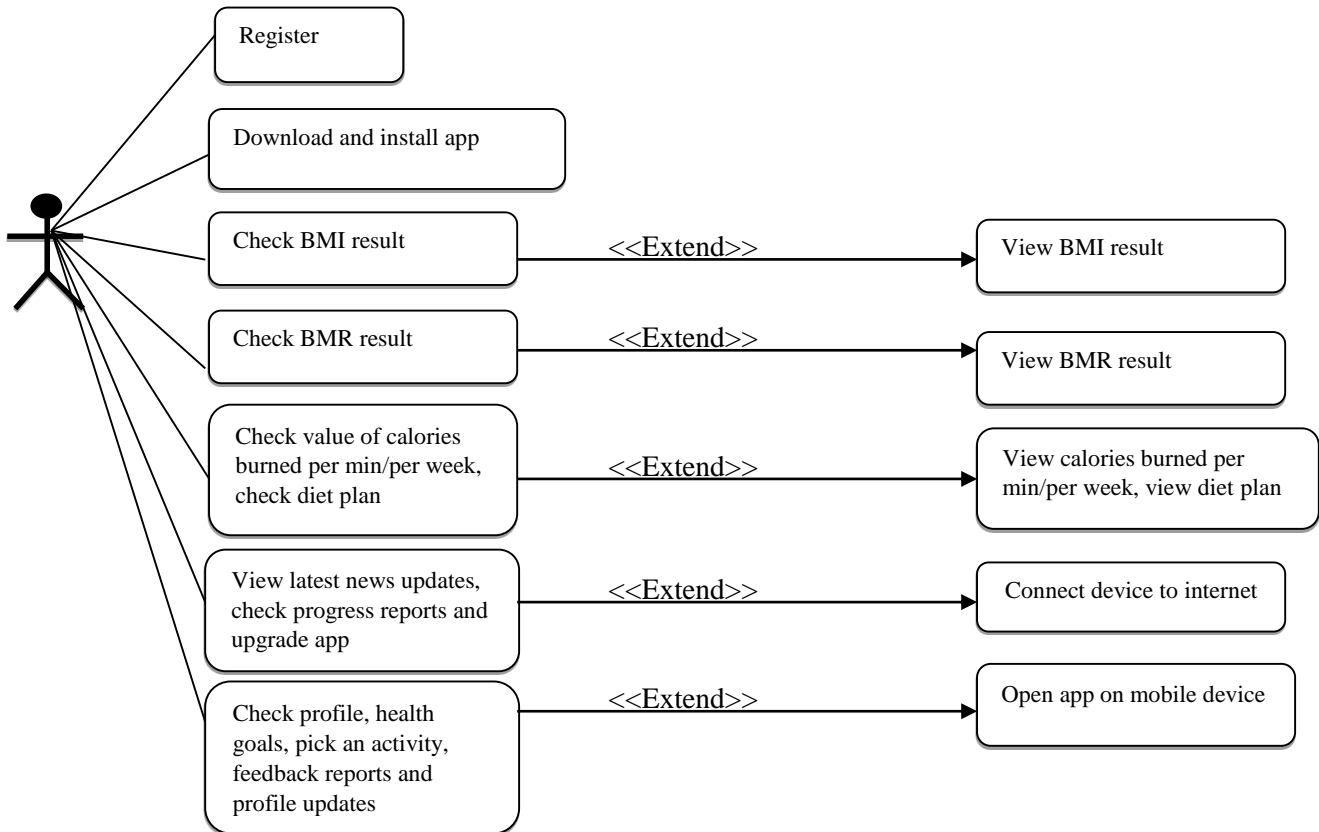


Figure 5: Use case diagram for User

Use Case diagram for Administrator

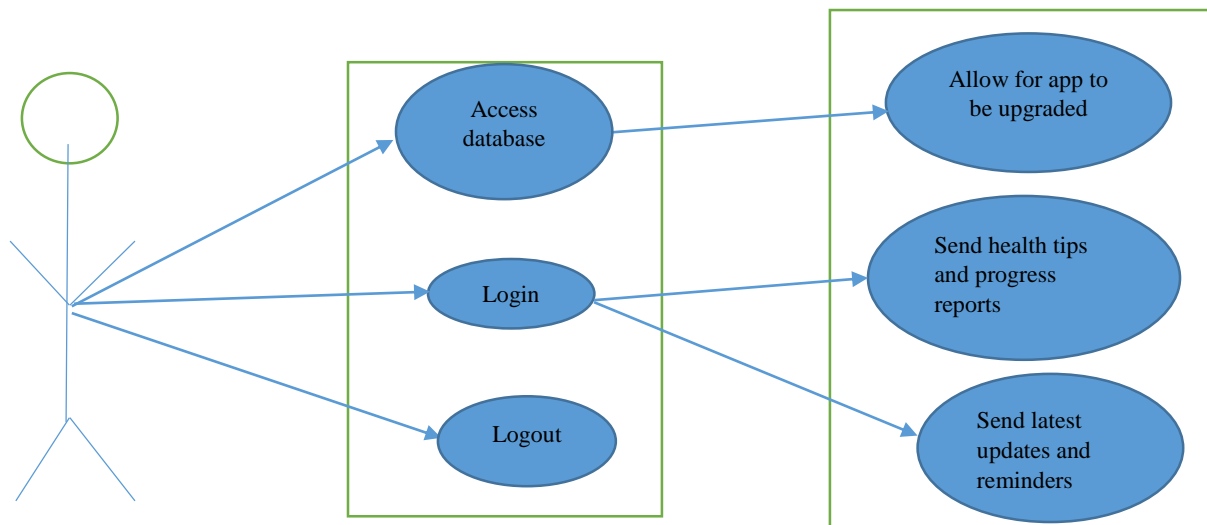


Figure 6: Use case diagram for Administrator

Entity-Relation Diagram

This shows the relationship among different entities in the database.

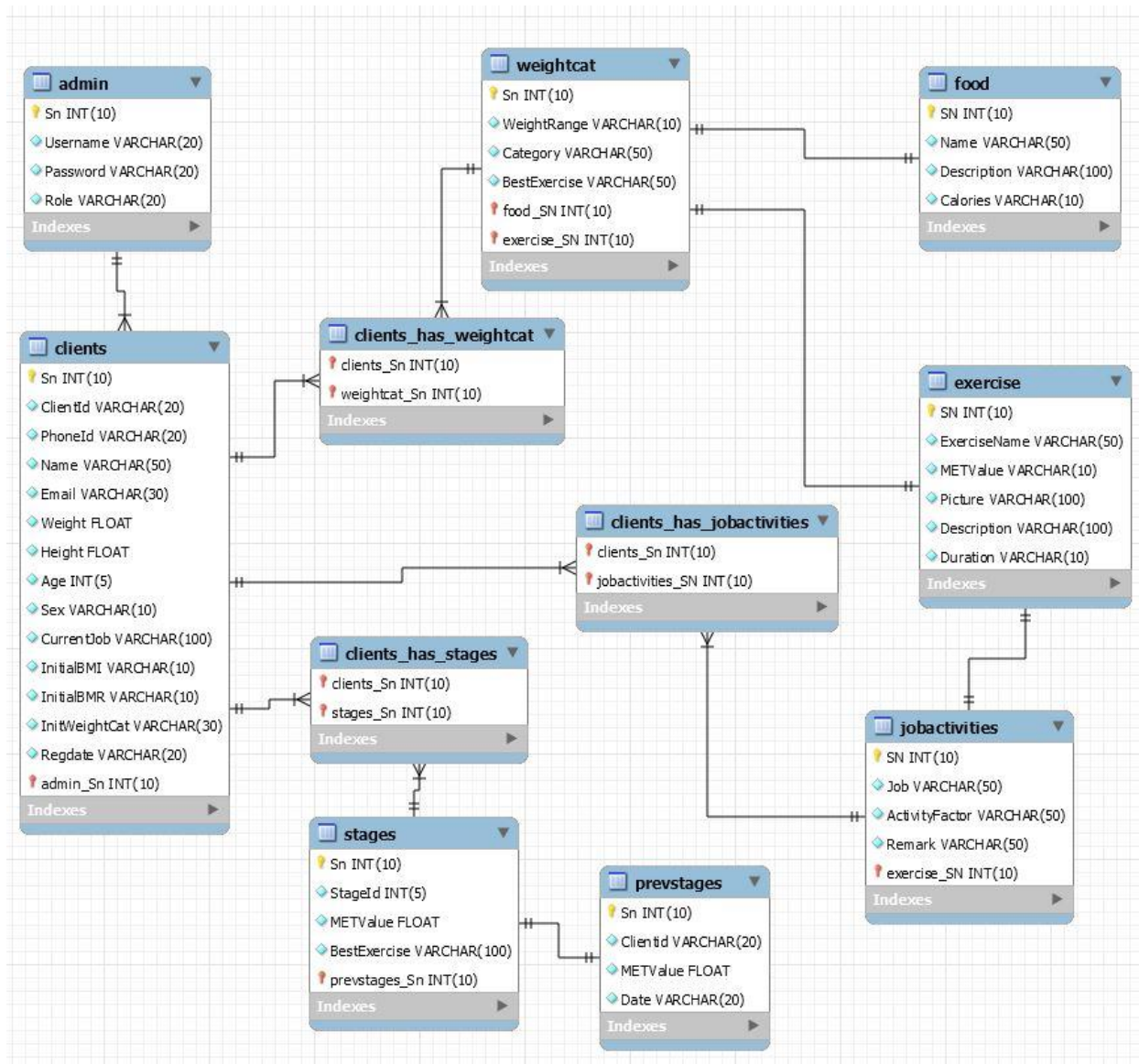


Figure 7: StayFit entity-relation diagram

3.3.2 User Authentication

Once the application has been downloaded and installed on users' mobile devices, they have automatic access into the application since it is assumed that they already have some sort of security measure to check and restrict access to their smart devices.

3.4 StayFit Evaluation and Comparison with Existing mHealth Applications

To evaluate StayFit, a group of users systematically performed cognitive walkthrough by using the attributes specified in the hierarchical usability model to compare it with two other mHealth apps called MyFitnessPal and Lose It. These apps were chosen based on their user ratings, high number of downloads and popularity in the Android play store. The usability model proposed in Kasali et al (2019) used to compare and choose the app that ranked highest based on decision makers opinions. The AHP-OS was used to get crisp values after evaluation. The persuasive

attributes in StayFit were evaluated using the PSD model. A group of five decision makers performed cognitive walkthrough using the attributes specified in the adopted usability hierarchical model. Sample size was determined by using the Problem Discovery Rate (PDR) model that has been widely used by numerous usability researchers (Al Ayubi et. al., 2014). The model estimates that 85% of usability problems will be revealed using five participants, and almost 100% of problems will be revealed using 14 participants (Nielsen & Landauer, 1993; Virzi, 1992).

3.5 Ethical Consideration

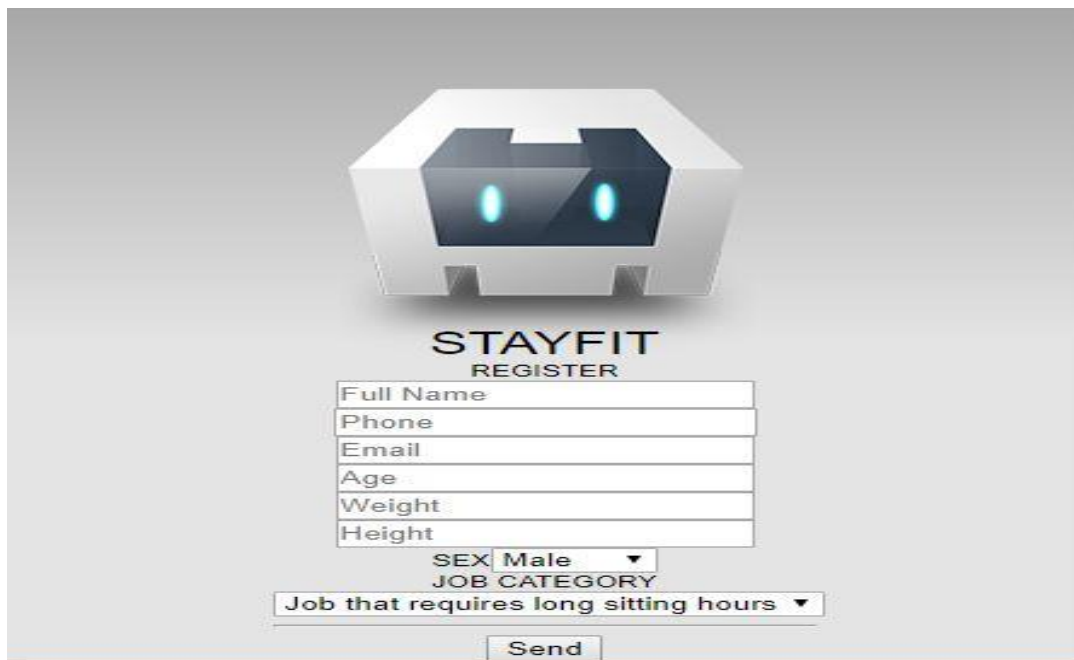
Persuasive system researchers continues to debate heatedly amongst themselves as such systems tends to have a profound effect on peoples nature behaviorally. In the context of this research work, various ethical approaches in designing persuasive technologies have been studied and Berdichevsky and Neuenschwander (1999) eight principles for persuasive technology design was adopted, from which the golden rule is considered the most important which states that “the creators of a persuasive technology should never seek to persuade a person or persons of something they themselves would not consent to be persuaded to do”.

4.0 StayFit Implementation and Results of Analysis

The implementation phase of StayFit covers the period from its design to the deployment of the first prototype.

4.1 Graphical Interface

StayFit was designed to be cross-platform, once a user fills the registration page, download and follow the installation process correctly on a mobile phone, the app is ready for use. Below are some screen shots of StayFit prototype.



The image shows a user registration form for StayFit. At the top, there is a 3D rendering of a white robot head with two glowing blue eyes. Below the robot head, the text "STAYFIT REGISTER" is displayed. The registration form consists of several input fields: "Full Name", "Phone", "Email", "Age", "Weight", and "Height". Below these fields, there are two dropdown menus: "SEX" with "Male" selected, and "JOB CATEGORY" with "Job that requires long sitting hours" selected. At the bottom of the form, there is a "Send" button.

Figure 8: Snapshot of User Registration Page



Figure 9: StayFit User report on BMI, BMR and suggested activities after registration

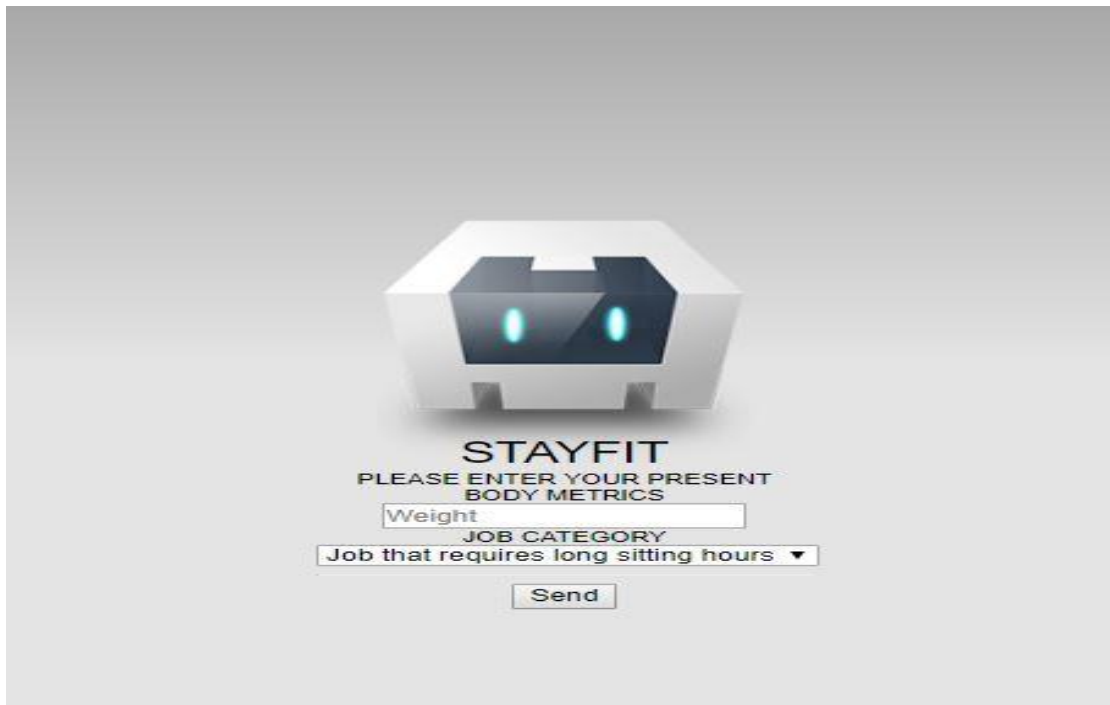


Figure 10: Snapshot of User's BMI analysis

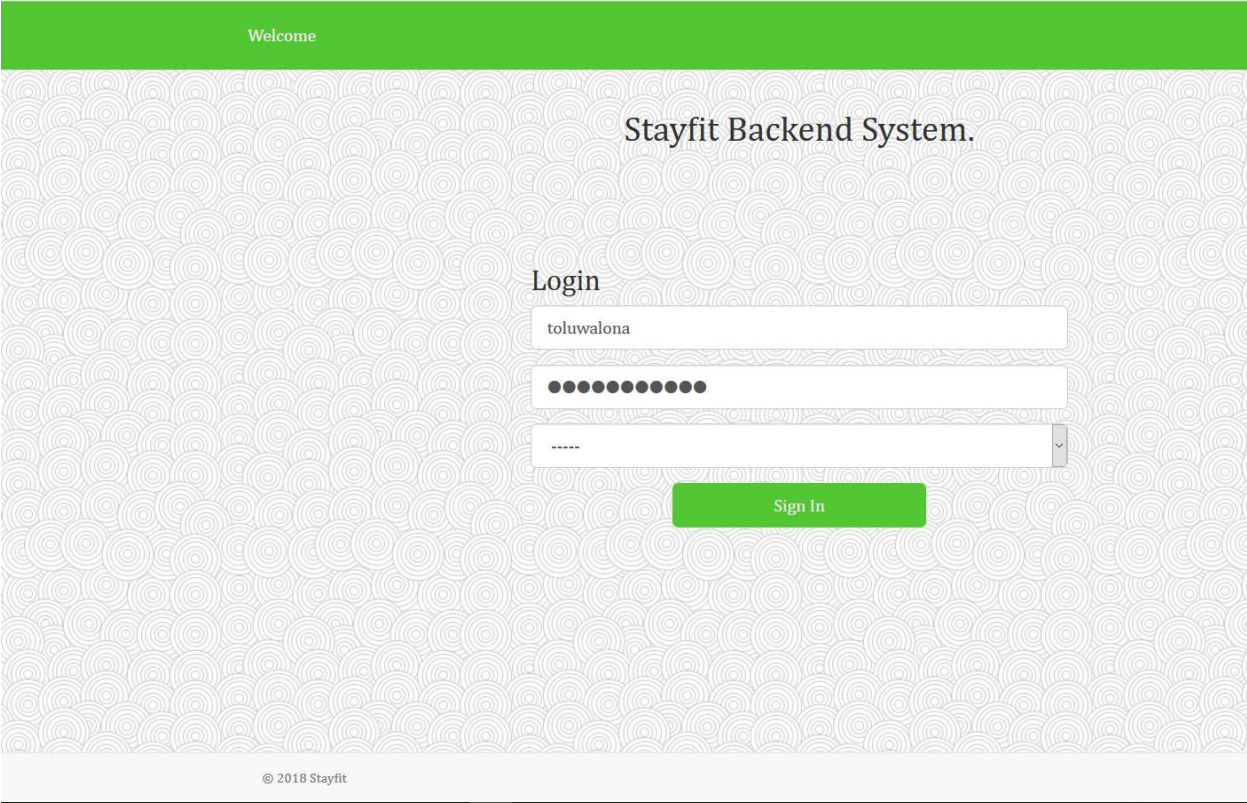


Figure 11: StayFit Admin Login Page

Admin Panel

Home || Add a Exercise || Add Food || Log out

[logout](#)

STAYFIT BACKEND.

[Generate report](#)

Client Name>	Phone	Email	Weight	Height	Age	BMI	BMR	Weight Category	Activity Category
Tayo Aderinnokun	09059759950	ty@yahoo.com	89	1.5	34	23	340	Overweight	Sedentary
ADEOLA SAM	08034890123	ret@yahoo.com	68	1.7	34	23.52941171622.34	Normal		
ADEOLA SAM	08034890123	ret@yahoo.com	68	1.7	34	23.52941171622.34	Normal		
ADEOLA SAM	08034890123	ret@yahoo.com	68	1.7	34	23.52941171622.34	Normal		Sedentary
ADEOLA SAM	08034890123	ret@yahoo.com	68	1.7	34	23.52941171622.34	Normal		Sedentary
ADEMOLA	07089021234	ademola@babcock.com	45	1.6	54	17.578125	1120.96	Underweight	Mild activity level
ADEMOLA	07089021234	ademola@babcock.com	45	1.6	54	17.578125	1120.96	Underweight	Mild activity level

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Figure 12: Admin Panel Page

4.2 Analysis of StayFit with the PSD model

Tables 3, 4, 5 and 6 present the analysis of StayFit persuasive characteristics based on the PSD model.

Table 3: StayFit Comparison with Primary Task Support Principles

Principle	Example requirement (as specified in the PSD model)	How feature was implemented in StayFit
Reduction	System should reduce effort that users utilize with regard to performing their main behavior.	Once users fill the registration page with the right input requirements, their BMI, BMR, TDEE, suggested exercise and food will all be given at once, no complicated approach is required to get all these.
Tunneling	System should guide users in the attitude change process by providing means for action that brings them closer to the target behavior.	The app suggests the type and right exercises to engage in after users' might have entered their Body Mass Index (BMI) and gender during installation.
Tailoring	System should provide tailored information for its user groups	User can set personal goals, set target duration for all exercised done, calories intended to be burnt amongst others.
Personalization	System should offer personalized content and services for its users.	This is very close to the principle of Tailoring. Users can set their own goals, change personal information, alter goals, add name/picture to the screen etc.
Self-monitoring	System should provide means for users to track their performance or status.	This app can monitor users' weight and calories requirement.
Simulation	System should provide means for observing the link between the cause and effect with regard to users' behavior.	Before-and-after pictures of people who have lost weight are presented on StayFit during app update.
Rehearsal	System should provide means for rehearsing a target behavior.	All exercises are accompanied with their pictures, descriptions, benefits and risks.

Table 4: StayFit Comparison with Dialogue Support Principles

Principle	Example requirement (as specified in the PSD model)	How feature was implemented in StayFit
Praise	System should use praise via words, images, symbols, or sounds as a way to provide user feedback information based on his/her behaviors.	StayFit uses praise via words after a user might have reached a set goal.
Rewards	System should provide virtual rewards for users in order to give credit for performing the target behavior.	StayFit gives users a virtual trophy if they follow and achieve their fitness target goals.
Reminders	System should remind users of their target behavior during the use of the system.	StayFit sends e-mails to its users telling them on the benefits of exercises, new updates on the app and added features.
Suggestion	System should suggest that users carry out behaviors during the system use process.	For healthier eating habit, StayFit suggests warm water to be taken immediately after exercise instead of cold water.
Similarity	System should imitate its users in some specific way.	StayFit uses slang names to motivate the younger ones.
Liking	System should have a look and feel that appeals to its users.	StayFit was designed to have an appealing user interface and other appealing qualities based on user requirements.
Social Role	System should adopt a social role.	StayFit supports and give answers to users questions/worries during app update.

Table 5: StayFit Comparison with System Credibility Support Principles

Principle	Example requirement (as specified in the PSD model)	How feature was implemented in StayFit
Trustworthiness	System should provide information that is truthful, fair and unbiased.	StayFit provides information related to its functionality rather than false or unnecessary advertisements.
Expertise	System should provide information showing knowledge, experience, and competence.	StayFit is updated regularly with relevant and correct health information.
Surface Credibility	System should have competent look and feel.	The system was designed according to users' needs, and where adverts are placed, logical reasons and explanations are given.
Real-world feel	System should provide information of the organization and/or actual people behind its content and services.	StayFit provides possibilities to contact specific people/health companies through sending feedback or asking questions.
Authority	System should refer to people in the role of authority.	StayFit quotes an authority during update where necessary.
Third-party endorsement:	System should provide endorsements from respected sources.	StayFit refers to its reward for high usability, sources for companies who deal in healthy living products to reward competent and disciplined users.
Verifiability	System should provide means to verify the accuracy of site content via outside sources.	Information claims on StayFit are supported by offering links to their right sources.

Table 6: StayFit Comparison with Social Support Principles

Principle (as specified in the PSD model)	Example requirement	How feature was implemented in StayFit
Social Learning	System should provide means to observe other users who are performing their target behaviors and to see the outcomes of their behavior.	Same fitness journal can be sent to all users e-mail for increased motivation.
Social comparison	System should provide means for comparing performance with the performance of other users.	Users' success stories can be shared to encourage others.
Normative influence	System should provide means for gathering together people who have the same goal and make them feel norms.	During app update, StayFit can share pictures of extremely obese people and their health challenges.
Social facilitation	System should provide means for discerning other users who are performing the behavior.	StayFit users can recognize how many other users are using the app at the same time as them.
Cooperation	System should provide means for co-operation.	StayFit can link interested users to perform the same behaviour.
Competition	System should provide means for competing with other users.	Online competition for users to lose a specified amount of weight is encouraged in StayFit maybe for a month and win a certain prize.
Recognition	System should provide public recognition for users who perform their target behavior.	Names of awarded users, such as "most disciplined of the month," are updated on the app. Success stories are also shared on the app.

4.3 Comparison of StayFit with Existing Apps

Table 7 shows the results of comparison of the three apps and Figure 13 shows the consolidated weights of each app compared.

Table 7: Alternatives Evaluation Result by Participants

Group Results	48.4%	28.7%	23.0%	4.9%
Participants	StayFit (%)	MyFitnessPal (%)	Lose It (%)	CR _{max} (%)
Respondent 5	42.9	31.5	25.6	9.8
Respondent 4	46.8	29.5	23.7	9.0
Respondent 3	49.2	31.6	19.2	9.8
Respondent 2	52.6	28.4	19.0	9.8
Respondent 1	48.9	27.5	23.6	14.1

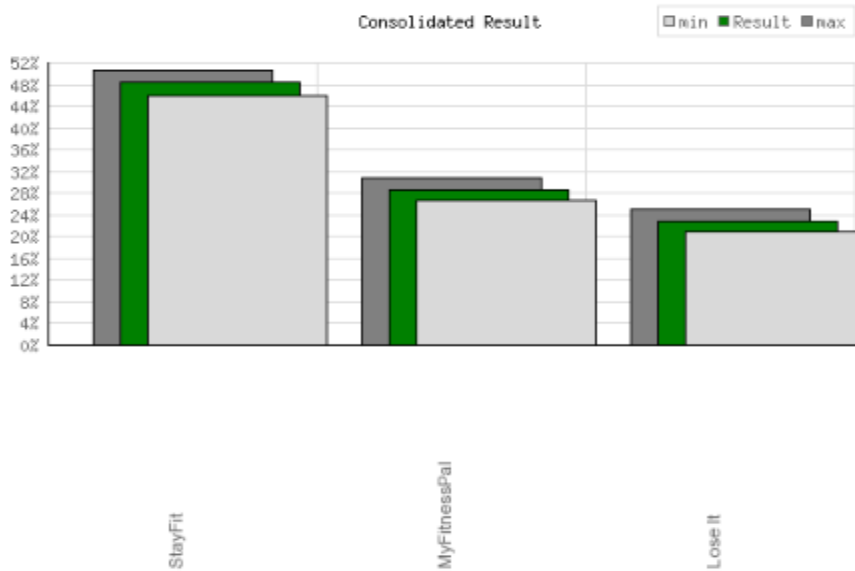


Figure 13: Consolidated Weights of Alternatives Compared

Table 8 depicts the results of the comparison of the three apps based on the adopted usability model and Table 9 gives the results of each participant.

Table 8: Alternatives Analysis Results based on the Usability Model

Criterion	Global Priority (%)	StayFit (%)	MyFitnessPal (%)	Lose It (%)	CR (%)	Group Consensus (%)
Comfort (D11)	0.5	0.212	0.520	0.268	0.0	61.6
Trust (D12)	3.4	0.527	0.350	0.123	3.5	68.4
Pleasure (D13)	0.5	0.261	0.562	0.177	0.5	60.4
Usefulness (D14)	1.8	0.498	0.383	0.119	1.8	78.6
Task efficiency (D21)	13.4	0.554	0.250	0.196	0.0	72.7

Time efficiency (D22)	6.9	0.547	0.211	0.243	3.4	58.6
Relative task time (D23)	10.0	0.642	0.135	0.223	0.0	94.0
Task completion (D31)	8.9	0.606	0.166	0.228	4.2	91.9
Task effectiveness (D32)	13.7	0.567	0.178	0.255	0.3	83.9
Error frequency (D33)	4.0	0.384	0.308	0.308	0.4	55.8
Time to learn (D41)	1.6	0.612	0.085	0.303	2.4	98.9
Memorability (D42)	2.6	0.505	0.188	0.308	0.4	56.9
Easy to understand error messages (D43)	0.7	0.317	0.423	0.260	0.1	57.5
Completeness of user documentation (D44)	0.8	0.549	0.295	0.156	2.0	60.7
Cognitive load (D45)	4.2	0.641	0.125	0.234	0.8	88.4
Understandable Input/output (D51)	3.3	0.386	0.422	0.192	0.6	71.7
Message clarity (D52)	2.8	0.606	0.100	0.294	1.8	98.2
Operational consistency (D53)	12.6	0.221	0.535	0.245	0.6	53.3
Cultural universality (D61)	0.4	0.070	0.671	0.259	3.0	98.3
Standard compliance (D62)	0.8	0.126	0.653	0.221	0.0	95.1
Accessibility (D63)	2.1	0.503	0.315	0.182	0.1	71.5
Customizability (D71)	1.6	0.151	0.586	0.263	4.9	70.6
Attractiveness of user interface (D72)	3.3	0.074	0.739	0.187	1.0	99.8
		UER= 48.4	UER = 28.7	UER = 23.0		

UER: Usability Evaluation Result

AHP-OS Scale: Below 50%: Very low (Disagreement); Low: 50%-65%; Moderate: 65%-75%; High: 75%-85%; Very High: Above 85%

CR < 10%: Acceptable Consistency in judgements made as a group

Overall Group Consensus: 76.1% which is high

Sensitivity Analysis Result

Sensitivity analysis was done to know the most critical criterion and the most critical performance measure when the ranks between two alternatives are changed. The percent-any critical performance measure is for MyFitnessPal under criterion operational consistency. A change from 53.5% by absolute -38.9% will change the ranking between MyFitnessPal and Lose It.

Table 9: Alternatives by Participants

Group Results	48.4%	28.7%	23.0%	4.9%
Participants	StayFit (%)	MyFitnessPal (%)	Lose It (%)	CR_{max} (%)
(+)	2.2	2.3	2.2	n/a
(-)	2.4	2.0	2.1	n/a
Respondent 5	42.9	31.5	25.6	9.8
Respondent 4	46.8	29.5	23.7	9.0
Respondent 3	49.2	31.6	19.2	9.8
Respondent 2	52.6	28.4	19.0	9.8
Respondent 1	48.9	27.5	23.6	14.1

5.0 Discussion, Conclusion and Recommendation for Further Studies

StayFit was developed using the extended PSD model, a model that can be used to design and evaluate persuasive systems easily. The app was designed to be cross-platform and technologies used include the Cordova platform, Android studio, MySQL, Apache Server, Node.js amongst others. StayFit was specifically designed to enable users check their BMI, MBR and TDEE. The persuasive characteristics in StayFit were evaluated using the PSD model and results of analysis showed that StayFit was implemented with most of the attributes specified in the model.

The persuasive characteristics in StayFit were evaluated using the PSD model and results of analysis showed that StayFit was implemented with most of the attributes specified in the model. StayFit was also compared with MyFitnessPal and Lose It, 2 apps randomly chosen from the Android play store based on their user ratings and popularity. Comparison was done using a group of 5 users with the usability model and evaluated with AHP. Results of analysis showed that StayFit ranked the highest with 48.4%, MyFitnesPal with 28.7% and Lose It with 23.0% while consolidated group CR was 4.9%.

This research paves the way for future research to consider additional MCDM techniques for comparison purpose and involve more decision makers in the opinion elicitation process both from the Industry and the Academia. The work provides an approach for developing cross-platform applications in order to target a wider range of platforms and audience without having to write numerous versions of codes, for cost control, quicker development time based on technologies used, easier implementation, sameness and uniformity. The mHealth persuasive app developed is able to assist users maintain a healthier lifestyle.

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