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Doctoral Thesis

Utilization of Personal Health Informatics Through Intermediary Users

Author:
Ntwa Katule

Supervisors:
Dr. Melissa Densmore and
Prof. Ulrike Rivett

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Declaration of Authorship

I, Ntwa KATULE, declare that this thesis titled, 'Utilization of Personal Health Informatics Through Intermediary Users ' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
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"Education is what remains after one has forgotten what one has learned in school."

Albert Einstein

UNIVERSITY OF CAPE TOWN

Abstract

Faculty of Science
Department of Computer Science

Doctor of Philosophy

Utilization of Personal Health Informatics Through Intermediary Users

by Ntwa KATULE

The Thesis Abstract is written here (and usually kept to just this page). The page is kept centered vertically so can expand into the blank space above the title too...

Acknowledgements

The acknowledgements and the people to thank go here, don't forget to include your project advisor...

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Abbreviations

BBM	**B**lack **B**erry **M**essenger
BMI	**B**ody **M**ass **I**ndex
CHW	**C**ommunity **H**ealth **W**orkets
GPS	**G**lobal **P**ositioning **S**ystem
HCI	**H**uman **C**omputer **I**nteraction
ICT	**I**nformation and **C**ommunications **T**echnology
ICTD	**I**nformation and **C**ommunications **T**echnology and **D**evelopment
MMS	**M**ultimedia **M**essaging **S**ervice
PDA	**P**ersonal **D**igital **A**ssistant
PSD	**P**ersuasive **S**ystem **D**esign
SIM	**S**ubscriber **I**dentity **M**odule
SMS	**S**hort **M**essaging **S**ervice
USSD	**U**nstructured **S**upplementary **S**ervice **D**ata
URL	**U**niform **R**esource **L**ocator

Physical Constants

Speed of Light $c = 2.997\ 924\ 58 \times 10^8\ \mathrm{ms}^{-\mathrm{S}}$ (exact)

Symbols

a	distance	m
P	power	W (Js^{-1})
ω	angular frequency	rads^{-1}

This work is dedicated to my great parents, my father, Andalwisye, and my late mother, Mary for supporting me throughout my academic journey...

Chapter 1

Introduction

1.1 Background

Obesity and overweight are currently global health concerns. A systematic review by Guh et al. (2009) concluded that both overweight and obesity are associated with increased incidence of multiple co-morbidities including type 2 diabetes, cancer and cardiovascular diseases (CVD). The number of people who are considered to be either overweight or obese stands to an approximation of 1.3 billion people (Steyn et al., 2006). A survey by Abegunde et al. (2007) which included a total of 23 low-income and middle-income countries had projected a loss US$84 billion of economic production in between 2006 and 2015 from heart disease, stroke, and diabetes alone in the absence of any measures in place. Co-morbidities that are associated with obesity are likely to inundate health care systems (Pollak et al., 2010). In addition to that, at the moment health-care systems have failed to optimally treat chronic conditions such as diabetes due to lack of time to continuously provide patient care which is essential in management of chronic conditions (Quinn et al., 2008). This calls for innovative and citizen-centric interventions to foster lifestyle changes in order to, both prevent or delay onset of chronic conditions and support patients in self-management of a chronic conditions (Korhonen et al., 2010; Årsand et al., 2012; Higgins, 2016).

Advancements in hardware and software technologies have presented opportunities for automation of health self-management processes (Årsand et al., 2010). Mobile phones are becoming omnipresent and people carry them most of the time (Mattila et al., 2008); hence their presence brings a "kairo factor" in delivery of interventions that target both health promotion (Pollak et al., 2010) and persuasion (Hsu et al., 2014). Smartphone based applications are rapidly gaining popularity as effective tools to support delivery of personalized health information (Handel, 2011). Mobile health apps (smart phone based

applications) that support self-monitoring are becoming useful in augmenting cognitive behaviour therapy - treatment of behaviour in clinical settings (Mattila et al., 2008; Medynskiy and Mynatt, 2010). These apps facilitate data collection of one's health parameters through inbuilt tools such as GPS, accelerometer (body activity sensor), etc; hence present an innovative way of monitoring and improving both health and fitness (Higgins, 2016). In order for such tools to support health behaviour change, theory based strategies such gamification (for enhancement of motivation), goal setting and feedback (for improvement of self-efficacy) and SMS reminders are often applied (Higgins, 2016; Consolvo et al., 2009; Cole-Lewis and Kershaw, 2010; Hamari et al., 2014a,b).

1.2 Statement of the Problem

A review by Higgins (2016) presented evidence that these apps can better help patients reach their health and fitness goals. However, such apps have limitations as they don't support specific interaction models that accommodate sharing of devices and indirect usage. Such mode of interaction are prevalent and relevant in the context of developing world ; hence they may not replicate well to some populations of users (Kaplan, 2006; Sambasivan et al., 2010), especially the ones that face barriers to direct access to user interfaces or technology (Kumar and Anderson, 2015). This research was exploring of how one could support a personal health informatics technology of which its usage is facilitated by intermediaries users on behalf of beneficiary users (indirect users). Despite a vast amount of literature on *intermediated technology use*, such persuasive technologies have not been extensively explored in this context. Persuasive technologies tend to have their unique design considerations, and intermediated technology use has its socio-technical aspects; hence one has to understand factors to consider and how to go about implementing a useful intervention that can work in such a complex context. This study had two main research questions as presented below.

1.3 Research Contribution

The contribution of this research is mainly on human factors to consider when designing a personal health informatics (PHI) for intermediated used. In this dissertation it is suggested that rather that designing a PHI only for the beneficiary, one can design for intermediated use, explicitly acknowledging the presence of more than one user of the application.

1.4 Thesis Organization

Chapter 2

Literature Review

2.1 Behaviour Change Support Technologies

Research on ubiquitous computing to support behaviour change in a myriad of domains has received a significant amount of attention. There has been an emphasis on the importance of having incentive systems with emotionally engaging and timely feedbacks to persuade people to change their behaviors (Nakajima and Lehdonvirta, 2013).

One of the early pioneers to formalize behaviour change technology as an area of research was B.J. Fogg[1] who coined a term "captology" which is an acronym for *Computers As Persuasive Technologies* (CAPT-ology), with focus on the planned persuasive effects of computer technologies (Fogg, 1999). In persuasive systems, persuasion is intentional and usually implemented through persuasive stimuli; hence providing a system with the ability to persuade (Hamari et al., 2014a). Persuasive technologies have applications in domains such as health-care, education and training, environmental sustainability, etc..

According to Langrial (2012), the evolution of research on behaviour change technologies through the realms of computing research started with digital interventions in early 1990s which were basically for intervening behaviours in the preventive health area primarily through reminders; to persuasive technologies - systems that implement various software functionality that utilize approaches such as social learning or comparison etc; to the current behaviour change support systems (BCSS) which provide models and frameworks for designing and evaluating persuasive technologies. Oinas-Kukkonen (2013) defined a BCSS as "a socio-technical information system with psychological and behavioural outcomes designed to form, alter or reinforce attitudes, behaviours or an act of complying without using coercion or deception".

[1] http://bjfogg.com/

Separate models (frameworks) to guide the design and evaluation of persuasive technologies have been proposed since models from information systems such as a *Technology Acceptance Model* (TAM) have limitations with regard to understanding the effectiveness of persuasive technologies (Oinas-Kukkonen and Harjumaa, 2009). Persuasive technologies' models tend to provide nuanced features and characteristics that define such systems. Fogg (2009a) recommended a behaviour model for persuasive design which asserts that for a person to perform a targeted behaviour, he or she must (1) be sufficiently motivated, (2) have the ability to perform the behaviour, and (3) be triggered to perform the behaviour. Fogg (2009b) also recommended a behaviour grid that one can use to design persuasive technologies. In this behaviour grid, persuasive strategies are matched to targeted behaviours.

Oinas-Kukkonen and Harjumaa (2009) extended Fogg's work (Fogg, 2009a) with a more comprehensive model known as a *Persuasive System Design* (PSD) model which suggested three initial steps: (1) analysis of the persuasion context, i.e. with focus on the intent of persuasion and context of use, user, and technology; (2) selection of persuasive features to use; and (3) selection of persuasion strategies to use i.e. whether to use a direct or indirect route of persuasion. The PSD model also outlined 28 design principles discerned into the following five categories: (1) *primary task support*, which includes activities such as, reduction of complex behaviours into simple tasks, guiding the user through experiences while persuade along the way, tailoring of persuasive information to factors relevant to a user group, personalization of content, and self-monitoring for users to keep track of their performance towards their specified goals; (2) *dialogue support*, which includes praises, rewards, reminders, similarity, liking, and social roles; (3) *system credibility support*, which includes trustworthiness, expertise, surface credibility etc; and (4)*social support*, which includes social learning, social comparison, and competition.

An extension to the PSD model was an *Outcome Change* (O/C) matrix of which one could use when analysing an intent of persuasion (Oinas-Kukkonen, 2013). The O/C matrix matches the type of change that needs to be applied with a specific outcome. A change could either be of compliance (C) or behaviour (B) or attitude (A), nature. While an expected outcome could be forming, altering, or reinforcing any of the aforementioned types of change. The extended PSD model with O/C matrix is called BCSS as mentioned in the classes of behaviour change systems above. BCSS is considered to be the foundation for studying persuasive systems and it is meant to provide a base for analysis, design, and evaluation of persuasive technologies. The next section highlights how behaviour change technologies have been applied in health domain.

2.2 Behaviour Change Technologies for Health

Health-care providers are eagerly seeking for innovative solutions that could help in monitoring and improvements of the patients' health (Higgins, 2016). Innovative ways to support health promotion and management are in need to respond to the health care crisis as the result of unprecedented increase in prevalence of lifestyle-chronic diseases (Årsand et al., 2010). Health-care systems don't not have sufficient resources to cope with the increasing burden of chronic diseases (Quinn et al., 2008; Årsand et al., 2010); hence these innovative ways aim at supporting the advocacy of shifting from physician centred care to patient-centred care (Korhonen et al., 2010; Higgins, 2016). Literature has demonstrated the dominance of persuasive technologies targeting health behaviour change. For instance one recent systematic review of 95 studies that examined the ability of persuasive technologies to persuade, had approximately included 47 % studies that targeted domains of health and exercise (Hamari et al., 2014a). The remaining 53% was shared by several domains such ecological consumption and/or behaviour (21%, second highest), education/learning economic (11%), etc.. Therefore, this indicates that health is an important area of concern when the notion of persuasive technologies comes in mind.

Chatterjee and Price (2009) classified three generations of technological evolution of hardware and software utilized in implementations of behaviour change interventions in health. The first generation started to emerge from 1960's and it was characterized by the prescriptive nature of information flow from physician, health care provider, or technology-based system to a health care recipient. Decades worth of research has shown that phone-based or simple messaging technologies can improve the quality of health care management and clinical outcomes. The second generation is characterized by the descriptive nature of information interaction between a user and the persuasive technologies and examples of such systems include interactive websites, personal data assistants (PDAs) that allow activity recording, and simple sensors that record and report basic health parameters. The third generation extends second generation by providing body-wearable sensors that support advanced health monitoring, use of context-aware computing to determine when to deliver "just in time" messages. While the second generation utilized PCs and later cellphones, the third generation is dominated mostly by cellphones and ubiquitous computing devices. The future generation is expected to be the one that will entail ubiquitous computing integrated seamlessly into people's daily lives and it will be supported with data mining techniques (Chatterjee and Price, 2009).

The first and second generations systems are the ones that have received most appraisal because of existing randomized clinical trials. The evidence of their dominance in public health is demonstrated by the preponderance in publications that report on the use web

based interventions integrated with SMS text-messaging on clinical settings. Existing systematic reviews (Cole-Lewis and Kershaw, 2010; Fjeldsoe et al., 2009; Krishna et al., 2009) reported more on the use of SMS reminders and feedbacks on areas of diabetes self-management, smoking cessation, and weight reduction therapy. There are mixed results on effectiveness of cellphone or other ICT interventions on weight loss production. For instance one randomized control trial (RCT) that was carried out for a period of two years (Svetkey et al., 2015), revealed that a control group that was supplied with only pamphlets materials with health information reduced weight significantly compared to two intervention groups; one group using a mobile app, and the other group using both a human coach and a mobile app. In addition to mixed results that are often found in such clinical trials. Cole-Lewis and Kershaw (2010); Kaplan (2006) also pointed out that the design of such interventions may not scale well to specific demographics within resource constraint contexts. From persuasive technology literature perspectives it has also been observed that there is a gap between research in persuasive technologies and RCTs in public health settings. Literature from public health is being criticized for lacking adequate information on how individual systems were designed as such systems are usually poorly described since most work is being published by public health practitioners without involvement of computer scientists (Oinas-Kukkonen, 2013).

Persuasive technologies provide means to personalize health information. Personalization of health information is advocated within public health domain as it allows consideration of individual needs of a person and it also gives a targeted person, a sense of control over their healthcare (McCallum, 2012). This research was focusing on personalized technologies that support data collection and feedback for an objective of health persuasion. These systems are referred to as wellness applications or personal health informatics.

2.3 Personal Informatics for Health Behaviour Change

Personal informatics is a class of interactive applications that support users to improve self-awareness of various facets of their lives by providing technological means to support in collection and analysis of personal data related to habits, behaviours, and thoughts (Li et al., 2011a, 2012). A personal informatics system augments the activity of *self-reflection* by complementing individuals in storing events that can hardly be recalled due to limitations in humans' memory (Li et al., 2010). The goal of personal informatics systems is to support individuals in having a better understanding of their lifestyle or

behaviours. These systems are important in promotion of positive behaviors in a myriad of domains such as healthy lifestyle (Korhonen et al., 2010), recycling (Comber and Thieme, 2013), energy conservation (Seligman and Darley, 1977), etc.

Research on personal informatics systems tends to focus on, effective ways of, collecting users' personal data in an effortless manner, and supporting for self-reflection through feedback mechanisms (Li et al., 2011b). Data collection is usually supported with context-aware sensors and self-reporting mechanisms. Sensors may be coupled together with a computing device for both analysis and feedback or may be coupled in an external device that transfer data through either wireless means or data cables, to a computing device responsible for analysis and feedbacks. Nakajima and Lehdonvirta (2013) proposed the use of a metaphor "*ambient persuasive mirrors*" to describe displays that can support self-reflection of one's own behaviour. These mirrors may be multifaceted and may apply transformation and integration of data from other sources, and their implementation can be on, personal mobile devices (Klasnja et al., 2009) or shared public interfaces (Lin et al., 2006).

Personal informatics systems can be applied in prevention of onset of chronic conditions by motivating healthy individuals to change their lifestyle. Specifically, these systems promote behaviours that are beneficial in, preventing weight gain or weight loss. These systems operate by facilitating logging of data related to personal behaviour. This act of behaviour logging can also be beneficial in self-management of chronic conditions as it provides support for a self-monitoring task. Self-monitoring is very essential in supporting cognitive behaviour therapy (CBT) within public health settings (Mattila et al., 2008), especially for individuals who are clinically obese (NIH et al., 2000). Health self-management programs usually ask participants to keep records of their activities, physiological variables and other health-related data; personal informatics applications can make this process simpler and easier (Medynskiy and Mynatt, 2010). For instance participants may record their daily calorie intake,and then have graphs that show trends of how far they have gone with reducing their intake. The essence of self-monitoring is to promote self-awareness of one's behaviour. That consciousness is fostered through behaviour observation. And behaviour observation can be achieved through behaviour recording. Therefore, collection of data on one's own behaviour can viewed as an important self-assessment approach for helping patients to observe and react on their own behaviours (Rapp, 2014). This implies that with a self-monitoring system or app, processes of recording and self-reflection are simplified through technology.

Literature presents a wide range of mobile phone based personal informatics systems for promotion of physical activity, blood glucose monitoring, and healthy eating. Some of these are specifically for chronically ill patients e.g. "Few Touch Application" which

targeted individual with *Type 2 Diabetes* (Årsand et al., 2010), and a system described by Arteaga (2010) that targeted teenagers with weight management issues. There also exists systems that target general populations, and used for promoting healthy eating habits and engagement in physical activity e.g. Fish'n'Steps(Lin et al., 2006), UbiFit Garden(Klasnja et al., 2009), Wellness diary(Mattila et al., 2008), ActivMon(Burns et al., 2012), PmEB(Lee et al., 2006), iCrave(Hsu et al., 2014), etc.

Models and frameworks for understanding both physical, social, psychological needs of users within the context personal informatics have been vastly explored. Kamal et al. (2010) presented a framework for designing a system that integrates online social networks and personal informatics to promote positive health behaviours. The framework was informed by theories from both health behaviour change and social networks. Li et al. (2010) proposed a model for understanding how people use personal informatics by transitioning between the following five stages: preparation, collection, integration, reflection, and action. The importance of identifying barriers at each stage is emphasized since these barriers may also cascade to later stages to hinder the process of data collection and self-reflection. In order to address cascading barriers, it was recommended that the design process should be carried out in an holistic approach that involves iterations between stages. The aforementioned model aimed at helping with the process of designing a personal informatics system. There are also studies that have explored design implications for data logging systems that support self-reflection. For instance Li et al. (2011b) highlighted that such tools should be designed to address six questions that users ask themselves when engaging with their personal data; these questions are based on, status towards achieving their goal, history for the purpose of discovering patterns that are crucial to the preferred behaviour, formation of goals to facilitate in attaining a preferred behaviour, discrepancies between their behaviour and goal, context of past behaviour in order to discover patterns, and discovering of factors that may affect their behaviours. The aforementioned questions are asked in two phases of which the user alternates in the course of using a personal informatics systems. The two transition phases of behaviour change are self-discovery and maintenance. In the self-discovery stage individuals collect a lot of data they can use to discover patterns in their behaviours. After discovering of a pattern they can move to the maintenance stage. The maintenance stage entails setting of a personal goal and monitoring of a status towards achieving that goal. Users don't stay permanently in one phase. It is possible for an individual in the maintenance phase to go back to discovery phase if there is a new unknown pattern that has emanated and appears to affect their behaviour. Another study by MacLeod et al. (2013) suggested factors that drive motivation of chronically ill people in engaging with their personal data as; curiosity, and self-discovery of what is happening in their health.

The most recent model to help in understanding how people use personal informatics systems, suggested that these systems are meant to be fully integrated into people's daily lives (Epstein et al., 2015a). This model extends Li et al. (2010)'s model, by splitting the preparation stage into *deciding to track* and *selecting tool* processes; and combining collection, integration, and reflection into tracking and acting. This model also includes further stages beyond tracking and acting and these were lapsing, and resuming tracking. From lapsing, issues that contribute to discontinuation or intermittent usage are explored, while in resuming tracking, issues such as switching of tools, incorporation of previous history/data while resuming to use are explored on this stage.

The last stage of the Li et al. (2010)'s model suggests on providing guidance to an end user towards an action. However, guiding an end user through an action/acting stage for the objective of minimizing barriers in execution of the action stage, can be perceived as an attempt to nudge individuals towards certain behaviours. There has been a debate from HCI research community of whether behavioural nudges are ethically accepted or not as some researchers are proposing a more neutral approach while others recommend application of intervals of behavioural nudges upon tracking (collection and reflection) activity. For instance, Munson (2012) advocates that the focus on personal informatics should be towards enabling end users to better know owns behaviour instead of applying behavioural nudges, and suggests that adoption should be voluntary. Also in Epstein et al. (2015a)'s model it is highlighted that sometimes people use personal tracking systems for other reasons beyond behavioural change goals such as instrumental benefits (i.e. to get rewards from location trackers like Foursquare), or out of curiosity. However, Epstein et al. (2015a), still shows that in most usage that is related to health domain i.e. in physical activity, behaviour change goal is a dominant motivational factor (Epstein et al., 2015a); hence suggestions on what actions an end user should take are inevitable. In addition to this, technology is considered not to be neutral (Oinas-Kukkonen and Harjumaa, 2009). Technology has a capability of presenting social cues that trigger emphatic responses from humans (Fogg, 2003). If no action is recommended, still an action can come from within a person using the system as the result of self-reflection. According to Fogg (1998) cited in Oinas-Kukkonen and Harjumaa (2009), intent of persuasion can originate from either of the three sources which are: (1) from the people who create or produce interactive technology; (2) from people who give access to or distribute the interactive technology to others; and (3) from the people who use or adopt an interactive technology. The intent of persuasion may also come from within the person using a system that does not recommend or suggest any actions. The persuasion may be as the result of cognitive dissonance after self-reflection. People like their views of the world to be consistent and It also assumed that people always make rational and informed decisions (Oinas-Kukkonen and Harjumaa, 2009). By using

personal informatics, individuals' decisions can be improved by being be able to see the discrepancies between their desired behaviours versus their performance (Comber and Thieme, 2013). If there are inconsistencies, then a cognitive dissonance is introduced which may mediate a change of attitude or behaviour in order to restore consistency between beliefs and actions (Oinas-Kukkonen and Harjumaa, 2009). Therefore, an act of tracking(collection and reflection) itself can mediate a behaviour change through cognitive dissonance. The motivation of usage of personal informatics in domains such as health and finance has been found to be related to a behaviour change goal (Epstein et al., 2015a). From this perspective, a basic personal informatics system with simply self-monitoring support can be viewed as a persuasive technology in contexts such as personal health and finance, because of its ability to trigger cognitive dissonance which can be considered as a persuasive stimulus. Knowing one self can be important in adoption of a better lifestyle. For instance one study found the use of pedometer alone (without other motivational affordances) increased physical activity by about 1 mile of walking per day (Bravata et al., 2007) cited in Albaina et al. (2009).

One of the common strategies to make cognitive dissonance more salient involves setting of personal health goals, which has been recently used in many developed systems i.e Few Touch Application (Årsand et al., 2010). This idea is derived from a goal setting theory (Strecher et al., 1995). An example of a goal could be to walk for at least 30 minutes every day or to increase the number of times a person eats fruits and vegetables or to reduce the amount of starch in a meal. One way of tracking progress towards the goal is through feedbacks that may simply implemented through SMS, or some sophisticated visualization approaches. The common data visualization techniques consists charts and graphs. Beyond charts and graphs, the use of metaphors that requires users to take care of virtual pets is becoming prevalent as a means to emotionally engage users with their personal data (Pollak et al., 2010; Nakajima and Lehdonvirta, 2013; Klasnja et al., 2009; Lin et al., 2006; Albaina et al., 2009). The most popular virtual pets are the ones that use plants or fish metaphors and these metaphors have shown promising results in supporting end users with their motivational needs. For instance Nakajima and Lehdonvirta (2013) described a situation of where participants felt guilty when their trees died. Another example is that of a Fish'n'Steps (Lin et al., 2006) application of where some of the participants were saddened when their fish appeared to be sad because participants had not walked enough steps. The aforementioned examples demonstrate how the use of virtual pets could invoke end users' emotional attachment with their virtual pets. Also there are studies that have utilized informal art displays (Nakajima and Lehdonvirta, 2013; Fan et al., 2012).

The motivational paradigms in persuasive technologies have also been extended to exploration of systems with social incentives that entail social collaboration, social interactions, social support, and competitions or social comparison for the purpose of enhancing engagement of end users (Ploderer et al., 2014; Chen et al., 2016; Epstein et al., 2015b; Reno and Poole, 2016), and this brings the notion of gamified personal health informatics (Lin et al., 2006; Chen and Pu, 2014; Han et al., 2014). Cooperation and competition features have been found to be among effective incentives in pervasive fitness applications (Chen et al., 2016). Also the use of social influence through social networks integrated with personal informatics is very promising. For instance in a BinCam (Comber and Thieme, 2013; Comber et al., 2013) system they used social norms influence as a motivation strategy to encourage individuals within a household to be more conscious of their recycling behaviours by comparing themselves with other households. Bales and Griswold (2011) proposed the idea of interpersonal informatics systems that aim at making the social influence more salient to individuals using the personal informatics. The authors of the aforementioned paper argue that personal choices are also as the result of the influence of social networks in which one participate. The essence of the aforementioned approach was to support individuals in becoming more aware of how those around them affect their habits, beliefs, and health.

Despite such tremendous development in the field of personal informatics for health promotion, most of these systems are designed for the developed world context. Even existence of randomized clinical trials on utilization of a simple technology such as SMS is largely dominated by countries from developed world (Cole-Lewis and Kershaw, 2010). From HCI point of view, engagement with personalized systems is currently considered to be more personal from data collection to reflection processes. These applications are personal in the essence of ownership of hardware, applications, data stored in application, and the process of interacting with a system for both data collection, and reflection. The technology interaction context of the existing applications may not be versatile in developing world perspective especially in low income communities of where both sharing in usage of technology and indirect usage through intermediary or proxy users are common (Kaplan, 2006; Sambasivan et al., 2010). HCI in the developing world is a complex relationship between technology, multiple users, indirect stakeholders, observers, and bystanders (Parikh and Ghosh, 2006). An interaction model that assumes one phone/device one person might not always be feasible in such contexts. Also in many contexts, interaction with technology may not be direct; intermediation by another person occurs when the primary user is not capable of using a device entirely on their own (Sambasivan et al., 2010). For users with limited technology literacy or education, direct access to a user interface might not even be feasible (Parikh and Ghosh, 2006); hence intermediation might be the only means for these people to be able to perceive the

benefits derived by the proliferation of mobile phones or any other ICTs. While many people in developing world context might lack textual and digital literacy, low-income communities are diverse and often there are some members who have competent skills to operate technology (Sambasivan et al., 2010), and these people may be able to help others to benefit from technology usage.

The complexity of usage through intermediaries is beyond help on the spot (Sambasivan et al., 2010); hence it cannot be merely solved by endeavours to simplify the user interface. In exploring of why intermediated technology use is beyond help on spot, one has to look at the notion of collectivist societies. In collectivist societies, people engage in tasks in group formation. For instance, India is considered to be a collectivist society of where individuals are prone to group orientation towards tasks (Parikh and Ghosh, 2006). This encourages usage of technology through human intermediaries. In such usage at least two users are involved in one interaction process. There is much more complexity on factors that influence intermediated technology use ; hence it cannot be simply explained by existing interaction models from computer supported collaborative work (Parikh and Ghosh, 2006). Sukumaran et al (2009) emphasizes the importance of having a better understanding of locally specific interaction models to address culturally influenced issues in using information technology throughout the developing world. Intermediated interaction in an example of such interactions that needs to be clearly understood.

In the context of personal informatics, frequency of usage may vary among different domains, with the ones targeting physical activity being used more frequent (on daily basis), while other domains usage is from once a week and beyond (Epstein et al., 2015a). Therefore, for a context where an end user needs help, motivation to use, is no longer just for this user but also it has to consider the person helping. This research was particularly focusing on how a personal health informatics system designed for a personal use can be adapted in the context where two sets of users are being involved in an interaction process (the first one being a beneficiary of that technology, meaning a person receiving help on an interaction task to both collect and self-reflect on their personal data, while the second one is an intermediary user, a person providing assistance to a beneficiary user).

The next section highlights the broader view of intermediated technology use in the context of both developing and developed world communities.

2.4 Intermediated Technology Use

The role of human intermediaries within the context of ICTD has well emphasized as to be beyond that of translators of policies to the ground level (Bailur, 2010). According to Heeks (1999), cited in Bailur and Masiero (2012), human intermediaries bridge a gap between what the poor have and what they would need in order to use ICTs. An example of scenarios of where intermediaries have been of great value is that public access venues (PAVs) such as telecentres. Without the presence of these facilitators in PAVs, the groups that are excluded from access due to their age, socio-economic status, level of education/literacy, gender, disability or caste are more likely to face barriers in accessing information (Ramírez et al., 2013). Therefore, human infrastructure within ICTD context plays an instrumental role in facilitating information and communication access in low income communities (Sambasivan and Smyth, 2010). It has been suggested on literature that one of the factors that contributed to failure of past PAVs initiatives is lack of understanding of position and motivation of intermediaries (Bailur, 2010).

Human factors that affect and shape the outcome of facilitating information and communication access through human intermediaries have been explored. For instance Bailur (2010) used structuration theory(Jones and Karsten, 2008), to understand the contradiction and conflict of intermediaries on interacting with their different networks i.e. how they play a liminal role with stakeholders of PAVs and multimedia centres (i.e. NGO or government, donor agency on one side and community on the other side). Bailur and Masiero (2012) argues that PAVs' intermediaries should not be taken for granted in the space of ICTD because they play a complex position of brokers and translators as they assume multiple identities to different stakeholders of which their roles are constantly negotiated and performed within these multiple constructed networks. Another study is by Ramírez et al. (2013) which investigated how human factors such as empathy and technical skills of infomediaries influence the outcomes of the process of infomediation to users at PAVs.

The ecosystem of utilization of intermediaries in PAVs or other community centres has also been examined through lens of HCI. Focus on HCI has been on engagement of all layers of users involved in intermediated interactions. Parikh and Ghosh (2006)'s study in India provided a taxonomy of intermediated information tasks from HCI perspective; of which different modes of access were distinguished, and each one of them was suggested to have its own design requirements. These modes of access were: (1) cooperative, of whereby several users fairly collaborate without domination by a single or fewer users; (2) dominated interactions, of whereby users collaborate but they is one or fewer users who dominate others in manipulating user interfaces; (3) intermediated interactions, this whereby the first user manipulates interfaces while the rest of users are

just observing what is happening; and (4) indirect interactions, of where one or multiple users are being assisted to interact with a system without being being present or observing while manipulation of user interfaces is taking place. Sukumaran et al. (2009) conducted an experiment that investigated how social prominence of an intermediary versus technology in a computer kiosk affects perceived information characteristics and attitudes towards an interaction by a beneficiary user/secondary user and found out that when the technology was more visible and an intermediary did not monopolize access (situation of social equality), beneficiaries tended to feel more engaged and positive.

Although intermediaries in public access venues are considered as policy implementers on the ground level through working with communities, their position is very complex as they are the bottom of the hierarchy but they are also perceived not to be part of the community; hence they cannot specifically identify with a certain group since their roles are adapted according to circumstances (Bailur, 2010). Motivation of intermediaries in this context of PAVs is negotiated relative to their particular network. A different ethnography study by Sambasivan et al. (2010), explored the dynamics of intermediation beyond public access venues (*i.e in inherent home, or community settings that involve neighbours and family members as intermediaries* –these intermediaries are more embedded to the community as they are considered part of it). Sambasivan et al. (2010) presented three distinct forms of intermediated interactions: inputting intent into the device in proximate enabling, interpretation of device output in proximate translation, and both input of intent, and interpretation of output in surrogate usage. This study also highlighted: (1) social mediators of motivation for intermediation such as interpersonal trust or prior social rapport, a give and take economy, social structures (i.e. access constraints due gender, economic status, tendency of reliance on others, etc.), etc.; and (2) design implications to enhance engagement of users (primary and secondary users) such as : reorientation of technology to allow sharing between primary and secondary users for asymmetric engagement; and supporting persistent storage of information for retrieval at later stages by beneficiary users. The study also proposed that measurement of use should go beyond ownership to also consider those who benefit without direct usage.

The concept of informal help in technology use within family and social network settings is not an exclusive phenomenon of developing world only; it is present in developed world as well. For instance Poole et al. (2009) cited in Katule et al. (2016) examined the dynamics of computer help-seeking and giving behaviors in the context of family and social networks settings, their findings indicated that an important factor that encourages help-seeking behaviors is availability of unlimited help provided as a part of a longer-term relationship, while in the case of help-givers, they are motivated by a sense of being accountable to their family members and friends.

In the next subsection it is discussed of how intermediaries have been used in other health behaviour change interventions in the context of developing world and what is the gap from literature.

2.5 Intermediaries in Supporting Health Behaviour Change

In the context, of health behaviour change, typical examples of human intermediaries is on utilization of community health workers who provide access to health information to less privileged individuals in resource-constrained environments. In many ICTD projects, CHWs, access health information on behalf of communities in which direct access to health resources is not possible, and are an effective bridge between communities and government-based resources (Katule et al., 2016). One project in India used community health workers (CHWs) -referred to as ASHAs (Accredited Social Health Activists), of where these ASHAs were empowered with mobile phones that contained persuasive messages. These messages gave ASHAs credibility in persuading pregnant and postnatal women together with their relatives on maternal health issues (Ramachandran et al., 2010a,b). Most of these ASHAs are women.

One project in Lesotho (Molapo and Marsden, 2013), empowered rural health trainers with a software application for creation of digital training content, voice-over images that can be used by low-literate CHWs to train clients in the villages. While the main objective of these podcasts was for training purposes, upon CHWs showing them to their clients, there were unintentional persuasive effects that motivated these clients to get tested for diseases such as tuberculosis.

A study by Kumar and Anderson (2015) in India, used a feminist reflexivity lens to study how patriarchal structures and social conventions constrain women in accessing maternal health information, and how these women leverage help from intermediaries within communities to navigate their way out. The study further highlighted different groups of intermediaries who facilitate dissemination of information and examples of these intermediaries include but not limited to mobile shop owners, children and youth, and ASHAs. Another finding from that study is that even ASHAs may also face constraints on the process of transferring mobile media to their phones; hence they tended to seek help from their family members. Another observation was on technology access in patriarchal families of where access to cellphones was mostly dominated by men. In such contexts children appeared to have free access to their fathers' devices; hence these children were using the same devices to facilitate their mothers with information access. Vashistha et al. (2016) conducted a fourteen (14) weeks experiment to compare

three distribution channels in dissemination of mobile videos on maternal health; mobile shop owners, laptop owners, and ASHAs. Both of the three distribution channels were found not to be very different, however, ASHAs were found to be more effective in distributing videos to the people who where need or demand of such videos.

In the aforementioned projects that utilize CHWs, these CHWs were acting as human access to information that had a persuasive effect. A challenge with utilizing CHWs is that their availability is limited to fewer visits in intervals of weeks or months; hence may not be suitable for a technology such as a personal health informatics of which its beneficiaries may need to engage with a it more frequent. Also other forms of distribution and viewing have limitations as it was found in Vashistha et al. (2016)'s study that dissemination decreased over time, therefore, it was suggested an exploration of alternative mechanisms to extrinsically motivate intermediaries and viewers for broader video distribution.

In the context of children and youth within family settings, one may argue that their innate tendency to care for members of their families or communities may be a sufficient motivational factor for sharing health information, however there may be some limitations to that approach considering the fact that a personal health informatics may require frequent engagement, and without intermediaries having an interest in the system, it is not possible to have sustained usage. A study by Epstein et al. (2015a) found that users of personal informatics that target health domains such as physical activity have tendency of using them more frequent (at least once per day) compared to personal informatics targeting other domains. Introducing such a system in an ecosystem of intermediated technology use can introduce the following implication on its utilization; there is a possibility that people who are less familiar with such systems to seek help more often. Dependence on an innate intrinsic motivation of intermediaries alone may hinder availability of such a system to beneficiaries. The outcome of this is that there will be an intermittent usage which may have an impact on self-reflection, therefore, introducing a bottleneck in persuasion. The caveat of relying on natural intrinsic motivation of children to help their parents is also exhibited in a study by Kiesler et al. (2000) about informal help, of where parents reported to be skeptical in seeking help from their children in order to avoid negative experiences (i.e annoying their children because of asking for help more often). This proves that for systems such as personal health informatics of which help may be solicited more often, there is a need to explore on motivation techniques to enhance user experience of intermediaries. In the next section, the discussion is centred on a theoretical foundation on, motivation and user experience strategies that were applied at later stages of this study in order to encourage utilization of a personal health informatics through family intermediaries. This study puts an

emphasis on engaging intermediaries to become part of that ecosystem. Motivation is explored through the lens of self-determination theory.

2.6 A Self-Determination Theory Approach to Motivation

Motivation is categorized into intrinsic motivation (i.e. inherently embedded with ones' values and goals), and extrinsic motivation (i.e. doing something because of expecting some external outcome) (Ryan and Deci, 2000a). Therefore, the locus of control is internal to the person in intrinsic motivation while in extrinsic motivation the locus of control is external to the person (Lee et al., 2015).

Self-determination theory (SDT)(Deci and Ryan, 1985a), a well grounded theory of human motivation, is concerned with how individuals develop interest to engage with certain activities that were once considered uninteresting (Ryan and Deci, 2000a). SDT has two sub-theories namely: (1) cognitive evaluation theory, which focuses on supporting of the certain basic psychological needs in order in increase enjoyment of an activity or task; and (2) organismic integration theory (OIT), which focuses on the process of internalization of a regulation of a behaviour through extrinsic motivations. The OIT further discerns extrinsic motivators that can foster intrinsic motivation from extrinsic motivators that can harm intrinsic motivations (Lee et al., 2015; Ryan and Deci, 2000b).

Cognitive evaluation theory suggests that an intrinsically motivated activity is performed out of satisfying some psychological needs, therefore, for an uninteresting activity to become interesting through external rewards, social factors must provide support for the following three basic psychological needs; competence, relatedness, and autonomy (Ryan and Deci, 2000a). Autonomy deals with volition in initiation and regulation of a behaviour. It also emphasizes on the importance of individual's freedom to choose their own identity to represent oneself. Autonomy gives individual freedom to choose when and how, they want to initiate a behaviour. Competence emphasizes the need for individuals to be presented with challenges that give them a chance to sharpen or develop skills that match presented challenges. Challenges should not be too difficult or too easy to accomplish (Zhang, 2008; Colineau and Paris, 2011). This process of providing challenges is appropriate for ones' health psychological development and overall well-being (Zhang, 2008). Competence has a tendency of improving perceived enjoyment provided that there is a guarantee of autonomy (Forde et al., 2015). Therefore, in the absence of autonomy, support for competence may not lead to positive outcome on intrinsic motivation. Relatedness is the desire by individuals to feel a sense of belongingness. This implies people enjoy to be connected to others.

The premise of self-determination theory is that a behaviour that is externally motivated can become internalized (Ryan and Deci, 2000a). Organismic integration theory stipulates that different levels of internalization for self-regulation of uninteresting but important activities to become interesting, of which these levels are classified into four stages namely; (1) external regulation, (2) introjected regulation, (3) identified regulation, and (4) integrated regulation (Ryan and Deci, 2000a). The four distinct levels of internalization are shown on Figure 2.1. In external regulation, individuals self-regulate because of an external outcome such as contingencies of, rewards or punishment. This similar to conditioning of where a good or bad behaviours have their respective contingencies of rewards and contingencies of punishment. In introjected regulation, individuals self-regulate as an attempt to raise their self-worth with respect to others. Therefore regulation is as the result of ego involvement. In identified regulation, individuals have put value into an activity, therefore, they try to self-regulate an activity because they consider it as important probably for achieving a much broader goal; while in integrated regulation, individuals have fully assimilated the self-regulation to their core values and beliefs. Integrated regulation shares values with intrinsic motivation although it is not intrinsic motivation since its self-regulation is due fulfilment of an external outcome while in intrinsic motivation self-regulation of an activity is as the result of an activity itself being interesting (Ryan and Deci, 2000a). It is possible after doing an externally motivated activity for so long individuals may start to enjoy the activity itself regardless of its external outcome, then at this level the activity has already become intrinsically motivated. The internalization process is governed by social and environmental factors of which individuals function (Lee et al., 2015; Ryan and Deci, 2000b).

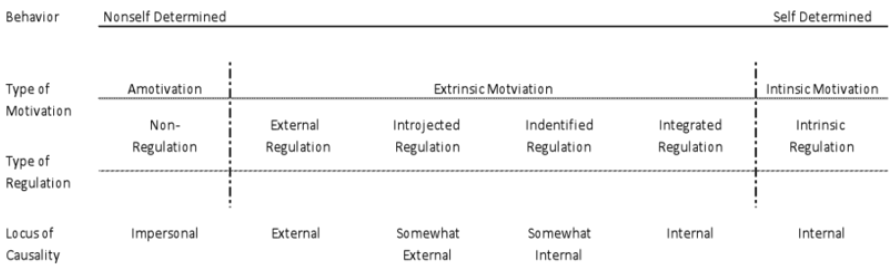

FIGURE 2.1: Organismic Integration Theory (Ryan and Deci, 2000a)

SDT has been used to understand motivation on various activities or behaviours such as; gaming (Ryan et al., 2006), physical activity (Power et al., 2011), tobacco cessation (Williams et al., 2006), energy saving (Webb et al., 2013), etc. This study brings the motivation pull of gamification in encouraging intermediaries to assist in utilization of personal health informatics. In the next section, gamification is discussed from perspective of self-determination theory.

2.7 Self-Determination Theory Support in Gamification

Zhang (2008) situated the need for autonomy, competence, and relatedness into motivational affordances to use ICTs and emphasized on the importance of supporting the aforementioned needs in order to foster motivation in usage of ICT systems. Ryan et al. (2006) investigated motivational pull behind video games using self-determination theory and found that needs for autonomy, competence, and relatedness independently predict enjoyment and future game play. Nakajima and Lehdonvirta (2013) argues that we should design systems to mimic the techniques used in games to build emotionally engaging persuasive systems. The motivational aspects of gaming have attracted researchers to explore their usage beyond gaming context and this has resulted to the advent of phenomena such as serious games and / or gamification. Gamification is the use of game design elements in non-game context (Deterding et al., 2011). Gamification tends to invoke users' intrinsic motivation through gameful experiences and affordances (Hamari et al., 2014a). Gamification is used outside game context to increase interest on uninteresting but instrumental activities (i.e. physical activity, crowd-sourcing tasks such as image annotation etc.). A systematic review on peer reviewed studies found that gamification provides positive effects and these effects are highly dependent on both the context in which gamification is implemented and the users using it (Hamari et al., 2014b).

The most popular extrinsic motivators in gamification are points, leader boards, achievement badges, levels, story theme, clear goals, feedback, rewards, progress, and challenge (Hamari et al., 2014b). There are different schools of thought on whether gamification itself is a game or not. Most debates are centred around what a typical game entails (i.e. presence of rules, meta-games, immersion, voluntarism in their adoption, etc.) (Seaborn and Fels, 2015). According to Deterding et al. (2011), users of gamification can socially construct a meaning of whether they perceive gamification as a game or not. The paper further argues what can be experienced in gamification can be termed as a gameful experience with an experiential "flicker" between gameful, playful, and other modes of experience and engagement. This means that users could perceive a gamified tool as a game or they could consider it as a tool that is instrumental for achieving a certain objective. For instance while users use a specific tool to achieve something, there is a possibility of the same people experiencing enjoyment from gameful or playful experiences. Seaborn and Fels (2015) argue that the goal of gamification is different from games, therefore, it should rather be considered as an act of integrating user experience to an activity outside game context. The use of gamification is influenced by social factors such as social influence, recognition, reciprocal benefit, and network exposure;

hence it is important to have a community of people who are committed to the goals that the gamification promotes (Hamari and Koivisto).

Sailer et al. (2013) used self-determination theory to understand the motivational pull of game design elements that can be used in non-game contexts of which their research attempted to provide examples of matching game elements to motivation mechanisms; for instance badges can be used to foster a sense of competence, while a leader board can be used to foster a sense of relatedness as it puts emphasis on collaboration among members of different teams.

Mekler et al. (2013a) conducted a study to evaluate if gamification harms intrinsic motivation. Gamification was added to an crowd image annotation tasks. In that study it was found that gamification can increase engagement but intrinsic motivation didn't change as it was not different from the control group. Depending on how a gamified system has been designed, it can either foster or hinder internalization of regulation that is externally rewarded. One way to foster intrinsic motivation is to ensure that gamification provides an optimal internalization (identified or integrated regulation). There are some suggestions of which one could use gamification without harming intrinsic motivation. An example of such a suggestion is to to make gamification meaningful. An experiment that examined facilitating contextual factors that can foster internalization of regulation of a behaviour, found out that the factors such as framing the task with a meaning (providing a meaningful rationale), being sympathetic about behaver's feeling, and conveying choice fostered integrated regulation (Deci et al., 1994). Nicholson (2012) presents a framework for meaningful gamification that put the user at the centre. The framework was inspired by organismic integration theory explained above, situational relevance and situated motivational affordance, universal design for learning, and player generated content. An example of meaningful gamification, is where by users are convinced that what they are doing is not just for the sake of playing a game but rather it has a contribution to a good cause. For instance, Mekler et al. (2013a) they had used points and leaderboard to encourage participants in image annotation tasks and found that even though gamification didn't harm intrinsic motivation but it had affected the quality of image annotation as participants were focusing on completing more tasks in order to advance in gamification. The same experiment was repeated except this time it had included gamification with meaningful framing of where participants in the meaningful framing were informed that their tags would help improve computerized affective image categorization and hence contributing towards an advancement in science. This resulted into better quality tags produced by participants in the meaningful framing condition (Mekler et al., 2013b) compared to participants in gamification without meaningful framing. In the context of this research it was hypothesized, pairing an intermediary and beneficiary that have a good social relationship would give

intermediaries a good cause as they will be helping people they care about; hence it was anticipated that this framing would make the collaborative gamified system to be perceived as meaningful.

The next section presents utilization of games and gamification in health interventions and what is lacking in literature as far those interventions are concerned with regard to supporting utilization of personal health informatics through intermediary users.

2.8 Games in Personalized Health Interventions

Following the diffusion of video games in many digital devices of which these games are solely used for entertainment purposes, there is an increasing interest on the potential of such entertaining platforms in influencing positive changes in health behaviours (King et al., 2013). Traditionally, games were sedentary, but nowadays there are games that require user to exert body movements in order to play a game. Researchers are exploring of how games could be adapted to engage people with personalized interventions for health (McCallum, 2012). Use of games for health includes exer-games, games with purpose (serious games), and gamification.

2.8.1 Exergames

In the past, traditional video games were mostly sedentary. Exergames are defined as a combination of exertion which is more than sedentary activities and video games, which may include strength training, balance, and flexibility activities (Oh and Yang, 2010). Exergames increase the amount of energy expended by the body (Graves et al., 2010). Examples of exergames include dance video games i.e. "Dance Dance Revolution" (Lieberman, 2006) or games such as Nintendo Wii Fit (Göbel et al., 2010). There also outdoor exergames such Zombie run, which allows a user to experience immersion while jogging through narratives that make the user believe that they are being chased by Zombies (Southerton, 2013). However, using of an exergame should never be confused to exercising (Oh and Yang, 2010). According to (Caspersen et al., 1985, p. 126) cited by Oh and Yang (2010), "*Exercise is doing a physical activity intentionally to improve or maintain physical fitness with a planned, repetitive, and structured format*"; hence playing an exergame entails exerting but it remains a physical activity which which may be remain for entertainment purposes unless an activity of exerting is performed according to the definition of exercise (Oh and Yang, 2010). An exergame is far much better than a sedentary video game as it promotes physical activity which is important in increasing energy expenditure. This form of energy expenditure which doesn't fit in a

category of exercise can be refereed to as *NEAT* – non-exercise activity thermogenesis. NEAT activities such as walking, taking stairs or exergaming (playing exergames) have been found to expend a significant amount of energy (Fujiki et al., 2008).

Exergames for elderly population have been explored. For instance a study by Brauner et al. (2013) developed an exergame that required players to pick fruits and vegetables from a virtual garden using an avatar that represents them on screen of where an interaction with an avatar was through a Microsoft kinetic sensor for detecting body movements and gestures. The aforementioned game was found to be enjoyable by the elderly participants. However, there was no personalization of information to support the player into resuming from previous state of the game and in addition the only interaction was through body movements; hence the interaction may be less complex (demanding less assistance from intermediaries) compared to the one required by a gamified personal health informatics. Older adults group is an example of demography that may need to utilize personalized health apps through intermediary users because this group have a tendency to be less conversant in technology. For instance a study by Chen et al. (2016) that evaluated an app that implements social incentives to encourage obese and diabetic patients to exercise, found out that technical literacy is a challenge for older patients. Also a review on popular personal apps has revealed that many don't accommodate the needs of older adults (Silva et al., 2014); hence this study emphasizes that one can leverage on existing usage through intermediaries for such populations as this mode of interaction is already prevalent in many low income communities of developing countries. Such an interaction may be possible in collectivist societies (Parikh and Ghosh, 2006). Exergames and systems that support competition on health self-reflection, that involve parents and children have also been studied (Grimes et al., 2009; Saksono et al., 2015) but not in the context of intermediaries supporting beneficiaries as it appears as if both parents and children are direct users of such systems.

2.8.2 Serious Games in Health

McCallum (2012) defines serious games as games that have been specifically designed to achieve some change in the player i.e. change in knowledge, attitude, physical ability, cognitive ability, health, or mental well-being. Serious games are sometimes referred to as games with purpose of where their intention is to provide experience and emotion with the goal of conveying a meaning at the end (Marsh, 2011). Areas on which serious games can be utilized in personal health include; preventive (exergames), therapeutic (rehabitainment), assessment (self-ranking), educational (medical information), and informatics (personal health records) (McCallum, 2012). As serious games add user

experience to an outside activity (probably uninteresting one), then there is an overlap of goals between serious games and gamification.

There is a rapid increase in the number of gamification-related studies within persuasive technology field (Hamari et al., 2014a). The following are examples of systems that use games/gamification in motivating particular healthily behaviours. These are games have been used specifically to encourage self-monitoring.

Lin et al. (2006) developed and evaluated *Fish'n'Steps* system, a computer game which links player's daily footsteps count to the growth and emotional state of a pet fish in a tank. The application was evaluated with a total nineteen participants in fourteen-week study. The findings indicated that the game catalysed promotion exercise and improvement players' attitudes towards physical activity. However it was observed that players' enthusiasm had declined towards the end of the second week of using the application manly due to players becoming accustomed to new routines into their daily lives that included a healthier pattern of physical activity.

Another application of games in physical activity is demonstrated through *Neat-o-Games* (Fujiki et al., 2008), a ubiquitous collection of PDA based games which allowed players to accumulate activity points which they could use in a race game. In addition, activity points could be used to provide hints in puzzle solving game called Sudoku. The usage of points in Sudoku, resulted in players to be left behind in a race game; hence motivated to do more physical activity. *Flowie* system designed for home settings, was a virtual coach to motivate elderly individuals to walk through use of, a frame casing with a touch screen display that shows a flower of which its vitality corresponds to the amount of physical activity captured by using context aware sensors (Albaina et al., 2009). A concept similar to Flowie system is that of UbiFit garden, which generates a garden with flowers of different types that discerned different types of activity such as cardio, walking, housework, etc. (Klasnja et al., 2009). There are also other studies that use gamification to motivate adolescents or teenagers in behaviours such as frequent monitoring of blood glucose or physical activity (Arteaga, 2010; Cafazzo et al., 2012). Apart from interventions that target promotion of physical activity, there are apps game based apps designed to encourage healthily eating. An example of such an app is *It's Time to Eat* - a mobile game designed to motivate children to practice health eating habits in the course taking care of their virtual pet (Pollak et al., 2010). In their game, players start to select a pet from a range of pets such a worm, dinosaur, dog, tree etc. Then players required to take care of their selected pets. Then, players can choose a name for their selected pet. The process of selection a pet and name giving is meant to give a player a sense of control or autonomy. Caring for pets entails a player feeding it through sending a photo of their breakfast, and then a nutritionist would give it a

certain score. Based on the total score, a virtual pet would respond with an emotional state. A healthily breakfast resulted into a pet becoming happy while if the meal is not healthily a pet would become sad. The finding from this study indicated that kids who played the game ate a healthy breakfast more frequently than those who didn't.

Another diet based game is called *LunchTime* (Orji et al., 2013), aimed at educating people to make healthily choices while eating away from home. This application utilized the following persuasive strategies: goal setting, feedback, social influence, and rewarding mechanisms. The games was played by a group of friends visiting a selected restaurant as customers. The game could award points to players according to how healthily the choice of their meals were. Initial A ten days evaluation of LunchTime on six participants (3 males and 3 females) aged between 19 and 40 years of age, indicated that the application facilitated learning and reflection. In addition to that, healthy eating attitude showed improvement at endline in comparison to baseline.

Apart from encouraging self-monitoring of diet and physical activity, games have also been used to support heart rate monitoring, for instance the case of *Live Pulse Games* (Han et al., 2014, 2015). Live Pulse Games is a collection of games that employ a novel technique to measure users' heart rate in real time by having them play casual games on their mobile phones. In order to gain some in-game control, the player has do some camera covering the lens with fingertips during the game play. For instance one game within Live Pulse Games is called *City Defender*. In the City Defender Game, an end user has to load the anti-aircraft artillery through lens covering actions. The heart rate is computed by by detecting changes in transparency of users' fingertips. The ubiquity of a mobile phone presents an opportunity for delivery of interventions that utilize aforementioned systems.

There is also a different approach that doesn't constitute adding user experience to a health behaviour instead a motivating sedentary game is interlaced with the targeted health behaviour. This based on a Premack's principle (Premack, 1959), which suggests using of an event with high probability such as playing a computer game, to motivate an activity with low probability such as doing physical activity. An example of a game that utilized such an approach is a game called *PLAY MATE* (Berkovsky et al., 2010, 2012). The aforementioned game take advantage of motivation factors of video games by introducing a burst of physical activity during a session a sedentary game play. *PLAY MATE*, which was an alteration of an open source computer based game called *Neverball*, which requires players to collect coins in a limited amount of time (Berkovsky et al., 2012). In PLAY MATE, players were allowed to gain in game virtual rewards (extra time) in return for performing a jump in the middle of a session of sedentary game play. Jumps were detected through a sensory devices (accelerometer and gyroscope) worn

on the waist. The preliminary evaluation of the aforementioned system indicated that skilled players had a tendency of performing less jumps compared to less skilled players; hence the game was modified to include an adaptive algorithm of where the level of difficult was personalized according to player's completion time of previous levels.

Most of the interventions reported on literature are carried out in contexts that are not constrained in resources with exceptions of fewer such as the one that developed an exergame for families in low socio economic areas (Saksono et al., 2015) or another study that used user centred approach in development of mobile game based applications for promotion of physical activity in low socio-economic status youths (Blackman et al., 2016). In the context of this research, the focus is in low resource settings of a developing country which may not be the same as a context of low socio economic status in developed countries. The second drawback of those gamified personalized interventions is that they tend to be designed for direct/primary users of technology as consideration is only on direct beneficiaries. In most of these interventions, the person (be an adult or young person) who is a targeted beneficiary of information on the app is expected to be an actual manipulator of user interfaces of such a system. Therefore, none of the aforementioned studies has explored utilization of gamification of where one user facilitate an interaction process while an actual beneficiary remains as an observant or indirect/secondary user. In addition, young people have an inclination towards playing computer games compared to old ones (Brauner et al., 2013); hence there is an opportunity of leveraging motivation of young people through gamification of collaboration between adults and children with the goal of children engaging adults who are less, conversant or motivated in gamified personal health informatics.

Chapter 3

Study Context

3.1 Obesity in South Africa

A person is considered obese if their body mass index (BMI) is ¿30 kg/m2 [1]. BMI is the ratio of a person's weight in kilograms over their height in meters (m) squared. BMI is strongly correlated with total body fat content in adults of age 35 years and older [3]. Most of apartheid policies towards health didn't focus towards these populations and some of the current health and economical concerns are as result of amplifications of apartheid social clusters (Benatar, 2013).

The risk of developing a number of obesity-related co-morbidities rises exponentially with increasing BMI over 30 kg/m^2, which is further associated with an increase in the relative risk of premature death, primarily from CVD (De Groot et al., 2000).

3.2 Context Description

Chapter 4

Contextual Enquiry

4.1 Study Description

The purpose of this study was to elicit preliminary requirements to inform the design of an early prototype of a personal informatics that can be utilized through intermediaries. Preliminary requirements were generated on collected insights on various issues related technology utilization, and barriers to behaviours that are considered healthy. These insight were generated as from data collected in hospital settings with patients who might be prospective beneficiaries of such a technology in future. The objective was to understand patterns in utilization of cellphone technology among adults obese patients. This study was approved by the respective institution's ethical review body [1].

I together with one research assistant conducted this contextual inquiry in between March 2013 and May 2015. We recruited a convenient sample of diabetic patients at a diabetes and endocrinology clinic of Groote Schuur Hospital in Cape Town.This is an outpatient clinic which runs on Thursdays and Fridays.

Participants were approached opportunistically as they waited to see their physicians. We conducted interviews in one of the vacant consultation rooms. This guaranteed confidentiality and privacy of participants. The main topics in these semi-structured interviews were focused around participants' general utilization of mobile phones, whether they seek help from intermediaries, and, if so, who their preferred intermediaries are. In addition we explored their current barriers to both exercise and adoption of healthy diets.

We obtained our data from a total of 30 participants. Twenty of the participants were females. Majority of the participants had low level of (education) as shown on Figure

[1] Human Research Ethics Committee of Faculty of Health Sciences at University of Cape Town

4.1 while their distribution by ethnicity is shown on Table 4.1 of which all of them were from previously disadvantaged races during apartheid era in South Africa. Majority of these participants were also low income earners (Figure 4.2), this income data was for individuals and not households. Twenty three percent didn't have any income and they depend on their family members to sustain themselves. In this group of people with no income, there was only one young person who was 21 years of age while the remaining participants were above 40 years of age.

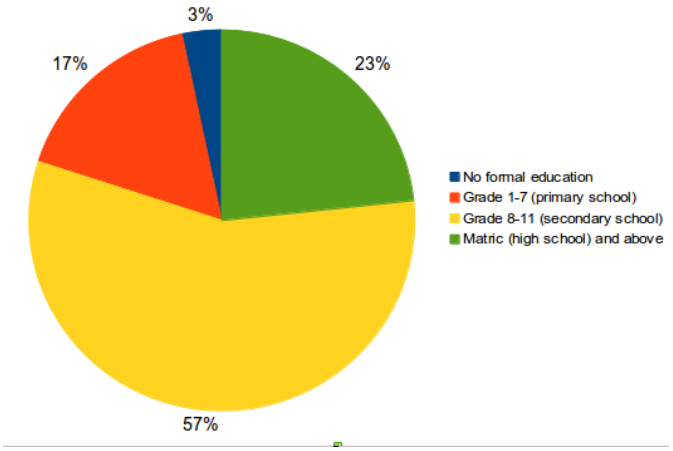

FIGURE 4.1: Participants' income distribution.

TABLE 4.1: Ethnicity of contextual inquiry's participants

Ethnicity	**No. of Participants**	**Percentage**
Black African	8	26.67%
Coloured	22	73.33%

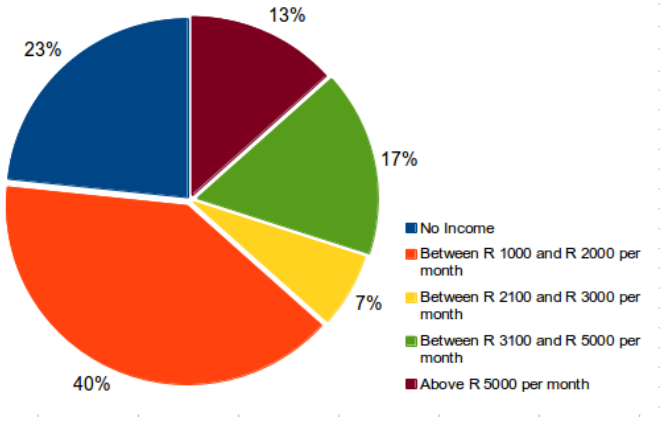

FIGURE 4.2: Participants' income distribution.

Most of them participants were either overweight or obese with an average body mass index (BMI) of 33.36 kg/m^2 (standard deviation of 5.74 kg/m^2). The average age was 53.13 years old (standard deviation of 11.77 years old). Almost 86% (26) were above 40 years of age. This means we were dealing with old participants and hence this group had a tendency of being inexperience with technology.

4.2 Data Collection Methods and Analysis

We used a semi structured questionnaire to interview participants. Each participant was interviewed for a period of 20 to 30 minutes. The questionnaire had four groups of questions and these included demographics: cellphone ownership and utilization; access to information and pedometers; and barriers to diet and physical activity.

I used both descriptive statistics and qualitative approaches to analyse the information obtained from participants' responses. Although our objective was to interview overweight and obese patients only but we included few participants who appeared to be thin but were diabetic. Since diabetes is a lifestyle related disease, we found that it would be interesting to also understand utilization of cellphones, and access to information even to individuals who appear not to be overweight but these individuals may had some input on various issues related technology utilization, and barriers to behaviours that are considered healthy. All the names that are used in presentation of findings are just pseudonyms to protect privacy of participants.

4.3 Findings

4.3.1 Utilization of Cellphones

Twenty nine out of thirty participants owned cellphones. The most used services were SMS and voice with at least 80% of the participants using each of the two services. It was found that at least 60% of the phones owned by participants were smart-phones (Figure 4.3), but utilization of functionality/services that are supported in smart-phones appeared to be lower relative to voice and SMS (Figure 4.4). Utilization of smart-phone supported services appeared to decrease with age. Utilization of Whatsapp appeared to be higher compared to other services that are specific to smart-phones. What led to adoption of Whatsapp is that participants were influenced by family members and friends who were already in Whatsapp. These influencers suggested Whatsapp as to be cheaper than SMS. For instance one male participant aged 47 years of age heard that

Whatsapp was cheap for communication, and his son helped him on loading it into his phone. Therefore, in this context, social influence played a role in adoption of some smart-phone supported services. There is a positive correlation between social influence and adoption of high-tech innovations (Vannoy and Palvia, 2010).

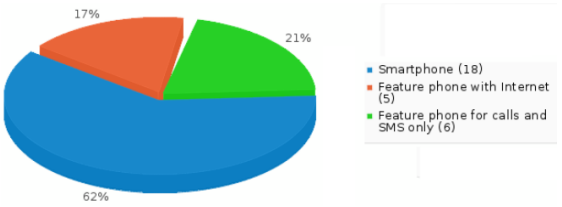

FIGURE 4.3: Participants' phones types.

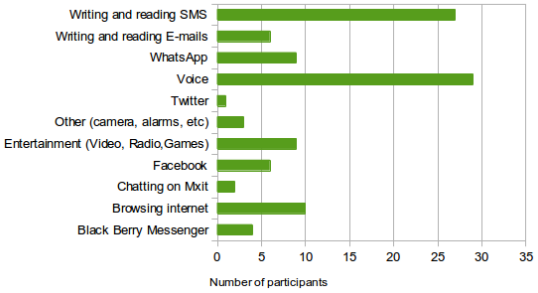

FIGURE 4.4: Participants' phones types.

4.3.2 Help Seeking in Utilization of Cellphones

There were several scenarios of informal help seeking in utilization of cellphones as highlighted on Table 4.2. Majority of the participants had solicited informal help from other people before, in tasks such as: (1) to configure services/apps on their phones (e.g. Whatsapp, Facebook); (2) habituation of skills required for utilization of various functionality (e.g. a phone book of a new or unfamiliar cellphone, Whatsapp); and (3) to interact with certain features such as SMS, Internet browsers, and etc.

There was a variation in the degree of help-seeking and it was determined by how often participants wanted to execute unfamiliar tasks. Tasks such as configuration of services and apps or teaching of individuals had rare occurrences as they only happened when participants had encountered a new application or device and they don't know how to make it functional.

Table 4.2: Scenarios of intermediated interactions

No.	**Scenario**
1	She is being helped to read SMSs by her *daughter*, but she could do it on her own when the daughter is not around.
2	He doesn't know how to reply back to an SMS. So his *grandson* always helps him with that.
3	Her *children* or *work colleagues* could help her to read SMS written in English that are received through her feature phone. She also mentioned that her two children were skilled in operating cellphone more than her and one of them had a Black Berry smart-phone.
4	He can take photos using his mobile phone's camera but he doesn't know how to save those photos on a memory card. His *son* helps him with that once in a while. But, also his son helped him in loading Whatsapp on the phone.
5	Her *children* have taught her on how to use Whatsapp, take video etc. Now she is learning on how to record sound, set reminders on the phone for insulin and medication.
6	The *son* would help her to interact with USSD service for checking loyalty points on MTN. MTN is a mobile communication service provider operating in many African countries.
7	She was taught her *son* on how to access a phone-book when composing SMS using her new phone.
8	She receives assistance from her *helper* when she wants to send messages to her children.
9	She was once helped to do set-up her new phone at a cellphone shop. She was also taught on how to operate BBM by her *grandson*.
10	He was once taught on how operate Whatsapp by his *niece*.
11	Her *son* and *grandson* have once helped to configure Whatsapp and Facebook on her phone. They have also taught her on how to use those two web services. In addition, she also asks the son to search for certain health information on the Internet, and once the search is done the the son would pass the phone to her to view that information. This happens once in a month.
12	Her *son* and *grandson* always teach her on how to use various functionalities like games etc., but she is not so much keen on operating those functionalities. She also admitted that her son and grandson are so much interested with their mobile phones and they spend a lot of time playing using phones something that she doesn't understand.
13	This participant didn't own a cellphone. She had no formal education and she was unfamiliar with how to operate a cellphone. Her son receives SMS directed to her and reads it aloud for her or translates an SMS to verbal communication. Also, the son receives phone calls and hands over the phone to her when the person on the other side of the line wants to speak to her.

4.3.3 Selection of Help Givers

Participants chose trusted individuals to act as their help givers, typically their children and grandchildren or, less often, children of relatives, family friends, or someone at a cellphone shop. Preference on who is likely to be solicited to assist favours family members. Help givers are selected based on the merit of skills/competence, and interpersonal trust based on a social relationship, and past experience of help seekers on specific help givers.

Interpersonal trust

Interpersonal trust in this context means that whether help-seekers may feel comfortable to seek help from specific people or not. Privacy and existing relationship between a help-seeker and help-giver were first concerns when deciding of who should be asked for help. In additional to that, there was also trust on whether a helper giver may be willing to deliver when solicited for help and this was influenced by experiences in past attempts to seek help. Experiences on past attempt to solicit help refers to help-seekers' positive and negative experiences as an outcome of seeking help. These experiences shaped perceptions of some of the participants towards seeking help with cellphone or any other technology. For instance, one female participant aged 67 years old reported that her daughter helped her once but she had no patience. A male participant aged 47 years of age mentioned that he would like to be assisted on using several services such as MMS, but he thinks that young people may not be having patience to help. Such negative experiences can hinder future help-seeking behaviours from specific help givers. This resonates with the following finding by Kiesler et al. (2000), parents may be hesitant to seek informal help from their children after encountering negative experiences.

Help-givers' Competence

In additional to interpersonal trust, the decision of who should be solicited for help was also influenced by help-seekers' level of trust on skills possessed by help-givers. Participants had confidence on competence of their children in using cellphones. Several participants sees their children as having technical know how skills in using cellphones. For instance one 31 years old female participant mentioned that her five years old son knows how to navigate through her whole phone and use it more than what she can do. Another female participant aged 56 years of age explained how children are eager to teach various things on a cellphone but she is not so keen in engaging to cellphones like they way her son and grandson do. A forty seven year of age male participant also

mentioned that young people in their families are more skilled in cellphone than old people. Participants reported that their kids were borrowing their phones to do other tasks and this demonstrated that their kids had better skills with technology. Scenarios of sharing are presented on Table 4.3 below.

TABLE 4.3: Scenarios of sharing of cellphones between participants and their children

No.	**Scenario**
1	"Zandile", a 47 years old female participant, mentioned that her 16 years old son could borrow her phone to use MXit. But herself she is not using anything else on the phone apart from calls and SMS. She also mentioned that she is not so much interested with technology. For example she has internet at work, but she is not really using it.
2	"Buyisiwe", a 31 years old female participant narrated an experience about her five years old son who uses her smart-phone to listen to music. But she has to lock it while he is listening, because it happened at one point that the son deleted almost everything on the phone.
3	"Celine', a 48 years old female participant lends her phone to her daughter who uses it for normal Internet browsing and Facebook. Celine owned an advanced feature phone enabled with Internet but she was not using internet on the phone.

In other scenarios participants mentioned that their kids borrow their phones to search for information related to school assignments. These examples demonstrate the level of skills that potential help-givers can have. Trust on skills possessed by help-givers has been found to be very important to individuals seeking help in the ICTD and HCI contexts. Ramírez et al. (2013) suggested that empathy and technical skills of infomediaries influence the outcomes of the process of infomediation to users at public access venues. Another study that examined motivations for informal support in utilization of computers at home found out that skills of help-givers to be one of the factors that influence help-seekers to solicit help from specific people (Poole et al., 2009).

4.3.4 Access to Health Information and Self-Monitoring Support

We have collected information about access to health information and self-monitoring support among our participants.The information support in which most the participants relied on is that one provided through face to face meetings with doctors or dieticians during hospital visits. Normal hospital visits are scheduled in intervals of every 3 or six months. But they do visit the hospital only two or three times in a year. In addition to face to face information, patients normally receive paper sheets with information that provide guidance on how to eat healthy. These paper sheets are normally received when patients attend clinic for the first time after being diagnosed with diabetes. Most patients

we interviewed were type 2 diabetic and overweight. Doctors and nurses encourage them to eat healthy and exercise.

Majority of the participant lacked informational support beyond hospital settings that can provide guidance in eating healthy and exercising. Very few participants had used cellphone services as means of querying or receiving information related to health. Only six participant had used internet to search for health information, while only one participant had used a cellphone app for health. Also only two participants had used SMS while only one had used voice to look for health information. Table shows some of the scenarios of where participants had used ICTs in relation to learning about issues concerning their health.

TABLE 4.4: Participants' usage of ICT to fullfil health information needs

No.	**Scenario**
1	"Anitha", a female participant aged 56 years old, would send SMSs to her son while he is at his workplace. This SMS is usually a request to check for certain health information on the internet and the son could print for all the material related to that information that was requested. She also follows Dr Oz program on TV about health stuff. If she misses she would go to the Internet and visit the programme's website
3	"Jane", a female participant aged 36 years old, had an app on her phone for giving health tips. She downloaded that app from the Internet.
4	"Maria", a female participant aged 57 years old mentioned that she uses Facebook. She has three diabetic friends and they share diet concerns, recipes, and discuss diabetic specific issues that they experience . They don't discuss about exercise. She sometimes searches on Google about medications especially when she starts using new medications. She uses Google to get more information on the things her doctor advises on.
5	"Evelyn", a female participant aged 63 years old, subscribes to health websites to receive emails with health tips and information. She sometimes calls a dietician to ask about certain diet information.

Self-monitoring of blood glucose seemed to be common among the participants because many of them were diabetic. Self-monitoring of other health parameters such as diet and physical activity seemed not to be done by many participants. Out of thirty participants we interviewed, only two participants had used a pedometer before. One participant reportedly to use a gym bicycle with a meter that can show distance cycled but she has abandoned using it. Only eight participants reported that they have used a diary before to record the food they have eaten. But this recording is not consistent. Some have stopped doing it although they claim that when they visit hospital, sisters (nurses) always remind them to record foods they have eaten. This food recording is mainly for controlling the levels of blood glucose. For instance, one participant mentioned that she has a note of where she records the blood glucose before she eats and the blood glucose

after she has eaten. So she records what she has eaten and the blood glucose levels before and after meals. But overweight and obese diabetic patients are also encouraged to lose weight. Because losing weight has an advantage of lowering levels of blood glucose. And the only way to lose weight is to follow the recommended diet and become more physically active.

4.3.5 Barriers to Adoption of Healthy Behaviours

The research teams also examined on barriers to adoption of healthy behaviours such as healthy diet and exercises.

On barriers towards adoption of healthy diet, 76% of the participants mentioned that the recommended healthy food is always expensive. For instance fat free foods are much more expensive compared to full fat foods. One participant associated eating of certain food cultural upbringing. She explained that Muslims in Cape Town often have very high fat and high sugar content foods such samosas. One of the comments that appeared to be common to many participants is that; it is difficult to have a budget for separate meals within the family, because diabetic members always have their diet food which seems not be preferred by the rest of the family. So diabetic members might end up eating what the rest of the family eats. They do try to have diet foods by it is not always manageable. But one participant who seemed to be highly motivated disagreed with that argument and said most people lack an understanding of what carbohydrate means. She further mentioned that, education about diet should be contextualized to terms that people are already familiar with. She said most people don't understand what is said by dieticians because it is not communicated in the context they understand. For example the concept of carbohydrates is not well comprehended by many people. But if the topic is well explained using what is already familiar to patients, then they are more likely to comprehend it.

On the question of perceived barriers to physical activity, nine(9) participants mentioned that lack of time to do physical activity because of a busy schedule contributes to less exercising. This is supported by some remarks shared by participants on Table 4.5. Seven participants mentioned that lack of areas to walk around is one of the perceived barriers to physical activity. The most common comment given out to support this argument was that, most of the areas where they live are not safe for somebody to be out walking all the time (Table 4.6). Most of these areas have high rates of crime.

But despite the claim of lack of both time and areas to exercise these participants mentioned that they been active when doing their daily errands (Table 4.7).

Table 4.5: Excerpts on observation of common participants' remarks on association between being less active and busy schedules

Participants	**Remarks**
1	She goes to work very early in the morning and comeback late at night.
2	Difficult to manage work and household.
3	She goes to work at 4.00 AM and come back at 7.00 PM. She works for 6 days in a week.
4	She looks after the family. She takes her sisters child to school, also she does the cooking. She does a lot of house work. So it is difficult to have a planned series of physical activity.
5	Difficult to balance between planned session for physical activity and manage both work and household at the same time.
6	Busy with house work at home.

Table 4.6: Excerpts on observation of participants' remarks on safety concerns on areas to do walking or running

Participants	**Remarks**
1	The neighbourhood is not safe to wonder around.
2	It is not safe in her area. She doesn't like to be outside most of the time.
3	It is unsafe at night and early morning.
4	The area where she stays is not safe to walk around.
5	Not safe to walk alone. She prefers to walk through houses.

Table 4.7: Excerpts on observation of participants' remarks regarding physical activities that were part of their daily lives' routines

Participants	**Remarks**
1	She walks from home to visit relatives and friends.
2	He only walks when he goes to church.
3	She walks to from her home to a bus station everyday and walks a lot at her work place, so it would be great for her to have something to keep track of how much exercise she gets. She wants to be more active but works 7 days a week.
4	She exercises in a group of people for three times a week and she now feels much healthier. They have a "biggest loser" competition going at the moment. She would like to have a pedometer to keep a better track of her activity.
5	She only walks when she has to. She only walks up and down in kitchen. She has a treadmill, but she doesn't use it.

4.4 Contextual Design Insights

These are some of the design insights that were uncovered from the aforementioned findings. In this context, majority of the participants were not utilizing ICTs in self-management of their healthy as they relied only on paper diaries. The only parameter that was being monitored by majority of the participants was blood glucose since all participants were diabetic. Blood glucose is usually controlled through many factors such as diet, exercise, and medication. Type 2 diabetes is linked to obesity and its self-management is mostly through diet and exercise. The process of self-management can be very cumbersome if it is done using pen and paper and this may reduce compliance (Mattila et al., 2008). A paper diary may not be as effective as an electronic diary when it comes into navigating across behaviour patterns for the purpose of self-reflection. Therefore, personal health apps may be important in supporting self-management of health. However, these personal health apps may not be very useful in this context considering the fact that majority of the participants have limited skills in operating technology. The findings above indicate that some participants with limited skills seek help from people with skills. But this approach has its limitations as it relies on existing intrinsic motivation of help givers. Long term usage is crucial for compliance (Mattila et al., 2008), but one cannot achieve this long term usage in the context where a technology needs to be utilized through help givers while most technologies were not designed to anticipate utilization through help givers as part of the usage ecosystem. As it has been advocated that novel approaches such as ICTs in lifestyle modifications may facilitate moving of management of lifestyle-related chronic conditions from healthcare system to citizen-centric health promotion and disease prevention interventions (Korhonen et al., 2010); hence it is important for one to think of how we can design technologies that can scale to demographics that are not well-considered in traditional interface design.

Sharing of phones between adults and kids suggests that it is feasible to design a system of which both kids and parents can have access to. What was observed from above is that kids borrow phones because they are motivated with specific things on the phone. One of those things is social media. Therefore if one could design a system that afford specific motivational needs of kids and integrate it with self-monitoring of behaviours of adults then we can enhance motivation kids to help their parents with self-monitoring tasks. With the guidance of self-determination theory, and techniques that have been used in the previous studies that utilized gamification (described on the *Literature Review* chapter), a prototype was developed. The iterations of prototype development and subsequent evaluations are discussed in the next chapters.

Chapter 5

Prototype I

5.1 Development of the Prototype

In this phase, I developed the first version of the application prototype. The prototype had features that allow individuals to self-monitor activity and diet. The manipulation of user interfaces of the app was specifically targeted to help givers/intermediary users. The prototype was designed to encourage a help-giver and a help-seeker to work together in a pair. To make the act of helping to be perceived as more meaningful, the first message on the app emphasized that the intermediary users were helping someone close to them to manage their wellness. To motivate ongoing use, the app had gamification features of where each pair could be awarded points, badges, nice looking gardens and fish tanks. In additional, within each pair's garden and fish tank, there was a Facebook social plug-in that could allow users from different teams/pairs to comment on or like each other. We also utilized Facebook groups to remind users to engage with the application. Ideally, the information flow supposed to be as suggested on Figure 5.1. A web app was developed using a combination of several web technologies such as HTML, JQuery, JavaScript, and CSS on the client side, while the server was implemented using Django Python framework. Sample screen-shots of the prototype are shown on Figure 5.2. Authentication was done through Facebook accounts of intermediary users". This prototype aimed at encouraging increase in physical activity and decrease of sedentary behaviours through informing individuals (help-seekers) about their level that could have an impact on their health. In addition, also individuals could monitor whether they are eating healthy or not. Some visualization techniques that are similar to this have been previously used in systems that were designed for direct users such as "Fish'n'Steps" (Lin et al., 2006), "Ubifit" (Klasnja et al., 2009), and "Few Touch Application" (Årsand et al., 2010). The idea of using a plate for showing distribution of meals is mimicking a practice

used by dietitians of where the amount of each food group that needs to be consumed is presented as a bisector of a pie chart.

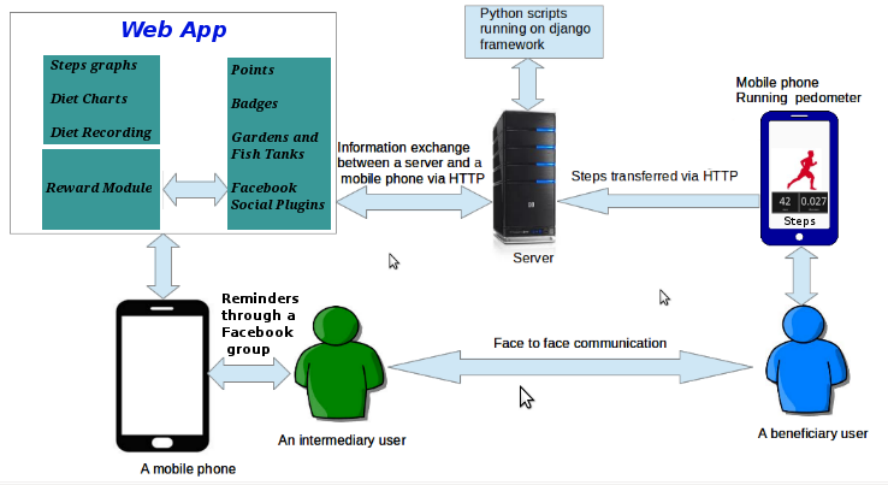

FIGURE 5.1: Information flow in the first prototype.

FIGURE 5.2: Sample screen-shots of the first prototype

5.2 Prototype Evaluation

In order to evaluate the prototype, I recruited participants through an NGO based in Cape Town called "***Mamelani Projects***". This NGO carries out outreach programs

on health education in less privileged communities. Mamelani trains women onissues of HIV/AIDS, nutrition, and gender equality.

The NGO helped to recruit participants among people who were part of their trainings in Philippi township. Criteria for recruitment were as follows: (1) participants aged 35 or above and (2) participants must have an intermediary person willing to work with them. The NGO identified the targeted participants that met the inclusion criteria. A total of six adult participants were recruited of which both were women above middle age (>= 35 years of age). Each one of the adults brought one intermediary to form a pair. Three intermediaries were girls in between 19-23 years of age. The remaining three intermediaries were boys aged between 14 and 19 years of age.

Participants were informed of their rights . Participants were also informed of which of their information will be collected by the study. Both adults and their respective intermediaries signed consent forms except for intermediaries who were minors, these signed assent forms that were approved by their respective parents/guardians.

The next step entailed training of intermediaries on how to use the app. The application was deployed to the field from the end of October 2014 to beginning of December 2014. In order to control the application environment, and limit potential complications from deploying the intervention on multiple platforms, each pair of participants was given one Android phone (Samsung GT-S5300) running the pedometer app. Participants were required to utilize the web application hosted at University of Cape Town by using a web browser built into their phones. In order to retain participants in the study each intermediary participant and each beneficiary participant who remained as part of the study received ZAR30 (ŨS$3) worth of airtime every week for the duration of the study. I collected qualitative feedback in the middle and at the end of the study

5.3 Findings

Observations and qualitative feedbacks from the six cases/pairs are presented below. The first three pairs consisted of parents working their children while the remaining three pairs it was just an adult working with either a close or distant relative in each pair.

Pair 1: Mother and Son

This pair consisted of a boy aged 17 years of age working with his mother. The boy is referred here with the name "**Jabulani**" and his mother is referred with the name

"**Nandipha**". Jabulani lives with his mother and other siblings. He seems to be passionate with social networks. He currently uses Twitter, and Facebook mostly. He mentioned that he felt happy helping his mother. He also articulated the reason for helping his mother as that he felt it was his duty since the mother took care of him when he was growing up. Nandipha also felt very happy being helped by her son and she mentioned that she thinks her son is very brilliant more than her and she gets to know things because of him.

Jabulani acted as an intermediary for his mother. He was the first one to engage with the app for at least three different days. All of a sudden his use stopped. When I asked Jabulani together with his mother of challenges that might have prevented them from using the app, their responses indicated that were more conscious about airtime as it was one of the reasons of why they didn't login more often. So there were times where they ran out of time. They thought having more data bundles might solve the problem. Another reason for why they didn't use the app more often is associated with lack of competitions from other pairs and also they had accomplished the highest challenge within few days. In the first few days they were so curious about attaining the highest badge. Jabulani claimed that her mother was walking up and down so that they reach that goal. Jabulani discussed with his mother that they must reach that goal in a week. They managed to reach the goal and there was no more boundary to break.

Badges were one source of motivation to this pair. Jabulani felt motivated by the badges and he was persuading his mother to work harder so that they reach the highest badge which was Queen/King. Also, Jabulani noticed something on the scoreboard. He and his mother were there leading. Another team (Pair 3) was in the second position. The third position was held by Pair 4. Then after few days Jabulani noticed that Pair 4 moved from a third position to a second position. So Jabulani told his mother that "we must not drop down because Pair 4 is going to reach us. So competition with others was a source of motivation for Jabulani. Although Jabulani was helping his mother but he thought like the ownership of the winning process as theirs because he used the word "We" all the time to imply that he felt that he was part of that process. Additionally, Jabulani liked information displayed by a botanical garden and a fish bowl. He expalned why he was so interested in such abstract visualizations. When he was growing up he used to watch cartoons. So when he sees those pictures of trees and fish he feels he is part of that process of making those images/cartoons. So drawing fish and trees through their team's performance motivates him more and he tells his mother that they must have more fish in the bowl. Also the idea of fish in the bowl motivated Nandipha. She mentioned that she doesn't like to see her bowl empty without any fish, so she tries to walk more steps as she can. These ideas of abstract visualization such as fish bowls/tanks and garden have been previously used in system that involve only one user on interaction with user

interfaces (Klasnja et al., 2009; Lin et al., 2006), the only difference in this context is that, the same ideas were extended and tested with two users who are collaborating to attain one objective.

Pair 2: Mother and Son

"**Dumisani**" was a 14 years old boy who lived with his mother, "**Kholiwe**". Dumisani was acting as an intermediary for Kholiwe. Dumisani and Kholiwe used the system for only the first three days and they dropped out. On responding to the question of why was it the case, Kholiwe mentioned that it was the inability to access the system every time they tried out. The web page was always giving them time-outs and this discourages them from trying. But it was also observed that Dumisani was not very familiar with Facebook authentication as he didn't have an account before. I created one account for him of which it wasn't very helpful. The decision in using Facebook authentication was based on an assumption that all intermediaries may have Facebook accounts which was no the case. However, despite technical challenges this pair also showed enthusiasm in using the app.

Pair 3: Mother and Daughter

"**Zama**" was a 20 years old girl who was supposed to act as intermediary for her mother, "**Fikile**". Since the daughter appeared to be interested to help her mother, then one would think that intermediation is possible. Unfortunately, the two lived in different houses and they never used the system at all. Their contact to discuss issues about the system was limited as Zama was raising a toddler at that time. In addition, Fikile appeared to had some expertise in using technology as she already was using Facebook, therefore she was interested to learn how to operate the system on her own because of the situation of her daughter. However, the system had been set up only to allow Facebook account for Zama.

Pair 4: Close Relatives

"**Lindiwe**" is a young girl in her early twenties. Lindiwe was acting as an intermediary for her auntie "**Nceba**" but they never lived together in the same house. The pair had not been interacting with the application at all. When I interviewed Nceba of why they were not using the app, her response was that she doesn't know how to operate it on her own and her intermediary seems not to be around most of the time. She is curious

to access the information but her intermediary seemed not to be cooperative. So she suggested to bring someone else who was also a close relative.

Pair 5: Close Relatives

"**Neliswa**" was a girl aged 23 years of age. Neliswa was acting as an intermediary for her auntie "**Nkosazana**" but they lived lived together in the same house. The pair had not been interacting with the application at all. I never had a chance to interact with this pair since they were not available. But from a personal observation during recruitment, Neliswa appeared to be less interested in the intervention even though he signed the consent form to participate.

Pair 6: Distant Relatives

"**Nkululeko**" was a boy aged 19 years of age. He was acting as an intermediary for her distant relative, "**Noluthando**. Nkululeko and Noluthando didn't live so close to each other but they did see each other more often. System logs showed that this team had not been engaging with the application. I interviewed both of them to find why that was the case. Nkululeko pointed out number of things. The first one was that he tried to access the application a couple of times but he was unable to proceed after login. He was using his personal phone. I checked his personal phone and I discovered that his web browser was the problem. He had never tried to do it using the experimental phone that was in possession of Noluthando. He had ne We tried together and it was okay on the other phone. But in addition to phone's problems he claimed to be busy with school. Despite him being busy, and his phone not being able to support the application, the absence of things like reciprocal benefits and a close social relationship with the beneficiary, might be the cause for his low intrinsic motivation in engaging. The previous user, Jabulani had a problem of accessing the application using his personal phone but he made an effort to access using the phone given to his mother. So the closeness/bond of the two sets users might be the base for the network effect to happen.

5.3.1 Discussion

Only two pairs of users engaged with the system for more than two days. Both of these two pairs consisted of a beneficiary and an intermediary living in the same house. These pairs consisted of mothers working with their sons. One of these two pairs was very motivated and enthusiastic about the system. But after some time they also got bored because they were not getting any competition from other teams and they had attained

all the challenges within a short period of time. In a third pair, a girl was working with her mother but they were not living together so it was difficult for her to commit to the application. Intermediaries from the remaining two pairs showed little enthusiasm in the project. There were three hypotheses for this lack of enthusiasm to engage with the system and these were: (1) due to lack of motivation to engage with system; (2) lack of a prior social relationship between the two users within each pair; and (3) Low frequency of interactions between the two users within a pair due to distance.

There was an indication that a prior social relationship is instrumental for intermediaries to perceive value in the act of helping their beneficiary users. In this case the interaction became more meaningful. It also becomes easier for the two users within a pair to negotiate for interaction. For three pairs that consisted of mother/son or mother/daughter there was a tendency for the two users to show the eagerness of working together. For three pairs where members of a pair didn't have a parent/child relationship, intermediaries showed little enthusiasms in the intervention. Another advantage of a prior social relationship comes to sharing of phones. It was observed that it was easier for an experimental phone to move from a beneficiary to an intermediary when a parent and child were involved in a pair. There was a form of trust that existed between the two users with a prior social relationship. In addition, intermediaries had more authority when they were helping a person who was close to them. If a pair with a prior social relationship needed to interact with the app, then the frequency of these interactions depended on proximity between the two users. For cases where they cohabited or lived nearby it increased the chances of them meeting. For instance, "**Zama**", an intermediary participant aged 20 years old was working with her mother. The challenge with this pair is that they didn't cohabit and Zama had a toddler hence this lowered her ability to participate in the intervention.

Prior social relationship also worked in parallel with the presence of interest to use the app/gamified features. A combination two factors played a some role in encouraging the two users within a pair to collaborate when they met. For instance , in the case of of Jabulani and Nandipha (mother and son), they discussed about strategies to win against other pairs. Although Jabulani was helping his mother but he thought like the ownership of the winning process is theirs because he used the word "We" all the time to imply that he felt that he was part of that process. In addition, if intermediaries are motivated they can become persuaders of beneficiaries that they have a prior social relationship with as it can be seen on Jabulani who encouraged his mother to walk more steps.

There were some drawbacks in utilization of this prototype. From participants' perspective , intermittent internet connectivity, insufficient airtime, less motivated intermediaries, and lack of competition/challenges with others in the gamified system were the key issues mentioned. Other factors include how often the two user meet (Whether they cohabit or they meet more often), and reminders were not timely. I had very high expectations that Facebook reminders will work for this community. An assumption was that every intermediary is probably using Facebook. Actually this was not the case. There were some intermediaries who had never engaged with Facebook before. And the ones who had engaged with Facebook were not doing it so often as I anticipated. For instance "Jabulani" had never used Facebook before. "Jabulani" was only engaging with Facebook at most twice in a week. Therefore, Facebook might not be an on time-platform for delivery of reminders or any messages to intermediaries in this context.

Findings from this informative evaluation led to another iteration in the design. It also informed the manner in which evaluations in chapters 6 and 7 were conducted.

Chapter 6

Prototype II

6.1 Prototype Development Iteration II

I started the next iteration of prototype development that aimed to improve the first prototype described in the chapter 5. In the second prototype the emphasis was more on improving support for the three psychological needs from self-determination theory (Ryan and Deci, 2000b) which are relatedness, competence, and autonomy. I substituted Facebook social plugins with features that could allow users to directly comment on or like each other. Facebook social plugins failed to integrate seamlessly with the app since the network signal was a bit poor in the area where I conducted experiments, therefore users failed to load them into the app. In addition, the system comprised SMS reminders and feedbacks instead of Facebook based reminders. The new system (Figure 6.1) had the following features of which most of them were improvements from the previous prototype:

1. Recording of meals consumed by a beneficiary user.
2. A pedometer for detection of steps walked by beneficiary user.
3. Pie charts that show summaries of food groups consumed by a beneficiary user.
4. Bar charts that show steps walked by a beneficiary user (daily intervals, 7 days intervals, and, weeks of a month intervals).
5. Avatars that can be changed in order to increase autonomy of intermediary users.
6. Badges that can be earned through a combination of steps walked by a beneficiary participant and the number of days they app has been utilized by a pair of users. In the previous prototype it was easier to jump from the lowest badge to the highest

without passing through intermediate badges as longer as a pair had enough clicks. Therefore, to move to a higher badge in this second prototype a pair was required to use an app for a certain number of days and then couldn't by [ass any badge as the process was incremental. To reach the highest badges pairs were required to pass through all the badges in between in different days, and also to meet requirements for the King/Queen badge which were at least an average of ten thousand (10000) steps walked by a beneficiary user in a day, and at least 18 days of usage activity detected from the app.

7. Score board/ leader board of which points were earned by averaging between points scored from usage (i.e each day of usage resulted into 1000 points earned) and points earned as the result of beneficiary's average number of steps walked (i.e. if the average is n steps/day then the number of points accumulated is "n")

8. Botanical gardens that consisted of trees and flowers. Trees on the garden grows proportional with badges while flowers grows proportionally with number of meals recorded. if a recorded meal contains fruits and vegetables it is an added advantage.

9. Fish tanks or bowls / Aquarium that consisted of Fish of different species. Number of species grows proportional with badges while the size of each specie is proportional to number of meals recorded. If a recorded meal contains fruits and vegetables it is an added advantage on the size.

FIGURE 6.1: Sample screen-shots of the second prototype

These rules were just arbitrary. The objective was to design challenges with an objective of increasing engagement between intermediaries and beneficiaries when the two users negotiate for interaction with the app.

6.2 Prototype Evaluation Description

The plan in evaluation was to recruit another group of participants. The NGO facilitated access to a group which resided in another side of Philippi where evaluation of the first prototype was conducted. The recruitment was facilitated by the same NGO in Evaluation. But the plan didn't materialize as the NGO advised that we try to look for a different group because the group they were working with expressed concerns regarding safety issues after they heard that they were going to be given phones to use throughout the evaluation period. The NGO was concerned of safety of researchers since rumour had spread throughout the community that someone is going to bring phones to that area. This poses risks to both prospective participants and the researcher. In response to that, this plan was revised and the researcher found another township called Langa, which was a bit smaller and more central township, safer than Philippi.

A research facilitator who is a resident of Langa helped with the recruitment process. This time the recruitment criteria were more stringent compared to the previous evaluation. One of the criteria was to have intermediaries that cohabit or live nearby the beneficiaries. Preference was given to school going children as there were more likely to be interested in gamification. A total of nine adult participants were recruited for the study. The distribution between male and female was three(3) and six(6) respectively. Their average age was 49.3 years old (SD=7.9 years). Each adult participants brought one intermediary participant and formed a pair. The distribution of intermediary participants by gender was 3 males and 6 females. The mean age of these intermediary participants was 14 years old (SD=4.3). Eight adults were relatives/familial related to intermediary participants while the remaining adult was just a tenant of her intermediaries' grandmother. Eight intermediary participants were school-going children. log out Prior to commencement of the study, both beneficiary and intermediary participants were given information about the study. Participants were informed that the study's cellphone will be collecting their information related to usage of the app, step walked, and diet and this information will transferred to the researcher's computer at University of Cape Town. All participants who were not minors signed informed consent forms while minors signed assents forms that were also signed by their respective guardians/parents.

Once consent and assent forms were signed, one day was allocated to train intermediary participants on use to use the app. After the training each pair was provided with an one android phone ((Samsung GT-S5300) that contained two native app. The first app was a pedometer which was not displaying any useful information apart from raw steps' data. The pedometer task was to send these steps to a server so that they can be presented and viewed in a better format through a web application. The second app

provided a link to the web application so that users don't have to type a URL every time they needed to access the web app.

In order to encourage participation, each beneficiary participant received ZAR 40 worth of airtime four times in a period of three weeks (ZAR 160 in total). To encourage participation of intermediary participants, each pair was credited 300MB of data to use on the Android phone as it was expected that intermediaries would borrow phones to access other things on the internet that are beyond prescribed uses.

I left the app in the field for three weeks before conducting an evaluation. After three weeks I conducted the evaluation which is described on the next sub-section.

6.3 Prototype Evaluation Methods

The evaluation relied in two approaches which are collecting user logs and interviews. In interviews, all respondents were familiar/comfortable with English, therefore, interviews were conducted in English. A total of three(3) intermediary participants, and five(5) intermediary participants were interviewed. These are the only participants that I could reach to during the time of interviews. These were short interviews which lasted up to 15 minutes for one person.

6.4 Findings

The key findings were based on social factors and motivational strategies that influenced usage of the app. Some of the findings from this chapter together with findings from the previous chapter (Chapter 5) have also appeared in a conference paper that I co-authored (Katule et al., 2016).

6.4.1 The Role of a Familial Relationship in the Intervention

As it was observed in the previous chapter (Chapter 5), a parent/child relationship may be important in implementation of such an intervention. In this case, a prior social relationship was also very important. Intermediaries that were working with their parents were eager to support their parents because they cared about them.

Usage of each pair was clustered its respective relationship type as shown on Figure 6.2. There were three three types of relationships:parent-intermediary, relative-intermediary,

and not related , with 4, 3, and 1 number of pairs respectively. Usage on each relationship type was measured through three dimensions: (1) the average number of days per pair; (2) the average number of sessions per pair; and (3) the average number of clicks per pair. More usage was observed on pairs with relationship of type parent-intermediary. In the case of parent-intermediary, or relative-intermediary relationships,

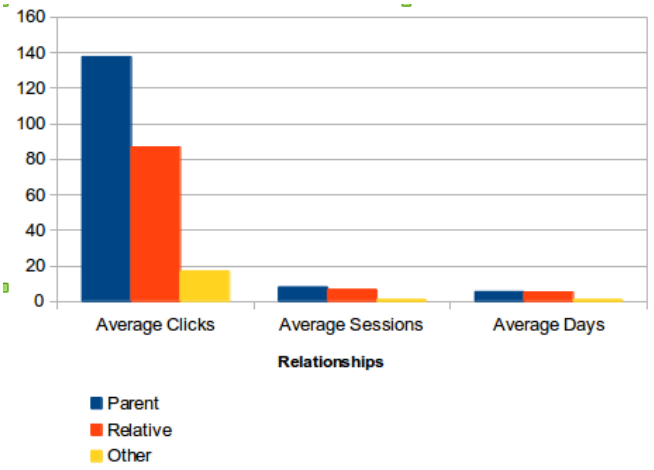

FIGURE 6.2: Usage in three groups of relationships(Katule et al., 2016)

negotiation for interaction that initiated by beneficiary users was more possible because of the nature of the prior relationship. For instance the following two scenarios, requests from beneficiaries where always successful most of the time. For instance, **Zandiwe**, *a beneficiary user, a woman aged 50 years old*, she was working with her sister daughter. Another case was shared by **Lulama**, *an intermediary user, a girl aged 20 years old* who was working with her mother, **Nokanyo**, *aged 57 years old.*

> *"I used to call Lindiwe like 'Lindiwe there is something that I don't understand'. Or I call her the day before when I walk for a long, I call her to come and help me some way somehow."*
>
> —***Zandiwe**, a beneficiary*

> *"My mother was the one who was pushing me, let's do it, let's do it. And we spent more time together. But we are always together around that time I do the app at around o'clock at night. So we talk more than before because she would ask 'How am I doing on this?"'*
>
> —***Lulama**, an intermediary*

There were scenarios of whereby a beneficiary user could request assistance at the time where an intermediary wes either resting or occupied by other activities or felt that there

was no urgency in fulfilling such a request. In such a scenario, a social relationship still had to play a role in motivating intermediaries to immediately attend to those requests.

Also for a parent-child relationship, intermediaries demonstrated sense of being co-owners of the information from the system. For instance, Lulama, used the terms "we" or "our" repeatedly to describe actions that needed to be carried out by her beneficiary user as actions that needed to be carried out by both of them.

> *"When I saw the garden I was like yeah, our garden is looking beautiful. Lets do more. Lets take more steps. Lets eat more veges, because it is the veges and fruits that are important."*
>
> —***Lulama**, an intermediary*

In addition, intermediaries from pairs with a prior social relationship had more authority in persuading their beneficiaries to do something in order to win. And it was not solely for winning purposes as they cared for health of the people they were helping. This phenomenon was observed in two pairs with the following excerpts.

> *"I am helping her so it [The app] has to mean a lot to me. I am helping her (Nokhanyo) because she doesn't know anything. She is like 'What is this?'. This is how you do this. She is like 'ooh okay' So it [The app] means a lot to me because I am helping someone I care about."*
>
> —***Lulama**, an intermediary*

> *"Sometimes she used to shout at me. 'No no you didn't eat that thing. Tell me what you ate in the morning. I saw you eating this. It seems there is nothing for fruits, peanuts. You must remind me to check you!"'*
>
> —***Nokhanyo**, a beneficiary user*

> *"It [The app] was really good because my mother was limiting herself on stuff like pies and fat food. I would tell her don't eat this don't eat that. She wasn't eating much vegetables but I was encouraging her to eat vegetables"*
>
> —***Lwazi** (an intermediary, a boy aged 14 years old)*

It was observed that for pairs that didn't have a parent-child relationship, interactions between intermediaries and beneficiaries where lesser or absent except for cases where an intermediary was motivated by access to the intervention's phone or motivation affordances provided by gamification. But in cases where intermediaries where driven by

those factors, still there was some form of a prior social relationship that played a role, i.e. relative-intermediary, although it was not as strong as a parent-intermediary relationship. In these cases, of relative-intermediary relationship, even if the intermediary is not motivated by gamification and the phone, they would still provide infrequent help to their beneficiaries. In one case where there was no relationship between an intermediary and beneficiary, even the infrequent help was not available i.e. in the case **Anele** (a beneficiary user, a 47 year old woman, who was working with the granddaughter of her landlord, hence, they were not related. Anele mentioned that every time she passed her request to be helped, her intermediary claimed to be busy and kept on procrastinating by saying they will do it the next day and when that day comes it was the same thing.

Therefore, a familial relationship played an important role in mediating motivation of some intermediaries to help.

6.4.2 Sources of Motivation for the two Sets of Users

In cases were both users of a pair were motivated to use the app and there was a prior social relationship between them, then a pair tended to interact in a more playful manner which brought the two users closer compared to before using the app. This happened in when an intermediary was reporting back the information to a beneficiary user. This made the interaction between an intermediary and beneficiary to be more enjoyable and less tense. These narration from participants describe how the interaction between an intermediary and beneficiary was enjoyable, when the two users were engaging with the app.

> *‘ When she got time, when she is done with her homework she comes and sees the app. And then laughs at me like ‘Yo yo yo [An interjection for Xhosa speakers to express the feeling of amazement by something] you can walk yo yo yo’, like ‘you walked a lot today’ and what what [She was implying to other words said by Lindiwe]”*
>
> —***Zandiwe**, a beneficiary*

In that excerpt above, Lindiwe showed excitement upon seeing steps walked by Zandiwe. Also Nokanyo mentioned how they laugh when she interacts with her daughter when they are exchanging information retrieved from the app. This playful environment fostered relatedness and made it easier for the two users from a pair to continue engaging with the app.

However in engaging with the app, intermediaries and beneficiaries had different motivational goals. Intermediaries were interested in pursuing a steps or diet goal in order

to achieve rewards in gamification. While for beneficiaries, their primary goal was to achieve more steps for the purpose of informal comparisons with others or for instrumental value to their health. These different sources of motivations are further expanded below.

6.4.2.1 Sources of Motivation in Beneficiaries

One of the factors that played a role in motivating beneficiaries was informal comparison of steps/diet. In the app there was no feature that supported direct comparison of steps or diet. Instead, beneficiary participants who knew each other they implicitly formed a social support group. In this support group, they interacted with each other through either face to face meetings or an SMS/a phone call. These interactions were centred around comparison of steps or diet among each other.

> *"We [with Nokanyo] were talking about what we ate. Like Tuesday I phone Nokanyo to ask her 'Did you eat a lot'. She said 'not today' But she said she ate a lot the day before. It was Monday."*
>
> —***Zandiwe**, a beneficiary*

These kinds of social comparisons led to competitions between beneficiary participants. Competition was a consequence of how the app was existing social context and not an intended goal of design as they happened beyond the app context. Some beneficiary set their target or goals in order to beat others within a social support group. These beneficiary participants were always curious about how other were doing within their support group.

> *"She [Nokhanyo] would ask 'I wonder how so and so is doing'. She would ask them when she sees them. She wouldn't ask on the app "*
>
> —***Lulama**, an intermediary user*

> *" I think I was in competition with steps [She is chuckling]. Because others would have said ooh I have walked, maybe we look at the thing to say let's 1900 steps. And for me I will say no, tomorrow I need to walk more than her because she walked 1900 steps. Then I need to walk 2500 steps"*
>
> —***Ndileka** (beneficiary user), 35 years old woman*

Also some beneficiaries got interested to some of the gamification features after *proximate translation by beneficiary users.* Therefore, intermediaries needed interpretation of what

is going on in gamification in order for them to understand it.

> *"She [Nokhanyo] saw the garden. The first day she saw just the house and brownish. She is like 'What is this'. I told her. She said 'Aha! [Expressing dissatisfaction]. It must look green and healthy'. And then she saw the garden again and said 'It is looking good."'*
>
> —***Lulama**, an intermediary*

> *"She [His mother] doesn't understand the app. I just tell her that people are having ones twos threes (on the scoreboard and badges) and she laughs"*
>
> —***Lwazi**, an intermediary*

Therefore, the most motivating factors for beneficiaries were steps feedback and comparison of steps with others.

6.4.2.2 Sources of Motivation in Intermediaries

There are several factors that motivated intermediaries to use the app, apart a prior social rapport. Factors that manifested in participants' responses include gamification features, effect of intervention's phones, and self-monitoring of steps. Some intermediaries nudged their beneficiary users to do more in steps or to eat healthy, so that their pairs would win rewards offered by gamified elements of the web app. The extent of nudging was evident in pairs with parent-intermediary relationship. Gamification features such as badges and scoreboard mediated competition between intermediaries.

> *"The app challenged me to compete [with others] because there was this lady I think it was Lulama. She was getting points and I was really stressed out because she was reaching the amount I was getting so I was pushing hard to get there. But now I am second. If I was using the app so much I was going to be number one but I am not using the app so much because my mother is not putting her sim card on the phone"*
>
> —***Lwazi**, an intermediary*

Intermediaries were able to interpret some of the intentional persuasive strategies for instance the concept of using the size of the fish in relation to recording of diet. For instance Lwazi was asked what was the size of fish in his tank and his response was as follows, *"They were medium sized because I wasn't really feeding them."*. By not feeding them he implied that he wasn't not doing enough in recording of meals eaten by his mother. This an example of a connection that was made between playful interfaces

and actual health self-monitoring behaviours. But there were also other unintentional persuasive effects resulted from SMS reminders. In one context, three participants (one intermediary and two beneficiaries) were convinced that messages were sent by the researcher. These messages were tailored with participants names and they were auto generated. Therefore, these participants perceived them as the researcher was following their performance and was trying to encourage them. For instance, Nokhanyo, every time she received a message she would call her daughter to come and see and tell that it is coming from so and so (mentioning the name of the researcher). This caused Lulama to panic thinking that there is something she did wrong whenever she heard her mother call her about a received SMS. In a different scenario, Lwazi thought that messages were sent by other participants through a message board that was on the app. Therefore, he passed these reminders to his mother telling her that people are saying to us about eating healthy and the mother was always responding with a laughter. But Lwazi used the same messages to encourage his mother to walk more steps and eat healthy.

Apart from gamification features, a phone had an effect in motivating intermediaries to participate especially the ones that had a prior social relationship with their beneficiaries. Intermediaries were involved in tasks that were non-prescribed in the course of carrying out tasks that within prescribed use. For instance two intermediaries aged 10 and 14 had installed games in intervention's phones that were possessed by their parents. The following is a case of an intermediary who lived a distance from a beneficiary but she came all the way to use the phone and to also interact with gamification.

> *"Lindiwe likes the phone too much. She is always here after school. She lives with my sister on the other side and she comes here everyday. Sometimes I call her to come. We are closer than before. We always talk about the app while other people (relatives) are around. These people also got interested"*
>
> —***Zandiwe**, a beneficiary*

> *""*
>
> —***Dlamini**, a beneficiary, man aged 72 years old*

There was also the novelty effect from the self-monitoring tasks (diet's pie chart and steps' bar chart). Some intermediaries got excited to see visualization of information about people they cared about. For instance one intermediary aged 10 years old mentioned that steps were the most interesting out of all features.

6.4.3 Perceived Value in Using the Prototype

Beneficiaries mentioned that they had gained value inform of knowledge and their health.

> *"There are a lot of things I didn't know I now know, like how to eat. I know walking is very important. Because you know I am fat. When I stay on the bed the whole day my blood doesn't circulate."*
>
> —***Zandiwe**, a beneficiary*

> *"The app helped me because sometimes you don't realize you eat more carbohydrate than fruits. You just eat bread but you don't know that bread is carbohydrate. So when it says large amount of carbohydrate, so you know I am eating large amount of carbohydrate. You think now I must eat more fruits than meat or less meat. So for me automatically it helped me to think that I need to eat large amount of fruits."*
>
> —***Ndileka**, a beneficiary*

The case of Ndileka above is referred to as cognitive dissonance. This is why self-monitoring is so important because it shows an individual if there is a discrepancy between their beliefs and their actions. Cognitive dissonance supports individuals to restore consistence between beliefs and actions(Oinas-Kukkonen and Harjumaa, 2009)

Intermediaries who engaged with the app also reported that their beneficiaries had have become more knowledgeable about living healthy.

6.5 Discussion

Existing social rapport is important for this kind of intervention. Social rapport creates a conducive atmosphere for using different strategies to motivate both intermediaries and beneficiaries. Social rapport and external motivation sources go in parallel and may depend on each other. For instance, external sources motivation such as phone effect and gamification can enhance an existing familial relationship as it is suggested on the findings. Perceived relatedness between family member had increased. In addition, familial relationship created an opportunity of utilizing young family members as persuaders for behaviour change. These intermediaries can create intents to persuade. This approach relied on social rapport within a household which can be much stronger than a social rapport with an individual who is not a family member. This approach is different from existing approaches in ICTD context. For instance there is a project in India that leveraged trust between community health workers and expectant mothers

for persuasion (Ramachandran et al., 2010a,b), and this trust was built based on persuasive information that community health workers (CHWs) possessed on their phones. Therefore, the prior social rapport is relatively weak, and the influence of these CHWs can be limited to infrequent visits, and much of the persuasive strategy relies on the messages possessed by CHWs (Katule et al., 2016).

Apart from the prerequisite of a prior social relationship, motivation strategies are important as they strengthen on what already the social relationship that exists. Intermediaries and beneficiaries had different motivational needs when engaging with the app. Intermediaries focused on gamification part as their primary objective. Steps and meals were secondary objectives since they were some how linked to the gamification part. Beneficiaries considered steps and meals as their primary objective. Intermediaries competed in points on the leader board but beneficiaries competed on the number of steps walked or healthy meals. Therefore, in this context there are two sets of users that need to be persuaded differently since they have different objectives. Motivational strategies for the two users need to be examined separately, and a designer has to come up with an optimal strategy that will combine motivational strategies for the two groups. An understanding of context is crucial and this has been emphasized by Oinas-Kukkonen (2013); Oinas-Kukkonen and Harjumaa (2009). Sharing of phones and gamification can be leveraged to increase engagement of young intermediaries, while support for direct comparison can be supported to increase engagement of beneficiaries. Designers need to think of how they can integrate how flow is maintained so that both users can stay on the loop. For instance, in the findings it is shown that SMS can be one of the ways of maintaining flow with the App and it is easier for both users to engage with SMS even if beneficiaries require proximate translations on SMS.

Chapter 7

Summative Evaluation

7.1 Recruitment of Participants

With help of a research assistant who was a resident of Langa, we managed to recruit a total of fourteen adult participants (beneficiary users). We recruited these participants from two townships in Cape Town: Langa, and Athlone. In Langa there were five adult participants while in Athlone there were nine adult participants. The average age of these adult participants was 44.21 years with a standard deviation (S.D) of 9.99 years. The youngest adult was 26 years of age while the oldest was 60 years of age. Thirteen participants were females.

Each adult participant (beneficiary user) elected one of their children/grand children to become their intermediary user to form a pair of users. The two members of a pair were required to work together in using the "Family Wellness App" to self-monitor the wellness of one member of a pair (a beneficiary user). All beneficiary users were working with their children but one whom was was working with her grand child. The average age of children participants (intermediary users) was 15.42 (S.D=2.06) years. The youngest intermediary user was 12 years of age while the oldest was 20 years of age. The number of females and males intermediary users were equal.

I gave out detailed information of what the study was all about to both intermediary and beneficiary participants. I informed them about different modes of which I will collect data. All beneficiary participants signed informed consent forms agreeing to be part of the study. Since all intermediaries were under 21 years of age, they signed assent forms which were also signed by their respective parents/guardians who were part of the study.

One day was allocated for training intermediary participants on how to use the "Family Wellness App". In addition, each intermediary was given a user manual. After the training, I gave out one Android phone (Samsung GT-S5300) to each pair of participants. These phones were installed with two natives apps. The first app was a pedometer and the second one was the main "Family Wellness App". The "Family Wellness App" loaded all its content from a web application hosted remotely. Each beneficiary participants was required to carry the phone with them all the time in order for the pedometer app to count their steps. The two apps (main app and pedometer) were made available to the participants for a total period of six weeks. Each pair of participants provided the service provider's number of the SIM card that was inserted on their given Android phone. I allocated 1.3 GB of data to each SIM card. In addition each beneficiary participant was given a total of ZAR 240 as a compensation for transport and their time for the duration of the study. The details of the experiments are outlined on the next section.

7.2 Experiments

This phase of the study evaluated the effectiveness of gamification/rewards in motivating both intermediaries and beneficiaries to engage with the "Family Wellness App". I was comparing two versions of the applications. The first version of the application was simply a logbook or journal that allows each pair of users to record and view wellness data of a beneficiary member of a pair. With the logbook app, users could, view physical activity graphs, and recording and viewing summaries of nutrition components of food consumed by a beneficiary within a pair. The second version of the application was an extension of logbook with an addition of a rewards/gamified subsystem. The experiments took place from the mid-October 2015 to the end of November 2015. The details of how experiments were designed and how data were collected are presented on the next sub-section.

7.2.1 Experiment Design

The study used "within-group" design for the experiments. In within-group design, the same group of participants were exposed to different experimental conditions. This helps to minimize the number of groups needed to test hypotheses as only one group is used for both control and intervention. Another advantage of within-group design is that it minimizes the effect of confounding factors. The only problem with this approach is the learning effect and in addition, it lengthens duration of a study. In order to minimize the impact of the learning effect on the outcome, I randomly assigned pairs of participants to two separate groups referred to as experimental sequences. The first experimental

sequence started with the "Logbook App" and finished with the "Gamified App". The second experimental sequence started with the "Gamified App" and finished with the "Logbook App". I used the following abbreviations "LG" and "GL" to refer to the first and second experimental sequences respectively.

A total of seven pairs of participants were assigned to the LG group while the remaining seven pairs were assigned to the GL group. Both groups spent the first four weeks in their first experimental conditions of which the "Logbook App" for the LG group and the "Gamified App" for the GL group. After 27 days (four weeks) each group was switched to a different experimental condition. The LG group started using the Gamified App while the GL group started using the Logbook App. The second phase of the experiment lasted for a total of 14 days (two weeks).

The explanation of why four weeks in phase 1 and two weeks in phase 2 is as follows. Initially the plan was to have time spent on each experimental condition, be three(3) weeks intervals, but phase one had extended beyond three weeks up to fourth week as participants were not available for midline assessments at the end of the third week. Therefore, The research team carried out the assessment at the end of the fourth week and then followed by swapping of participants from one experimental condition to the other. This shortened the period for phase two from three to two weeks. Also, It was not feasible to extend phase two since it was approaching December of whereby most people travel for holidays, therefore, gathering participants during that time may have been impractical.

7.2.2 Data Collection Methods and Analysis

Data collection was a triangulation of application's logs,questionnaires and interviews.

7.2.2.1 Family Wellness App Logs

Application's logs consisted of information regarding the time when there were users' activities on the app, the pair that was accessing the app at that time, and the functionality that was being accessed by that pair. Logs were categorized to their respective experimental conditions. Usage was measured by counting the number of sessions and clicks. A new session was defined as a period of detection of user's activity in an absence of any activity from this user/pair in the past one hour or more.

I carried out usage comparison in two dimensions. The first comparison entailed comparing the daily total number of sessions between the two experimental conditions for 41 days of experiments.

In the second comparison, it was pairwise comparison of users' sessions in between logbook and gamification conditions. In order to ensure this comparison of usage is not affected by different experimental durations, I opted to use a relative number of unit measurement. In this case I used the number of sessions per day since the number of days on which pairs of users spent on a particular experimental condition differ between LG and GL group. For instance the LG group spent nearly four weeks in logbook and two weeks in gamification while the GL group spent four weeks in gamification and two weeks in logbook. In this second usage comparison, there were four pairs that were excluded from this usage analysis. These are pairs that faced hurdles on utilizing the app and this affected their ability to fully experience and engage with what was being offered by the gamified system. These pairs are listed on Table 7.1. For **Pair A**, the

TABLE 7.1: Pairs with usability/technical problems that hinder their participation

	Pair	Experimental Sequence	Problem
1	Pair A	GL group	App not loading
2	Pair B	GL group	Lack of data bundles.
3	Pair C	LG group.	Pedometer never transmitted data to the server.
4	Pair D	LG group.	Pedometer stopped transmitting data to the server.

app failed to load every time their intermediary user tried to use it. What was observed from the house where this pair lived in is that there was a poor Internet signal, hence the app was always failing to load most of the time. The second pair (**Pair B**), data was allocated to the wrong phone number at the beginning of experiments but they never reported on time. These two pairs (Pair A and Pair B) had the lowest usage days which were 2 and 3 days respectively and they they had used the app only in gamification condition.

For the last two pairs (**Pairs C** and **D**) on Table 7.1, their pedometers were not transmitting steps' data to the server. Steps data were important for advancement of badges, and improvement of both the fish tank and botanical garden in gamification condition. Pair C's pedometer never transmitted any readings to the server even in logbook condition. Pair D's pedometer stopped transmitting steps data on the fourth week of running the experiments and this was before this particular user was switched to gamification condition. The two intermediary users from Pair C and Pair D were close friends. Although the pedometer never transmitted data in Pair C since the beginning of experiments, an intermediary user from this pair continued to use the wellness app because of the informal comparison with an intermediary user from Pair D while they were both still in logbook condition. The usage in Pair C and Pair D were both eleven days. Their drop out started during gamification condition. Pair C used the app for only three days and

Pair D used it for only one day. Since gamification depended on transmission of steps to the server, pedometer problems affected Pair C and Pair D motivations to participate in gamification phase despite their efforts during logbook condition. The learning effect coupled with problems with their pedometers mediated their decrease in usage with the app. An intermediary user from another pair in "LG" group who happened to live close to the Pair D and Pair C, shared her concerns about the rewards from the gamified app. This was during the endline interviews. This particular intermediary user didn't appreciate her advancement in badges because she admitted that her peers (the two intermediary users from Pair C and Pair D) did more efforts than her but they were not getting anything so she didn't understand why she was ahead of them. She was referring to their usage during logbook condition as they were both using the "logbook App" at the same time. This proves that usability problems played a role to the some extent in demotivating participation in gamification condition of intermediary users from Pair C and Pair D. So to compare usage the hypothesis of interest is:

1. Hypothesis 1
    - H_0:There is no difference in number of sessions between a logbook app and gamified app
    - H_A:There is a difference in number of sessions between a logbook app and gamified app

7.2.2.2 Questionnaires

The research team administered questionnaires at baseline, mid-line (during switching of experimental conditions), and end-line. These questionnaires targeted both intermediary and beneficiary participants. The list of questionnaires is provided below.

1. **Intermediaries** Intermediaries had three questionnaires that were administered at baseline, midline, and endline.
    - **Baseline Questionnaire**: Intermediaries participants' baseline questionnaire had three sections. The first section captured demographic information such as age,gender, and number services/apps used on cellphones.The second section included an IMI (Intrinsic Motivation Inventory) questionnaire to assess participants' intrinsic motivation in using cellphones. The third section included an IMI questionnaire to assess participants' intrinsic motivation in helping their parents with cellphone based tasks.

- **Midline Questionnaire**: Intermediaries participants' midline questionnaire had only one section which included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app.
- **Endline Questionnaire**: Intermediaries participants' endline questionnaire had only one section which included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app.

2. **Beneficiaries**

- **Baseline Questionnaire**: Beneficiary participants' baseline questionnaire had four sections. The first section included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app. The third section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of diet/nutrition. The fourth section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of physical activity.
- **Midline Questionnaire**:Beneficiary participants' midline questionnaire had three sections. The first section included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app. The third section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of diet/nutrition.The fourth section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of physical activity.
- **Endline Questionnaire**: Beneficiary participants' endline questionnaire had three sections. The first section included an IMI questionnaire to assess participants' intrinsic motivation in using the family wellness app. The third section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of diet/nutrition.The fourth section included an IMI questionnaire to assess participants' intrinsic motivation in self-monitoring of physical activity.

I developed the IMI questionnaires with the guidance of materials found on a "Self-Determination Theory"[1] website which is maintained by researchers working on the theory including Richard Ryan and Edward Deci(Deci and Ryan, 1985b) whom were early pioneers in developing the theory. I pretested these questionnaires during the informative evaluation of prototype II in chapter 6. The most most important sub-scales for our theoretical construct were perceived competence and perceived autonomy which are part of the three basic psychological needs. The relatedness sub-scale is not yet

[1] http://www.selfdeterminationtheory.org/intrinsic-motivation-inventory/

validated but it was included in all questionnaires. Other sub-scale that was included in all questionnaires is perceived enjoyment. Perceived enjoyment is the only direct measure of intrinsic motivation while perceived competence and perceived autonomy are predictors of intrinsic motivation. Self-Determination theory suggests that a behaviour can be started as externally motivated and if external motivators support the three basic psychological needs which are relatedness, competitiveness, and autonomy then a behaviour that was once externally motivated can be internalized and users will start doing it because it is a good thing to do.

In addition to the aforementioned sub-scales, perceived usefulness and perceived efforts also appear in specific questionnaires (i.e self-monitoring of diet and activity, use of cellphone). These specific questionnaires don't assess specific constructs of self-determination theory as they focus on the overall intrinsic motivation. The overall IMI scores were computed by averaging the scores from each sub-scales. In each question from the IMI sub scales, respondents were supposed to rate there experience in a scale of 1 to 7 points which means that 1 implies the statement is "not true at all" and 7 means the statement is "very true".

There were two main objectives of using the IMI questionnaire. The first objective was to assess the ability of the two prototypes in supporting the participants with the three basic psychological needs. The difference in experimental durations was expected not to have any effect on motivations to use either of the two systems since both logbook and gamification were both present in both phases of experiments. Therefore, effects on motivations due to different durations were expected to cancel each other during analysis. I compared between the ability of the two prototypes in affording three basic psychological needs suggested by self-determination theory. In addition, I also included perceptions on enjoyment as it is a direct measure of intrinsic motivation. The corresponding scales from the IMI questionnaire were administered at midline and endline . Therefore, there were four sub-scales; perceived competence, perceived autonomy, perceived enjoyment and perceived relatedness.

The second objective of using IMI questionnaires was to assess motivations/self-determinations of beneficiaries in self-monitoring of diet and activity, and motivation/self-determination to use cellphone of both intermediaries and beneficiaries. These IMI questionnaires included perceptions of beneficiaries on competence, autonomy, relatedness, enjoyment, effort, and usefulness.

The hypotheses of interest for both intermediaries and beneficiaries on usage of the app were:

2. Hypothesis 2

- H_0:There is no difference in perceived competence in using the app between a logbook app and gamified app
- H_A:There is a difference in perceived competence in using the app between a logbook app and gamified app.

3. Hypothesis 3

- H_0:There is no difference in perceived autonomy in using the app between a logbook app and gamified app
- H_A:There is a difference in perceived autonomy in using the app between a logbook app and gamified app

4. Hypothesis 4

- H_0:There is no difference in perceived relatedness in using the app between a logbook app and gamified app
- H_A:There is a difference in perceived relatedness in using the app between a logbook app and gamified app

The hypotheses of interest for beneficiaries in self-monitoring of behaviours were:

5. Hypothesis 5

- H_0:There is no difference in the overall self-determination to self-monitor diet of between a logbook app and gamified app
- H_A:There is a difference in the overall self-determination to self-monitor diet of between a logbook app and gamified app

6. Hypothesis 6

- H_0:There is no difference in the overall self-determination to self-monitor activity of between a logbook app and gamified app
- H_A:There is a difference in the overall self-determination to self-monitor activity of between a logbook app and gamified app

In motivations to self-monitor diet and activity, I excluded pairs (A,B, C, and D) from Table 7.1 with problems that led to discontinuation of usage. In total only ten out of fourteen beneficiaries had their results included for analysis. In the comparison for self-monitoring of diet and activity, the first IMI comparison entailed comparing the IMI score of each participant at baseline, midline, and endline regardless of an experimental

condition. In the second comparison I compared scores at baseline, logbook, and gamification condition. The IMI score was computed from the average of all scores from subscales of perceived competence, perceived autonomy, perceived relatedness, perceived enjoyment, perceived effort, and perceived usefulness. I used one way ANOVA with repeated measures to test if there was a difference between scores at: (1) baseline, midline, and endline, and (2)baseline, logbook and gamification. I used Mauchy's test[2] to checked if different measuring points had the same covariance in each ANOVA test I carried out and this helped in deciding of whether to "Sphericity Assumed","Greenhouse-Geisser", or "Huynh-Feldt" of SPSS output.

7.2.2.3 Interviews

I also conducted short unstructured interviews at midline and endline. I selected fewer intermediaries and beneficiaries for the interviews. Interviews responses were important in supplementing data collected through questionnaires and application's logs.

7.3 Findings

There were four primary outcomes in analysing the findings and these are: (1)usage trend of the app; (2) user experience/intrinsic motivation of both intermediaries and intermediaries in using the app; (3) intrinsic motivation of beneficiaries in self-monitoring of diet/nutrition; and (4) intrinsic motivation of beneficiaries in self-monitoring of physical activity.

7.3.1 Usage Outcome

The average number of days on which pairs used both versions of the application was 10.5 (SD=7.39) days. The most active usage was from a pair that utilized the app for a total of 26 days. The less active usage was from a pair that had used the app for only two days out of 41 days. Findings on comparison of daily total number sessions summed from all users in each experimental condition showed that gamification had a significant total number of daily sessions compared to logbook as demonstrated by a non-parametric test called Mann-Whitney U Test on Table 7.2. I made a decision to use the aforementioned test because the two independent samples were not distributed normally (From "*Shapiro-Wilk Normality Test*"[3]). Also, Figure 7.1 shows trends on

[2]Read more on how Mauchy's test is used from http://www.statisticshell.com/docs/repeatedmeasures.pdf
[3]http://sdittami.altervista.org/shapirotest/ShapiroTest.html

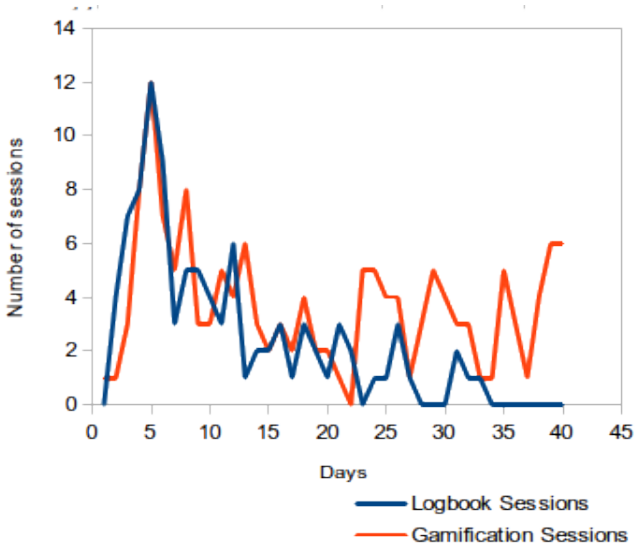

FIGURE 7.1: Total daily number of sessions from the two experimental conditions.

total daily sessions in between logbook and gamification conditions. This finding shows that there is a higher likelihood of a gamified system to be used more frequent compared to a logbook system. The pairwise usage comparison on number sessions between

TABLE 7.2: Daily usage comparison between Logbook and Gamified systems for 41 days

Groups	N	Rank Average	Sum Ranks	U	Z	P
Daily logbook sessions	41	33.72	1701.5	1159.5	-2.9538	0.00318
Daily gamification sessions	41	49.28	1701.5			

users on two experimental conditions which excluded four pairs showed that the Log mean of number of sessions per day was significantly higher on gamification condition, M=0.459; SD=0.336, when compared to logbook condition, M=0.201 ;SD=0.196 with (t(9)= -2.6593 ; p= 0.0261 ; 95% CI= -0.477 to -0.039). The finding above suggests that there was an indication of a significant increase in frequency of daily usage when pairs where in gamification condition. The log mean is used in this case because the differences of logbook and gamification didn't have a normal distribution shape. Therefore, I performed transformation using a natural logarithm equation and after transformations on the original data, the differences of the new data on logbook and gamification had a normal distribution shape.

The utilization of different self-monitoring functionality on Figure 7.2. showed that usage of some of the main self-monitoring features for steps and diet is lower in gamification

compared to when in logbook condition. An explanation to this is that during gamification condition users divided there attention between main logbook and virtual rewards. However, the trend in recording of diet/meals continued to remain the same between the two experimental conditions as the process of recording meals played an important role in earning some of the virtual rewards, therefore, intermediary users had to continue using that feature while in gamification condition. Figure 7.3 shows the distribution of clicks among feedback features of the "Gamified Wellness App" and "The Logbook App". From Figure 7.3, we can see that gamification condition's clicks on feedback

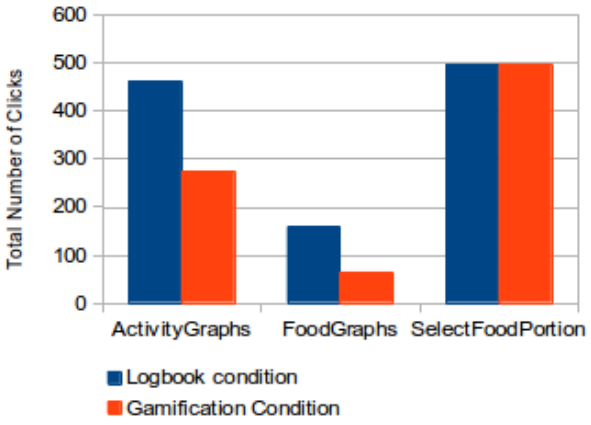

FIGURE 7.2: Total clicks on feedback features for self-monitoring of wellness: "Logbook App" versus "Gamified App".

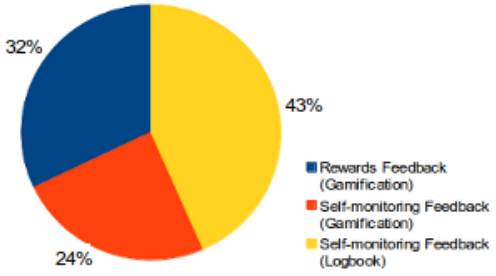

FIGURE 7.3: Total clicks on feedback features in the two experimental conditions : self-monitoring features versus rewards features.

features are distributed between the main self-monitoring and virtual rewards features. The number of clicks on the main self-monitoring feedback features had decreased as users became interested to feedbacks provided by virtual rewards features more than the main self-monitoring features.

From Figure 7.1 above the trend shows the drop on Logbook condition as users who had been exposed to gamification condition before logbook condition became less interested with the "Logbook App" after being switched to it. The baseline data can explain this

usage information using descriptive trends since they were not statistically sufficient to explain the above usage. The drop in the total number of logbook sessions appears slightly the same in both younger and older intermediaries as shown on Figure 7.4. But contrary to this is that younger intermediaries had slightly higher average on total number of sessions compared to the older ones while in gamification condition as shown on Figure 7.5. Also on the average of total number sessions in both experimental conditions, the trend on average shows that younger intermediaries to have more sessions in overall as shown on Figure as more sessions were from gamification condition. The term olerd and younger are defined by the age >= and <median age (15.5 years old) respectively. Although the total number of sessions is relative to the number of days in which a pair of users had a particular experimental condition available to them, but younger and older intermediaries were evenly distributed to both experimental sequences (LG and GL groups). This means young and old intermediaries were both present in almost the same number in both experimental sequences hence their differences in number sessions which is influenced by the number of days (27 days in phase 1 and 14 days in phase 2) are expected to cancel each other. The distribution by age group is presented on Table 7.3.

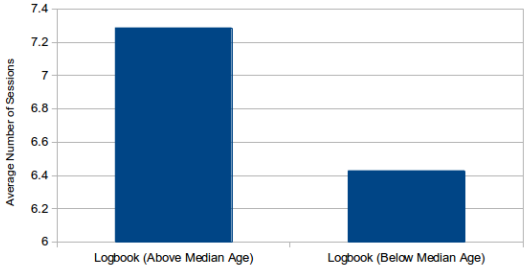

FIGURE 7.4: Average number of logbook sessions on 14 intermediaries: Age >= median age(=15.5) versus Age <median age.

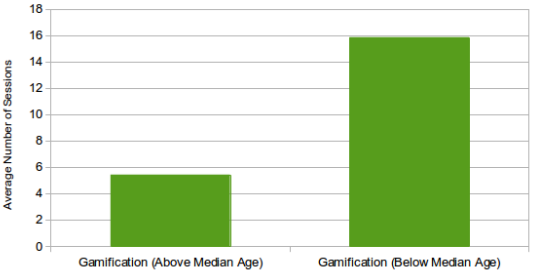

FIGURE 7.5: Average number of gamification sessions on 14 intermediaries: Age >= median age(=15.5) versus Age <median age.

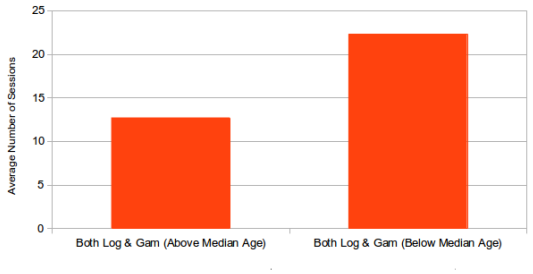

FIGURE 7.6: Average of total number of sessions of 14 intermediaries on both experimental conditions: Age >= median age(=15.5) versus Age <median.

TABLE 7.3: Age groups of intermediary participants

	Age Groups	**Total users**	**No. of GL sequence**	**No. of LG sequence**	**No. of Females**	**No. of Males**
1	Age >=15.5 years	7	3	4	4	3
2	Age <15.5 years	7	4	3	3	4

For pairs who had usage problems on Table 7.1,three out of four intermediary users were above the median age and one below age. A different trend that excludes the intermediary users that belong in these four pairs still appears to be similar to Figures 7.4 and 7.5. For logbook condition, only intermediary users from Pairs A, B were removed as their participation as they terminated their early before switched to logbook condition. Pairs C and D started with Logbook and they participated through logbook conditions despite problems in Pair C since the beginning of experiments. Therefore, the new logbook trend only excluded pairs A, and B (Figures 7.7). For the gamification condition, we removed pairs A,B,C, and D, as usage problems affected their ability to continue engaging with the app, therefore the new trend on average sessions is shown on Figure 7.8.

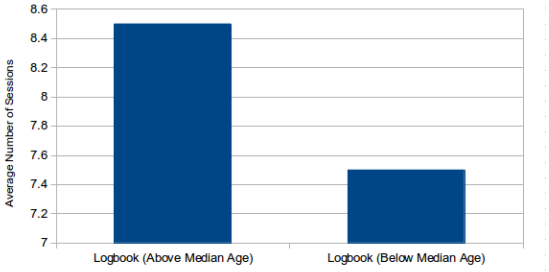

FIGURE 7.7: Average number of logbook sessions on 12 intermediaries: Age >= median age(=15.5) versus Age <median age.

The same trends continue to hold as younger intermediaries appear to have higher

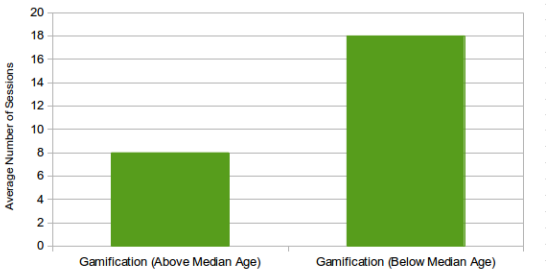

FIGURE 7.8: Average number of gamification sessions on 10 intermediaries: Age >= median age(=15.5) versus Age <median age.

average number sessions in gamification condition and lower average number of sessions in logbook condition. Koivisto and Hamari Koivisto and Hamari (2014) found that the usage of a gamified system is highly affected by the novelty effect which is inversely proportional to the age of participants, meaning that highly usage due to the novelty effect may be reported in much younger participants.

The next trend is just looking at usage with respect to both ages of beneficiaries and intermediaries. If we consider all beneficiary users from all fourteen pairs then the trend on average number of sessions is as shown on Figure 7.9. The median age for intermediaries was 15.5 years old while the median age for beneficiaries was 44 years old. Therefore an individual participant belongs to either younger or older group depending on whether ones age is below or above their respective median age. Pairs with a combination of a younger intermediary, and younger beneficiary appears to have more sessions in average. Most of these sessions were contributed by gamification.

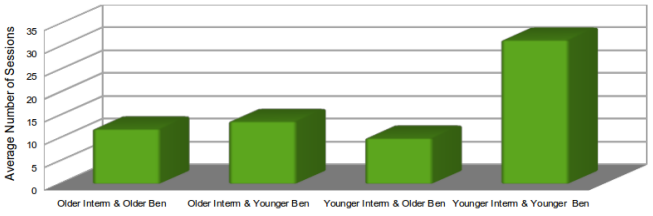

FIGURE 7.9: Average number of sessions on 14 pairs by age groups: intermediaries and beneficiaries

On the next sub sections, user experiences of both intermediaries and beneficiaries are reported.

7.3.2 Intermediaries' User Experience

Most of the time, beneficiaries' usage of the app was facilitated by intermediaries in proximate enabling and proximate translation. These types of intermediated interactions have been discussed in the work by Sambasivan et al.Sambasivan et al. (2010). Baseline data indicated that interest of intermediary participants in using cellphones was higher than that beneficiary participants. For instance, in overall IMI scores to use cellphone, intermediaries (M=5.76, S.D= 0.41, N=14) scored significantly higher than beneficiary participants (M=5.06, S.D= 0.71, N=13) with (t(25)= 3.1764, p=0.0039, 95% CI = 0.2472 to 1.1589).

In user experience of intermediaries, the first finding is on how baseline intrinsic motivation and demographic information such as age of intermediary users influenced user experience. From Figure 7.6 above, young intermediaries (age<median=15.5 years) appeared to had more number of sessions per day on average, but contrary to this trend was that, at baseline the average perceived enjoyment on helping with cellphone related tasks was higher in intermediaries with age>=median compared to intermediaries with age<median for the 12 intermediary users as shown on Figure 7.10. The descriptive

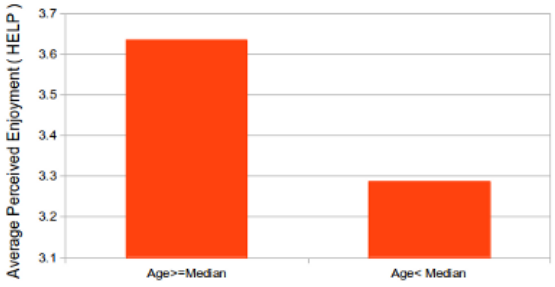

FIGURE 7.10: Intermediaries' average perceived enjoyment to help others with cellphone tasks versus age group.

finding on perceived enjoyment to use the family wellness app by age at midline and endline for the 12 intermediary users (excluding users from pairs A and B since they terminated their usage too soon) showed that the averages are higher on the intermediaries with age <median for both midline and endline points (Figure 7.11). If we split the two age groups by, participants with different characteristics are evenly present to both groups as shown on Table 7.4. Therefore, comparison of trends by age groups in not much influenced by other factors such the experimental sequence of which participants were assigned to or gender.

The trend on average perceived enjoyment in both logbook and gamified conditions appeared to be slightly higher in younger intermediaries compared to older intermediaries as shown on Figure 7.12.

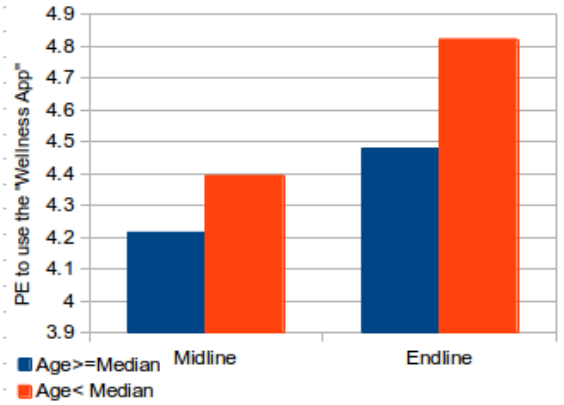

FIGURE 7.11: Intermediaries' average perceived enjoyment in using the app versus age group.

TABLE 7.4: Age groups of intermediary participants

	Age Groups	**Total users**	**No. of GL sequence**	**No. of LG sequence**	**No. of Females**	**No. of Males**
1	Age <15.5 years	6	3	3	2	4
2	Age >=15.5 years	6	2	4	4	2

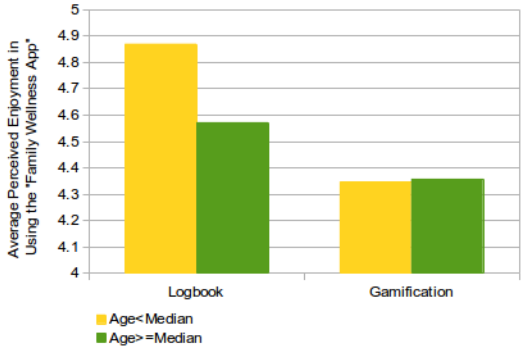

FIGURE 7.12: Intermediaries' average perceived enjoyment in using the app versus age group (Logbook and Gamification).

Figures 7.11 and 7.12 suggest that the task of helping was more interesting to younger intermediaries due to the existence of the aforementioned motivational affordances.

There several factors that influence intermediaries to use the app and these are:

1. **The phone effect**: The phenomenon of sharing phones was important in nurturing the relationship between intermediaries and beneficiaries. Parents were lending their phones to their kids to access social media sites and games. Having access to a phone while providing help to beneficiary participants can be viewed as one of the motivating factors to intermediary participants who didn't have smart-phones or

data bundles in their smart-phones. Some intermediary participants had installed games, other apps on those phones.

> *"I had freedom [in using the app] because sometimes she left the phone with me and I was able to play games"*
>
> —***Siyamthanda**, a female intermediary from Langa, 12 yrs old*

> *"We would fight over it[the app]. Because he always wants to be on the phone. Always always."*
>
> —***Aziza**, a female beneficiary from Athlone, 35 yrs old*

> *"I didn't feel burdened. You know I also play games on the phone. [Implying he also played games with the phone during logbook condition therefore he didn't feel burdened to help his mother]"*
>
> —***Likhaya**, a male intermediary from Langa, 16 yrs old*

Therefore, a phone had some effect, since intermediaries were helping in return they have access to cellphone to access functionality or services they like.

2. **Gamification comparison**: The "Gamified App" was designed in such a way that a pair will earn rewards based on usage and the average number of steps walked by a beneficiary participant who is a member of the pair. The purpose of rewards was to foster users' intrinsic experiences such as competitiveness and a sense of autonomy which are predictors of intrinsic motivation. Rewards depended on four parameters and these were the number of steps walked by a beneficiary user, the number of days the app has been used by an intermediary to either to record meals or to view feedback on meals, points, steps, gardens, etc.

   Comparison on virtual rewards among intermediaries motivated intermediaries to check the app more often compared to when they were in logbook condition as highlighted on the aforementioned usage findings (sub section 7.3.1). Intermediaries were competing which other on the leader board and they talked about their

points whenever they meet face to face.

> *"He [Leon (her 15 years old son)] likes this exercise (using the app) because among him and his friends, they would have that competition like 'I got more points than you' and that motivated him to get interested with the app"*
>
> —***Jenner**, a female beneficiary from Athlone, 45 yrs old*

The competition also led intermediaries to work closer with their beneficiaries.

> *"When I see other people trying to come above me [on the leader board]. I hand over the phone to my mom so she can walk more steps."*
>
> —***Kelvin**, a male intermediary from Athlone, 15 yrs old*

> *"I told my mom that me my self I want our team to have the highest points. Yes she said she is going to do that."*
>
> —***Celine**, a female intermediary from Athlone, 16 yrs old*

> *"Sometimes that person may be first so I tell my mom that we must also be at the first place.[She looks at the leader board and she sees so and so is at first place there she talks to her mother that they should also aim for the first position] "*
>
> —***Sophia**, a female intermediary from Athlone, 17 yrs old*

> *"When he [Leon] looked through it [The app] and sees their points, he would say 'Mom, we need to do something here, because look at their points and our points'. So it was quite interesting."*
>
> —***Jenner**, a female beneficiary from Athlone, 45 yrs old*

There was a scenario of one pair of whereby not only the beneficiary was using the pedometer, an intermediary was also taking turns to use the pedometer, therefore they were collaborating in accumulating steps. Both an intermediary user and a beneficiary user had discussions of whether the person whose turn it was had walk enough steps. They did this to accumulate more steps than other pairs. In addition to comparison other intermediary users came to the app to the gamified app to connect to other users.

> *"I ask her how far did you walk? She would say she walked very far. She tells me that I must have the phone to walk more steps. She would say 'I got more more walking than you' [They were collaborating with her mother in accumulating steps]. She sometimes writes the steps on the page and she tells me yesterday I day I had more points than you [points referring to steps]"*
>
> —***Celine**, an intermediary*

Rewards were specific for gamification condition by they appeared to also affected pairs that had started with logbook conditions as some intermediary users were

pushing their beneficiaries to do more by expecting to get rewards once they are switched to gamification condition.

> *"I think we talk more than before the family wellness app. Before the family wellness app, after work it was just "Hi" and then I go to my room but now. But now she would come to my room and say let me see your phone, what did you eat today, and write everything down on the phone. So we are more closer than before because of this. Most of the time she used to say that 'we must win this"'*
>
> —***Kefiloe**, a female beneficiary from Langa, 26 years old*

3. **Requests from beneficiary users**: There were times where intermediary users engaged with the app only upon receiving requests from beneficiaries. In both absence and presence of gamification, intermediaries had to fulfil requests from beneficiaries. But during logbook condition, intermediaries appeared to be less enthusiastic in handling those requests. Some beneficiaries complained that there were several incidences of where intermediaries were refusing to fulfil these requests and it happened more often during logbook condition. It was observed that in most of these cases, intermediary participants' autonomy was violated as requests came at times where intermediary participants were either studying for exams or doing something else and they felt it was not the right time to fulfil those requests. This made some of the intermediary participants to feel that their parents were nagging them. For instance, **Lunga**, a male intermediary participant from Langa, aged 17 years, felt annoyed when his mother insisted they should enter the family wellness app while he was busy using social media through the intervention's phone. This happened during logbook condition. Also a similar situation happened to **Jennifer**, female intermediary participants from Athlone, aged 18 years who also felt irritated by her mother's constant requests during logbook condition. In addition she felt the app was not that exciting as she said "*The app was okay first but it started to get boring. You don't want to go into it any more. I think there will be some excitement now if the game comes in. When do we get the game*". She was curious to know when they will be switched to gamification because she thought the logbook condition was boring.

   Interest of intermediaries or pairs in general varied as some exhibited interests on interacting with others through the app while others where focused on achievements (i.e. dominating others in competitions). Gamification appeared to be the

most dominant factor that influenced usage as we have already seen that the frequency of usage showed a higher value in gamification when compared to logbook.

> *"We [with Kelvin] were not talking to others because all we wanted was to win. We didn't want them to know but they could see from the app"*
>
> —***Aziza***

Only two intermediaries had tried to interact with others using social features of the app or comment on rewards from their peers. These are some of the comments that were shared by these participants.

> *"Fish are increasing neh.[He commented this on a fish tank owned by Kelvin and his mother]"*
>
> —***Simon**, a male intermediary from Athlone, 15 yrs old*

> *"Wow it shows that you are working hard Clara#2.[She congratulated a female intermediary called Clara for being on the second position on Fish tanks.]"*
>
> —***Siyamthanda**, a female*

However, not all intermediaries had a positive user experience on utilizing gamification, that is why the average perceived enjoyment appears to be lower for both age groups while in gamification condition compared to the logbook condition (Figure 7.12).

Leader-board can demotivate those users that are at the bottom but it can foster aspects of relatedness for all users (Sailer et al., 2013). In this case there were users who never made any advancement in badges hence they appeared at the bottom of the leader board. Some participants it was due to technical problems as reported on Table 7.1. But there few exceptions of which two users had no technical problems but never had any advancement in badges despite their efforts in using the gamified system more than the logbook condition as shown on Figure 7.13. One user was from the 'LG' group (Keller), while the other one was from the 'GL' group (Leon). Their beneficiary participants were not walking enough steps despite the fact that these two intermediaries had put more efforts in using the app during gamification condition than in logbook condition.

Badges were earned in combination of both the app usage and average number of steps walked by a beneficiary user. One beneficiary who was working with one of these intermediary users also reported in interviews that there was always a contention with her intermediary when this beneficiary wanted to see what was going in the app as the intermediary was not voluntarily willing to help some of the time. It is hypothesized that this could be one of the factors that played a role in demotivating some participants

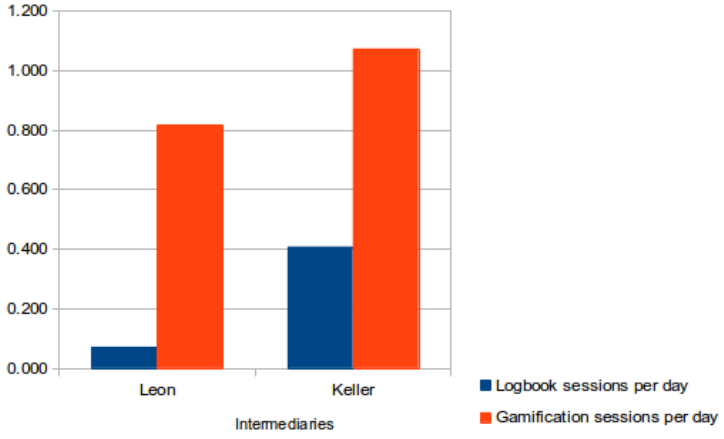

FIGURE 7.13: Logbook Vs Gamification for two users that had no technical problems but never had any badge advancement.

during gamification condition. There were also cases of where intermediaries doubted the credibility of the system because their peers appeared to be more engaged with the app, but were at lower positions on the leader board.

> *"It [The experience in using the gamified app] was the same as last time (during logbook condition) except for the game part. I was actually above some of the others. That was weird. Because they were more interested in the app than me."*
>
> —***Akhona**, a female intermediary from Langa, 16 yrs old*

On the aforementioned excerpt, *Akhona* was referring to the two intermediaries from pairs C , and D that had usage problem (Table 7.1) as these two users used the app more in logbook condition, therefore, Akhona's anticipation was that they would be more competent than her but surprisingly she was ahead of them. Therefore, even in perceived competence Akhona reported lower score in gamification compared to logbook despite using gamification for 7 out of 14 days and logbook for only 4 out of 27 days.

Therefore, in comparing the support for the three basic psychological needs, pairs that never had any advancement in badges were not considered on aspects of perceived competence and autonomy since majority of them appeared to have a lower perceived enjoyment in gamification when compared to logbook. Autonomy and competence are major predictors of perceived enjoyment. An assumption was that a negative experience was the result of failure of the gamification design to match challenges with abilities. i.e. efforts of beneficiaries differed hence challenges should have matched with individual abilities of beneficiaries within pairs. When challenges are too difficult as they don't match users' skills, end users can become demotivated (Zhang, 2008). In addition, some

of those that had technical problems, their problems were so severe to the extent that they were unable to participate fairly in gamification condition. A total of five intermediary users never had any advancement in badges, therefore, they were excluded in the analysis of motivation of which three are from those that had technical problems (Pairs A, C and D on Table) and two, they had dome more efforts in using the gamified system but there less steps detected from their beneficiaries. As result only nine intermediary users were considered in the perceived competence, and perceived autonomy.

On the aspect of relatedness, all intermediaries were considered because all of them had directly or indirectly use at least one of relatedness features such as receiving SMS showing which teams have advanced in badges, viewing a leader board that shows teams' points, viewing gardens or tanks of different people, and display of badges from each team. These are some of mechanisms to support an aspect of relatedness(Sailer et al., 2013). But in additional, there are intermediary users who knew each other before, and they talked about thinks on the app such as steps comparisons. However there are this that interfered with experiments.

The findings (Table 7.5) indicate that perceived competence of intermediaries in using the "Family Wellness App" was significantly higher in the gamified condition than in the logbook condition in the nine intermediaries that were analysed. Perceived autonomy and perceived relatedness were all not different between gamification condition and logbook condition. When I compared perceived autonomy during phase 1 of experiments (at midline point) and during phase 2 of experiments (endline), thehttp://www.kat.ph/ perceived autonomy was significantly higher at midline (M=4.44; S.D=0.93) than at endline (M=3.89; S.D=0.76), (t(8)= 2.5298; p=0.0353; 95% CI= 0.049 to 1.062). Several reasons contributed to this, and these include (1)the learning effect as users became used to the application and the whole exercise was not exciting any more, and (2) most intermediaries were writing exams, and felt that they had no time to do the app, although their beneficiaries kept on pushing them to do the app.

TABLE 7.5: Comparison of ten intermediaries' scores on sub-scales of competence, autonomy, enjoyment, and relatedness in using the "Family Wellness App

Mean	Logbook App	Gamified App
Perceived competence	M=5.42; SD=0.88	M=6.03; SD=0.65
	t(8)=3.1418; p=0.0138 ; 95% CI= -1.0712 to -0.1643	
Perceived autonomy	M=4.0; SD=0.92	M=4.33; SD=0.84
	t(8)= 1.2344; p= 0.2521; 95% CI= -0.956 to 0.289	
Perceived relatedness	M=4.20; SD=0.59	M=4.5; SD=1.04
	t(13)= 1.5046; p=0.1563; 95% CI= -0.725 to 0.13	

7.3.3 User Experience of Beneficiaries

As most beneficiaries only interfaced with the app through intermediary users, beneficiaries' user experience relied on cooperation they got from intermediaries. On support for the three basic psychological needs, there was no difference between logbook and gamification. However, aspects of relatedness (N=14) appeared to improve significantly with time when compared between midline (M=4.43; S.D=0.92) and endline (M=5.38; S.D=1.08) with (t(13)= 2.3736; p= 0.0337; 95 % CI=-1.819 to -0.0855). Therefore, the intervention in general made beneficiaries felt more closer at end-line.

On utilizing the app through intermediaries, there are cases where beneficiaries had a negative experience as result of intermediaries refusing to assist upon being given requests. This happened in cases of where intermediary users didn't feel like helping because of being occupies by other tasks such as reading for exams or because they felt the app was boring especially in logbook condition. Younger beneficiaries had a tendency of being keen to compete with others. But for older intermediaries, interests what happening in gamification In addition to that, from Figure 7.9, a combination of younger intermediary and beneficiary users had more sessions in average and this is because gamification influenced younger intermediary users to use the app, while it also influenced younger beneficiaries to pass their requests to their respective intermediaries more often. For instance in interviewing one pair that consisted of a younger intermediary and beneficiary users, this pair had highest number of sessions in gamification. In the course of using the app they both exhibited playfulness behaviours in engaging with gamification of whereby they discussed strategies about beating other teams. So every time a beneficiary user from this pair would request her intermediary to open the app so that she can see if they are ahead of other teams.

In the next sub-section, the IMIs in self-monitoring of diet and activity are reported. Four pairs with usage problems (Table 7.1) were excluded.

7.3.3.1 IMI in Self-Monitoring of Diet

The results on self-monitoring of diet (baseline, midline, and endline) are shown on Table 7.6. The Mauchly's test indicated that the assumption of sphericity was not violated with $\chi^2(2)$=3.76, p=0.152. The results (N=10) on "Self-monitoring of Diet" shown on Table 7.6 were from "Sphericity Assumed" output. ANOVA showed that there was a significant difference of average IMI scores on self-monitoring of diet measured at baseline, midline and endline. A finding from a pairwise comparisons (a paired student t-test) indicated that the IMI score at endline was significantly higher than at baseline

TABLE 7.6: Comparison of ten beneficiaries' IMI scores in self-monitoring of diet at baseline, midline and endline

Mean IMI Score	Baseline	Midline	Endline
Self-monitoring of Diet	M=4.48; SD=1.24	M=5.07; SD=1.19;	M=5.55; SD=0.95
	F(2,18)=3.787; p=0.042		

(Table 7.7). There was no significant difference on baseline versus midline and midline versus endline (Tables 7.8, and 7.9). Motivation to self-monitor diet appeared to increase with time as shown on Figure 7.14. The interpretation of the above findings are that the wellness app appeared to had a significant effect of time on motivation of beneficiaries to self-monitor their diet.

TABLE 7.7: Pairwise comparisons of IMI scores in self-monitoring of diet: Baseline versus Midline

Mean	Baseline	Midline
IMI Score	M=4.48; SD=1.24	M=5.07; SD=1.19
	t(9)=-1.298; p=0.227 ; 95% CI= -1.621 to 0.439	

TABLE 7.8: Pairwise comparisons of IMI scores in self-monitoring of diet: Baseline versus Endline

Mean	Baseline	Endline
IMI Score	M=4.48; SD=1.24	M=5.55; SD=0.95
	t(9)=-2.457; p=0.036 ; 95% CI= -2.06083 to -0.08517	

TABLE 7.9: Pairwise comparisons of IMI scores in self-monitoring of diet: Midline versus Endline

Mean	Midline	Endline
IMI Score	M=5.07; SD=1.19	M=5.55; SD=0.95
	t(9)=-1.975; p=0.08 ; 95% CI= -1.0342 to 0.07017	

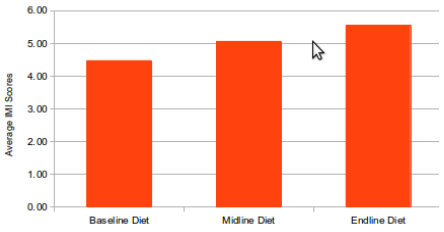

FIGURE 7.14: Trend on Average IMI Scores of Self-Monitoring of Diet at Baseline, Midline, and Endline.

The aforementioned ANOVA finding on comparison among baseline, midline, and end-line doesn't discern between different experimental conditions of which pairs of users were exposed to. The ANOVA finding (N=10)(Table 7.10) on the comparison of IMI scores to self-monitor diet, among baseline, logbook, and gamification conditions showed that there was no significant difference of average IMI scores on self-monitoring of diet measured during baseline, logbook and gamification conditions. This finding is from the "Sphericity Assumed" output of the ANOVA test since the Mauchly's test indicated that the assumption of sphericity was not violated with $\chi^2(2)=2.19$, p=0.335. The trend on averages shows both logbook and gamification to be slightly higher than baseline as shown on Figure 7.15. The conclusion from this finding is that both versions of the prototype have shown an indication of increasing motivation of beneficiaries to self-monitor diet.

TABLE 7.10: Comparison of ten beneficiaries' IMI scores in self-monitoring of diet at baseline, after logbook, and after gamification conditions

Mean IMI Score	Baseline	Logbook	Gamification
Self-monitoring of Diet	M=4.48; SD=1.241	M=5.28; SD=1.05	M=5.34; SD=1.16
	F(2,18)=3.787; p=0.087		

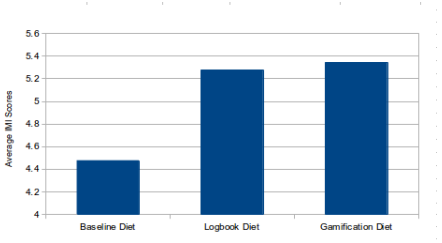

FIGURE 7.15: Trend on Average IMI Scores of Self-Monitoring of Diet at Baseline, Logbook, and Gamification.

7.3.3.2 IMI in Self-Monitoring of Activity

The results (N=9) on self-monitoring of activity are shown on Table 7.11. The results are based on a sample of nine beneficiary users as one participant didn't complete this part of the questionnaire at baseline. The Mauchly's test indicated that the assumption of sphericity was violated with $\chi^2(2)=8.248$, p=0.016. The value ϵ on Greenhouse Geisser was "<0.75", therefore, the results on "Self-monitoring of Diet" shown on Table 7.11 were selected from "Greenhouse-Geisser" output. ANOVA showed that there was no significant difference of average IMI scores on self-monitoring of activity measured at

baseline, midline and endline. The trend of means appears to increase from baseline to endline as shown on Figure 7.16.

There are several factors that could have contributed to results not being significant among baseline, midline,endline points,. The first hypothesized reason is tracking of physical activity appeared to be easy in majority of the participants even without tracking devices as people can estimate the distance they walk daily and they consider this as tracking even though they might have means to record this information, hence their motivation was high at baseline unlike diet self-monitoring which they consider it to be cumbersome due to external barriers such as health food being expensive, therefore at baseline participants felt more motivated to track their activity. The second hypothesized reason is that the sample size was small hence there was a smaller power in detecting significant difference. But we have seen that the trend in motivation increases with time.

TABLE 7.11: Comparison of ten beneficiaries' IMI scores in self-monitoring of activity at baseline, midline and endline

Mean IMI Score	Baseline	Midline	Endline
Self-monitoring of activity	M=4.82; SD=1.002	M=5.28; SD=1.003	M=5.41; SD=0.894
	F(1.182, 9.455)=2.936; p=0.116		

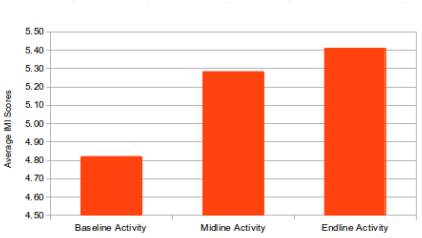

FIGURE 7.16: Trend on Average IMI Scores of Self-Monitoring of Activity at Baseline, Logbook, and Gamification.

The finding from an analysis (N=9) that examined if there is a difference among baseline,logbook, and gamification in self-monitoring of activity, showed that there was no significant difference of average IMI scores on self-monitoring of activity measured at baseline, logbook and gamification (Table table:imiactivity2benf). The Mauchly's test indicated that the assumption of sphericity was violated with $\chi^2(2)=6.788$, p $=0.034$. The value of ϵ on Greenhouse Geisser was "<0.75", therefore, these results on "Self-monitoring of Activity" were selected from "Greenhouse-Geisser" output of oen way with repeated measures ANOVA test. The trend in motivation increases in both logbook and gamification compared to baseline as shown on Figure 7.17

TABLE 7.12: Comparison of ten beneficiaries' IMI scores in self-monitoring of activity at baseline, logbook and gamification

Mean IMI Score	Baseline	Logbook	Gamification
Self-monitoring of activity	M=4.82; SD=1.002	M=5.33; SD=0.9762	M=5.37; SD=0.9276
	F(1.234, 9.872)=2.783; p=0.123		

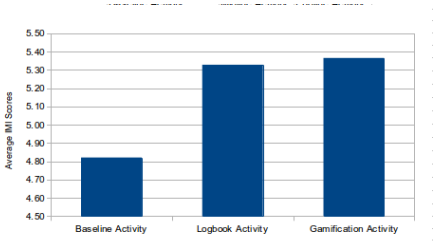

FIGURE 7.17: Trend on Average IMI Scores of Self-Monitoring of Activity at Baseline, Logbook, and Gamification.

7.4 Discussion

In many cases, usage of the app was controlled by intermediaries. Intermediaries engaged with the app mostly because of two factors and these were: either competitions with others or request from their beneficiaries. Beneficiaries interests varied and it was influenced by either one of the following factors or both: (1) leader board; and (2) instrumental value provided by the app. Not all beneficiaries were motivated by gamification. However, gamification was the main source of motivation to intermediaries and it played a pivotal role in mediating usage. Gamification also mediated intermediaries to influence or persuade their beneficiaries. For instance, in one scenario a beneficiary described how serious her son was engaged in competition with others and was always reminding her to carry the pedometer whenever she wants to go out as shown on the following excerpt.

> *"Sometimes may be I forget to take the phone when I go walking and he would ask me 'did you take the phone with you' Ooh Gosh I forgot. Because when I walk to Park Town to exercise and sometimes I am in such a hurry I forget the phone, he will be crossed with me. "*
>
> —***Jenner**, a female beneficiary from Athlone, 45 yrs old*

For intermediaries that started with logbook, majority of those that engaged with logbook many times did with an interest of winning the competition once switched to gamification. Therefore, this affected the separation of experimental as users were aware

that they will be switched to gamification at some point. For the case of perceived competence, the difference between logbook and gamification was statistically significant and intermediary user in gamification felt more competent.Statistical significance in difference was not achieved in cases of autonomy and relatedness due to the learning effect and a smaller sample size.

Apart from gamification, another important source of motivation that can be leveraged is, beneficiaries' phones. Beneficiaries were custodians of intervention's phone. But in many cases when beneficiaries were at home they left the phone with the intermediaries who were interested with social media sites and games. Intermediaries were interested with those phones because of either of the two reasons or both: (1) Interventions phone's were better than intermediaries' phones or intermediaries didn't have smart phones that can enable to access services they desire; and (2) Availability of data bundles in intervention's phones through inserted SIM cards. In these scenarios, some intermediaries were implicitly reciprocating the favours of having freedom to use the phone by serving requests from their beneficiaries. In the context of ICTD, non-prescribed use of devices or other technologies allocated for an intervention is considered to be an aspect of play which is a capability as it fosters motivation to participate in an intervention (Ferreira, 2015). Therefore, one can capitalize on this motivation introduced as the result of sharing phones and it can be viewed as part of motivational affordances to encourage ongoing use of a system through young intermediaries within family settings. Utilization of the motivational effect of the phone in mediating such an intervention depends on interest of beneficiaries on the intervention. Without requests from beneficiaries, and with absence gamification on the app for intermediaries, the phone effect itself cannot mediate usage of the app unless it goes in parallel with those two mediating factors for usage.

Gamification was the most dominating motivational affordance. However, there are some factors that need to be taken into considerations in design of gamification in order to curb negative experiences which appeared to harm intrinsic motivation of some intermediary users. Awarding virtual rewards to intermediary users based on partial efforts from beneficiary participants seemed not to resonate with the notion of matching challenges to skills of the main users. For instance in awarding badges there were two conditions to be met. The first condition was that the app has to be used for a certain minimum number of days as specified by requirements of a specific badge. The second condition was that, an average number of steps that have been walked so far has to be not below a certain threshold for that specified badge. It became impossible for some intermediary users to move from one badge to the next because efforts by beneficiary users differed and this may impacted motivation of intermediary participants and this harmed their intrinsic motivation. When challenges are too difficult as they don't match users' skills, end users can become demotivated (Zhang, 2008).

Another shortcoming observed in the app, is that the gamified system didn't give users much autonomy apart from only configuration of avatars and editing of profiles. For instance, freedom to select the level of gamification appropriate to the skills they possess at a particular moment was not supported in the app. Examples of ways on which autonomy is supported include profiles, avatars, macros,configurable interface, alternative activities, privacy control, etc. (Francisco et al., 2012).

One of the approaches that could be used to minimize the effect of the aforementioned shortcomings is to give users more autonomy to select different levels of gamification they want to participate. There could be levels such as beginners, intermediate, advanced, etc. Pairs that are on the same level could be grouped together and not mixed with pairs with levels that are different. In addition, users could be allowed to select which features they would like to include in their interfaces from a range of features such as chat rooms, leader-boards, botanical gardens etc. More autonomy can also be given in customization of privacy in terms of whether they would like to share their information or not. Customization of avatars is also important because It was observed that most users changed their avatars during gamification and one user explained that she sees the avatar she selected as a representation of herself. Through avatars, these users embodied their identities.

A different approach in increasing engagement of intermediary users is to allow intermediary participants to participate with their information, by incorporating their wellness data i.e. steps. The former can also be combined with the latter. There were some observed scenarios that support the utilization of the latter approach. For instance, there was one pair of whereby not only the beneficiary participant was using the pedometer as an intermediary was also using it. They were taking turns to use the pedometer, therefore, they were collaborating in accumulating steps. This pair had discussions of whether the person whose turn it was had walked enough steps. The goal was to accumulate more steps than other pairs. A similar concept has been explored with participants in a low income neighbourhood in USA , of whereby there is an exergame that encourages cooperation between parents and children (Saksono et al., 2015).

Also another way of increasing engagement is the one reflected by intermediaries who claimed to also be benefiting from nutrition/diet information since the same type of meal is shared at home, therefore, if beneficiary participants ate something that is not healthy while at home then there is a likelihood of an intermediary participant to have eaten the same type of meal too. Also literature suggests that parents who live a healthily lifestyle are likely to also influence their children to live healthily (Grimes et al., 2009). Therefore, by creating a system that allows intermediaries to also benefit from usage one can foster internalization through identified and integrated regulations which are

somehow close to intrinsic motivation as these intermediaries are going to put more value to the system because of its perceived benefits.

Chapter 8

Overall Discussion

The main research questions were centred around factors that may affect utilization of a personal health informatics through intermediaries, and also the effectiveness of gamification in increasing engagement of intermediaries. The most prominent factors are social relationships, support for the two sets of users to achieve an optimal flow, and different requirements for motivation strategies for users from each set. On the effectiveness of gamification, it has demonstrated a potential too increase frequency of usage through intermediaries even though it has some challenges and limitation that need to be addressed.

In this chapter, the focus of discussion is on design considerations for the overall intervention. These design considerations include some of the aforementioned social factors that may contribute to the success of the intervention, and approaches that can be utilized in order to keep both intermediaries and beneficiaries engaged with a personal health informatics system.

8.1 Leverage Family Settings

Informative evaluations revealed that involving children who are family members is the key to success of this intervention. This idea of collaborative interfaces for health information within family settings has been explored in computer supported collaborative work (CSCW) literature. Colineau and Paris (2011) designed a system to support a family to select a collective health goal and receive feedbacks that entailed comparisons between families. Their system was found to encourage members from within a family or members of different families, to work together and in particular to help each other in finding ways to live a healthily lifestyle.

Family settings provide an idyllic opportunity for members to discuss healthy issues collaboratively. Collaboration between a parent and a child or close family members had a positive impact on child's perception as some intermediaries shared testimonies about their habituation of skills on eating healthy. In addition, intermediaries in some cases logged their data about meals because what they ate was not different from what had been eaten by their respective beneficiaries. A study by Grimes et al. (2009) identified four key areas of consideration in which sharing of, and reflection on, health information can be leveraged within family context as follows: (1) overlaps of routines between family members through shared meals, space, etc which can provide opportunities for collaborative data logging and reflection among family members; (2) sharing is done at the expense of balancing competing values of openness, caring, and modelling with the value of protection; (3) understanding of sensitivity on comparisons and competition based upon health information in the context of the family as it may have negative consequences; and (4) collaborative sharing of, reflecting on, health information can also foster family's bond. In the context of this research, it was evident that the app had increased the bond between participating family members as majority of them claimed that were interacting more often. This is also demonstrated by playfulness behaviours that were exhibited in the process of sharing information as it was shown in one of the excerpt in chapter 6 (Evaluation of Prototype II):

> *' When she got time, when she is done with her homework she comes and sees the app. And then laughs at me like 'Yo yo yo [An interjection for Xhosa speakers to express the feeling of amazement by something] you can walk yo yo yo', like 'you walked a lot today' and what what [She was implying to other words said by Lindiwe]"*
>
> —***Zandiwe**, a beneficiary*

In existing work from computer supported collaborative work it appears the emphasis is on parents trying to model health behaviors of their children. For a instance in a study by Saksono et al. (2015), a collaborative exergame was developed in order to support both parents and kids to exercise together. Although their goal was to help kids learn from their parents, the collaborative environment was beneficial to both parents and children.

In our case it was peculiar that children were attempting to nudge their parents to live healthily. Therefore, it not only about the parent guiding the child also the child can become a facilitator for guiding the parent about health choices. This was mediated by an existing familial relationship.

Therefore, this work continues to emphasize on the value of familiar relationships in making the collaboration more interesting. Some playful visualization techniques can

make the collaboration between two users more enjoyable. In the next section, ways on which one could improve engagement of both sets of users are discussed.

8.2 Sustaining Engagement

In order to enhance user experience, support for factors such as task mastery, support for reflection, enhancement of collaboration within a family (intra-families), or inter-families collaboration are emphasized.

8.2.1 Support for Task Mastery Features

In this work, it was clear that gamification promoted collaboration between participating pairs that had a prior social rapport. In addition, gamification in particular social comparison and competitions, both the one socially construed by users, and the one implemented as an intentional design goal, increase engagement of both intermediary and beneficiary users.

However, researchers have highlighted that if social comparisons and competitions in health settings is not carefully examined it can lead to negative consequences (Grimes et al., 2009). There is an emphasis on supporting challenges on the level of "*task mastery climate*" rather than on competition that has "*ego involved climate*" as the former foster intrinsic motivation while the latter can harm it (Saksono et al., 2015). When "ego is involved", participants may do things just to maintain their self-worth, and this is equivalent to introjected regulation as postulated by organismic integration theory of SDT(Ryan and Deci, 2000b). In introjected regulation individuals don't see a value in regulating a behaviour rather they perform it merely for the purpose of outdoing others or maintaining their social status. For instance, the idea of having a leader board in this intervention encourages competition and it affected motivation of intermediary users who didn't do so well. Features such as fish tank and botanical garden appear to promote task mastery. For instance in one scenario reported in chapter 6 (Evaluation of Prototype II), a beneficiary user was dissatisfied by the look of their garden.

> *"Nokhanyo saw the garden. The first day she saw just the house and brownish. She is like 'What is this'. I told her. She said 'Aha! [Expressing dissatisfaction]. It must look green and healthy'. And then she saw the garden again and said 'It is looking good."'*
>
> —***Lulama**, an intermediary*

This important finding suggest that such features can encourage task mastery climate.

If designers have to use a leaderboard, they need to be cautionary of negative impacts on users' competence despite its ability to foster relatedness (Sailer et al., 2013). Leader board can also result into an extreme competition between intermediaries which can result into a negative impact on a relationship by an intermediaries in cases where an intermediaries feel of being let down by their beneficiaries. Such a scenario is exhibited in the following excerpt on chapter 7 (Summative Evaluation)

> *"Sometimes may be I forget to take the phone when I go walking and he would ask me 'did you take the phone with you' Ooh Gosh I forgot. Because when I walk to Park Town to exercise and sometimes I am in such a hurry I forget the phone, he will be crossed with me."*
>
> —***Jenner**, a female beneficiary from Athlone, 45 yrs old*

In the aforementioned case, an intermediary got angry because of her mother tendency of forgetting to take the pedometer (phone) when she goes out for walking. Therefore this highlights the importance of paying more attention should on features that support task mastery climate.

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