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USABILITY IMPACT OF USER PERCEPTION IN MHEALTH:

THE CASE OF GHANAIAN MIGRANTS

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Abstract

Mobile health technology has the potential to transform the face of the health care industry globally. Mobile phones have become ubiquitous, unhampered by race, class or geographical boundaries, and provide a sound base for mHealth technology to break all boundaries and reach people from all walks of life with essential health information. However, despite the hype, mHealth technology has failed to reach its potential due to lack of evidence-based research on the effectiveness of mHealth applications. Literature on usability studies conducted among migrant consumers is also limited. Migrant communities in the U.S. have been sidelined when it comes to studies in usability and acceptance of mobile health applications. In order to optimize the potential of mHealth applications, there is a need to explore how these applications are perceived by end users, especially disparate communities. The study aims at contributing to the understanding of usability and user perception factors among migrant communities. Specifically, this dissertation investigates usability impact of user perception in mHealth, from the perspective of Ghanaian migrants. Findings from this study indicate that user perception of Ghanaian migrants affects usability in mHealth. Thus, by understanding the factors that affect usability, the objective of this study is to ultimately increase usability and adoption of mHealth applications by Ghanaian migrants living in the United States.

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Chapter 1: Introduction

1.1 Introduction

Health Information Technology (HIT) is a growing area that is increasingly being used by healthcare providers to improve patient care. HIT is defined as "the application of information processing involving both computer hardware and software that deals with storage, retrieval, sharing, and use of health care information, data and knowledge for communication and decision making" (Thompson & Brailer, 2004). HIT has grown from the use of mobile devices, such as personal digital assistants in the 1990's, to the use of more complicated and real time electronic health (e-health) interventions such as mobile health applications (Luxton et al. 2011; Silva, B. M. et al. 2015). Mobile health (mHealth) applications allows users to be in charge of their healthcare and have access to real time information through a variety of peripheral devices. With more than 1 billion smartphones and 100 million tablets in use today, mHealth applications promises to be an invaluable tool in healthcare management (Gunther, 2013). However, there is limited research on the accessibility and sustainability of mHealth use in migrant populations in the United States (Srinivasan et al. 2003). Although there are few examples of mHealth tools that are quite popular in the United States, the use of mHealth tools is variant from community to community and are usually dependent on simplicity of use (Sama et al. 2014).

Experts in the field have demonstrated that there has been an increase in access to information and communication technology (ICT) and a growing penetration of smartphones (Gunther, 2013; Luxton et al. 2011). However, despite the well documented health disparities among immigrants especially in ethnic minorities (Benz et al. 2011;

Flores & Tomany-Korman, 2008), there is limited information about the actual adoption, usage and attitudes of migrant populations towards mHealth services.

There is a need for further exploratory studies in migrant groups in relation to mHealth and user accessibility and sustenance. Årsand et al. 2012, authenticate the need and importance of more studies in mobile health technology and the potential to engage and empower all users to be in control of, and to manage their healthcare. In their study conducted in 2012, they analyzed the performance of a mobile health research application, the Few Touch Application (FTA) to identify the best way forward in designing effective mHealth applications. In all stages of the analysis, they actively engaged end users and referred to user data for the purpose of design and evaluation. One key finding they outlined was the inclusion of context sensitivity in applications in efforts to improve usability. They concluded by highlighting the importance of engaging representative end users in all phases of design and implementation to leverage mHealth applications. A study conducted by Fleming, Hill, & Burns (2017) on the mHealth application 'TODAY', a phone-based intervention for young sexual minority (homosexual) men, also shed light on the importance of usability testing within intended users. These findings buttress the point that exploring the usability of mobile health technology among migrant groups will highlight behavioral patterns and provide useful data to improve the design and utilization of mobile health interventions. This will allow migrant communities to have access to mobile health applications that are specifically designed with their inclusion and engagement.

1.2 Background of the Study

Technology has evolved over the years. Before the manufacture of smartphones, palm pilots and other personal digital assistants were used in the early 1990's (Teall, 2009; Vishwanath, et al. 2009). This era was followed by the use of portable electronic devices and specialized software like Apple Newton, which were utilized for health research and patient care (Schweitzer & Hardmeier, 1996; Stratton et al. 1998). This shows how far we have come to the advent of smartphones. Smartphones have an advanced operating system, which incorporates the features of all the above devices as well as other high-tech features such as voice, facial and fingerprint recognition. Smartphones fulfill users' needs for communication, GPS navigation, digital messaging and personal medical application assistance (Boulos et al. 2011).

Technology offers innovative opportunities to change and improve the face of healthcare by making it more personalized, accessible, and reducing medical errors and costs (Meingast, Roosta and Sasty, 2006; Roepke et al. 2015). Smartphones provide the platform to harness the opportunities offered by new technologies and place quality healthcare at the fingertips of all individuals. Smartphone applications offer many useful functions that can be integrated into conventional healthcare treatment plans. Voice and short messaging services allow two-way communication in real time. Cameras can be used for picture or video capture that can be shared with health providers. High data processing and storage capabilities supports the analysis and sharing of data in several formats such as graphic, audio and video. In addition to the basic features, smartphones use internal sensors to gather context data such as user movement, emotion and social engagement (Dennison et al. 2013). Smartphones also have the added advantage of the global positioning system (GPS) functionality, which can be used by behavioral health applications to find the exact location of the device and thus the user. This is a useful feature that helps in locating users such as patients with dementia (Miskelly, 2005). There are also smartphones with inbuilt biofeedback sensors that are used to track biological variables and monitor physiological signals (Luxton et al. 2011), thus recording and relaying actual real time user data which is beneficial to both the user and care providers. These are just a few examples among many, of the advanced features of current smartphones.

The existing and future technologic capabilities of smartphones has the potential to make them an increasingly essential personal health tool. In other words, the possibilities are endless. However, to realize or optimize the potential of mHealth applications, there is the need to explore how these applications are perceived by end users, especially disparate communities who stand to benefit by having a wealth of health information placed in their hands via their smartphones. The goal is to improve the quality of healthcare and well-being of marginalized groups such as Ghanaian migrants.

There are many divisions of healthcare that can be improved by using mobile health technology. However, there have been barriers such as ease of use, literacy, access to technology and affordability, which have been a challenge in the role that information technology plays in healthcare improvement and inclusion of disparate populations (Martin, 2012). These barriers that existed have been reduced, and mobile technologies that can be employed in mHealth applications have become affordable, easy to use and widely adopted across socioeconomic status (Klasnja & Pratt, 2012). Mobile technologies have become strategic tools for health education and intervention because more members of the general population now have access to mobile technologies than in the past. Mobile technologies have also become equalizers, in that access to quality information is placed within the reach of people from all walks of life through smartphones and other mobile devices.

Access to mobile phones has been found to run high within all ethnic groups in the United States, with Hispanics at 76%, Whites at 85%, and Blacks at 79% (Martin, 2012). This high dispersal of mobile phones among diverse populations makes it a promising tool for patient engagement and healthcare management through mHealth applications. It is estimated that currently there are approximately six billion mobile phone users, and half of the global population use smartphones (Dalkou, Nikopoulou, & Panagopoulou, 2015). According to Tate et al. (2013), 12% of American smartphone users have at least one health application to access health information. This is very promising in light of the potential benefits of smartphones, but the question still remains, 'how many migrants such as Ghanaians, are utilizing this technology'? The Health Information Technology for Economic and Clinical Health (HITECH) Act offers a platform that serves as a policy model for mHealth technologies by putting in place incentive structures that promote the use of technology in healthcare. One of the core objectives of HITECH is to provide secure communication and other objectives aimed to improve healthcare, especially in disparately impacted populations, which includes migrant populations.

In the United states, scientific research has long established the presence of health and health care disparities within racial and ethnic minorities. The US Department of Health and Human Services released a report in 1984 which stated that, "while the overall health of the nation showed significant progress, major disparities existed in the burden of death and illness experienced by blacks and other minority Americans as compared with the nation's population as a whole” (Gibbons, 2005). A report released by the Institute of Medicine (IOM) in 2003 confirmed the existence of significant racial and ethnic disparities within the United States even among individuals with access to care (Smedley, Stith & Nelson, 2003). There is no consensus about what constitutes a health disparity but the cause of the disparities is thought to be related to sociocultural, behavioral, economic, environmental, biologic and societal factors (Gibbons, 2005), and groups identified as underserved and affected by health disparities within the United States include among others, African Americans, racial and ethnic minorities, people with English as a second language, and immigrants (Montague & Perchonok, 2012). All these criteria describe the characteristics found in Ghanaian migrants in the United States, thus the specific interest in this group of people.

1.3 Purpose of Study

Understanding usability and user perception of mHealth is key in promoting self-healthcare interventions and improving user experience in mobile technologies (Azhar & Dhillon, 2016). This can be used by interface designers as they design for the global market with cognition of all ethnic minorities. Literature review establishes that there are opportunities for mobile applications to address healthcare needs relative to intervention (Latif et al. 2017; Luxton et al. 2011; Harrison. et al. 2011). The purpose of this study is to investigate if usability affects user perception of mHealth tools using Ghanaian migrants as a case study. The study will focus on three main objectives:

1. Investigate user perception on mobile Health technology usage.
2. Design, develop and validate a mobile health application as an intervention for Ghanaian migrants.
3. Enhance the application usage and adoption through incorporation of findings from iterative usability testing within the target population.

Therefore, by investigating the usability of mobile health applications for personal healthcare management within a specified minority group, in this case Ghanaian migrants, the following question will be addressed:

Can usability impact user perceptions of mHealth: The Case of Ghanaian migrants?

Chapter 2: Literature review

2.1 Introduction

Overall, literature review establishes that there are opportunities for mobile applications to address healthcare needs relative to prevention and living a healthy lifestyle among migrants. (Latif et al. 2017; Luxton et al. 2011; Harrison et al. 2011). mHealth technology has the potential to offer Ghanaian migrants a better user experience as they interact with technology for healthcare management and as a behavior change tool to promote healthy lifestyles as a preventive measure. Interaction with devices such as smartphone applications can link users to their physicians and deliver tailored health management and behavior change information. Culture specific lifestyle advice, culture specific tools, guides, trackers, support groups, and referral to specific providers, are all examples of expected benefits to such communities. Research has shown that there are several mHealth applications in existence that migrants interact with, however the question of the impact of such application on disparate groups needs to be addressed.

According to a preliminary study, Ghanaian working-class migrant users between the ages of 30 and 55 years old in the United States do not access applications to assess their health issues (Owusu & Chakraborty, 2019). Advances in mobile technology have altered the outlook on strategies for reaching consumers across different populations. To that end, the consumer sectors who interact with health applications are explored in this study. Remodeling an application by customization can improve the user experience for Ghanaian migrants providing an accessible means for them to examine, analyze and adopt smart health and healthcare tools. Common uses of mHealth technologies include reminders for postoperative checkups and other appointments, fitness management, and management of chronic diseases (Kahn et al. 2010). In order to investigate how mobile technology can help migrant communities to promote self- health intervention and improve user experience by making them accessible and sustainable tools, existing mHealth tools, application design and development and usability testing needs to be examined.

The main objective of the literature review is to investigate previous studies on user perceptions of mHealth among minorities or disparate communities. It is speculated that a mobile application interface will be developed to provide a tailored and specific behavior change solution to enable Ghanaian migrants manage and improve their healthcare.

2.2 Human Computer Interaction (HCI)

Human-computer interaction (HCI) is a fast-growing component of computer science that is concerned with understanding how people make use of computational devices and systems, and how the usefulness and usability of such devices and systems can be improved (Carroll, 2003). Unlike in the past where work in HCI focused on office systems, today HCI bridges the gap between social and behavioral sciences, and computer and information technology, with a wide range of methods for understanding the tasks and work practices of people and their organizations in ways that help structure new prospects for computer support and increase usefulness and usability of devices and systems (Carroll, 2003). In a nutshell the idea behind HCI research is to create better interfaces, to improve interaction, and to adapt computer technology to users, by research in the various disciplines of computer science, sociology, and psychology.

According to Dix (2017), HCI is founded on three broad foundations, namely principles, practice and people. By his explanation principles involves the underlying intellectual theories, models and empirical investigations that are central to HCI. Practice involves the provision of practical guidance to experts in interface design and also learning from existing practical innovations, and people consists of the researchers, practitioners, and educators who drive the HCI field forward with their inspiration. Because HCI draws from several disciplines, it is important for researchers to be always cognizant of standards and principles in the related disciplines, and always be aware of who the target audience is - other researchers, system developers, or public policymakers (Lazar et al. 2017). The focus of HCI research on human-centered technologies that are designed to fit the daily requirements of users is what is referred to as user-centered design. With emphasis on building user-centered design systems, HCI research has the potential to provide useful insight into how people incorporate smart technology into their behavior change efforts, as well as how to design more effective behavior change technologies (Poole, 2013). In light of the above, the current trend in HCI research that studies the roles in which sensors, smartphones, and other technologies are able to record behavior change related to lifestyle habits and chronic disease management (Poole, 2013), promises to be a major contribution to the success of mobile health interventions. An important component of HCI is usability. As the goal of HCI is to produce systems that are easy to learn, easy to use, and with limited frequency and severity of errors (Issa & Isaias, 2015), usability is a tool that helps researchers and developers achieve this goal.

2.3 Usability

Usability is a concept that has been defined in several ways over the years. In the past the concept of usability was more focused on the characteristics of the design or system and not the user. Eason (1984) defined usability as determined by whether a system or facility is used or not. Ravden and Johnson (1989) also defined usability as a function of whether a system is usable or not based on system characteristics such as visual clarity, consistency, appropriate functionality, flexibility and control. These definitions fall short, in that based on them a system may be classified as usable because it adheres strictly to design guidelines, but the definition of usability is incomplete if it is limited to interface attributes.

A more pragmatic and widely accepted definition is given by the International Standards Organization (ISO) in the 9241 series of standards, where usability of a product is defined as ‘‘the degree to which specific users can achieve specific goals within a particular environment; effectively, efficiently, comfortably, and in an acceptable manner.’’ This definition is clearly reflected by Shackel (2009), who explains usability of a system as “the capability in human functional terms of a product to be used easily and effectively by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of environmental scenarios”. These expanded definitions are widely accepted as they better explain the concept of usability with emphasis on subjective users. Here emphasis is placed on the human interaction aspect of technology and highlights the fact that usability is largely determined by the environment in which a technology is supposed to operate, not on interface attributes. This buttresses the point that in an environment with different users, a technology that has been accepted as usable in one environment, could be less usable in another environment with different group of users, as is seen in migrant communities in the United States. One feature about different environment which affects the usability of a product is the cultural background of users (Wallace & Hu, 2009; Hornbæk, 2006). Hornbæk's study conducted in 2006, identified that most aspects of usability such as user perception of effectiveness, levels of satisfaction, efficiency and effectiveness were affected by the cultural background of users. This study seeks to explore the above by determining the factors that affect usability within subgroups like migrant communities.

2.4 Mobile Health Technology (mHealth)

Mobile phones have become ubiquitous. The features that make them popular are their mobility and their technological capabilities. There were nearly 5.3 billion mobile phone subscriptions in the world by the end of 2010, and over 85% of the world's population are now within range of a commercial wireless signal (Ryu, 2012). Access to mobile phones has been found to run high within all ethnic groups in the United States, with Hispanics at 76%, Whites at 85%, and Blacks at 79% (Martin, 2012). This high dispersal of mobile phones among diverse populations makes it a promising tool for patient engagement and healthcare management through mHealth applications. The global increase in mobile technology access and usage, as well as advancements made in their use within the health industry has evolved into a field of electronic health known as mobile health. There is no single definition of mHealth but Helbostad et al. 2017, describes it as an aspect of electronic health that focuses on the delivery of health care services via mobile communication devices. WHO also describes it as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices." WHO further explains mHealth as the delivery of electronic health through mobile technology or wireless devices and sensors that are worn, carried, or accessed by a person during normal daily activities.

mHealth applications use and engage the central voice and short messaging service of a mobile phone, as well as more complicated functions and applications such as third- and fourth-generation mobile telecommunications systems, general packet radio service, global positioning system, and Bluetooth technology (Ryu, 2012). With the benefits of mobility, compact size, and capitalization on the core functions and applications of a mobile phone, mHealth offers a platform for users to perform numerous activities on the go, activities which would only have been possible with a traditional personal computer in the past.

mHealth technology employs the use of a wide range of wearable biometric sensor. Wearable devices such as smartphones, smart watches, and wristbands, all have sensors that are useful for discreet, passive, continuous monitoring of biological and behavioral data, as well as provision of interventions and evaluation of outcomes (Helbostad et al. 2017). Examples of such sensor systems are accelerometers, gyroscopes, magnetometers, barometers, sensors for the measurement of heart rate and galvanic skin response, cameras, and geo-sensors (GPS) for tracking a person's exact geographical position (Helbostad et al. 2017). These sensors are worn by an individual and are in direct contact with their body, thus information being recorded or relayed, whether biological or behavioral, is precise and in real time. This also provides the added benefit of accurate data provision for monitoring specific health aspects over long periods of time.

There are several wearable biometric devices that are commercially available today. An example is a device that enables an individual to determine their cardiac rhythm by using their smartphone for rhythm capture or by wearing a patch for rhythm tracking (Barrett et al. 2014). Examples of developments underway are blood pressure monitoring without cuffs, and sensor technologies that continuously track blood glucose concentrations (for people with diabetes) (Steinhubl et al. 2015).

Two other areas of mHealth capabilities mentioned by Steinhubl et al. (2015) are 'Lab on a chip', and 'Imaging from afar'. Lab on a chip – The digitization of bodily fluids and breath is made possible by a combination of microelectronics and microfluids, thus allowing for a range of medical testing to be brought directly to individuals, cutting out specialized core laboratories (Steinhubl et al. 2015). Imaging from afar- Smartphones are equipped with high quality camera lenses and high screen resolution which provides an optical system that can be exploited for a multitude of medical diagnostic and imaging applications (Steinhubl et al. 2015). All the above highlight the fact that there is great potential for mHealth technologies to radically transform almost every aspect of healthcare, however several literature reveals that evidence-based research necessary to drive the change is lacking. (Free et al. 2013; Prgomet et al. 2009; Steinhubl et al. 2015).

2.5 Health disparities among migrant communities

In the United states, scientific research has long established the presence of health and healthcare disparities within racial and ethnic minorities. The initial awareness and focus on health disparities was created by the US Department of Health and Human Services in a report (Heckler,1985) released in 1985 that asserted that despite significant progress in the overall health of United States, major disparities existed in the burden of death and illness experienced by blacks and other minority Americans as compared with the nation's population as a whole. The Heckler report brought to light the low health status, low outcome and limited access to medical care that has been faced by African Americans for more than 300 years. A second report released by the Institute of Medicine (Institute of Medicine (IOM), 2003) further confirmed the existence of significant racial and ethnic disparities within the United States even among individuals with access to care. The IOM report encouraged dialogue on health disparities by revealing even more evidence of bias and discrimination experienced by some populations with regards to access to healthcare (Nelson, 2002). A National Institute of Health report (National Institute of Health (NIH), 2014) reiterates the above statements by indicating that in the United States notable disparities exist in the burden of illness and death faced by historically underserved populations, despite reported achievement of overall improvement in health and health determinants. These disparities are seen in almost all areas of health, such as access to care, quality of health care, utilization of health care, and health outcomes.

There is no unified agreement on what constitutes health disparity, but it is defined as differences that occur in specific population groups in the United States in the achievement of full health potential that can be measured by differences in incidence, prevalence, mortality, burden of disease, and other adverse health conditions (CDC, 2014). The Institute of Medicine provides another definition that states that health disparities are racial or ethnic differences in the quality of healthcare that are not due to access-related factors or clinical needs, preferences, and appropriateness of intervention. The cause of the disparities is thought to be related to sociocultural, behavioral, economic, environmental, biologic and societal factors (Gibbons, 2005), and groups identified as underserved and affected by health disparities within the United States include among others, African Americans, racial and ethnic minorities, people with English as a second language, and immigrants (Montague & Perchonok, 2012). To effectively address disparities eHealth research and application is an area that is highly recommended (Gibbons, 2005). There are many divisions of healthcare that can be improved by mHealth technology, but there have been barriers such as ease of use, literacy, access to technology and affordability, which have been a challenge in the role that information technology plays in healthcare improvement and inclusion of disparate populations (Martin, 2012).

2.6 mHealth and User Behavior

Most health interventions are based on the 'Social Cognitive Theory', which holds that by providing an agent or platform, people are enabled to play a part in their self-development, adaptation, and self-renewal with changing times (Bandura, 2001). mHealth interventions are designed with the aim of educating and empowering individuals to increase healthy behavior(s) and/or improve disease management. Potential increases in healthy behavior includes among others, reduction in alcohol consumption, increase in smoking cessation, increase in physical activity, reduction in calorie intake and increase in safer sexual behavior. Improvement in disease management includes increased adherence to prescribed medicine, improvement in control of chronic diseases, and delivery of therapeutic interventions (Free et al. 2013).

There are numerous mHealth applications in the market today. For the purpose of this study existing literature was reviewed on research done on the effectiveness of these applications in altering user behavior or improving health outcomes. Franklin et al. (2006) conducted a 12-month study to assess an e-health text-messaging support system designed for pediatric patients with Type 1 diabetes called Sweet Talk. Their findings indicated that the application was associated with improved self-efficacy and adherence and had positive effects on clinical and psychosocial outcomes. Yoo et al. (2009), conducted a study to investigate the effectiveness and applicability of the Ubiquitous Chronic Disease Care (UCDC) system that targets overweight patients with both Type 2 diabetes and hypertension. After comparing several factors such as systolic and diastolic pressure, and total cholesterol, the study concluded that the UCDC system did infact improve multiple metabolic parameters simultaneously among patients. The feasibility of a telemedical support system and its ability to improve glycemic control in adolescents with type 1 diabetes was also investigated by Rami et al. (2006). This study also provided positive evidence that the application did improve glycemic control in adolescents.

A number of recent studies on several mHealth applications (Pop-Eleches et al. 2011; Maged et al. 2014; Lin et al. 2016; Hanauer et al. 2009), all found a positive impact on user behavior. However, the demographics, content, delivery mode and intensity of the interventions were noted to have an effect on the effectiveness of the mHealth applications (Free et al. 2013). Notable, however, in the above examples was the short duration of the studies. This is addressed by Free et al. (2013), who indicate that there is suggestive evidence of short-term benefits for behavior interventions, but it would be clinically important if these results could be replicated in the long term.

A few examples of studies done within migrant communities are as follows. A multifaced application that tailored HIV behavior change interventions was developed for young women in Vietnam who had internally migrated from other areas and lost their rights because of migrating. The study results indicated that the application had led to increased knowledge and improved sexual behavior practices (Vu et al. 2016). Price et al. (2013), conducted a study in the united states to determine the attitude of Hispanic migrant workers towards mHealth devices. This revealed a positive attitude towards mHealth applications, however actual user behavior was not assessed. A systematic review of existing literature evaluating health interventions for immigrants, was conducted by Diaz et al. (2017). This indicated that in general the interventions were beneficial, however with a number of challenges.

The implementation of health technology is a national priority in the United States and widely discussed in literature. However, the observation made while conducting this review on existing literature, was the sparsity of literature on the use and feasibility of mHealth technology by historically underserved populations in the United States. One would have assumed that the proliferation in mHealth research would reach all sectors of society, but this is not so. This confirms earlier findings by Montague & Perchonok (2012), which revealed that information on culturally informed health and wellness technology and the use of these technologies to reduce health disparities facing historically underserved populations in the United States is sparse in literature (Montague & Perchonok, 2012). Given the high potential health benefits, the increasing economic investment, and the great hype about mHealth technologies, it is apparent that further research is necessary to unearth the status of mHealth and user behavior among migrants in the United States. This will go a long way to provide useful information to inform the design, implementation and promotion of mHealth interventions for migrants and other populations facing health disparities.

2.7 Culture and Usability

Culture is very broad and complex to define (Spencer-Oatey & Franklin, 2012). According to Hofstede (1994), 'culture' refers to the collective programming of the mind which distinguishes the members of one group or category of people from another (Hofstede,1994). Spencer-Oatey, (2008), define culture as a fuzzy set of basic assumptions and values, orientations to life, beliefs, policies, procedures and behavioral conventions that are shared by a group of people, and that influence (but do not determine) each member's behavior and his/her interpretations of the 'meaning' of other people's behavior.'

In any particular group or organization culture is displayed at three fundamental levels: (a) observable artifacts, (b) values, and (c) basic underlying assumptions (Spencer-Oatey, 2012). Observable artifacts are what a person observes and feels when they enter an organization. This includes behavior patterns and environmental layout. Examples include dress code, the smell and feel of the place, and the manner in which people address each other. Values on the other hand are imperceptible and control why people behave the way they do. The only way one can deduce the value of a group of people or organization is by interviewing or analyzing artifacts. Basic underlying assumptions are unconscious assumptions that govern how members of a group perceive, think and feel. These are unconscious learned behaviors that originated as adopted values (Spencer-Oatey, 2012). With this basic understanding of culture one can safely infer that in designing usable systems that fit the requirements of target audiences, culture is an element that cannot be overlooked.

In the field of HCI, which has mainly been governed by Western ideas and values, cultural diversity has currently become a challenge. The user base of technology has changed from Western users to users from diverse cultural backgrounds, creating a cultural gap between designers and users. Although culture was a marginal issue in HCI, current studies indicate that culture has gained increased attention in mainstream HCI. This has resulted in the focus of HCI shifting towards a culture-centered design approach (Kamppuri, 2006).

Cultural factors affecting usability present a challenge to system designers as the user base of technology broadens globally. As noted by Li et. al. (2007), the perspective of interface design has to change towards culture-centered interface design, where users from diverse cultures are not subjected to the same standard interface applications that remain a usability challenge. Wallace and Yu (2009) suggested in their findings that the cultural background of a user is a likely factor in determining the usability of a consumer electronic product (Wallace & Yu, 2009). They established that every group is different hence what may seem to be good usability design for one culture may not be perceived as such by another. Usability research has to be done on the general effect of individual components of consumer product design, such as size, look and feel, etc. on different cultures (Wallace & Yu, 2009).

Culture plays a major role in cross-cultural usability. Reinecke and Bernstein (2013) summarized research studies that discuss the influence of user preferences and perceptions on designing interfaces. Language is one element that can affect where users focus their attention. For example, the writing and reading direction of a language can determine the way people design interfaces (Reinecke, & Bernstein, 2013). Hofstede (2010) highlighted the importance of understanding cultures by indicating six dimensions used to understand cultural differences and their consequences, which includes, power distance, individualism verses collectivism, masculinity verse femininity, uncertainty avoidance, long term verse short term orientation and Indulgence versus restraint (IVR).

Hofstede’s findings illustrate that Ghana has a high-power distance which is based upon a clear system hierarchy, whereas Ghana scores low in individualism which could be understood by the fact that Ghanaian culture is a collectivistic one. Ghanaian men are more concerned about material goods and success, while Ghanaian women tend to be more modest and concerned about equality in life. Ghanaians in general are not so strict with uncertainty avoidance element. They are also considered to be a long-term oriented culture (Furber et al. 2012; Mohammed, 2009; Ansah, 2015).

As illustrated by the above examples, a single interface cannot be used to fit every user due to vast cultural differences. This calls for more research studies to evaluate HCI and understand how users interact with interfaces based on their cultural backgrounds. This is significant for cross cultural usability design to address migrant communities who have been sidelined in mHealth technology.

2.8 User Experience

User experience (UX), according to ISO 9241-210, is a person's perception and response resulting from the use and/or anticipated use of a product, system or service (Bevan, 2009). Hassenzahl (2008), defines UX in two parts. He defines it firstly as a momentary, primary evaluative feeling of good or bad, while interacting with a product or service. And secondly, as a consequence of fulfilling the human needs for autonomy, competency, stimulation, relatedness, and popularity through interacting with a product or service. Words such as beauty, hedonic, and affective, are a few of several of meanings that are also associated with the term 'user experience' (Hassenzahl & Tractinsky, 2006). These definitions clearly indicate that user experience is not a feature of technology or products but of end users and their perception. UX is not about how a product functions on the inside, but how users feel or what they experience when they interact with a product.

Measuring the user experience of a product directly is difficult because the qualities of UX are subjective and concerned with how a product feels to a user. However, effects such as a user's satisfaction and performance with attaining pragmatic and hedonic goals, and pleasure can be used to measure UX (Bevan 2008).

Currently UX has gained a lot of interest by HCI researchers due to the fact that unlike traditional usability which places emphasis on user cognition and user performance factors such as learnability, accessibility and safety, UX shifts the focus of human-technology interactions to user effect, sensation, meaning, and the value of routine human computer interactions (Law et al. 2009). Punchoojit & Hongwarittorrn, (2017), explain UX by three characteristics; Firstly, they indicate that UX is holistic in nature, in that UX covers a wide range of qualities such as visual, tactile, and auditory features of a system, and also includes how a system functions under a suitable environment or context of usage. The second characteristic is that unlike user interface, which is focused on the technical or computer aspect and can be measured quantitatively, UX tends to focus on user's perspective in terms of how users think, feel and behave. The third characteristic is that UX is an essential factor to be considered in the design process of a product or service due to its strategic value. Despite its popularity and several explanations, there is no accepted universal definition of UX, and there are discrepancies in what user experience (UX) means and what it comprises (Law et al. 2009; Hassenzahl & Tractinsky, 2006).

The terms usability and user experience are often used interchangeably but it is important to note that although they are linked, they are not the same. According to Punchoojit & Hongwarittorrn, (2017), usability is actually a component of user experience, in that a visually pleasing product induces positive first-contact experience, whereas if usability is inadequate it negatively affects the overall user experience. By end user participation and inclusion in product design it is envisaged that the right mechanisms will be in place to foster positive user experience.

2.9 User Interface

Head (1999), define an interface as the visible piece of a system that a user sees, hears or touches. For interactive products the user interface is defined by Mayhew & Mayhew (1999), as the languages through which the user and the product communicate with one another. In other words, a user interacts with a system through its interface. To get a task done a user might have to use a mouse, keyboard, remote control, a switch, a dial, or voice commands. Whatever the means by which a user communicates with a system to get a task accomplished, they do so through the interface of the system. A good interface is one which conveys in an easy manner to users how to navigate and achieve tasks without presenting any frustration. According to Mayhew & Mayhew (1999), to achieve usability the user interface of an interactive system must take into account several features including the following:

- The cognitive, perceptual, and motor capabilities and constraints of people
- Special and unique characteristics of the intended user population
- Unique characteristics of the user's physical and social work environment
- Unique characteristics and requirements of the user's tasks, which are being supported by the product
- Unique capabilities and constraints of the chosen software and/or hardware and platform of the product

To produce usable user interfaces, clear usability goals need to be set for the development of iterative products. Usability in product interface design is achieved through a structured process known as 'usability engineering'. Mayhew & Mayhew (1999), state that the discipline usability engineering is itself rooted in several disciplines including cognitive psychology, experimental psychology and software engineering. They explain these disciplines as follows:

Cognitive psychology – This involves the study of human perception (vision, hearing, etc.) and cognition (human memory, learning, problem solving, decision making, reasoning, language, etc.). Usability engineering draws information from these properties of human psychology and exploits from the known strengths and weaknesses of the human information processes, to design user interfaces that are of the best fit for specific target users.

Experimental psychology – This discipline studies human behavior by use of empirical methods. In designing user interfaces usability engineering draws from these findings to measure performance and satisfaction.

Ethnography - A scientific research method used to study, analyze, interpret, and describe unfamiliar customs and cultures. Usability engineering draws from this science to study users and establish user and usability requirements for interface design.

Software engineering – This is the general software development process that involves defining application requirements, setting goals, and iterative design cycles. Usability engineering draws from these mechanisms to provide a similar process for the production of usable interfaces (Mayhew & Mayhew, 1999). Proper interface design incorporates a fusion of well-designed input and output mechanism that satisfy a user’s needs, capabilities, and limitations in the most effective way (Galtiz, 2007).

2.10 User Centered Design

ISO 9241-210:2010 defines Human-centered design as an approach to interactive systems development that aims to make systems usable and useful. In user-centered design the aim is to design systems that are tailored to fit the characteristics and needs of the intended users by active involvement of users at every stage of the design process. User-centered design has become an important concept in the design of interactive systems that focus on users, and the use of technologies by users in their day to day routines (Issa & Isaias, 2015). In order to increase user productivity and satisfaction, increase user acceptance, decrease user errors, and decrease user training time, and produce systems that are easy to learn, it is necessary to employ fundamental principles of good design at the onset and throughout the cycle of the system design process (Johnson et al. 2005). Norman, 1988 (cited in Abras et al. 2004) emphasizes design usability by recognizing the needs and interests of users and lays down four basic suggestions on system design that place users at the center of the design process.

- It should be easy to determine what actions are possible at any moment.
- Things should be made visible, including the conceptual model of the system, the alternative actions, and the results of actions.
- It should be easy to evaluate the current state of the system.
- The design process should follow natural mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state. (Norman, 1988)

Fundamental principles of design, and suggestions, all provide guidelines for user-centered design. However, the application of generic guidelines alone cannot guarantee optimal design. As indicated by Mayhew & Mayhew, (1999), every product and its intended users are different, thus as well as well-established design principles, there is the need for tailored guidelines that are validated against the unique product requirements. Factors that are attributed to poor system development and redundant systems include lack of user-centered design knowledge by developers (Johnson et al, 2005). According to Smith, 1993 (as cited in Johnson et al. 2005), findings by the US General accounting office indicate that 98% of software designed for the US government was considered “unusable as delivered”. Only 61% of information systems projects meet user requirements, and 63% of projects go over budget mainly due to initial inadequate user analysis (Johnson et al. 2005).

As users suffer with unusable systems, the time and cost implications of such shortfalls to system developers are enormous. The healthcare industry is an area that is challenged with an ever-increasing workload, infrastructural constraints and noted cases of disparity in service delivery. This industry stands to potentially benefit from the optimal design of usable software that are specifically tailored for the healthcare industry. However, this industry faces several expectation challenges. The healthcare industry continues to deal with unusable systems or systems that decrease productivity due to software developers for the health care industry overlooking pertinent user information (Johnson et al. 2005). mHealth applications also have the potential to change the face of the healthcare industry. However, this area is also encumbered with several challenges. Despite the numerous potential benefits, studies indicate that a quarter of all mHealth application downloads are used only once, as consumers do not return to interventions that do not immediately engage them, thus undermining the potential effectiveness of the application (McCurdie et al. 2012). Designing mHealth applications and other applications via a user-centered approach serves to improve the effectiveness of the intervention and also promotes user engagement (McCurdie et al. 2012; WHO)

2.11 Usability and Iterative Design

The concept of adopting technologically based tools is to develop a system that "fits" an end user, in terms of motor skills, problem solving strategies, and cognitive organization. This means that instead of the user being forced to adapt to new technology, the new technology must adapt to the user (Buxton et al. 1980). To develop this "fit" user testing and other evaluation methods are used to progressively improve user interfaces through iterative development. According to Gould & Lewis (1985), iterative design is a way of tackling unpredictable user needs and behaviors that that can lead to comprehensive essential changes in a design. They assert that problems in user testing must be fixed through a cycle of design, test and measure, and redesign, repeated as often as necessary. In order words, keep trying until you get it right (Buxton et al. 1980).

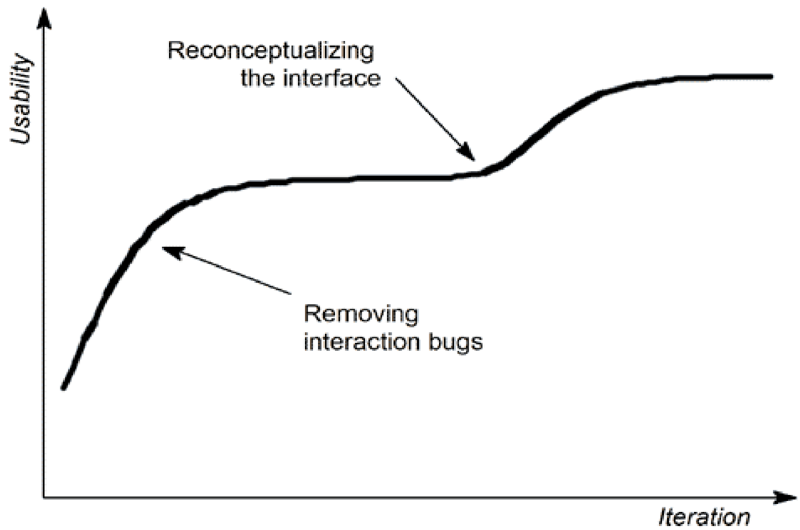


Figure 1. Interface quality as a function of the number of design iterations (Nielson, 1993).

Figure 1 is a conceptual graph used by Nielson to explain the general nature of interaction between usability and iteration. As an interface is refined through iteration, its usability also increases as problems are found and fixed. The plateau on the curve refers to the point where all the major usability challenges in an interface have been addressed and subsequent iterations have only small impact on usability. Nielson projects a phase of diminishing returns where a design may become so refined that very limited potential for further refinement remains. He further explains that a design may become so refined that it reaches its limit as far as usability can be achieved. At this point developers would have to completely reconceptualize an interface based on a new design in order to increase usability after the plateau phase. A modern example is the yearly introduction of new interfaces by iPhone designers.

As a feature of user interface usability has many dimensions, and the 5 attributes often associated with it are described by Nielson as follows:

- Easy to learn: The user can quickly go from not knowing the system to getting some work done with it.
- Efficient to use: Once the user has learned the system, a high level of productivity is possible.
- Easy to remember: The infrequent user is able to return to using the system after some period of not having used it, without having to learn everything all over.
- Few errors: Users do not make many errors during the use of the system, or if they do make errors, they can easily recover from them. Also, no catastrophic errors should occur.
- Pleasant to use: Users are subjectively satisfied by using the system; they like it.

All the above aspects of usability are important, but during iterative design it might be necessary to prioritize one over the other. This is acceptable as long as the values remain above a minimally acceptable value (Nielson, 1993).

2.12 Conceptual Framework

In order to better understand user perceptions in mHealth, the conceptual framework for viewing mHealth usability, the unified theory of acceptance and use of technology (UTAUT2) is worth reviewing. UTAUT was a model developed by Venkatesh et al. (2012) as a unified framework extracted from eight related technology acceptance models.

These are the diffusion of innovation theory (IDT), the theory of reasoned action (TRA), the theory of planned behavior (TPB), the motivation model (MM), the hybrid model of TPB and TAM, the original technology acceptance model (TAM), the PC utilization model (MPCU), and the social cognitive theory (SCT). The UTAUT model proposes four constructs namely performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al. 2003), and is used by researchers to explore user acceptance of mobile technologies. Based on UTAUT, a new model UTAUT2 was developed in 2012. UTAUT2 is an extension of UTAUT, however UTAUT2 focuses on individual perceptions in the adoption of technology and explains user variances in technology adoption (Venkatesh et al. 2012). The UTAUT2 was adopted for the purposes of this study as it provides more insight into factors that affect user adoption of technology.

Having an existing framework enables designers and developers assess and refine the design of mHealth applications and make modifications required to improve the application. What this means is that maintaining a framework for user centered design will allow incremental changes that improves usability.

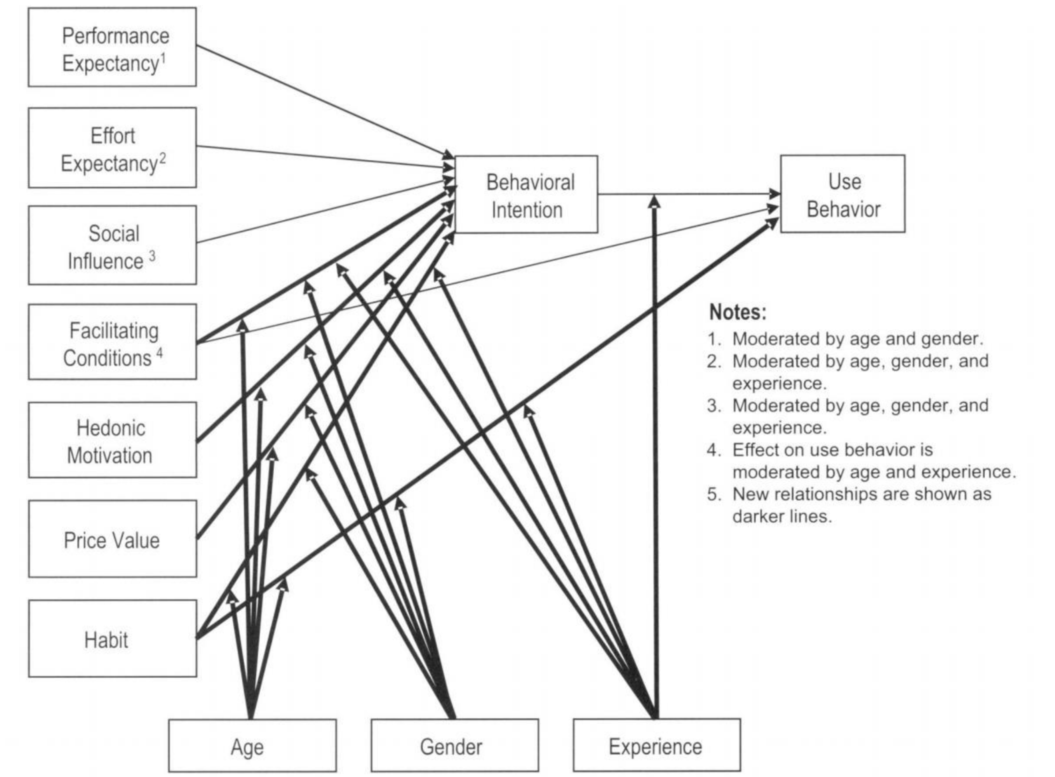


Figure 2. Unified theory of acceptance and use of technology (UTAUT2) model

In addition to the four key constructs of UTAUT, namely performance expectancy, effort expectancy, social influence, and facilitating conditions, UTAUT2 places emphasis on consumer user context by considering, hedonic motivation, price value, and habit as indicated in figure 2. In this context, UTAUT2 is more applicable to Ghanaian migrants in this study.

Performance expectancy - the ‘‘degree to which using a technology will provide benefits to consumers in performing certain activities.

Effort expectancy - the degree of ease associated with the consumers’ use of technology.

Social influence - the degree to which individuals perceive that other important to them believe they should use a technology.

Facilitating conditions - factors in the environment that either facilitate or impede acceptance of technology. Facilitating conditions include many aspects that can influence the actual behavior directly, such as the training or knowledge individuals obtained. Some health and fitness applications may require more knowledge or resources from users than the others. As a result, knowledge of how to use mobile applications can also influence users' continued usage.

Hedonic motivation - ‘‘the fun or pleasure derived from using a technology.’’ In terms of health and fitness applications, although they are not designed purely for hedonic motivations, many of them also include some entertaining features in order to keep users involved and engaged.

Price value - consumers' cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them. Three types of price schemes exist in the current application market: free, paid, and freemium. Free applications are free to download and use; paid applications have to be paid for by the user, before downloading. Freemium applications provide an opportunity for consumers to try an application for free before they decide to buy additional features. (Venkatesh et al. 2012).

Habit - conceptualized as self-reported perception of automatically engaging in a certain behavior, which has been found to be a significant predictor of mobile Internet use. They further explained that performance expectancy, effort expectancy, social influence and facilitating conditions are moderated somehow by age, gender and experience to determine behavioral intention and use behavior.

According to Davis (1989), perceived usefulness is the degree to which a person believes that performance will improve by using the system (Davis et al. 1992). The authors also commented that user acceptance is highly affected by the user's culture. (Evers & Day 1997, Rashed et al. 2013, Seyal and Turner, 2013). While literature suggests that end users could increase their motivation in using the mHealth application (Yuan et al. 2015), it does not provide insight in migrant users adoption of mHealth application or in this respect motivation in using the application.

2.13 Summary of Findings

The findings from literature review expose a lack of substantial literature on mobile health applications tailored for underserved communities and ethnic minorities in general. The literature review also reveals lack of mHealth applications developed with end user inclusion for underserved communities in the United States. Thirdly, the literature review indicates there is limited evidence on the impact or effectiveness of mHealth applications in relation to desired outcomes, thus limited evidence supporting the use of mHealth applications. Mobile phones have become ubiquitous, and mHealth technology promises to be a formidable behavior change and health management tool that cuts across all limitations to reach people from all walks of life with essential health information. Despite the great hype and expectations, the potential of mobile health applications to transform the healthcare industry and the potential to empower underserved communities is hampered by the lack of empirical studies and evidence-based research necessary to foster interest and adoption. It is evident that no significant research or studies have considered the role of user perception of mHealth applications or interventions within migrant communities such as Ghanaian migrants in the united states. The gap in the literature highlights a gnawing concern and a niche that needs to be filled. There is a need for further research within underserved communities. This will inform the development of mobile health applications that are designed for, and with specific cognizance of migrant users, considering user specific cross cultural and usability factors.

Measuring usability requirement will augment the Ghanaian user to drive the design. To that effect, incorporating behavioral and cultural preferences with emphasis on ease of use, user satisfaction, and accessibility, will advance the use of mHealth applications within the Ghanaian migrant communities. User interface designers will also benefit as they design for the global market with cognition of all ethnic minorities. Most of the existing mobile health interventions are based on are based on healthcare system constructs and not on end user needs and requirements, thus limiting its effectiveness.

Chapter 3: Methodology

3.1 Introduction

This methodology will address the research question, hypothesis, experimental design, pilot study and sampling technique. It discusses the instrument and rationale for the research design and how data was collected. The study will focus on three main objectives. The first objective is to investigate user perception of mobile health technology usage as a health intervention among Ghanaian users. This will generate user requirements for the second phase. The second objective is to design, develop and validate a mobile health application as an intervention tool. The third objective is to enhance the application usage and adoption through incorporation of findings from iterative usability testing within the target population.

The background study revealed there are limited studies on the adoption, usage and attitudes of migrant communities towards mobile health technologies. Therefore, by investigating the usability of mobile health applications for personal healthcare management within Ghanaian migrant communities, this research will address the question: Can usability impact user perceptions of mHealth: The Case of Ghanaian migrants? This will examine the hypothesis: Usability impacts user perceptions of mHealth - The Case of Ghanaian migrants. To address this research question, a pilot study was conducted to investigate the Ghanaian users perception of mHealth technology usage.

3.2 Experimental Design

This study will utilize qualitative and quantitative data collection methods to gather data requirements to create a functional and usable mobile application. The data collection for the development and validation of the prototype mobile application will consist of a usability lab testing and a post experiment interview.

3.2.1 Pilot Study

As part of the of this research, a preliminary study was conducted to determine how Ghanaian end users perceive mobile technology usage for health interventions. To address the objective of investigating user perception in mobile Health technology usage, a survey/interview in the form of a questionnaire was conducted to gather user requirements. This was necessary because understanding user requirements is a fundamental part of the application design and considered to be key to the success of interactive functionalities. Factors such as ease of use, and cross-cultural interface design were considered in developing the questionnaire for this preliminary study towards the objective of developing a usable application that will gain acceptance among the Ghanaian end users.

This preliminary study was undertaken in two phases. The first phase was a need analysis study within the target population. This was to gain insight about the mindset of Ghanaian end users and gather information on their needs, knowledge and practices that are peculiar and presenting gaps in accessing available mobile health technologies. The data collection was carried out within a one-month period. A qualitative questionnaire

was developed with open-ended questions, closed questions and Likert scales.
A stratified random sampling approach was used in selecting participants.

The second phase consisted of requirement gathering. This was important to determine the specific needs of Ghanaian users. The data collection was carried out within a five-month period. A qualitative questionnaire was developed with open-ended questions, closed questions and Likert scales. This preliminary study was necessary to validate the research problem and also to examine any new patterns to address the hypothesis of the study.

3.2.2 Pilot Study Participants

Participants were recruited by word of mouth and recommendation. Participants for both phases of the preliminary study were from the age bracket 25- 65, and 30-55 respectively. All the participants were Ghanaians residing in the geographic location Frederick, in Maryland, United States. The purpose of the preliminary study was explained to all participants including the right to terminate their participation at any time. All participants were asked to sign a consent form. Participants were also assured of confidentiality and no personal information was collected.

3.2.3 First Set of Data Collection

A random sampling approach was used in both sets of data collection. All participants agreed to be interviewed on a one on one basis at a convenient location of their choice. The facilities used for the interviews were the Frederick shopping mall or participant’s residence. Each interview lasted 10–15 minutes. First set of data was collected from 27 Ghanaians comprising of 13 males and 14 females. All participants were interviewed face to face. At each interview, the interviewer explained the purpose of the study to the participants and assured them of confidentiality. A questionnaire was given to the participants to follow through the interviewer's questions, which allowed for consistency of responses relevant for the study. Data was captured directly by marking or writing responses on the questionnaire for the different question types. The data obtained from the interview was cleaned, analyzed and relevant patterns recorded. The questionnaire for the first set of data collection is attached as Appendix B-1a.

As part of the part of the first part of the preliminary study, two focus group discussions were conducted to get an idea of community perception of mHealth. Each group comprised 4 participants. The selection of participants was also done by word of mouth and recommendation. Participants were selected from ages 30s, 40s and 50s to get a fair representation of all groups. During the discussions, the facilitator guided the groups using the questionnaire (attached as Appendix B-1a), and captured data by writing responses on the form. To clean the data, all completed forms were thoroughly examined to ensure that all data was accurate and complete.

3.2.4 Second Set of Data Collection

The second set of data for the preliminary study was to determine the user requirements. The study was developed using qualitative data collection techniques. The goal of this approach was to gather and better understand Ghanaian end user requirements. Data was collected from 30 Ghanaians comprising of 12 males and 18 females. The selected age groups that participated were within the ranges of age 30 to 55 and above. During each interview, the interviewer explained the purpose of the study to the participants and assured them of confidentiality. A questionnaire was given to the participants to follow after the interviewer's questions, which allowed for consistency of responses relevant for the study. Data was captured directly by marking or writing responses on the questionnaire for the different question types. The data obtained from the interview was cleaned, analyzed and relevant patterns recorded and then analyzed. The questionnaire for the first set of data collection is attached as Appendix B-1b.

3.2.5 Findings from Preliminary Study: Phase One

Findings were as follows; 41% (11) of participants were within the age group 25-44 years, 44% (12) were within the age group 45-64 years, and 15% (4) were within the age group 64 and above. All 27 participants used smartphones. Participants used smartphones for these purposes: banking, communication, socializing, referencing, information gathering, and medical and health education. 93% (25) indicated that they use their smartphones to search for medical related information from the web, while 7% (2) did not. 81% (23) of participants indicated they were very familiar with health conditions like diabetes, 15% (4) were not well familiar with diabetes. 85% (22 out of 26) indicated that they would alter their behavior based on medical related information gained from the web, 15% (4 out of 26) indicated they would not, one participant did not respond. 93% (25) indicated that using smartphone to monitor their health would benefit them, 7% (2) responded they will not benefit. 67% (18) indicated that they would be interested in paying for an application to monitor their health, 33% (9) said no or were unsure. With regards to what specific features they would like in an mHealth application to achieve their health goals, 100% of respondents said that they would like mHealth applications developed specifically with the Ghanaian diet and lifestyle in mind.

One finding from the focus group discussion was that participants were more likely to download and use an mHealth application, if it was recommended by their primary care provider. One other finding was that participants were inclined to use mHealth applications if it met their specific needs. From the interviews and discussions, one key factor that was highlighted was that respondents were highly interested in a tailored mHealth application that takes into cognizance Ghanaian preferences in terms of ease of use, interface design, and accessibility. Understanding what motivates consumers from a cross-culture perspective is important for positioning brands in different markets. Such implicit cultural values need to be considered when designing applications intended to reach end users from all cultural backgrounds.

The data obtained from this study provides useful insight on the needs of the Ghanaian end user and indicates promising evidence to harness the increasing presence and use of smartphones to deliver mHealth services to migrant communities.

3.2.6 Findings from Preliminary Study: Phase Two

All participants had smartphones with 56.7% (17) having iPhones and the remaining 43.3% (13) having android phones. 56% of participants rated themselves as advanced mobile technology users, whiles 43.3 rated themselves as moderate mobile technology users. 80% (24) of participants already had mobile applications on their phones that they used to manage their health. Main features participants did not like about the applications they were currently using included its complexity (36.7%), lack of accuracy (13.3%), limited options (10%) and security concerns (10%). 66% of participants indicated that they would be interested in a mHealth application specifically designed for Ghanaians. 27% declined to answer. 7% said no, with the reason being security/trust issues. With regards to the question on what specific features and functionalities participants would need in an application designed to help them achieve their health goals, answers obtained have been grouped into functional and nonfunctional requirements and represented in the chart (table 1) below.

Table 1

User needs categorized into functional and nonfunctional requirements.

Functional Requirements	**Percent (%)**	**CI* (95%)**	**Different from Zero**
Diet management / Ghanaian foods	20.5	6.05% to 34.95%	Yes
Fitness management	6.8	-2.21% to 15.81%	No
Health management	22.7	7.71% to 37.69%	Yes
General wellness information	27.3	7.71% to 37.69%	Yes
Voice command function	2.3	-3.06% to 7.66%	No
Nonfunctional Requirements			
Privacy	2.3	-3.06% to 7.66%	No
Availability	4.5	-2.92% to 11.92%	No
Ease of Use	11.4	0.03% to 22.77%	Yes
Performance	2.3	-3.06% to 7.66%	No
Total	**100**		
*CI: Confidence interval			

The results obtained indicated that 100% of participants used smart phones. 80% of participants had mHealth application on their phones, with the most popular applications being Apple health and Samsung health. With the advent of smartphones there has been an increase in the mobile phone applications. This high usage of applications among participants is very encouraging due to the fact that applications play an essential role in patient education, disease self-management, remote monitoring of patients, and collection of dietary data. This is promising in light of the validating the research problem.

Participants were very elaborate on what they needed in an application tailored for Ghanaian migrants. The list of functionalities needed include Diet management, health management, ease of use, fitness management, General wellness information, privacy, good performance and availability. The most significant of the needed functionalities, with high confidence intervals (Table 1), were general wellness information, health management, diet management, and ease of use. A noteworthy point is that when indicating their needs all participants specified the need for the functionalities to be delivered in the Ghanaian context where possible. For example, a diet management application in this context, should include the Ghanaian cuisine repertoire with its emphasis on starchy vegetables and legumes, and should also provide users with dietary information such as caloric contents for Ghanaian specific foods. Although general messages have been shown to have an impact on behavior change, evidence indicates that tailored messages stimulate greater cognitive ability in its audience. In this respect making health, wellness, fitness and diet information relevant in context to the Ghanaian audience will be key in increasing uptake, acceptability and adoption within this group.

These findings are key foundational points that should inform the design when tailoring an application for Ghanaian migrants, however subsequent studies with larger data sets might be needed to substantiate the findings.

3.2.7 Summary of findings from Preliminary Study

Measuring usability requirement augments the Ghanaian user to drive the design. To that effect, incorporating Ghanaian user requirements with emphasis on tailored information on general wellness, health management, and diet management, was significant to advance the development of the mHealth application. Taken cues from a cross-cultural usability studies by providing a preliminary understanding from Ghanaian user perspective, the needs of Ghanaians in terms of content and features, of a tailored mHealth application. The pilot study was an important step needed to provide accurate data and information for developing guidelines for iterative prototype design for Ghanaian users.

3.3 Development of Prototype mHealth Application

Findings from the pilot study phase one and phase two was a major consideration for the development of the prototype mHealth application. The main aspects from the pilot studies that influenced the design were features such as ease of use, and incorporating features on wellness, health and fitness, and diet in a Ghanaian context.

Based on the findings, the investigator designed and developed a mobile prototype called MotiFit (Motivational Fitness). The prototype mHealth Application was built on the IOS platform using Adobe XD, Swift language and XCode. The software and hardware environment used are detailed in Appendix E-1. The process was undertaken with consideration of the conceptual framework of the extended unified theory of acceptance and use of technology (UTAUT2) model by Venkatesh et al. (2012), which emphasizes perceived usefulness, perceived ease of use, hedonic motivation, price value, and habit (Venkatesh et al. 2012). To validate the research question in measuring the usability factors, ease of use and interface design were considered at the structuring of the design.

3.3.1 Cultural Elements in User interface (UI) Design

To maximize usability of the prototype application, an important feature that was strategic in the interface design process was incorporating the existing unique values and characteristics of the intended Ghanaian user population. As indicated by Mayhew & Mayhew (1999), to achieve usability the user interface of an interactive system must take into account several features including the cognitive, perceptual, and the special and unique characteristics of the intended user population. According to Spencer-Oatey (2012), people from a particular group or culture have observable artifacts and values that control how they perceive, think or feel. Wallace and Yu (2009) also suggest that the cultural background of a user is a factor in determining the usability of a consumer electric product. In light of this, taken into cognizance the role of culture in cross-cultural usability, the cultural beliefs and values of Ghanaians were considered in the user interface design stage of the mHealth application. The Ghanaian national colors are red, yellow and green, which are symbolic of blood (red) from the struggle for freedom, mineral wealth (yellow), and rainforest (green). In this regard, the selection of the user interface color scheme and themes for the mHealth application, were derived from the cultural context of the Ghanaian national colors red, gold and green. In order not to confuse users with design complexity, emphasis was placed on clarity of the application by the use of red and white colors for the layout, as they complement each other. This will create a level of emotional connection and acceptance, as well as provide easy navigation and readability with Ghanaian users. It is presumed that this will attract the Ghanaian user's attention, promote confidence and foster a greater sense of ownership in the mHealth application.

3.3.2 Workflow and Wireframe Planning

Using a use case scenario based on the user requirement gathering, a visual representation of the user interface was planned to form the fundamental structure of application. This initial concept of the application was designed by a rough sketch outlining the workflow of application demarcating the relevant features of the application, such as sign-up and login, onboarding, navigation, menus, and push notifications. Sketches were then turned into wireframes detailing their design elements. Factors such as constituency and smart organization were considered to reduce cognitive load. This is show in Appendix C-1 through Appendix C-5.

3.3.3 Prototype Design

A quasi realistic representation of the application was designed for the Ghanaian user to interact with and tested in order to help validate the design. The prototype will help to validate the research question in terms of usability issues in order to measure the impact of user perception. Using open user interface (UI) kits and wireframes kits, all icons and screens were illustrated using ellipse, rectangles, pen tools, symbols and grids in Adobe XD software. This formed the fundamental structure of transition and interactions of the application. Special attention was given to the flow of the screen navigation layout with emphasis on the menu and the core features such as consistency and smart organization, in order to reduce cognitive load and visual hierarchies. To achieve ease of use for the users to interact with the application, the researcher selected clickable wireframe for prototype design.

All screens were linked accordingly linking to relevant features such as Body Mass Index (BMI), food diary and workout. Identifying the main screen features, the application was organized into screen functionalities such BMI, Diary and nutrition and workouts, following the outlined workflow diagram.

The extended Unified Theory of Acceptance and Use of Technology (UTAUT2) framework was adopted for this study, as it places emphasis on consumer user context, highlighting the key constructs – habit, hedonic motivation, and price value, in addition to the original UTAUT constructs – facilitating conditions, social influence, effort expectancy and performance expectancy. The use of the UTAUT2 model for this research provides the framework for refining the prototype design and allows for modifications and incremental changes, as expected in the iterative design process, in order to improve usability.

3.3.3.1 The Design Process

- Reference to the wireframe already created was implemented serving as requirement needs for the application design.
- An artboard was created with the dimension weight and height of 375 X 812 pixel
- A logo called MotiFit which means motivational fitness lifestyle was conceptualized and designed for the application. The colors of the logo emphasize the Ghanaian national colors.
- The artboard background color was set with the fill tool.
- A native UI kit was Imported for IOS.
- The screen layout was copied and duplicated for consistency.
- Assets panel was used to make the design elements consistent. This includes colors, character styles, symbols and images.
- Color scheme was customized to match the Ghanaian colors.
- Next, all elements were grouped, and each layer was named for easy traceability.
- Finally, after designing all screens, the prototype transitions were linked according to the relevant screens. Options such as scroll and click were applied for easy navigation.
- Changes made were previewed repetitively to prevent any unpredicted errors. Screen shots of the user interface design and workflow are shown in Appendix D-1 through Appendix D-5.

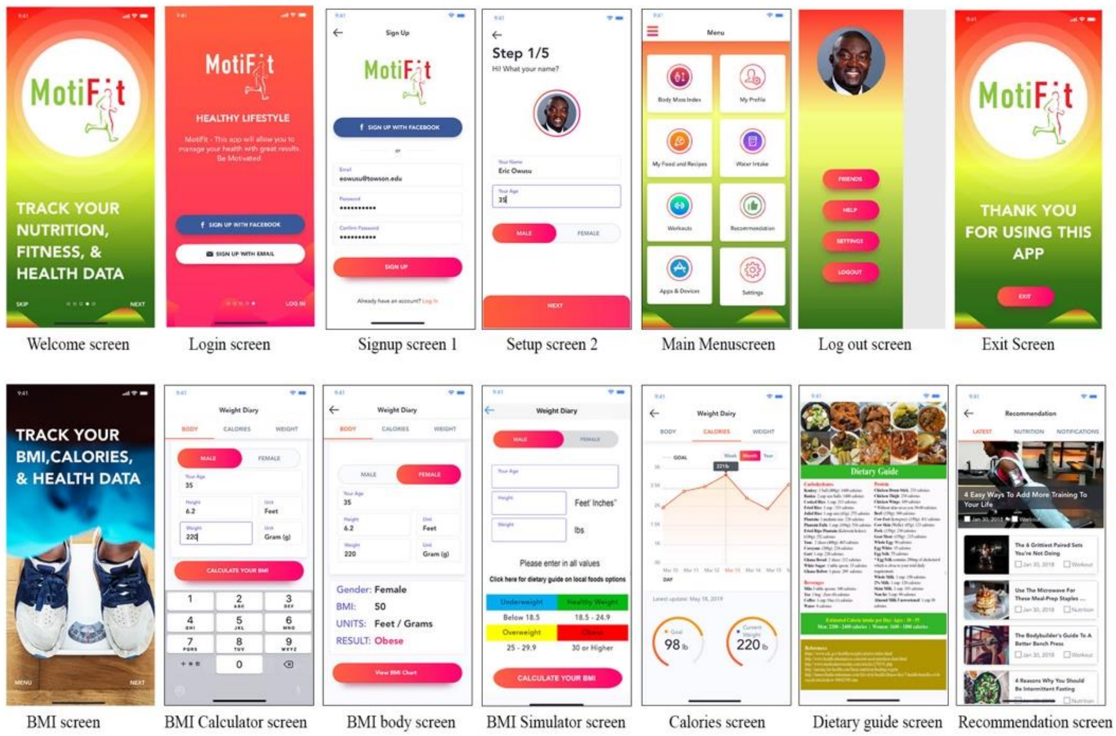


Figure 3. MotiFit Interface prototype screens display

3.4 Usability Testing

Usability testing of the prototype mobile application tool was carried out with the purpose of determining how real users, in this case Ghanaian users, interact with the developed prototype. The objective was to improve or validate the prototype design based on the user feedback. This was done in several phases. These phases included instruction for participants, informed consent, task setup, and post experiment questionnaire. IRB obtained for the usability testing is attached as Appendix A-1-A-2.

3.4.1 Usability Testing Data collection

The full study timeframe was carried out over the Summer and Fall semester of 2019. After IRB permission was received, we began the study to answer the research question. A stratified random sampling approach was used in selecting participants comprising of Ghanaian migrants living in Maryland, U. S. A. Participants (Ghanaians) were chosen by word of mouth and recommendation from other participants who had volunteered. This usability testing included a cohort of 50 individuals in total. All participants agreed to have data collected on a one on one basis at a convenient location of their choice with no offer of compensation. Each survey lasted approximately 15 minutes. Data was mostly collected after work hours between 5p.m. to 9p.m., Monday through Friday, and at weekends between 10am and 6pm. Participants were between ages 30 to 55.

Upon arrival, the principal investigator introduced himself, and appreciated participants for accepting to participate in the study. The purpose of the study was explained to all participants including the right to terminate their participation at any time. All participants were asked to sign a consent form. Participants were assured of confidentiality and no personal information was collected. After completion of the consent form, Participants were introduced to the pre-installed MotiFit application and the investigator explained how to navigate through the MotiFit application tool, after which participants were asked to proceed to complete the paper-based task list. (Table 2).

Each participant was then presented with a mobile device (IOS iPhone 8 plus) with the MotiFit prototype application pre-installed and turned on. They were asked to interact and familiarize themselves with the application before proceeding to specific tasks. The mobile application task outline was then given to each participant to follow through. Below is the Task list (Table 2) participants performed as they interacted with the prototype mobile application.

3.4.2 Task and Procedure

Table 2

Participant Task List

Task No.	What to do
1	Start application (Login) Preloaded
2	Skip registration
3	Navigate through the application
4	Explore the Interface of the application, taking note of colors, typeface (font) and layout
5	Explore the functionality of application example diary, workout and goals
6	Navigate to the BMI screen and choose Gender
7	Enter Age, Height and Weight
8	Calculate BMI
9	Navigate weight graph to learn more about the BMI results
10	Exit and complete post-experiment questionnaire

3.4.3 Usability Testing Questionnaire

After completion of the outlined tasks the participants were asked to complete a questionnaire related to their user experience with the application. This can be seen in Appendix B1-B2. Data was captured directly by marking or writing responses on the provided questionnaire for the different question types. The methods used helped determine the participants likes, dislikes and preferences for the mobile application. The IBM SPSS application was used to statistically analyze the data to draw conclusions for the study. Multiple linear regression was used to analyze the user experience and perception data obtained to predict trends in the data. Confidence intervals was scrutinized to justify that findings are not due to chance results. Ordinal scale was used to determine normality. Correlation between the study variables was analyzed to determine the relationships and individual differences.

Chapter 4: Results

4.1 Reporting Results

This chapter reports the findings of the usability study to determine the impact of user perception in mHealth among Ghanaian migrants. The results are defined in relation to the research objective and research questions to evaluate the hypotheses. In order to answer the research question, this research examines the hypothesis with three main objectives:

1. Investigate user perception on mobile Health technology usage.
2. Design, develop and validate a mobile health application as an intervention to manage and control health challenges among Ghanaian migrant.
3. Enhance the application usage and adoption through incorporation of findings from iterative usability testing within the target population.

A pilot study was conducted using objective 1 and 2 to generate preliminary findings that was relevant in enhancing the design and developing the application.

4.2 Hypothesis Review

The experiment was based on the hypothesis that usability impacts user perceptions of mHealth, the Case of Ghanaian migrants. Therefore, this experiment was designed to determine if a mobile health application designed with Ghanaian migrants' inclusion would increase uptake, acceptability and adoption within this group. To this end, the following research questions were investigated in this study: Can usability impact user perception in mHealth?

The independent variable was the design and modification of the mHealth application, and the specific tasks outlined for the Ghanaian users. The dependent variables were the user satisfaction and feedback. In order to achieve the objective of enhancing the application usage and adoption, the prototype application (independent variable) was tested by means of an iterative usability study with user experience feedback. For this purpose, a qualitative questionnaire with open-ended questions, closed questions and Likert scales was developed. (attached as Appendix B-2)

4.3 Result Analyses

This usability testing results were important to validate the research question of the study. Despite the unique individual preferences and cultural pigeon-holes that influence the adoption of new technologies by indigenous groups, the results obtained in this study generally indicate a positive attitude towards the prototype mobile health application. The full study results showed that the mHealth application was generally well received by the Ghanaian end users.

4.3.1 Descriptive Data

Descriptive data was analyzed for all study variables, which can be categorized into performance expectancy, effort expectancy, facilitating conditions, age, gender and experience, based on the framework of the UTAUT2. Categorical and ordinal variables were analyzed for frequencies and percentages. Ordinal and Likert-type scale variables were also analyzed for central tendency, spread, skew, and kurtosis. Table 3 represents the frequencies and percentages for individual characteristics.

Table 3

Frequencies and percentages for individual characteristics

	Frequency	Percentage
Gender		
Female	28	56.0
Male	22	44.0
Age		
30-35	10	20.0
36-40	8	16.0
41-45	12	24.0
46-50	15	30.0
51-55	5	10.0
Knowledge of Mobile Applications		
Moderate	14	28.0
Above Moderate	21	42.0
Technical	15	30.0
Mobile phone daily usage		
0-1 hrs	1	2.0
2- 4 hrs	9	18.0
4-6 hrs	11	22.0
6-8 hrs	5	10.0
8-10 hrs	4	8.0
more	20	40.0

Healthcare internet research		
0-1 days	3	6.0
2- 4 days	9	18.0
4-6 days	6	12.0
6-8 days	6	12.0
8-10 days	4	8.0
more	22	44.0

As indicated above (Table 3), the participants were 56% female and 44% male. Participant age was fairly evenly distributed across the age groups. Fifteen (30%) of the participants were between 46 and 50 years old, the largest age group. Twelve (24%) were between 41 and 45, ten (20%) were between 30 and 35, eight (16%) were between 36 and 40, and 5 (10%) were between 51 and 55. Knowledge of mobile applications was moderate to high (technical). All participants rated themselves at least moderate, with "above moderate" being the most common answer with 21 (42%). The most common mobile phone usage frequency was more than 10 hours per day, with twenty (40%) giving this answer. The participants also conduct their own healthcare internet research quite frequently each month. Twenty-two participants (44%) do more than 10 days of healthcare internet research each month.

For all ordinal scale variables in the study, central tendency, variability, skew, and kurtosis were also analyzed (Table 3). For variables like age and mobile phone hours per day, the mean was not representative of precise age or amount of use, because the values were grouped into ordinal categories, thus the median was used as a measure of central tendency.

Table 4

Descriptive data for ordinal scale study variables

	Mean	SD	SE	Median	Mode	Skew	Kurt.
Age Range	2.94	1.300	0.184	3.00	4	-0.175	-1.119
Knowledge Mobile Applications	3.02	0.769	0.109	3.00	3	-0.035	-1.281
Mobile phone hours per day	4.24	1.673	0.237	4.00	6	-0.206	-1.555
Days health research per month	4.30	1.787	0.253	5.00	6	-0.451	-1.362
Application ease of use	1.36	0.485	0.069	1.00	1	0.602	-1.708
Would use application if free	1.28	0.497	0.070	1.00	1	1.521	1.439
Would use if helped health	1.40	0.535	0.076	1.00	1	0.835	-0.457
See personal benefits	1.32	0.513	0.073	1.00	1	1.261	0.589
Would pay to use application	1.60	0.728	0.103	1.00	1	0.792	-0.669

SD- Standard Deviation
SE- Standard Error

As shown above (Table 4), the typical participant was in the age range 36-40, while the typical knowledge of mobile application was "above moderate". Mobile phone hours usage per day had a median at 6-8 hours, and days of health research had a median of 8-10 days. Ratings for the application (Application ease of use through “Would pay to use application”), was on a scale from 1 (Strongly Agree) to 5 (Strongly Disagree), with 3 as Neutral. Ratings overall were very positive, most agreeing or agreeing strongly. The highest rated was using the application if it were free with a mean score of 1.28. The lowest rated was paying to use the application with a mean of 1.60.

For all of the variables, approximate normality was determined, to see if parametric statistics were appropriate. In general, skew and kurtosis values with an absolute value less than 2 are considered to be acceptable. In both cases of this study where skew and/or kurtosis are not within the preferred range, this was a result of most participants giving the best rating of "strongly agree" as in the example of “participants that would use application if free” (skew 1.5, kurtosis 1.4) and participants that would use the application if they could “see personal benefits” (skew 1.3, kurtosis 0.6).

4.3.2 Correlation between Study Variables

Correlations between study variables were also analyzed as an initial indication of important relationships in the findings, and to determine if any individual differences should be used as control variables (Table 5).

Table 5

Pearson product-moment correlations between study variables

		1	2	3	4	5	6	7	8	9	10
1.	Age Range	-	-0.104	-0.142	-.294*	-.326*	-0.192	-0.195	-0.141	-0.032	-0.134
2.	Gender	-0.104	-	-.453**	-0.066	-0.077	0.161	-0.069	-0.015	-0.156	0.235
3.	Knowledge Mobile applications	-0.142	-.453**	-	0.155	0.085	-0.129	-0.122	-0.218	0.190	-0.168
4.	Mobile phone hours	-.294*	-0.066	0.155	-	.562**	-0.159	0.016	0.027	-0.139	0.064
5.	Days health research	-.326*	-0.077	0.085	.562**	-	0.038	-0.051	-0.043	-0.241	-0.157
6.	App ease of use	-0.192	0.161	-0.129	-0.159	0.038	-	0.251	0.220	0.020	.416**
7.	Would use app if free	-0.195	-0.069	-0.122	0.016	-0.051	0.251	-	.723**	.362**	.485**
8.	Would use if helped health	-0.141	-0.015	-0.218	0.027	-0.043	0.220	.723**	-	.343*	.419**
9.	See personal benefits	-0.032	-0.156	0.190	-0.139	-0.241	0.020	.362**	.343*	-	0.186
10	Would pay to use app	-0.134	0.235	-0.168	0.064	-0.157	.416**	.485**	.419**	0.186	-

* Correlation (r) is significant at the 0.05 level (2-tailed)

** Correlation (r) is significant at the 0.01 level (2-tailed)

There was a significant gender difference ($r = -.453$, $p < .01$) in self-reported knowledge of mobile applications, with female participants reporting lower knowledge. There was also a negative correlation between Age and mobile phone hours ($r = -.294$, $p < .05$), as well as Age and days of health research ($r = -.326$, $p < .05$).

With regards to relationships between "ease of use" and ratings about intentions to use the application, and perceptions of the application's usefulness, there was one significant relationship within these comparisons. Application ease of use was positively correlated with willingness to pay to use the application ($r = .416$, $p < .01$).

4.3.3 Design and Satisfaction with Features

Participants were asked to identify features of the application that they felt were well designed or poorly designed, as well as which features with which they were satisfied or dissatisfied. Participants were required to identify any features for these labels and could also choose as many features as they wanted. As a result, only a small number of participants chose to identify particular features in this way. The benefit of this approach is that the participant only identifies the features that stand out to them as particularly good or bad in some way.

To determine which features were related to perception of and willingness to use the application, all possible comparisons were made using ANOVA tests for significance. Because the feature variables were treated as two groups, those who selected the feature as well designed, (for example) and those who did not, the ANOVA tests are also equivalent to independent-samples t-tests. This can be viewed in Table 6.

Table 6

Features Significantly Predicting Intention to Pay for Application

Feature (# endorsing)	Mean Diff.	SS	df	Mean Sq.	F	p
Recommendation well designed (10)	.63	3.125	1	3.125	6.557	.014

From table 6, only one feature selection variable, identifying the recommendations as well designed, was related to willingness to pay for the application (F = 6.56, p = .014). Ten participants chose to identify the recommendations as well designed and on average were .63 points (where 1 point is equivalent to 1 rating category, such as moving from agree to strongly agree) more willing to pay for the application. The significance of this is that there is 98.6% certainty that in the population (Ghanaian migrants) the individuals who think the application is well designed will also be more likely to pay for the application.

Table 7

Features Significantly Predicting Willingness to Use Free Application

Feature (# endorsing)	Mean Diff.	*SS*	*df*	Mean Sq.	*F*	*p*
less cultural symbols dissatisfied (2)	-.75	1.080	1	1.080	4.713	.035
Not enough foods on dietary guide dissatisfied (4)	-.51	.960	1	.960	4.146	.047
Interface layout dissatisfied (2)	-.75	1.080	1	1.080	4.713	.035
Graphics well designed (1)	-1.76	3.019	1	3.019	15.991	.000
Recommendation well designed (10)	.35	.980	1	.980	4.238	.045

Mean Diff. = Mean difference
SS = Sum of squares
df = Number of groups minus one
Mean Sq. = Mean Square
F = F statistic

Several feature selection variables were related to using the application if it was free. One participant noted that the graphics were well designed, but also had a much lower rating for willingness to use the application if free. While this result was statistically significant due to the large difference in the score, it was based on only one participant. 10 participants identified the recommendations as being well designed, and they were more likely (.35 points) to use the application if free. Three additional features were related to being less likely to use the application if free, and as expected were dissatisfactory comments about the features. These were dissatisfaction due to less cultural symbols (F = 4.71, p = .035, Mean Diff. = -.75), dissatisfaction due to not enough foods on dietary guide (F = 4.15, p = .047, Mean Diff. = -.51), and the interface layout (font size) being dissatisfactory (F = 4.71, p = .035, Mean Diff. = -.75).

Table 8

Features Significantly Predicting Perception of Personal Benefits from Using Application

Feature (# endorsing)	Mean Diff.	SS	df	Mean Sq.	F	p
Not enough foods on dietary guide dissatisfied (4)	-.74	2.010	1	2.010	8.878	.005

One feature variable, dissatisfaction due to not enough foods on dietary guide, was related to lower perception that the user will receive personal benefits from using the application (F = 8.88, p = .005, Mean Diff. = -.74).

4.3.4 Linear Regressions

To determine if the ease of use for the application was predictive of perception and intentions, linear regression tests were conducted (Table 8). From the results it emerges that ease of use significantly predicted willingness to pay for the application (*B = .625, t* = 3.17, *p* = .003). For an increase of 1 point on ease of use, a .625-point increase in willingness to pay for the application was observed. This correlational finding does not establish a cause and effect relationship but suggests that participants are more willing to pay for the application if they perceive as easy to use.

Table 9

Linear Regression: Ease of Use Predicting Perceptions & Intentions Toward Application

DV	*B*	*SE(B)*	β	*t*	*p*	*R2*
Would use app if free	.257	.143	.251	1.796	.079	.063
Personal Benefits	.021	.153	.020	.137	.892	.000
Would pay for app	.625	.197	.416	3.170	.003	.173
Use app to improve health	.243	.155	.220	1.566	.124	.049

4.3.5 Frequencies and percentages of indicators variables

Table 10

Frequencies and percentages for design-related indicators variables

	Frequency	%
Well designed		
All	18	56.0
BMI	13	26.0
My Food and Recipe	1	2.0
Workout	3	6.0
Recommendation	10	20.0
Dietary Guide	11	22.0
Water Intake	2	4.0
Color Scheme	2	4.0
Interface Layout	2	4.0
Cultural Features	2	4.0
Menu	4	8.0
Easy navigation	7	14.0
Graphics	1	2.0
Inadequately designed		
More details	4	8.0
Recommendation	2	4.0
Interface layout	2	4.0
Less cultural symbols	1	2.0
Dietary font too small	1	2.0

Participants were asked to identify any features of the application that were well designed. More than half (56%) of the sample indicated that all of the features were well designed. Some specific features were frequently identified as well designed, including BMI (26%), Dietary Guide (22%), and Recommendation (20%). A few participants also identified Easy Navigation (14%) and Menu (8%) as being well designed.

Participants also were asked if any features were inadequately designed. Only a small number of participants selected features as inadequately designed. These included More details (8%), Recommendation (4%), Interface layout (4%), Less cultural symbols (2%), and Dietary font too small (2%).

Table 11

Frequencies and percentages for satisfaction indicators variables

	Frequency	%
Satisfied		
All	5	10.0
BMI	17	34.0
My Food and Recipe	6	12.0
Workout	5	10.0
Recommendation	7	14.0
Dietary Guide	17	34.0
Color scheme	4	8.0
Interface layout	4	8.0
Cultural features	1	2.0
Menu	5	10.0
Easy Navigation	6	12.0
Graphics	1	2.0
Dissatisfied		
Dietary Guide	2	4.0
Not enough foods on dietary guide	4	8.0
Dietary font too small	2	4.0
Limited food categories	1	2.0
search into other liquids like alcohol	2	4.0
restricted to only Ghanaians	1	2.0

less cultural symbols	2	4.0
More details on information	2	4.0
Color scheme	1	2.0
Keyboard to big	1	2.0
No Language option	1	2.0

Table 12

Frequencies and percentages comment indicators variables

	Frequency	%
All	2	4.0
User friendly	9	18.0
Ease of use	7	14.0
Ghanaian specific	17	34.0
African foods	6	12.0
Water	1	2.0
Zoom	1	2.0
Simple Appealing	8	16.0
Healthy	2	4.0
Colorful	1	2.0
Layout	1	2.0

When participants were asked to share comments about the application, the most frequently identified items were Ghanaian specific features (34%), User friendly (18%), Simple appealing (16%), Ease of use (14%), and African foods (12%).

Table 13

Frequencies and Percentages indicators variables groups

	Frequency	%
What comments do you have about the functions of the mobile application?		
Ease of use	18	36.0
Cultural factors	25	50.0
Health related	5	10.0
Interface Design	13	26.0
Overall, what features were you satisfied with regarding the mobile application?		
Ease of use	12	24.0
Cultural factors	33	66.0
Health related	34	68.0
Interface Design	15	30.0
Overall what features were you dissatisfied with regarding the mobile application?		
Ease of use	0	0.0
Cultural factors	12	24.0
Health related	4	4.0
Interface Design	3	6.0
Which features of the application do you think were well designed?		
Ease of use	25	50.0
Cultural factors	36	72.0
Health related	46	92.0
Interface Design	25	50.0
Which features of the application do you think were inadequately designed?		
Ease of use	0	0.0
Cultural factors	1	2.0
Health related	6	12.0
Interface Design	3	6.0

4.4 Summary

The purpose of this study was to determine if usability impacts user perception in mHealth. The full results attained in this experiment largely indicate a positive attitude towards the prototype mHealth application and showed that the mHealth application was well received by the Ghanaian end users.

From the findings, age of participants was fairly evenly distributed across the age groups, with 56% female and 44% male. Significant gender difference in self-reported knowledge of mobile applications, with female participants reporting lower knowledge. Negative correlation was indicated between age and mobile phone hours of usage, as well as age and duration of mobile health research. This indicating a negative relationship that number of hours and days of usage of these variables decreased with increasing age. For comments and recommendations users highlighted several interesting factors such as: Modification of the gender options to include “others”; Versatility of the application in terms of language options allowing for Ghanaian language option and also considering other African languages; The dietary guide being modified to include the entire Ghanaian food repertoire, considering other common African foods, and also providing advice for healthier food choices; The need to include more cultural symbols and colors representative of the Ghanaian culture.

In summary the application was very well received, with many more positive than negative features identified. The features identified as important, including the core features (BMI/Recommendation/Dietary Guide), usability (Ease of Use, Navigation, Dietary Guide), and cultural features (Ghanaian specific, African foods), were also rated or commented on very positively. The weaknesses were limited to some disagreement on the usefulness of recommendations, and the lack of details. Given the satisfaction with the most fundamental features, implementation of the application is likely to be successful and improvement of details and recommendations can be pursued as the application further develops. Two features, Workout and My food and recipe, did not get a large number of positive or negative comments. These can be targeted for optimization as well, by collecting more feedback in larger samples as the application increases in user base.

Chapter 5: Conclusion

The purpose of this empirical study was to explore the impact of user perception on the usability of mobile health applications. Specifically, this experiment was established to determine if mHealth application user perception by Ghanaian end users affects usability and adoption. This chapter includes a discussion of major findings as outlined in the descriptive analysis. Also included is a discussion on the findings in this study and the correlation to the conceptual framework. The chapter concludes with a discussion of limitations of the study, direction for future research and conclusion.

With current advances in technology, the global market is inundated with smartphones and mobile communication devices that are used as platforms for mobile health applications. The use of compact mobile devices for the monitoring of health status and delivery of health care information has great potential to transform the healthcare industry by reaching and empowering users from all walks of life with valuable and timely health information. However, literature review indicates that the proliferation of mHealth applications is not backed by evidence-based research on their effectiveness or the perception of end users. With specific reference to migrant populations, literature review further indicates a lack or sparsity of information on the adoption, usage and attitudes of migrant populations towards mHealth applications.

Usability testing offers a distinctive opportunity to study the cognitive interaction patterns and perceptions of end users, thereby highlighting differences or concerns that need to be addressed in order to maximize the usage or adoption of mobile health applications.

This study seeks to answer the research question: Can usability impact user perceptions in mHealth? In order to answer the research question, this study gathers relevant information from Ghanaian migrants necessary to determine their perception and design a tailored and customized mobile health application for this specific user group. By so doing it is hoped that there will be an increase in usage and adoption of the mHealth application, resulting in positive behavior change and improved health outcomes.

The study hypothesized that the mHealth application will positively impact user perception. The results obtained indicate the application was well received by Ghanaian end users and indicate a positive attitude towards the prototype mHealth application. Overall the results obtained from this study indicates promising evidence to increase usability of mHealth applications by detailed customization and design improvement based on usability studies and iterative design process with target user groups.

5.1 Interpretation of the Findings

The International Organization for Standardization (ISO 9241) defines usability as the “Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. The measurable factors affecting the usability of a system as outlined by the ISO standard are;

Effectiveness - Accuracy and completeness with which users achieve specified goals.

Efficiency - Resources expended in relation to the accuracy and completeness with which users achieve goals.

Satisfaction - Freedom from discomfort, and positive attitudes towards the use of the product.

In order to shed light on the measurable factors as an indicator of the usability of the prototype mobile application, the data collection tool was designed with questions based primarily on the categories- performance expectancy, effort expectancy, behavioral intent, user experience and facilitating conditions.

5.2 Demographics and Experience

In terms of age and gender the results indicated a fair distribution between the sample, with 56% males and 44% females. Age was also fairly evenly distributed with a mean of 10 participants within each age bracket as indicated in table 3. Using an even age and gender distribution of sample helps eliminate age or gender bias in term of results obtained. However, results were further analyzed for correlation between age or gender and the study variables.

With regards to prior knowledge or experience pertaining to mobile applications all participants rated themselves from moderate to high (technical), with "above moderate" being the most common answer with a frequency of 21 (42%). Results also indicated participants frequently conducted online healthcare research, with twenty-two participants (44%) indicating that they undertake more than 10 days of internet healthcare research each month. The experience of participants with mobile applications and online healthcare research is a very useful asset in this study, as it indicates that the concept of this study is not new to participants. Thus, the past experience of participants, whether positive or negative, will inform the comments and recommendations provided, and highlight key factors necessary to address in order to develop a mobile application that meets the needs of the user group it is being tailored for.

5.3 Descriptive Analysis

Analysis of the results on the comments about the functions of the mobile application, indicates that the features participants liked about the mobile application can be categorized into cultural features (50%), Ease of use (36%), interface design (26%) and Health information delivery (10%). Table 12. The high preference for cultural features, which includes Ghanaian specific foods, dietary guide, color scheme and African foods in general, suggests that the application being tailored to meet the specific cultural needs of Ghanaians was important to the users. Preference for ease of use (36%) which included comments on the application being simple or appealing, suggest that using the application easily without discomfort or complication is also important to users. This falls under user satisfaction and makes sense when thinking about how many times per day the application may need to be used to successfully track or change daily behaviors.

Analysis of results for user identification of satisfaction with features (Table11) indicated that 66% of participants were satisfied with the cultural features of the phone such as the Ghanaian food and recipe list, dietary guide and color scheme, while 68% of participants chose satisfaction with the health related features such as BMI, workout guide and recommendations. Satisfaction with functional phone features such as interface design and ease of use lagged behind at 30% and 24% respectively. Satisfaction with the cultural features of the application and the health-related features being top of the satisfactory features can be interpreted to be indicative of participants being more interested in the perceived benefits and cultural markers of the application. Satisfaction with ease of use and interface design being bottom of the list implies that these important features need to be improved on to be as highly rated as the others.

Only 38% of participants chose features they were dissatisfied with regarding the mobile application. These were cultural features (24%), health related factors (8%), and interface design (6%). Comments from users selecting cultural features dissatisfaction included, limited Ghanaian food categories in dietary guide, the need to include Ghanaian alcoholic drinks in the dietary guide, not enough cultural symbols, and the need for language options (ability to choose between English or the Akan Ghanaian language). These findings echo the results obtained in the preliminary study. In the requirement gathering phase conducted during the preliminary study, some participants recommended that although the mobile application was being tailored for Ghanaians, in addition to the Ghanaian foods they wanted to be informed about other African foods. This is a notable recommendation as it would increase the versatility of the mobile application by making it appeal to migrants from other African countries. Interestingly, some participants in the preliminary study also indicated that they would like to get information on Ghanaian local drinks and alcoholic beverages.

Results obtained on dissatisfaction with interface design included comments on fonts sizes being too small and the keyboard being too big. Comments on dissatisfaction with health-related factors was the need for more information on healthy diet and exercise. Selecting a feature as dissatisfactory does not necessarily indicate design inadequacy but highlights features that need to be improved on in subsequent designs.

Analysis of results for participants perceptions of the application as well designed or inadequately designed indicated more than half 56% of the sample thought all the features of the application were well designed. Well-designed features can be further categorized into health-related features (92%), cultural features (72%), ease of use (50%) and interface design (50%). Features chosen as inadequately designed were only a few in frequency, with cultural factors (2%), interface design (6%), and health related features (12%). Taken together the results for feature design suggest that the core features of BMI, Dietary, Guide, and Recommendation were well received, however some did not like the recommendations. Additional comments about recommendations and why they do or do not work well for individual users should be collected in further application development. Interface layout had equal numbers identifying it as well designed or inadequately designed, again suggesting the need for more information from users.

A noteworthy and interesting finding from the above results was the fact that participants had a higher preference for cultural features and the health-related features of the application over functional features of the application such as ease of use and interface design. This could be interpreted to imply that users were attracted to applications that had colors, symbols, artifacts, and information representative of their culture. It also implies that aside aesthetics, users are attracted to applications that give them accurate and in-depth information on their health and how to adopt healthy lifestyles. In other words, one can say that the key thing that attracts users to an application is the ‘content’ and ‘context’. In this regard, the content or information being delivered, has to be accurate and relevant, and the context or how the information is delivered, has to be culture specific. This can be done by the active engagement and inclusion of end users at every stage of the design process.

The literature review revealed the lack of mHealth applications developed with end user inclusion for underserved communities in the united states. General messages have been shown to have an impact on behavior change, but evidence indicates that tailored messages stimulate greater cognitive ability in its audience (Kreuter et al., 2003). In this respect making health, wellness, fitness and diet information relevant in content and context to the Ghanaian audience will be key in fostering a sense of ownership and increasing adoption within this group.

5.4 Correlation between Study Variables

Correlation (r) is an important indicator of relationship between variables. Thus in order to gain as much information as possible from the data obtained, the data was further analyzed to determine the relationships if any, between the study variables (Table 5).

5.4.1 Demographics

A negative correlation was identified between age and the variables mobile phone usage ($r = -.294$, $p < .05$), and days of online health research ($r = -.326$, $p < .05$). The negative relationship indicates that number of hours and days for these variables decreased with increasing age. This implies older participants used their phones less and do not conduct as much online health research as the younger participants. Additional information would have to be collected specifically from the older age group to determine how best to engage them with mobile health applications. Font size and voice control options are examples of features that have to be addressed to bolster interest of the mobile application by older users.

The only significant correlation between gender and the other study variables was in the self-reported knowledge of mobile applications. Female participants reported lower knowledge of mobile applications ($r = -.453$, $p < .01$) as compared to the males. It would be interesting to collect additional information from female users on the reason for the above and how best to increase usage among female users. Of particular interest was relationships between “ease of use” and ratings about intentions to use the application, and perceptions of the application’s usefulness. A significant relationship noticed within these comparisons was that, application ease of use was positively correlated with willingness to pay to use the application ($r = .416$, $p < .01$). The correlation was that participants that perceived the application as easy to use were also more likely to pay for the application. Analysis of the results indicates that ease of use significantly predicted willingness to pay for the application. This correlation suggests that participants are more willing to pay for the application if they perceive as easy to use.

There was also 98.6% certainty significance that in the Ghanaian migrant population individuals who perceive the application as well designed will also be more likely to pay for the application. Dissatisfaction due to less cultural symbols, dissatisfaction due to not enough foods on dietary guide, and the interface layout being dissatisfactory were related to lower perception that users will receive personal benefits from using the application, and participants being less likely to use the application if free. This implies participants are less likely to pay for the application or use the application even when free, if in their perception there are inadequate cultural symbols, inadequate information of Ghanaian local foods, or if they are dissatisfied about ease of use or interface layout. The inference from the above and its significance to this study is that if more emphasis is placed on cultural markers, inclusion of more culture specific food categories, optimizing ease of use, and options to customize font size and interface layout, it can significantly increase adoption of the mobile application.

5.4.2 Usability and Cultural beliefs and values

One thing that is apparent when analyzing the results is that the perceptions of users is strongly influenced by culture. Users could be given an application that has been expertly proven to be perfect in all the usability performance indicators such as effectiveness, efficiency, and satisfaction, but their perception and adoption of the application would still be influenced by the presence or absence of cultural markers. As discussed in the literature review, a key factor that determines the usability of a consumer electronic product is the cultural background of a user. Thus, what may seem to be good usability design for one culture may not be perceived as such by another (Wallace & Yu, 2009). Cultural markers that affect user perception include imperceptible values and dispositions that users might not be aware of, but which become apparent when a study like this is conducted. The implication for this study is that, to positively influence user perception towards mHealth applications, apart from providing a functionally useful product, the aim should be to let the targeted user group feel at home. To achieve this, specific emphasis has to be placed on cultural elements indicated by the users such as national foods, language and symbols, as well as subtle cultural elements such as spatial orientation, shapes, colors, text, and graphics.

For example, in this study participants commented that one of the key attractions to use the mobile application was due to emphasis placed on the overall interface color scheme, which was achieved by the use of the Ghanaian national colors: red, yellow and green. Comments made by participants indicated that they liked the bold Ghanaian colors (red, yellow and green) used as a theme throughout the application. But they mentioned that the application should incorporate more of the Ghanaian "Adinkra" symbols (cultural symbols) signifying the traditional values of Ghanaians. This implies that there was a level confidence and emotional connection to the MotiFit application generated by the cultural elements.

In general, understanding what motivates end users from a cultural perspective, will have a significant impact on how designers develop strategic, tailored and value-based mHealth applications for the global market.

5.5 UTAUT2 Framework

Three constructs of the conceptual framework (UTAU2) adopted for this study were used to assess key factors that influence the Ghanaian users intention to adopt the MotiFit application.

5.5.1 Behavioral Intention

This implies that if a consumer has a positive or enjoyable experience while using a technology, they are more likely to repeat using the technology. Repeated use of the technology results in routine behavior or habit which in turn reduces the enjoyability of using the technology and subsequently reduces behavioral intention. From the results and the personal observations made when conducting this study, participants were happy about their experience with the MotiFit application. Comparing their experience with the

MotiFit application with other health applications, although other health tools were working for participants, most felt the key features were general and boring. Participants were excited about the MotiFit application primarily because of the tailored cultural context and the sense of ownership and inclusion it created. To sustain the use of the application and boost behavior intention, it will be necessary to introduce features that will motivate or drive the interest of users, such as group challenges, and games, or solicit directly for user feedback.

5.5.2 Price Value

Cognitive trade-off between the perceived benefits of the application and the monetary cost for using the application was examined in this study. Most participants indicated they were willing to use the application if free. But beyond that, from the results there was 98.6% certainty that in the population (Ghanaian migrants) the individuals who think the application is well designed will also be more likely to pay for the application. Participants willingness to pay for the application was also significantly predicted by the ease use of the application. This is a very positive feedback for this study as it implies participants (Ghanaian migrants) are willing to use the application if it meets their expectations, regardless of cost. As mentioned in the literature review there are three types of price schemes (free, paid, and freemium) that exist in the current application market (Venkatesh et al. 2012), and price value has an effect on behavioral intention. User centered design, as done in this study results in the development of technology that benefits the targeted audience. Thus, the audience realizes the benefits of the technology, rather than the cost.

5.5.3 Hedonic Motivation

The purpose of this study was not to design an application for the fun and pleasure of the targeted audience, but attention to specific cultural elements such as inclusion of colorful images of national foods, display of cultural (adinkra) symbols on the pages, and designing the application in the colors of the national flag, created a pleasurable ambience necessary to keep users interested and engaged in the application. The positive effect of this is indicated in the positive attitude of users in the usability testing.

Overall the findings indicate that, measuring usability requirement will augment the Ghanaian user to drive the design of tailored mobile applications. To that effect, incorporating behavioral and cultural preferences with emphasis on ease of use, user satisfaction, and accessibility, will advance the use of mHealth applications within the Ghanaian migrant communities. User interface designers will also benefit as they design for the global market with cognition of all ethnic minorities.

5.6 Lessons learned

Culture has a strong impact on usability, thus in usability testing it is important to ensure that participants are culturally representative of the intended user group. Testing Ghanaian migrants who have "westernized" and have no sense of their culture may seriously distort the results of a usability study. This was exhibited in the preliminary study where some participants expressed their interest in a mHealth application tailored for Ghanaians, however they were unable to answer follow up questions on what they specifically liked in a tailored mHealth application.

Getting participants to willingly spend time and participate in a study of this nature is not an easy task. The researcher had to be strategically professional, approachable and patient in recruiting for participants. It was necessary to give participants the background of the study, answer all their questions, and ensure they were comfortable in taking the survey.

In allocating time for the data gathering phase, it was important to set more time aside than was anticipated for each interview. Several participants were late for their scheduled interviews, and some participants took more time than anticipated in answering questions. After answering the questions some participants also wanted to talk to the researcher about their views on such an application for Ghanaian migrants. Setting aside ample time for each interview allows for all such eventualities without pressure on the researcher or participant. This also builds the interest of participants as they wait to experience an application that was informed by their specific requirements.

The researcher anticipated that not everyone will be open to undertake the survey, but after explaining the concept of the study to participants and assuring them that no answer was wrong, participants where more than eager to test the application. Participants freely gave out their comments and recommendations knowing it will inform the design of the application made specifically for them.

Participants rated the application highly based on the inclusion of cultural features that made them ‘feel at home. However, it is important to go a step further to sustain behavioral intent so as to always engage users. For example, instead of simply including caloric information on national foods in the dietary guide, extra features such as different ways of food preparation, alternative foods, nutritional information and nutritional content comparison should be added to sustain behavior intent and increase hedonic motivation and price value.

Lastly, users are already being bombarded with mobile applications that claim to do one thing or another, thus all efforts should be made to promote context sensitivity in order to improve usability within the targeted audience.

5.7 Limitations

A larger sample size would have been ideal for such a study. Although it was successful to statistically analyze the results from the number of participants, a larger study with a greater number of other migrant participants would have resulted in more conclusive findings. As a result, data collection incorporating a larger sample size might be needed to clarify or substantiate findings in this study

In the preliminary study (phase 1&2), identifying the appropriate requirements to interpret was challenging. There were inconsistencies in answers provided. Participants had unclear statements, and contradicting requirements. This become challenge during the sampling, coding and analyzing the data. For example, some participants indicated although they already had a mHealth application they were using they were more interested in a mHealth applications that was tailored for them as Ghanaians, however they refused to answer follow up questions on what they would specifically like in a tailored mHealth application. In this instance quantitative questions would have been more helpful.

Another limitation of the study was the testing environment. Some participants preferred testing the application in the comfort of their homes. There was one instant where a participant was willing to participate but had a baby at home who interrupted the task twice. As a result, the process of filling the questionnaire took an hour to complete. The researcher needs to secure a suitable and conducive testing environment in future studies.

5.8 Future Research

Future research patterns should include expanding this study to encompass a larger cohort of participants form different locations. This research should also be extended to other migrant groups in the United States, to determine their perception and interaction with mHealth applications. Current research primarily focuses on the different mHealth applications that are available, and their use for various health challenges, it is imperative that more evidence-based research is conducted on the actual impact of mHealth applications not just for migrant populations, but for the general population as a whole. There is the need for extensive research for data gathering within underserved communities, to inform the development of mobile health applications that are designed for, and with specific cognizance of migrant users, considering user specific cross cultural and usability factors.

5.9 Conclusion

Despite the unique cultural preferences and bias that influence the adoption of new technologies by indigenous groups, the results obtained in this study generally indicate a positive attitude towards the prototype mobile health application. The careful consideration and inclusion of the unique needs of Ghanaian end users during the design process cultivated a greater sense of ownership and acceptance as indicated by the willingness to pay for the application if necessary. End users are more likely to embrace mHealth technology when the implicit cultural values embedded in artifacts during the design stage reflect the values of end users (Leidner & Keyworth, 2006). With respect to this, it is strongly recommended that user interface, user experience designers and researchers gain better understanding of targeted cultural preferences and the role it plays in the design process and usage of mHealth technology (Chakraborty, Delinger & Hritz, 2017).

Appendices

Appendix A-1: IRB Consent Form

Informed Consent Form

CONSENT FORM

PRINCIPAL INVESTIGATOR: Eric Owusu PHONE: 301-693-2168

Purpose of the Study:
The purpose of this study is to investigate if usability impact migrant user perceptions in mobile Health technology. To that effect a mobile health application will be designed, developed and validated as an intervention to manage and control diabetes among Ghanaian migrants. Additionally, to enhance the application usage and adoption through incorporation of findings from iterative usability testing within the targeted population.

Procedures:
Participants will be met at Towson University Universal Usability Laboratory by the principal investigator. The principal investigator will explain the purpose of the study to the participant and will inform the participants of their rights, including the right to terminate their participation at any time. After this stage, the participant will be asked to sign the consent form. Upon signing of the form, participants will be asked to complete a task using the develop mobile health application tool. The participant will be asked a series of questions starting with pre-test questions. Afterwards, the participant will be asked to navigate through the interface and the functionality of the mobile application followed by a post-test questionnaire in respect to their personal experience and perceptions about the mobile application tool. An in-depth interview guide in the aspects of user satisfaction, ease of use and user acceptability topics will be asked. Participants responses and reactions will be documented using a pen and paper. Each interview is expected to last approximately 15 minutes.
Two focus groups will participant in a discussion to get an idea of Ghanaian migrant perceptions in using mHealth technology. Each group will comprise of 4 participants at the Burr Artz Public Library Frederick downtown by the principal investigator. Selected participant will be ages from 30 to 55 to get a fair representation of all groups. The complete procedure for the steps would be approximately a maximum of 1 hour.

Risks/Discomfort:
There are no known risks associated with participation in the study. Should the interview become distressing to you, it will be terminated immediately, or participant may ask for a break.

Benefits:

This research is a partial fulfilment of Doctor of Science degree for the Principal Investigator. The study may contribute to the solution of bridging the gap of healthcare management among marginalized communities using mHealth technologies.

Alternatives to Participation:
Participation in this study is voluntary. You are free to withdraw or discontinue participation at any time. Refusal to participate in this study will in no way affect any of your academic status.

Cost Compensation:
Participation in this study will involve no costs or payments to you.

Confidentiality:
All information collected during the study period will be kept strictly confidential. You will be identified through identification numbers. Identifying your name is completely optional. No publications or reports from this project will include identifying information on any participant.

If you agree to join this study, please sign your name below.

_____ I have read and understood the information on this form and have had any questions answered to my satisfaction.

____
Subject's Signature Date

____
Witness to Consent Procedures Date

____June 14, 2018______
Principal Investigator Date

If you have any questions regarding your rights as a research participant please contact the Institutional Review Board Chairperson, Dr. Elizabeth Katz, Office of University Research Services, 8000 York Road, Towson University, Towson, Maryland 21252; phone (410) 704-2236. If you have questions about the study or if you wish to withdraw your consent, please contact the Investigators, Eric Owusu at 301-693-2168 or Dr. Joyram Chakraborty at (410) 704-2109 Department of Computer and Information Sciences. 7800 York Road, Suite 406, Towson University, Towson, Maryland 21252; (410) 704-2633).

THIS PROJECT HAS BEEN REVIEWED BY THE INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN PARTICIPANTS AT TOWSON UNIVERSITY

Appendix A-2: IRB Approval Letter

TOWSON UNIVERSITY

APPROVAL NUMBER 1806035913

Office of Sponsored
Programs and Research

Towson University
8000 York Road
Towson, MD 21252-0001

t. 410 704-2236
f. 410 704-4494

MEMORANDUM

TO: Eric Owusu

FROM: Institutional Review Board for the Protection of Human Participants, Elizabeth Katz, Chair

DATE: March 20, 2019

RE: Approval of Research Involving the Use of Human Participants

Thank you for submitting an Application for Approval of Research Involving the Use of Human Participants to the Institutional Review Board for the Protection of Human Participants (IRB) at Towson University. The IRB hereby approves your proposal titled:

Usability Impact of User Perceptions in mHealth - The Case of Ghanaian Migrants

Please note that this approval is granted on the condition that you provide the IRB with the following information and/or documentation:

N/A

If you should encounter any new risks, reactions, or injuries while conducting your research, please notify the IRB. Should your research extend beyond one year in duration, or should there be substantive changes in your research protocol, you will need to submit another application for approval at that time.

We wish you every success in your research project. If you have any questions, please call me at (410) 704-2236.

cc: Joyram Chakraborty

Appendix A-3: Exempt Research Cover letter

Exempt Research Cover Letter

June 14, 2018

Dear Participant,

My name is Eric Owusu and I am a doctoral candidate in the Department of Computer and information Science at Towson University. As part of the research for my dissertation, I will be conducting a survey to investigate usability impact of user perceptions in mHealth (Mobile Health Technology). Participation in this study is voluntary. Should you choose to participate in my experiment, you will be asked to sign a consent form and complete a short survey. It is not necessary to answer every question, and you may discontinue your participation in the experiment at any time. Your decision whether or not to participate in the project or to withdraw from the study at any time will in no way affect your status. I have been given permission to conduct my study at this community and as such if you participate no one else will know how you respond.

Please do not put your name or any other identifying marks on the survey form. If you do choose to participate in the study, your participation will be completely anonymous. Neither anyone reading the results of the survey nor I will be able to identify you.

If you have any questions about the study, you may contact me, my faculty advisor, Dr. Joyram Chakraborty at, or the Chairperson of Towson University's Institutional Review Board for the Protection of Human Participants, Dr. Elizabeth Katz. A copy of the results of the survey, reported in aggregate form, will be available to you upon completion of my study if you request to see it. Copies will be forwarded to the Ghanaian community where you are located if you request a copy.

Thank you for your time.
Sincerely,
Eric Owusu
Doctoral Student

THIS PROJECT HAS BEEN REVIEWED BY THE INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN PARTICIPANTS AT TOWSON UNIVERSITY.

Appendix B-1a: Pre-Experiment Questionnaire

Your participation in this study is very much appreciated. All information provided will be held and maintained in the strictest confidence. The aim of this study is to determine user acceptance for mobile technology among Ghanaian Migrants resident in the United States of America.

Please circle the correct responses as appropriate

Age

a. 18-24 years
b. 25-44 years
c. 45-64 years
d. 64-and above

Gender

a. Male
b. Female

Educational Attainment

a. Not high school graduate
b. High school graduate
c. Some college or associate degree
d. Bachelor's degree
e. Master's degree
f. Doctoral degree or Professional degree

Do you use a smart phone?

a. Yes (If Yes why?)

b. No (If No, why?)

On the average, how much time do you spend on your smart phone in a day

a. Less than 30 minutes
b. From 30 minutes to an hour
c. From 1 to 2 hour
d. From 2 to 3 hours
e. More than 3 hours

What do you use your smart phone for? Could you tell us some of the reason(s) what you use it for?

Approximately how many years have you been browsing on the internet, using your mobile phone?

How often do you visit your primary care physician?

a. 1 – 2 weeks
b. Every month
c. 3 – 6 months
d. Other

Are you familiar with diabetes?

a. Very much familiar
b. Not Quite well
c. Not at all

Do you search for any medical related information from the web using a smart phone?

a. Yes (If Yes why?)

b. No (If No, why?)

Could such results from above alter your behavior?

a. Yes (If Yes why?)

b. No (If No, why?)

Could using a smartphone to monitor your health be a benefit to you?

a. Yes (If Yes why?)

b. No (If No, why?)

Would you pay for any application to monitor your health that will potentially increase outcome?

Appendix B-1b: Pre-Experiment Questionnaire

Identify your age from the ranges listed below.

18- 29   30 - 35   36 - 40   41 - 45   46-50   51-55

Gender

Male   Female

What mobile device do you currently use?

iPhone

Android

Windows

How long have you owned/been using this mobile device?

0 - 6 months

6 months – 1 year

1 - 3 years

Over 3 years

How would rate yourself about mobile technology usage?

Novice

Moderate

Advanced

How often do you use mobile applications?

0-30 minutes per day

1 hour per day

More than 2 hours per day

Other, ……………………………………

What mobile applications(s) do you currently use regarding health?

………………………………………………………………………………………

What specifically do you like most about the application that you use, in terms of functionality and features?

Why………………………………………………………………………..

……………………………………………………………………………………..

What specifically do you like the least about the application that you use? Why?

………………………………………………………………………………………

………………………………………………………………………………………Does the application help you to fulfil the health reason for which the application is intended?

If yes, how……………………………………………………………………….……

If no, why? ………………………………………………………………………………

As a Ghanaian, would you use an application that is specifically designed to address health issues for Ghanaians currently living in the USA?

If yes, why? …………..……………………………………………………………………

………………………………………………………………………………………

If no, why? ………………………………………………………………………………

………………………………………………………………………………………

What specific features and functionalities would you expect the application to have to help you achieve your health goals?

………………………………………………………………………………………

Appendix B-2: Post Experiment Questionnaire

It is easy to use the mobile application.

Strongly agree Neutral Disagree Strongly disagree

Will use this application if it was free.

Strongly agree Neutral Disagree Strongly disagree

If you had an application that could help you or a family member their diabetes effectively, how would you use it?

Strongly agree Neutral Disagree Strongly disagree

Would you pay to use this particular application to monitor your health that will potentially impact your health positively?

Strongly agree Neutral Disagree Strongly disagree

I can see advantages for me personally in using mobile application within healthcare

Strongly agree Neutral Disagree Strongly disagree

What parts of the application tool did you think were well designed?

Which parts of the systems did you think were inadequately designed?

Do you have any comments about the mobile application functions and regarding its usability?

What feature/function were you satisfied with regarding mHealth application?

What feature/function were you dissatisfied with regarding mHealth application?

Appendix C-1: Workflow MotiFit Mobile Application

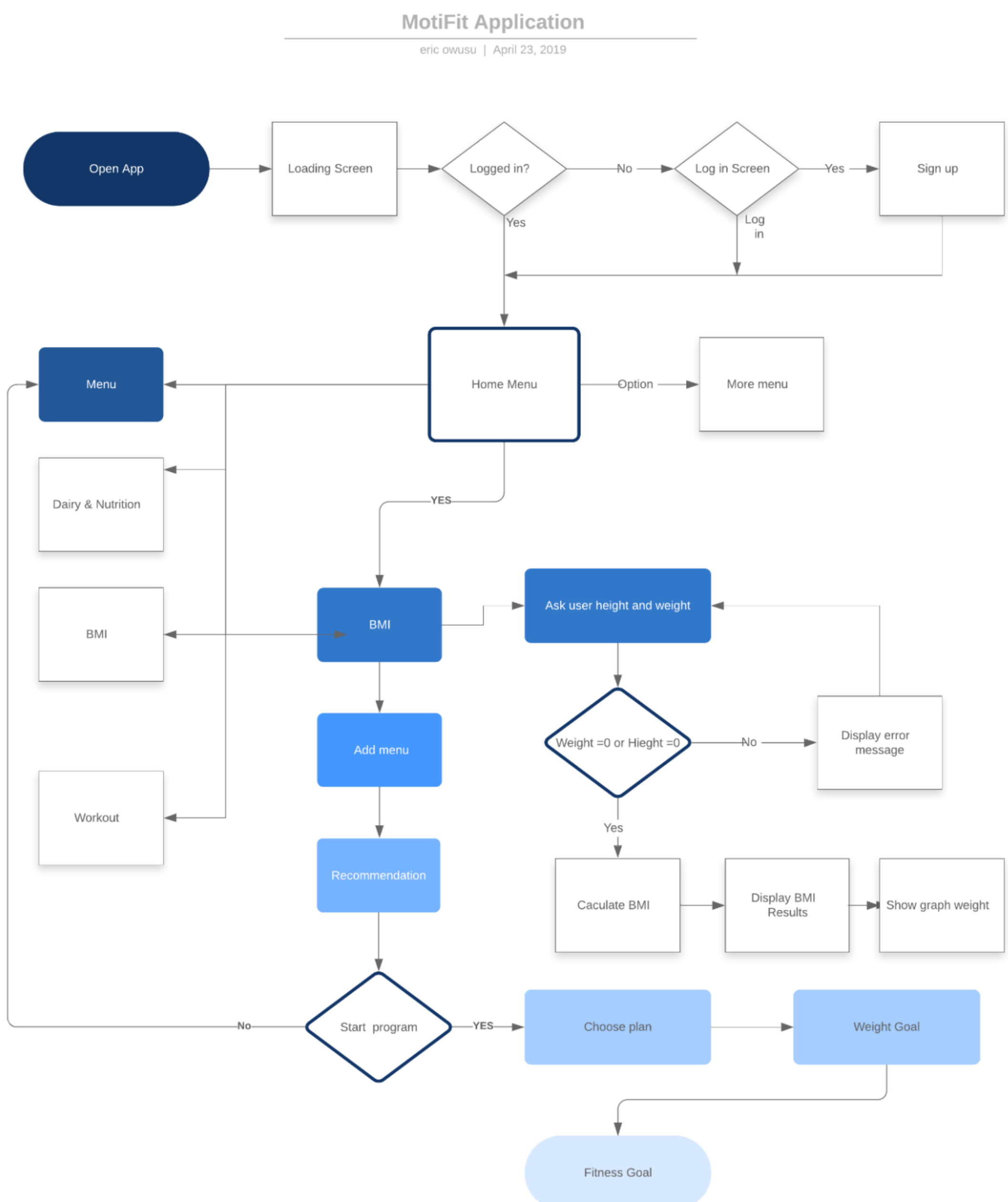


Figure 4. Workflow Wireframe: MotiFit mobile application

Appendix C-2: Use Case Diagram

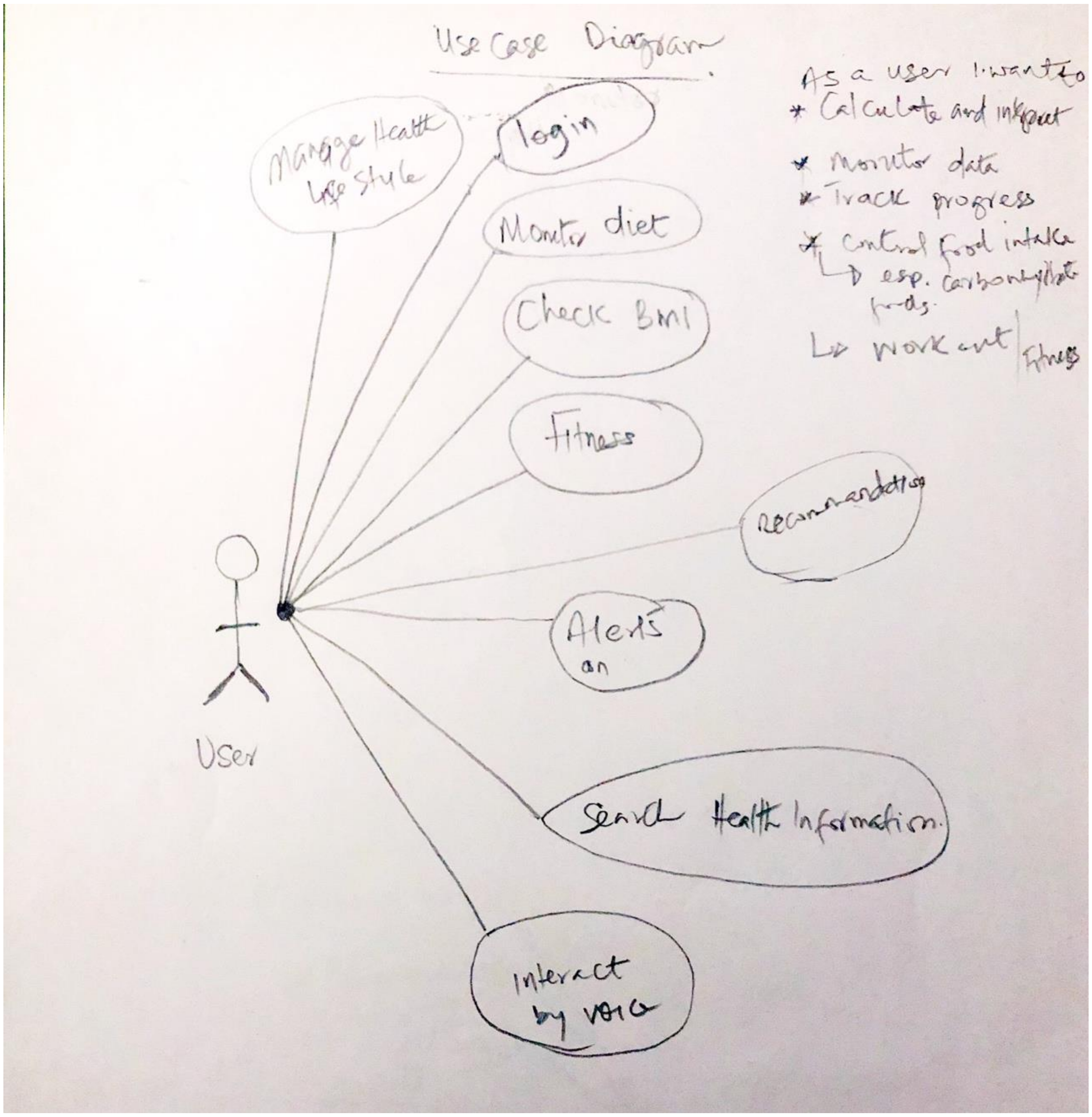


Figure 5. Application use case diagram

Appendix C-3: Wireframe- Welcome screen, Sign up Sign-in

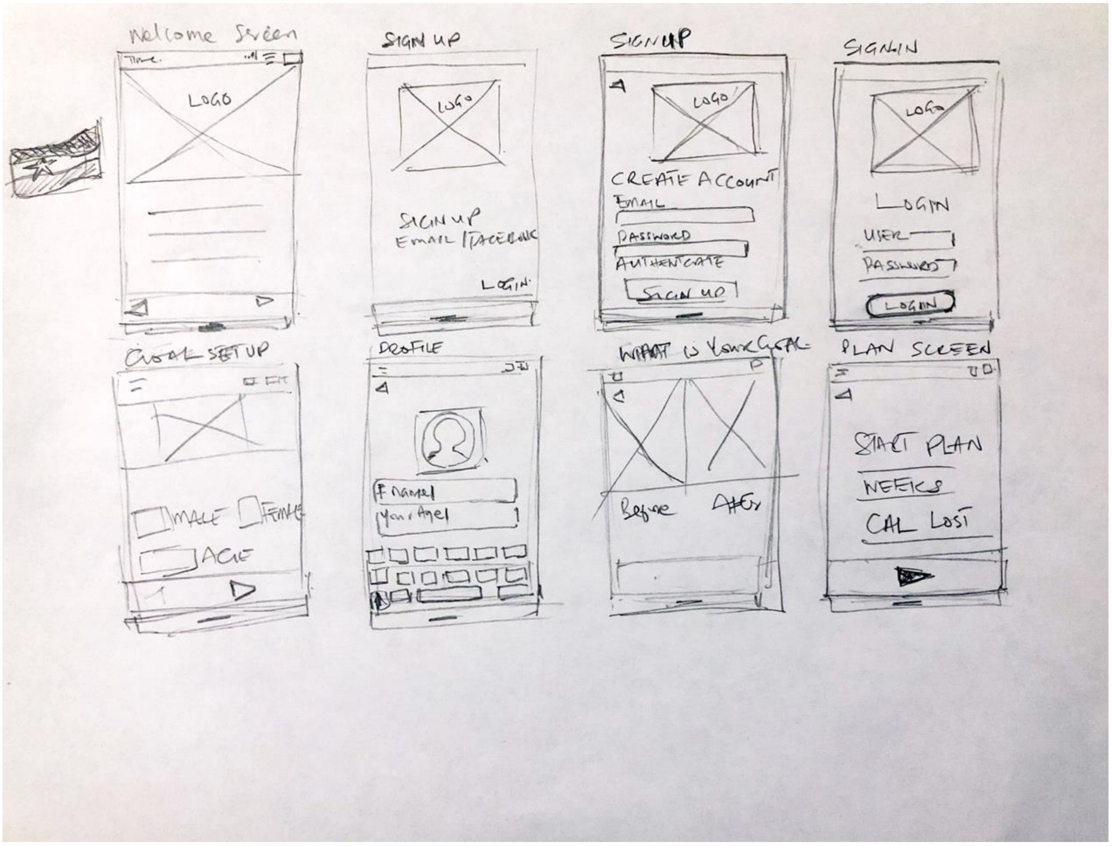


Figure 6. Welcome screen, sign up and sign up wireframe

Appendix C-4: Wireframe- Home screen, BMI Calculator

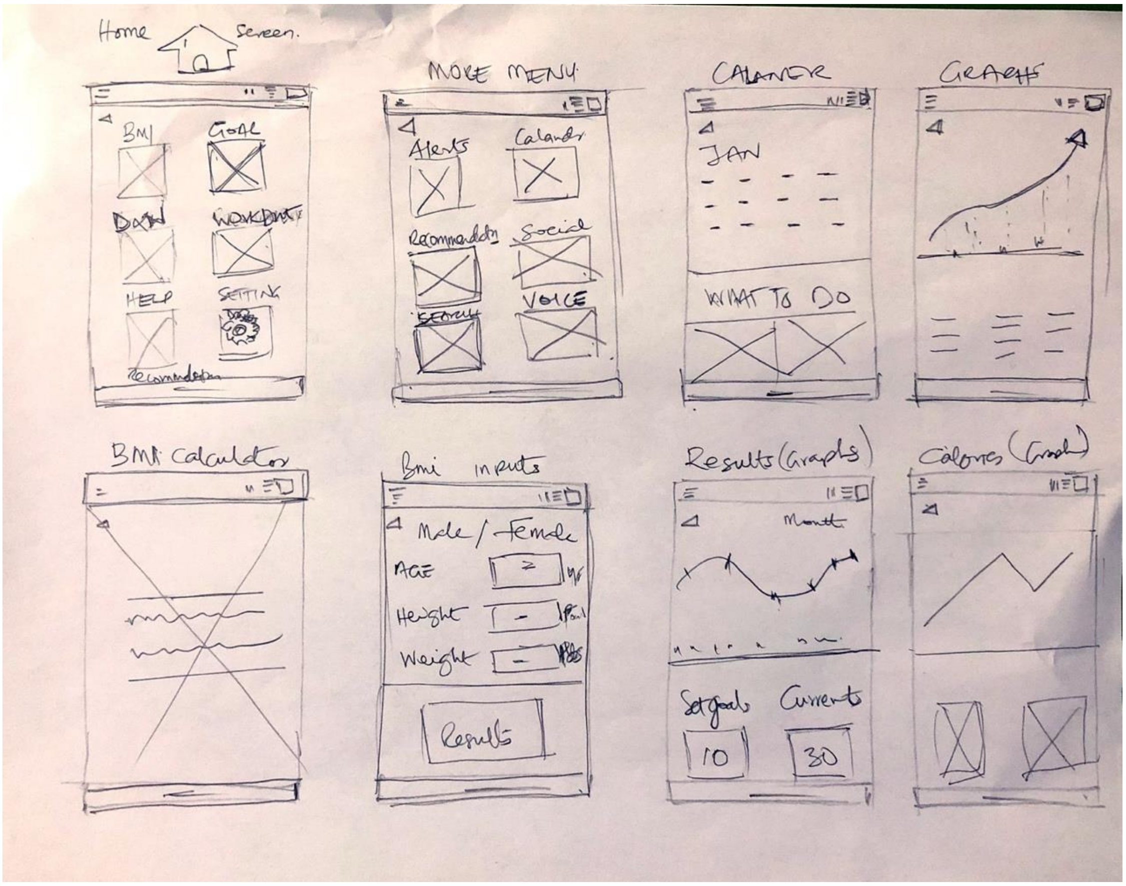


Figure 7. Wireframe: Home screen, BMI calculator

Appendix C-5: Wireframe-BMI Calculator

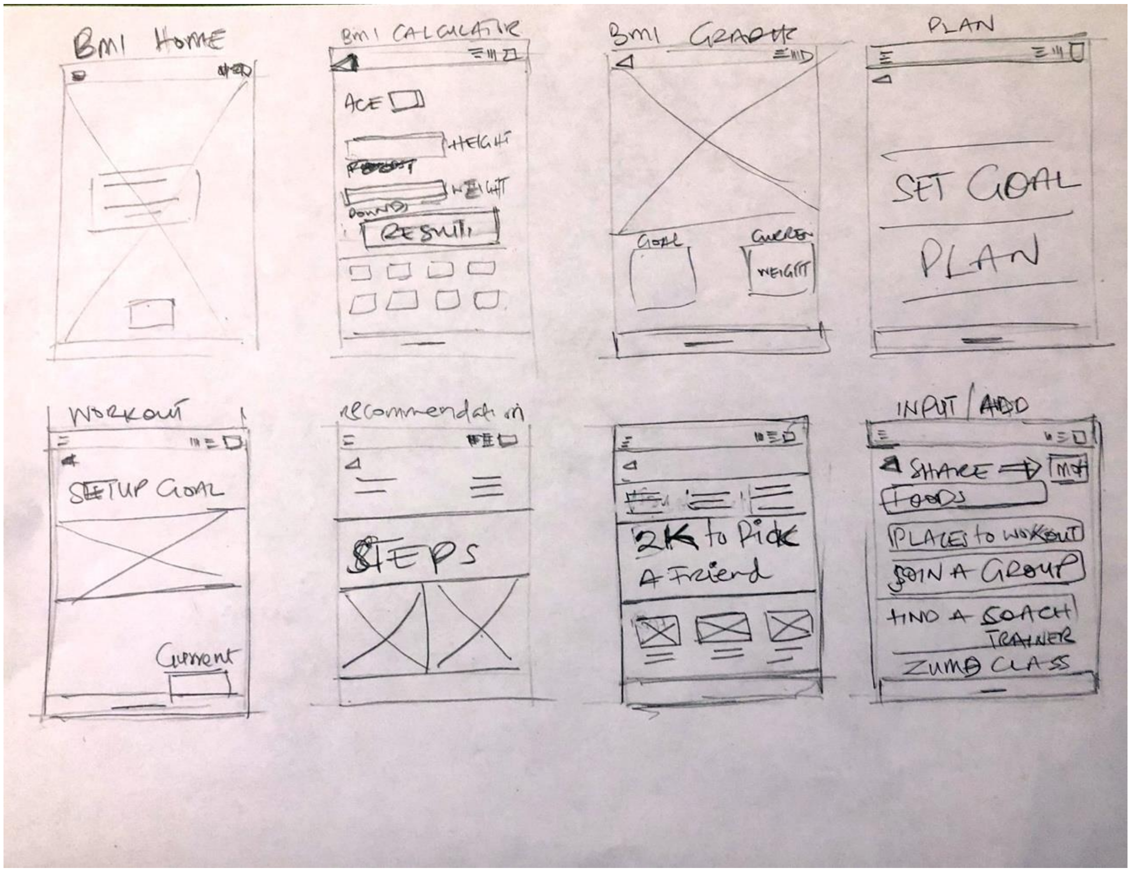


Figure 8. Wireframe: BMI calculator

Appendix C-6: Wireframe: Diary, Meal, Nutrition

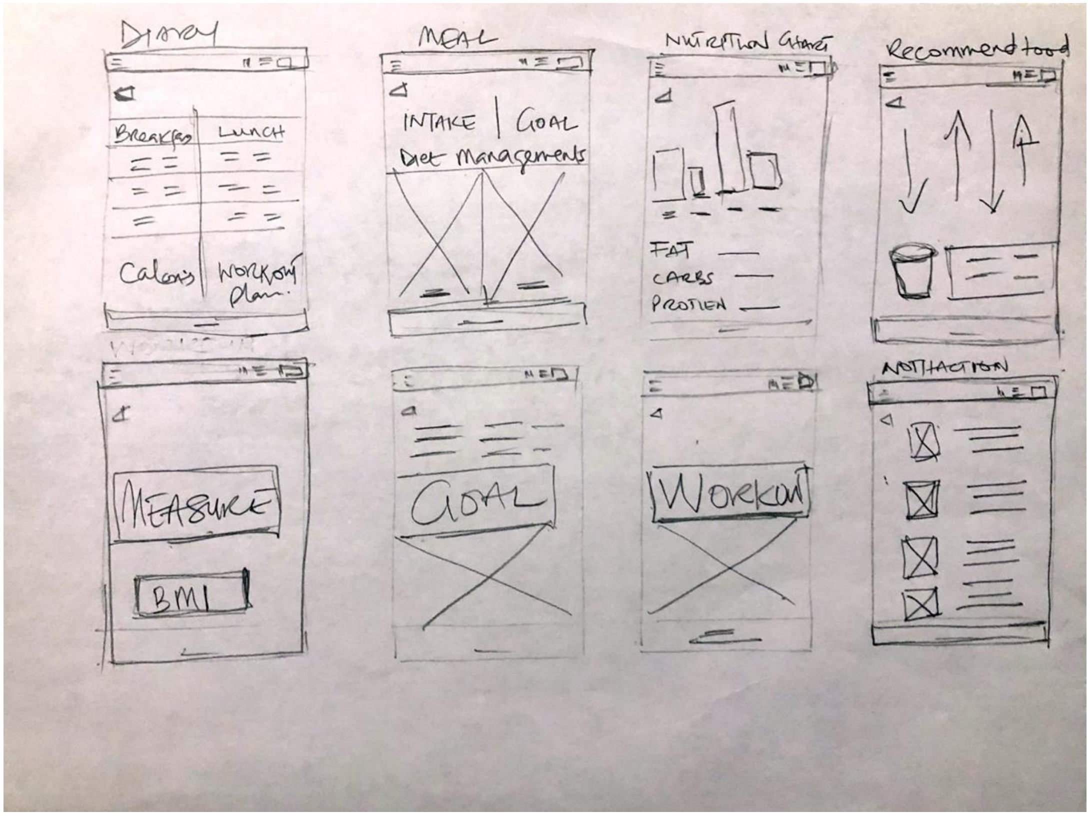


Figure 9. Wireframe: Diary, Meal, Nutrition

Appendix D-1: Screenshots of Welcome Screen, Login and BMI

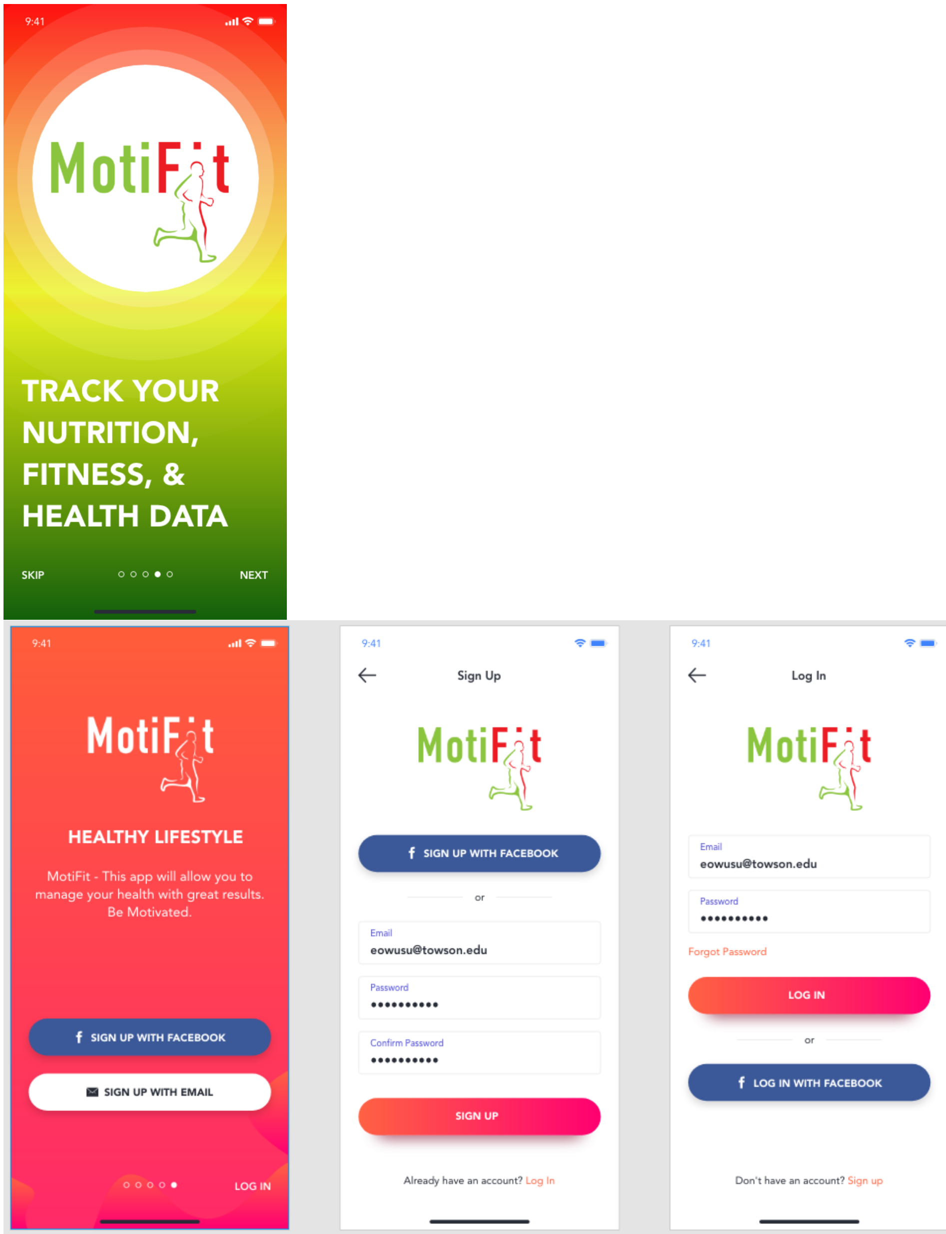


Figure 10. Screenshot of Welcome screen, Sign up and Log In

Appendix D-2: Screen shot of BMI Calculator

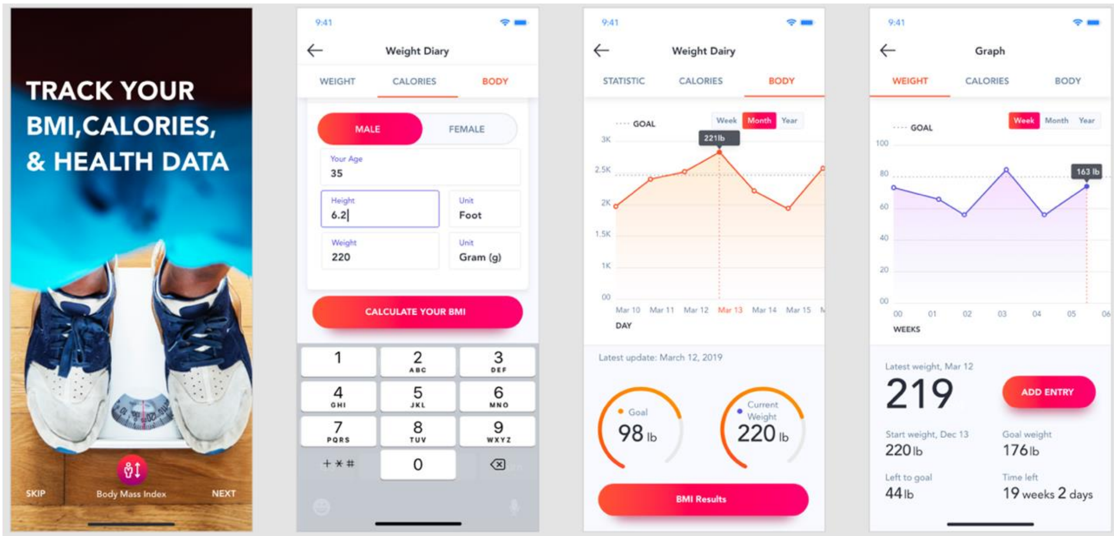


Figure 11. Screenshot: BMI calculator

Appendix D-3: Screen Shots of Food Diary

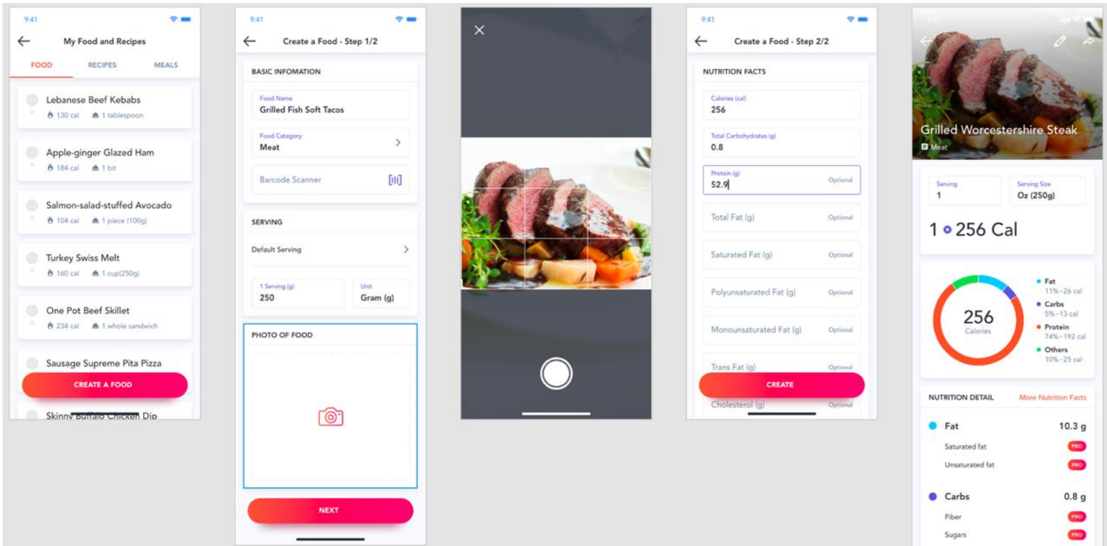


Figure 12. Screenshot: BMI calculator

Appendix D-4: Screen Shots of Profile and Notification

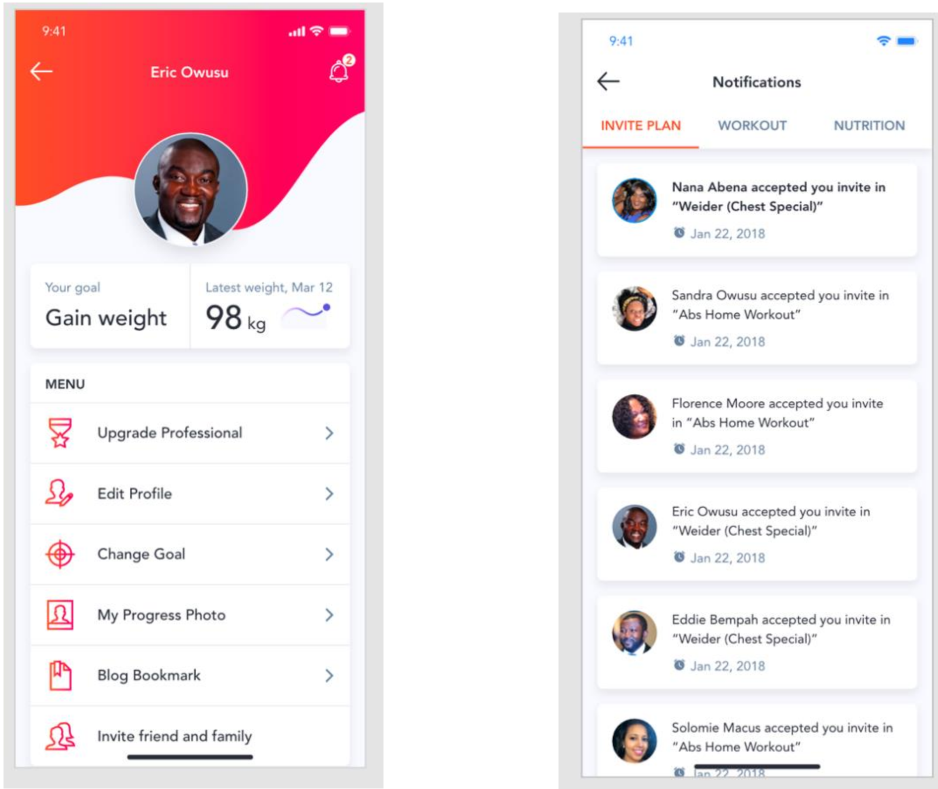


Figure 13. Screenshot: Profile page and Notification page

Appendix D-5: Screen Shot of the designed Prototype workflow linked Screen

Figure 14. Screenshot: Prototype workflow and link screen

Appendix E-1: Mobile Application Minimum System Requirements

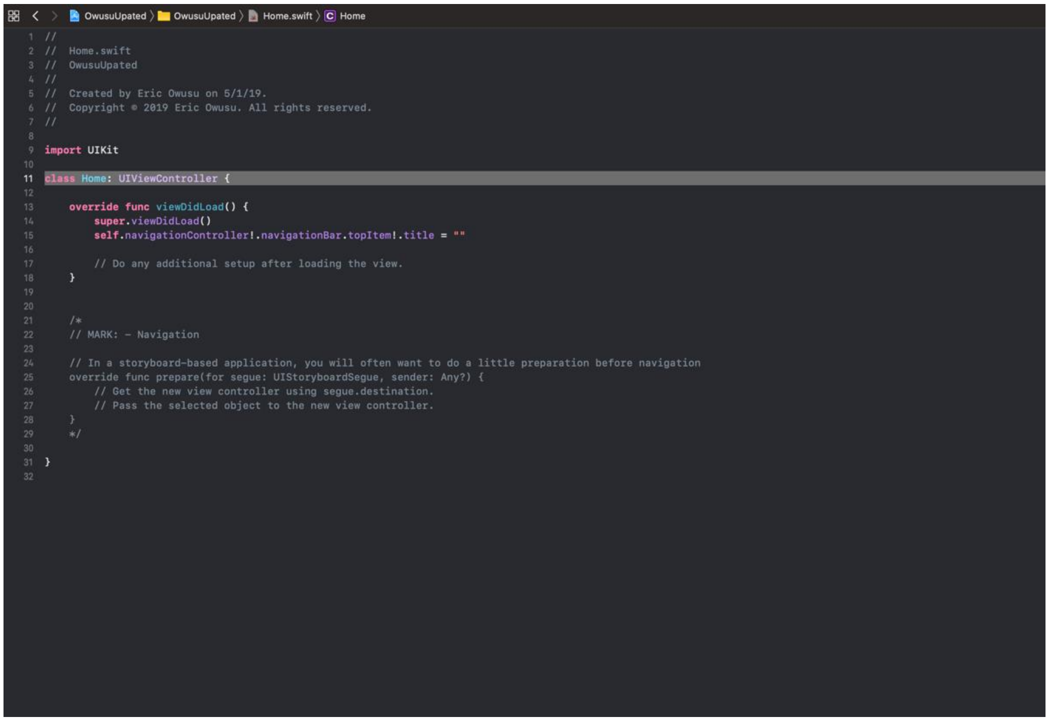
iOS - only 64-bit devices are supported
Android - devices with Open GL ES 2.0 are supported; x86 Android devices are not supported.

iOS	Android
64-bit devices: • iPhone: XR, XS, XS Max, X, 8, 8 Plus, 7, 7 Plus, 6, 6 Plus, 6S, 6S Plus, SE, iPhone 5S • iPad: iPad (2018 and 2017), Air, Air2, mini 2, mini 3, mini 4, and iPad Pro (generations 1, 2, 3)	Tested on: • Samsung Galaxy S6, S7, S9 • HTC One M9 • LG G4 • Nexus 5X • Nexus 6P
Apple iOS versions 11.0 or later	Android 6.0 or later

Mobile browser

- Default browser on Android 4.2.
- Chrome on iOS 9+. Voice capabilities are not supported in Chrome on iOS.
- Safari for iOS 8+

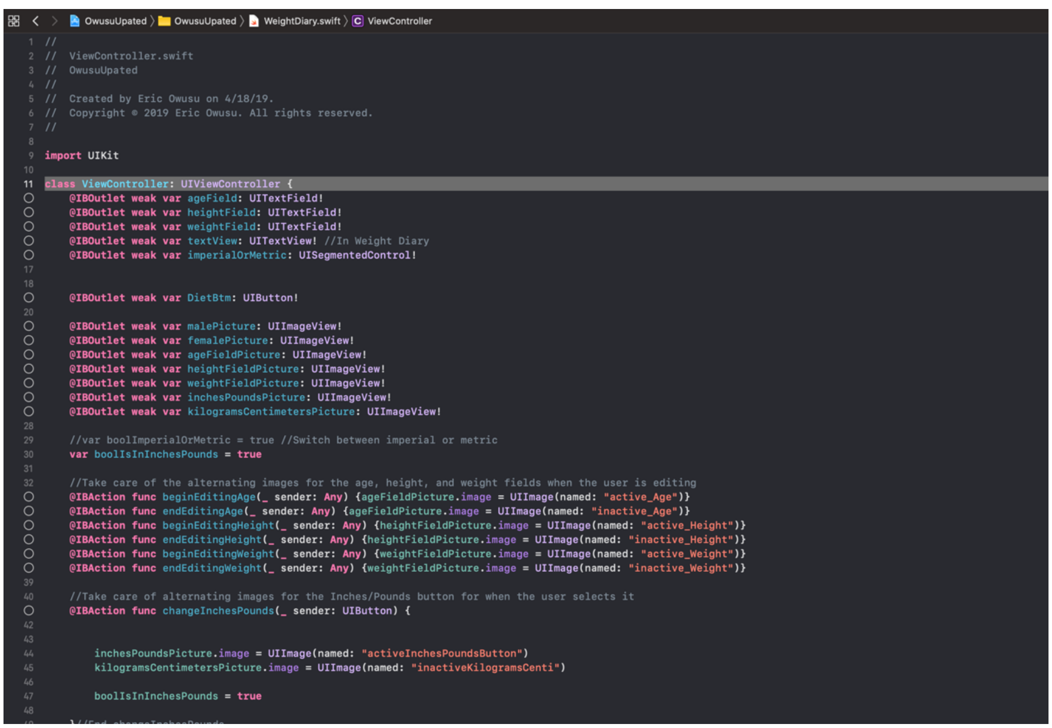
Appendix F-1 Screen shot of Swift codes



OwusuUpated 〉 OwusuUpated 〉 Home.swift 〉 Home

```swift
//
//  Home.swift
//  OwusuUpated
//
//  Created by Eric Owusu on 5/1/19.
//  Copyright © 2019 Eric Owusu. All rights reserved.
//

import UIKit

class Home: UIViewController {

    override func viewDidLoad() {
        super.viewDidLoad()
        self.navigationController!.navigationBar.topItem!.title = ""

        // Do any additional setup after loading the view.
    }


    /*
    // MARK: - Navigation

    // In a storyboard-based application, you will often want to do a little preparation before navigation
    override func prepare(for segue: UIStoryboardSegue, sender: Any?) {
        // Get the new view controller using segue.destination.
        // Pass the selected object to the new view controller.
    }
    */

}
```

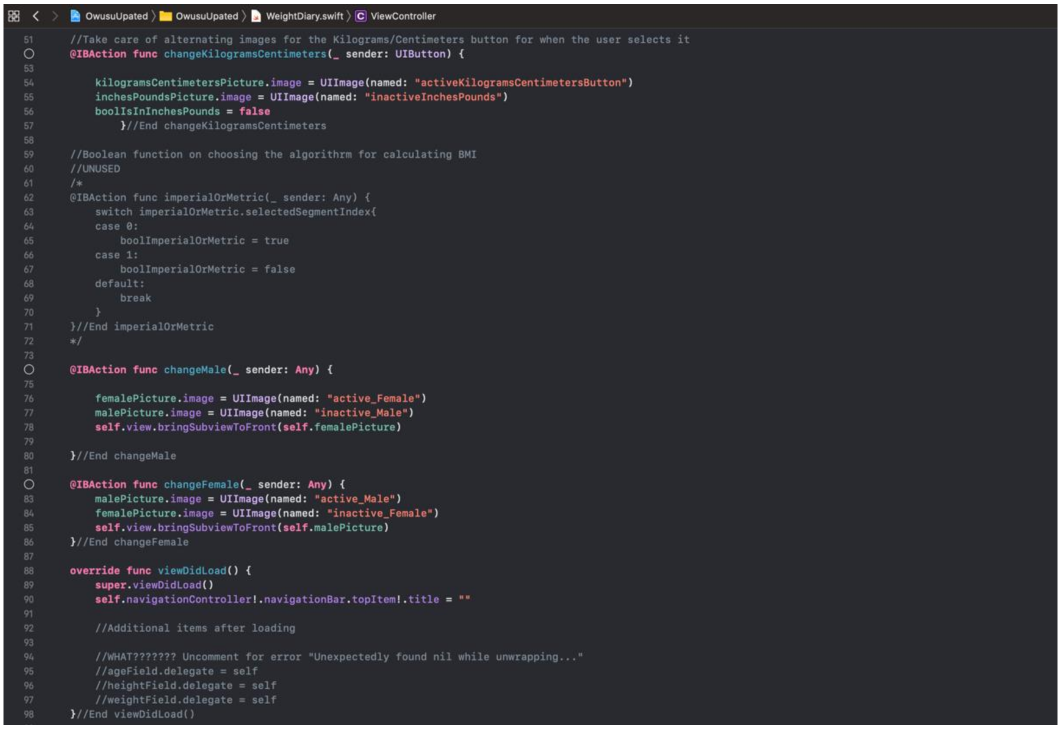
Figure 15. Screenshot: Home page Code



OwusuUpated 〉 OwusuUpated 〉 WeightDiary.swift 〉 ViewController

```swift
//
//  ViewController.swift
//  OwusuUpated
//
//  Created by Eric Owusu on 4/18/19.
//  Copyright © 2019 Eric Owusu. All rights reserved.
//

import UIKit

class ViewController: UIViewController {
    @IBOutlet weak var ageField: UITextField!
    @IBOutlet weak var heightField: UITextField!
    @IBOutlet weak var weightField: UITextField!
    @IBOutlet weak var textView: UITextView! //In Weight Diary
    @IBOutlet weak var imperialOrMetric: UISegmentedControl!


    @IBOutlet weak var DietBtm: UIButton!

    @IBOutlet weak var malePicture: UIImageView!
    @IBOutlet weak var femalePicture: UIImageView!
    @IBOutlet weak var ageFieldPicture: UIImageView!
    @IBOutlet weak var heightFieldPicture: UIImageView!
    @IBOutlet weak var weightFieldPicture: UIImageView!
    @IBOutlet weak var inchesPoundsPicture: UIImageView!
    @IBOutlet weak var kilogramsCentimetersPicture: UIImageView!

    //var boolImperialOrMetric = true //Switch between imperial or metric
    var boolIsInInchesPounds = true

    //Take care of the alternating images for the age, height, and weight fields when the user is editing
    @IBAction func beginEditingAge(_ sender: Any) {ageFieldPicture.image = UIImage(named: "active_Age")}
    @IBAction func endEditingAge(_ sender: Any) {ageFieldPicture.image = UIImage(named: "inactive_Age")}
    @IBAction func beginEditingHeight(_ sender: Any) {heightFieldPicture.image = UIImage(named: "active_Height")}
    @IBAction func endEditingHeight(_ sender: Any) {heightFieldPicture.image = UIImage(named: "inactive_Height")}
    @IBAction func beginEditingWeight(_ sender: Any) {weightFieldPicture.image = UIImage(named: "active_Weight")}
    @IBAction func endEditingWeight(_ sender: Any) {weightFieldPicture.image = UIImage(named: "inactive_Weight")}

    //Take care of alternating images for the Inches/Pounds button for when the user selects it
    @IBAction func changeInchesPounds(_ sender: UIButton) {


        inchesPoundsPicture.image = UIImage(named: "activeInchesPoundsButton")
        kilogramsCentimetersPicture.image = UIImage(named: "inactiveKilogramsCenti")

        boolIsInInchesPounds = true

```

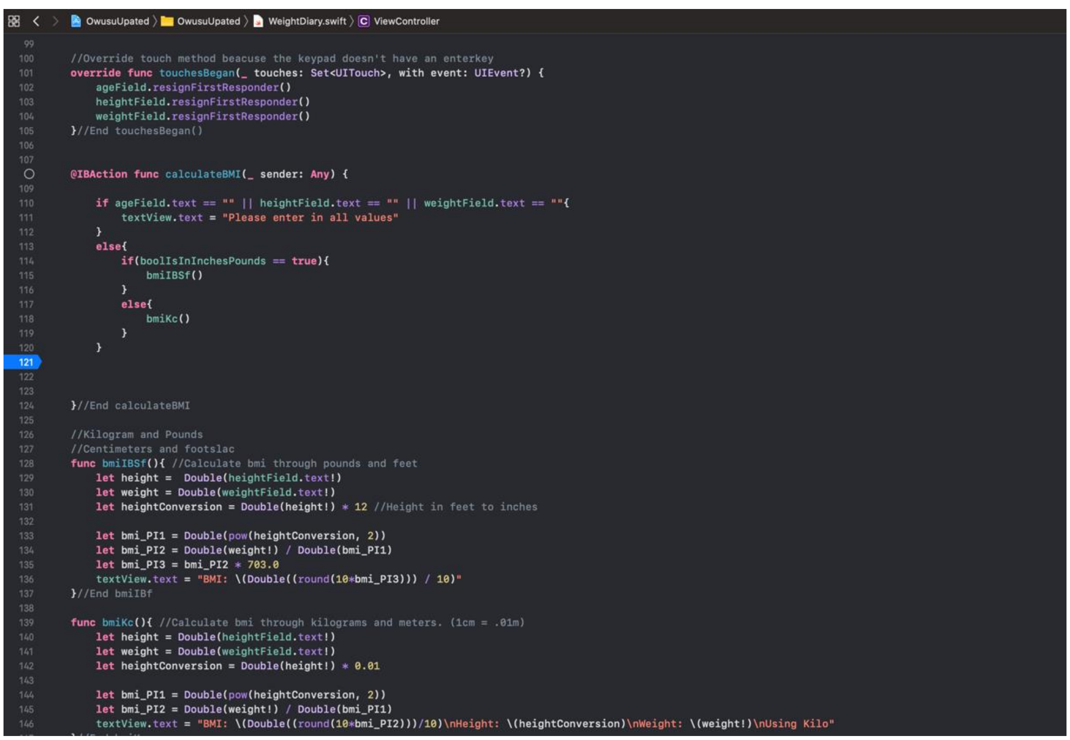
Figure 16. Screenshot: View Controller page Code_1



OwusuUpated 〉 OwusuUpated 〉 WeightDiary.swift 〉 ViewController

```
    //Take care of alternating images for the Kilograms/Centimeters button for when the user selects it
    @IBAction func changeKilogramsCentimeters(_ sender: UIButton) {

        kilogramsCentimetersPicture.image = UIImage(named: "activeKilogramsCentimetersButton")
        inchesPoundsPicture.image = UIImage(named: "inactiveInchesPounds")
        boolIsInInchesPounds = false
            }//End changeKilogramsCentimeters

    //Boolean function on choosing the algorithrm for calculating BMI
    //UNUSED
    /*
    @IBAction func imperialOrMetric(_ sender: Any) {
        switch imperialOrMetric.selectedSegmentIndex{
        case 0:
            boolImperialOrMetric = true
        case 1:
            boolImperialOrMetric = false
        default:
            break
        }
    }//End imperialOrMetric
    */

    @IBAction func changeMale(_ sender: Any) {

        femalePicture.image = UIImage(named: "active_Female")
        malePicture.image = UIImage(named: "inactive_Male")
        self.view.bringSubviewToFront(self.femalePicture)

    }//End changeMale

    @IBAction func changeFemale(_ sender: Any) {
        malePicture.image = UIImage(named: "active_Male")
        femalePicture.image = UIImage(named: "inactive_Female")
        self.view.bringSubviewToFront(self.malePicture)
    }//End changeFemale

    override func viewDidLoad() {
        super.viewDidLoad()
        self.navigationController!.navigationBar.topItem!.title = ""

        //Additional items after loading

        //WHAT??????? Uncomment for error "Unexpectedly found nil while unwrapping..."
        //ageField.delegate = self
        //heightField.delegate = self
        //weightField.delegate = self
    }//End viewDidLoad()
```

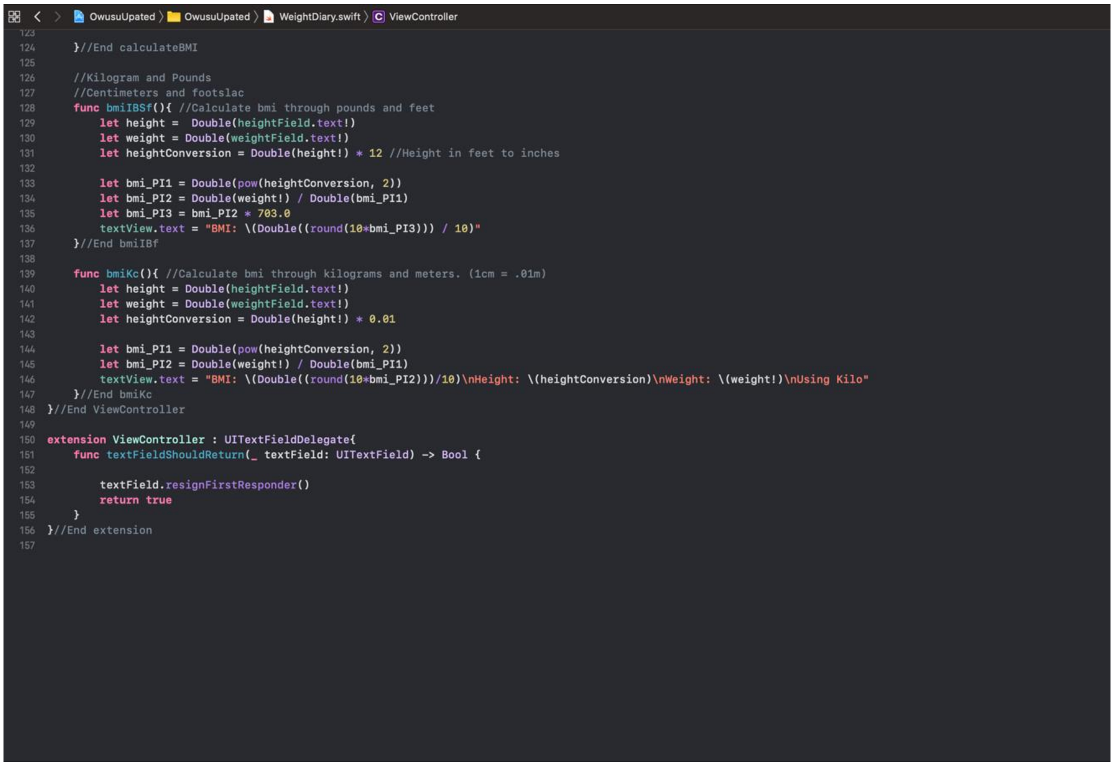
Figure 17. Screenshot: View Controller page Code_2



OwusuUpated 〉 OwusuUpated 〉 WeightDiary.swift 〉 ViewController

```

    //Override touch method beacuse the keypad doesn't have an enterkey
    override func touchesBegan(_ touches: Set<UITouch>, with event: UIEvent?) {
        ageField.resignFirstResponder()
        heightField.resignFirstResponder()
        weightField.resignFirstResponder()
    }//End touchesBegan()


    @IBAction func calculateBMI(_ sender: Any) {

        if ageField.text == "" || heightField.text == "" || weightField.text == ""{
            textView.text = "Please enter in all values"
        }
        else{
            if(boolIsInInchesPounds == true){
                bmiIBSf()
            }
            else{
                bmiKc()
            }
        }



    }//End calculateBMI

    //Kilogram and Pounds
    //Centimeters and footslac
    func bmiIBSf(){ //Calculate bmi through pounds and feet
        let height =  Double(heightField.text!)
        let weight = Double(weightField.text!)
        let heightConversion = Double(height!) * 12 //Height in feet to inches

        let bmi_PI1 = Double(pow(heightConversion, 2))
        let bmi_PI2 = Double(weight!) / Double(bmi_PI1)
        let bmi_PI3 = bmi_PI2 * 703.0
        textView.text = "BMI: \(Double((round(10*bmi_PI3))) / 10)"
    }//End bmiIBf

    func bmiKc(){ //Calculate bmi through kilograms and meters. (1cm = .01m)
        let height = Double(heightField.text!)
        let weight = Double(weightField.text!)
        let heightConversion = Double(height!) * 0.01

        let bmi_PI1 = Double(pow(heightConversion, 2))
        let bmi_PI2 = Double(weight!) / Double(bmi_PI1)
        textView.text = "BMI: \(Double((round(10*bmi_PI2)))/10)\nHeight: \(heightConversion)\nWeight: \(weight!)\nUsing Kilo"
```

Figure 18. Screenshot: View Controller Page Code_3




```swift
    }//End calculateBMI

    //Kilogram and Pounds
    //Centimeters and footslac
    func bmiIBSf(){ //Calculate bmi through pounds and feet
        let height =  Double(heightField.text!)
        let weight = Double(weightField.text!)
        let heightConversion = Double(height!) * 12 //Height in feet to inches

        let bmi_PI1 = Double(pow(heightConversion, 2))
        let bmi_PI2 = Double(weight!) / Double(bmi_PI1)
        let bmi_PI3 = bmi_PI2 * 703.0
        textView.text = "BMI: \(Double((round(10*bmi_PI3))) / 10)"
    }//End bmiIBf

    func bmiKc(){ //Calculate bmi through kilograms and meters. (1cm = .01m)
        let height = Double(heightField.text!)
        let weight = Double(weightField.text!)
        let heightConversion = Double(height!) * 0.01

        let bmi_PI1 = Double(pow(heightConversion, 2))
        let bmi_PI2 = Double(weight!) / Double(bmi_PI1)
        textView.text = "BMI: \(Double((round(10*bmi_PI2)))/10)\nHeight: \(heightConversion)\nWeight: \(weight!)\nUsing Kilo"
    }//End bmiKc
}//End ViewController

extension ViewController : UITextFieldDelegate{
    func textFieldShouldReturn(_ textField: UITextField) -> Bool {

        textField.resignFirstResponder()
        return true
    }
}//End extension
```

Figure 19. Screenshot: View controller page code_ 4

Appendix G-1 Screen shot of MotiFit BMI display platform links page

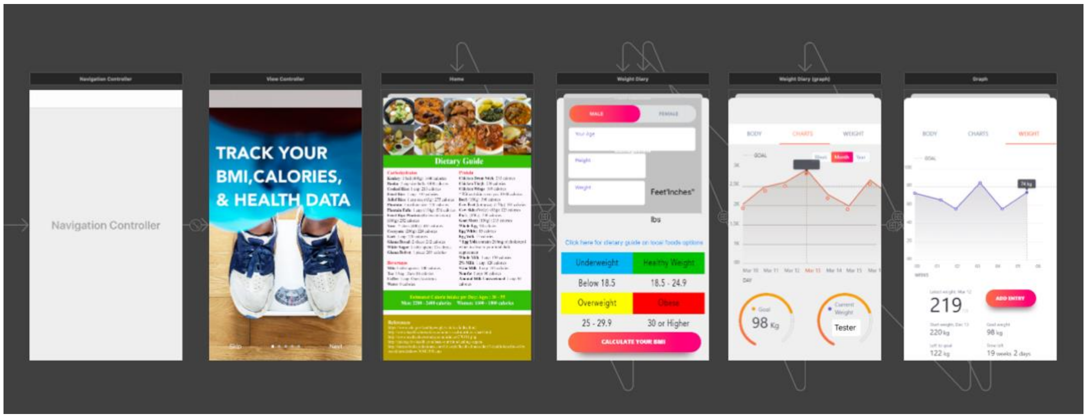


Figure 20. Screenshot: MotiFit Application XCode link page

Appendix H-1: Usability Test Results – Demographics

Table 14

Results of Pre-test

Participant	Age	Gender	Experience	Mobile phone use hours per/day	Days per month use of the internet to research healthcare information?
1	30-35	Female	Moderate	4-6	8-10
2	30-35	Male	Technical	More	More
3	46-50	Female	Above Average	4-6	More
4	51-55	Female	Moderate	2-4	4-6
5	30-35	Female	Technical	More	More
6	41-45	Male	Technical	More	2-4
7	46-50	Female	Above Average	8-10	More
8	36-40	Female	Technical	4-6	8-10
9	41-45	Female	Above Average	More	More
10	46-50	Male	Above Average	More	More
11	46-50	Female	Technical	More	4-6
12	30-35	Male	Above Average	More	More
13	46-50	Male	Technical	4-6	0-1
14	36-40	Female	Above Average	More	2-4
15	51-55	Female	Moderate	More	More
16	46-50	Male	Technical	2-4	0-1
17	41-45	Female	Above Average	2-4	6-8
18	36-40	Female	Above Average	4-6	4-6
19	46-50	Female	Moderate	4-6	2-4
20	41-45	Female	Above Average	8-10	4-6
21	46-50	Female	Moderate	6-8	0-1
22	41-45	Male	Technical	More	More
23	46-50	Male	Above Average	6-8	2-4
24	46-50	Male	Technical	2-4	6-8
25	36-40	Female	Above Average	2-4	2-4
26	51-55	Male	Technical	0-1	2-4
27	36-40	Male	Technical	4-6	More

28	46-50	Male	Technical	2-4	2-4
29	41-45	Female	Above Average	More	More
30	41-45	Male	Technical	More	More
31	46-50	Male	Moderate	6-8	6-8
32	41-45	Female	Moderate	2-4	6-8
33	46-50	Female	Moderate	2-4	4-6
34	30-35	Male	Above Average	4-6	8-10
35	30-35	Male	Above Average	More	More
36	30-35	Female	Moderate	2-4	4-6
37	46-50	Female	Above Average	6-8	More
38	41-45	Male	Above Average	4-6	6-8
39	41-45	Female	Moderate	8-10	4-6
40	36-40	Male	Above Average	More	More
41	41-45	Male	Technical	8-10	8-10
42	36-40	Female	Moderate	4-6	2-4
43	30-35	Female	Above Average	More	More
44	51-55	Female	Moderate	4-6	2-4
45	41-45	Male	Technical	More	More
46	30-35	Female	Above Average	More	More
47	51-55	Male	Moderate	6-8	More
48	36-40	Female	Above Average	More	More
49	46-50	Male	Above Average	More	More
50	30-35	Female	Above Average	More	More

Appendix H-2: Usability Test Results - Comments

Table 15

Post Questionnaire Results

Participant	Comments on the functions	Comments on User Satisfaction	Comments on overall features dissatisfied
1	User friendly	BMI, Workout	Dietary Guide
2	Ghanaian tailored features	Navigation	Not enough foods on dietary guide
3	Ease of use	My Food and Recipe	Dietary font too small
4	Ease of use	Navigation	No Language option
5	more accurate than existing ones	BMI, Recommendation	None
6	Ghanaian tailored features, more accurate than existing ones	Interface layout	None
7	Ghanaian tailored features, more accurate than existing ones	BMI, Recommendation	None
8	Ease of use, User friendly	My Food and Recipe, Recommendation, Dietary Guide	None
9	User friendly	Menu, Graphics	None
10	Ghanaian tailored features, User friendly	BMI, Dietary Guide	None
11	Add feature for the healthy	BMI, Recommendation	Dietary Guide
12	Layout, Ghanaian tailored features	My Food and Recipe, BMI, Recommendation	None
13	Simple and appealing, colorful	Dietary Guide	Limited food category
14	All	All	None
15	Simple and appealing	Dietary Guide	None
16	Research more into new healthy Africa Foods, more accurate than existing ones	Menu, Dietary Guide	None
17	Research more into new healthy Africa Foods	Dietary Guide, Workout, BMI	None

18	Ghanaian tailored features	Dietary Guide, BMI, Workout	None
19	Simple and appealing	My Food and Recipe	search into other liquids like alcohol
20	Research more into new healthy Africa Foods	All	None
21	Simple and appealing, Ghanaian tailored features	BMI	None
22	Research more into new healthy Africa Foods	My Food and Recipe	None
23	Research more into new healthy Africa Foods	Recommendation	None
24	Zoom for dietary	Workout	None
25	Water intake	All	None
26	User friendly	Dietary Guide	restricted to only Ghanaians
27	Ease of use	BMI	None
28	add feature for the healthy	Dietary Guide	search into other liquids like alcohol
29	More accurate than existing ones	Dietary Guide	None
30	Ghanaian tailored features	Navigation	None
31	Ghanaian tailored features	BMI	less cultural symbols
32	Ease of use, Ghanaian tailored features	Easy Navigation, Color scheme	More details on information
33	Ghanaian tailored features	Dietary Guide	Color scheme
34	Ghanaian tailored features	Color scheme, Dietary Guide, interface layout	
35	Simple and appealing	Cultural features	Not enough foods on dietary guide
36	Ghanaian tailored features	Interface layout, Color scheme	None
37	more accurate than existing ones	Dietary Guide, BMI	More details on information
38	Ghanaian tailored features	Dietary Guide	Not enough foods on dietary guide
39	Ease of use, simple and appealing	Menu, Color scheme	None

40	Simple and appealing	BMI, Workout, Workout	Not enough foods on dietary guide
41	Simple and appealing, User friendly	All	None
42	Ghanaian tailored features	Recommendation, BMI, interface layout	None
43	User friendly	Menu, Easy Navigation	None
44	Ease of use	My Food and Recipe	None, less cultural symbols, Dietary font too small
45	Research more into new healthy Africa Foods	Easy Navigation, Menu	None
46	User friendly	BMI	None
47	Ghanaian tailored features	Dietary Guide	None, keyboard too big
48	Ghanaian tailored features	BMI, Dietary Guide	None
49	User friendly	All	None
50	All	BMI, Dietary Guide	None

Appendix H-3: Usability Test Results - Design

Table 16

Post Questionnaire

Participant	Features well designed?	Features inadequately designed?	Comments on the functions
1	Workout, BMI	Dietary Guide	User friendly
2	Navigation to exit application	Recommendation	Ghanaian tailored features
3	My Food and Recipe	None	Ease of use
4	Menu	Settings	Ease of use
5	BMI	None	more accurate than existing ones
6	Navigation, Dietary Guide	Dietary Guide	Ghanaian tailored features, more accurate than existing ones
7	BMI	None	Ghanaian tailored features, more accurate than existing ones
8	BMI, Dietary Guide, Recommendation	gender	Ease of use, User friendly
9	Menu	None	User friendly
10	BMI, My Food and Recipe, Recommendation, Workout	None	Ghanaian tailored features, User friendly
11	My Food and Recipe, BMI	None	add feature for the healthy
12	My Food and Recipe, BMI	None	layout, Ghanaian tailored features
13	My Food and Recipe, BMI	keyboard too big	simple and appealing, Colorful
14	Cultural features	None	All

15	BMI	None	simple and appealing
16	BMI, Dietary Guide, Recommendation	None	Research more into new healthy Africa Foods, more accurate than existing ones
17	All	None	Research more into new healthy Africa Foods
18	Dietary Guide, BMI	Workout	Ghanaian tailored features
19	My Food and Recipe	None	simple and appealing
20	My Food and Recipe	All	Research more into new healthy Africa Foods
21	BMI	None	simple and appealing, Ghanaian tailored features
22	Dietary Guide	Dietary Guide	Research more into new healthy Africa Foods
23	My Food and Recipe	None	Research more into new healthy Africa Foods
24	Recommendation	None	zoom for dietary
25	My Food and Recipe	None	Water intake
26	Menu	None	User friendly
27	My Food and Recipe	Menu	Ease of use
28	My Food and Recipe	None	Add feature for the healthy
29	Menu	None	More accurate than existing ones
30	All	None	Ghanaian tailored features
31	Graphics, Easy Navigation	None	Ghanaian tailored features
32	Easy Navigation	None	Ease of use, Ghanaian tailored features

33	Interface layout, Color scheme, Easy Navigation	None	Ghanaian tailored features
34	Interface layout	None	Ghanaian tailored features
35	All	None	Simple and appealing
36	Easy Navigation, Dietary Guide, Color scheme	None	Ghanaian tailored features
37	Easy Navigation	Recommendation	More accurate than existing ones
38	All	Color scheme	Ghanaian tailored features
39	BMI, Recommendation, Water Intake	None	Ease of use, simple and appealing
40	My Food and Recipe, Recommendation	Dietary Guide	Simple and appealing
41	BMI	None	Simple and appealing, User friendly
42	Dietary Guide, Water Intake	None	Ghanaian tailored features
43	BMI, Recommendation, Dietary Guide	None	User friendly
44	Dietary Guide, Recommendation	None	Ease of use
45	Workout, Dietary Guide, Recommendation	None	Research more into new healthy Africa foods
46	My Food and Recipe, BMI	None	User friendly
47	BMI, Dietary Guide	None	Ghanaian tailored features
48	Recommendation, Cultural features	None	Ghanaian tailored features
49	BMI	None	User friendly
50	All	None	All

Appendix H-4: Usability Test Results – Benefits/Pay to Use

Table 17

Post Questionnaire Results

Participant	Age	Gender	Use application if free	Benefit you or family	Personal benefits	Pay to use
1	30-35	Female	Agree	Agree	Strongly Agree	Agree
2	30-35	Male	Agree	Agree	Neutral	Agree
3	46-50	Female	Strongly Agree	Agree	Strongly Agree	Agree
4	51-55	Female	Agree	Agree	Agree	Agree
5	30-35	Female	Strongly Agree	Strongly Agree	Agree	Agree
6	41-45	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
7	46-50	Female	Strongly Agree	Strongly Agree	Strongly Agree	Neutral
8	36-40	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
9	41-45	Female	Strongly Agree	Strongly Agree	Strongly Agree	Agree
10	46-50	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
11	46-50	Female	Strongly Agree	Strongly Agree	Agree	Strongly Agree
12	30-35	Male	Strongly Agree	Agree	Strongly Agree	Neutral
13	46-50	Male	Agree	Agree	Agree	Neutral
14	36-40	Female	Agree	Agree	Strongly Agree	Neutral
15	51-55	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
16	46-50	Male	Strongly Agree	Strongly Agree	Agree	Strongly Agree
17	41-45	Female	Strongly Agree	Strongly Agree	Agree	Strongly Agree
18	36-40	Female	Agree	Strongly Agree	Agree	Neutral
19	46-50	Female	Strongly Agree	Agree	Agree	Agree

20	41-45	Female	Agree	Agree	Strongly Agree	Agree
21	46-50	Female	Strongly Agree	Strongly Agree	Strongly Agree	Neutral
22	41-45	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
23	46-50	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
24	46-50	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
25	36-40	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
26	51-55	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
27	36-40	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
28	46-50	Male	Strongly Agree	Strongly Agree	Agree	Agree
29	41-45	Female	Agree	Agree	Strongly Agree	Neutral
30	41-45	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
31	46-50	Male	Neutral	Neutral	Agree	Agree
32	41-45	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
33	46-50	Female	Strongly Agree	Strongly Agree	Strongly Agree	Agree
34	30-35	Male	Agree	Agree	Strongly Agree	Agree
35	30-35	Male	Agree	Agree	Agree	Agree
36	30-35	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
37	46-50	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
38	41-45	Male	Agree	Agree	Agree	Strongly Agree
39	41-45	Female	Strongly Agree	Strongly Agree	Strongly Agree	Agree
40	36-40	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
41	41-45	Male	Strongly Agree	Agree	Agree	Strongly Agree
42	36-40	Female	Strongly Agree	Agree	Agree	Agree

43	30-35	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
44	51-55	Female	Strongly Agree	Agree	Strongly Agree	Strongly Agree
45	41-45	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
46	30-35	Female	Agree	Agree	Strongly Agree	Agree
47	51-55	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
48	36-40	Female	Strongly Agree	Agree	Strongly Agree	Strongly Agree
49	46-50	Male	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree
50	30-35	Female	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree

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Yuan, S., Ma, W., Kanthawala, S., & Peng, W. (2015). Keep using my health applications: Discover users' perception of health and fitness apps with the UTAUT2 model. *Telemedicine and e-Health*, 21(9), 735-741

Curriculum Vitae

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EDUCATION

D.Sc., Information Technology, (May 2020*)*
Towson University, Towson, MD
Dissertation: "Usability Impact of User Perception in mHealth: The Case of Ghanaian Migrants"
Advisor: Dr. Joyram Chakraborty

M.S., Information Technology / CERT. in Cyber Security, (December 2014)
Hood College, Fredrick, MD

M.A., Publications Design
University of Baltimore, Baltimore, MD (December 2011)

B.F.A., Graphic Design
Kwame Nkrumah University of Science & Technology, Kumasi, Ghana (June 2007)

RESEARCH INTERESTS

- Human Computer Interaction
- User Experience (UX) Research and Design
- User Interface (UI) Design
- mHealth technology
- Artificial Intelligence

TEACHING INTEREST

- Information Systems
- Interface Design
- Information Security
- Web Technologies
- Electronic Commerce
- Mobile Computing
- Business Analytics

PUBLICATIONS

Owusu, E., & Chakraborty, J. (2019). Usability Impact of User Perceptions in mHealth—The Case of Ghanaian Migrants. In *International Conference on Intelligent Human Systems Integration*, pp. 557-562.

Owusu, E., & Chakraborty, J. (2019). User Requirement Gathering in mHealth: Perspective from the Ghanaian End User. In *International Conference on Human-Computer Interaction*, pp. 386-396.

Owusu, E., & Chakraborty, J. (2020). Preliminary Findings of a User Centered Design Study of Mobile Health Technology for Ghanaian Migrant Families. *Cambridge Workshop on Universal Access and Assistive Technology CWUAAT*, pp. 87-96.

PRESENTATIONS

Co-Chair and Presenter
"Usability Impact of User Perceptions in mHealth—The Case of Ghanaian Migrants" International Conference on Intelligent Human Systems Integration. San Diego, California, February 2019.

Presenter
"User Requirement Gathering in mHealth: Perspective from the Ghanaian End User" International Conference on Human-Computer Interaction, Orlando, Florida, July 2019.

TEACHING EXPERIENCE

Adjunct Faculty, Graduate Assistant (August 29, 2016 – Present)
Department of Computer and Information Sciences
Towson University, Towson, Maryland
Classes taught

- ITEC 231: Fundamentals of Web Technologies (January - May 2020)
- CIS 211: Fundamentals of Information Systems Technology (January - May 2020)
- CIS 211: Fundamentals of Information Systems Technology (August - December 2019)
- CIS 211: Fundamentals of Information Systems Technology (January - May 2018)
- CIS 211: Fundamentals of Information Systems Technology (August - December 2018)
- CIS 211: Fundamentals of Information Systems Technology (January - May 2018)
- CIS 211: Fundamentals of Information Systems Technology (August - December 2017)

Graduate Assistant (August 24, 2015 - May 20, 2016)
Department of Computer and Information Sciences
Towson University, Towson, Maryland
Classes taught

- COSC 111: Information and Technology for Business (January - May 2017)
- COSC 109: Computer and Creativity (August - December 2017)
- COSC 109: Computer and Creativity (January - May 2016)
- COSC 109: Computer and Creativity (August - December 2016)
- COSC 109: Computer and Creativity (August - December 2015)

Participated in Faculty Guild professional development (January – December 2018)
Towson University, Towson Maryland

- Pedagogical teaching techniques
- Teaching success movement

PROFESSIONAL EXPERIENCE

Adjunct Faculty / Graduate Assistance (August 24, 2015 – Present)
Department of Computer and Information Sciences
Towson University, 8000 York Road, Towson, MD 21252
Supervisor: Dr. Karne Ramesh, Director of Doctoral Program (2015 – 2016)
Phone 410-704-3955
Supervisor: Dr. Chao Lu, Director of Doctoral Program (2017- present)
Phone 410-704-3950

- Teaching Fundamentals of Information Systems Technology, Business in IT, Computer and Creativity, and Fundamentals of Web Technologies
- Managing undergraduate laboratory projects
- Grading class assignments and projects
- Assisting students during office hours

IT Consultant (February 2012 – Present)
Youths Map, Frederick, Maryland

- Program advisory board member
- Data organization, website design and management
- Assisting in project planning and implementation
- Mentoring youth from local communities
- Annual activities coordination and participant registration
- Training of project team

Graphic Designer (December 2011 – December 2012)
International Arts & Artists, Washington, DC

- Served as an assistant to the Studio Director
- Weekly project reporting
- Designed print and web marketing
- Enforced quality control in all deliverables

Graphics Lab Manager (January 2010 – December 2011)
Rosenberg Center for Student Involvement
University of Baltimore, Baltimore, Maryland

- Supervised operations of the Graphics Lab
- Managed the Graphics Lab Student Assistants
- Managed and executed all design and printing projects

- Assisted in developing communications and marketing strategies
- Managed inventory of graphic supplies
- Prepared monthly sales report

PROFESSIONAL AFFILIATIONS

- **Faculty Guild**, Towson University Participant (January – December 2018)
- **Project Management Institute** (PMI), Baltimore Chapter (January 2017 – Present)
- **IEEE**, Washington Section, U.S.A, Member (January 2015 - Present)
- **American Institute of Graphic Arts** (AIGA), Baltimore Chapter (September 2010 – Present)

TECHNICAL SKILLS

Operating Systems:

- Linux
- Mac OSX
- Windows OS

Program languages:

- JavaScript
- XCode
- Swift
- HTML
- CSS

Software:

- MS Visio
- MySQL
- Adobe Creative Suite: Adobe XD, Illustrator, InDesign, Photoshop, Lightroom, Premiere Pro, Adobe Flash, Animate, Camera Raw, Bridge, InDesign, Dreamweaver, Acrobat DC
- Microsoft Office Suite: MS Word, MS Excel, MS Access

Certificate:

- AWS Certified Developer - Associate (November 2018)
- ITIL Certified (November 2016)