A Family Health App: Engaging Children to Manage Wellness of Adults

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ABSTRACT

The pandemic of lifestyle-related chronic diseases has led to an advent of personal health informatics, with the goal of persuading individuals to adopt healthful lifestyles. Such systems implement various motivational strategies to promote ongoing use. Existing initiatives to design such systems focus on engaging only the beneficiary of information derived from those systems. In this study, we explored how one can use gamification to motivate ongoing usage of such systems in the context of intermediated technology use. We studied the effect of gamification in motivating young family members to assist adults who might be less conversant or intimidated with such a technology. We compared two designs of a mobile wellness application of which one prototype is gamified and the other one is not gamified. Our findings suggest that virtual rewards can enhance usage of such systems through intermediary users. We highlight some of the challenges and design implications in order to foster engagement in using such a system.

CCS Concepts

•**General and reference** → **General conference proceedings;** •**Human-centered computing** → *Empirical studies in HCI;* •**Social and professional topics** → User characteristics;

Keywords

HCI4D,ICTD, intermediated interactions, persuasive technologies, gamification, personal informatics, motivational affordances, health

1. INTRODUCTION

Lifestyle-related diseases are now attracting many players seeking to design low cost and tailored information and communications technology (ICT)- based systems for supporting lifestyle change and disease management[1], with most recent development focusing on development of persuasive technologies. A recent systematic review on persuasive technologies that included 95 studies suggested that these systems have a capability to persuade because their design include implementation of persuasion stimuli [18].

Persuasive technologies include quantified self-tools which are referred to as personal informatics systems. These systems are interactive applications that support users to become more aware of self-behaviours, by providing means to collect personal data, as well as tools for its review or analysis [27, 29]. An implementation of persuasion stimuli in a typical personal informatics system relies on supporting reflective learning/self-reflection [28]. Reflective learning entails reviewing of collected personal data to learn about oneself and the end user alternates between two phases known as discovery of a behaviour pattern (data collection over a period of time) and maintenance of a better behaviour (through feedbacks) [28]. Feedback mechanisms are usually presented in form of visualizations such as bar charts or other affective mechanisms such as gardens that represent steps walked (i.e Ubifit[22]). The aforementioned techniques can further be supplemented with social comparison[36] or competitions with others[5] in some systems.

However, utilization of such systems may be constrained to specific demographics such as young or experienced users of technology. For instance, one study evaluated two of the popular fitness apps, Nike+ and RunKeeper, and concluded that the two apps are not ready to accommodate older adults needs [49]. In addition to that, in developing countries there are scenarios of intermediated technology use for users who are excluded because social structures, and inexperience or intimidated by technology [47, 24]. Many of the existing apps are designed to accommodate only direct users of technology [47]. Therefore, in personal health informatics, features that foster ongoing use are targeted towards beneficiaries of the information processed by the app. But in the context of intermediated technology use, there is an intermediary user who is there to facilitate information access to a beneficiary user, hence that facilitator needs to also be accommodated when designing to support ongoing use of a personal health informatics system.

In our work, we merge the idea of intermediated technology use into personal health informatics. For instance, instead of just involving only an adult beneficiary user in interacting with a system, we bring young family members to be-

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come part of an interaction process and apply gamification to foster an ongoing use. We report on the outcome of using gamification and how different it is in comparison to involving intermediary users without gamification. We also propose approaches that can enhance the impact of such an intervention.

2. RELATED WORK

Gamification is an idyllic motivational strategy for engaging users with persuasive technologies because of its ability to trigger intrinsic experiences [18]. Gamification borrows game design elements such as avatars, points, leader-boards, badges, etc into non-game contexts [12]. It brings together the "*motivation pull from video games* [45]". Gamification has been found to have a potential to address motivational mechanisms and thereby fosters motivation [46]. The motivational factors of gamification are explained using a self-determination theory[9].

2.1 Overview of Self-Determination Theory

Self-determination theory (SDT) is a well established theory of motivation that explains why people choose to engage or disengage on various activities. The choice depends on social conditions of which people develop and function, of whereby these conditions mediate of whether people will become interested with certain activities or lose interest on those activities. SDT research has been focusing on social conditions that positively or negatively affect the natural process of motivation, and health psychological development [44]. SDT postulates the extent to which a behaviour is internally self-regulated and how one can apply external rewards to increase internal self-regulation of a behaviour [44]. This process of transmuting an externally rewarded activity to intrinsically motivated activity is called internalization. Since behaviours can be influenced by social conditions, then it means at one point a behaviour that was once externally motivated can become internalized.

An assumption from SDT is that people have tendencies of naturally being motivated by integrating their social and physical world to self-regulation of behaviours [25]. Underlying the core of SDT, there are two sub-theories namely cognitive evaluation theory and organismic integration theory [44]. The former explains about social factors that drive intrinsic motivation of a behaviour. The latter focuses on external factors that can harm or foster intrinsic motivation. Within the cognitive evaluation theory, SDT suggests the basic psychological needs for a behaviour to become intrinsically motivated and these are (1) autonomy; (2) competence; and (3) relatedness [9].

The following explanation of the three basic psychological need is based on these sources ([9, 44, 25]). Autonomy is freedom to self-initiate and regulate a behaviour. Autonomy emphasizes on the importance of individual's ability to choose their own way of presenting oneself without peer pressure. With autonomy people can uniquely choose an identify to represent oneself. Autonomy gives individuals 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 an opportunity to sharpen their skills in order to match those challenges. This process is appropriate for ones' health psychological development and overall well-being [54]. Relatedness is the desire by individuals to feel a sense of belongingness. People like to be connected to others.

SDT emphasizes that external rewards that support the three aforementioned basic psychological needs can foster internalization of a behaviour, however, there is a caveat on introducing external rewards to an already intrinsically motivated behaviour because external rewards can harm intrinsic motivation [44].

Organismic integration theory explains the process of internalizing a behaviour through external rewards. External rewards can result into four classes of internalization, *external, introjected, identified, and integrated regulations* [44, 25]. In an external regulation, the causality of regulation of behaviour is coming from outside. This can be monetary rewards or other forms of rewards, while,in an introjected regulation, individuals self-regulate a behaviour but they don't fully integrate it as their own therefore it continues to be influenced by the need to maintain self-worth by seeking approval from peers.[25]. In identified regulations, individuals have accepted a behaviour and its regulation by putting value to a behaviour, while in integrated regulation, a behaviour is fully integrated on ones sense of values and needs [25]. Identified and integrated regulation are more close to intrinsic motivation and can have lasting effects compared to external and introjected regulations [43].

SDT is very powerful as it can explain motivational factors from myriad of domains such as gaming[45], physical activity[41], tobacco cessation[52], energy saving [50], etc. In the next sub-section it is explained how SDT fits within user experience and its relation to gamification.

2.2 SDT in User Experience and Gamification

One study emphasized on the importance of fulfilling six of the ten human needs such as, autonomy, relatedness, competence, stimulation, influence, and security when using interactive products and media in order to improve user experience [51]. The first three human needs are the core to self-determination theory. Partala and Kallinen [39] evaluated most satisfying and unsatisfying user experiences in terms of experienced emotions, psychological needs (from SDT), and contextual factors and found out that the feeling of autonomy and competence to be the most satisfying user experiences, and these two were never reported in the category of unsatisfying experiences [39].

The idea of user experience expands to motivational affordances to use ICTs. Zhang et al.[54] suggested a list of motivational affordances that could be implemented in a system in order to foster its usage such as: (1) the system should afford self-identity and autonomy;(2) the system should support provision of challenges/competitions; (3)the system should allow users to relate to each other; etc.

Sailer et al.[46] explored the motivation mechanism of game elements from self determination perspective and provided the following examples of matching game elements to motivation mechanisms; for instance badges can foster the players feel of competence, while a leader board can foster the feelings of social relatedness as it puts emphasis on collaboration among members of different teams.

Different gamification theoretical frameworks for user engagement have been developed with an inspiration from SDT. Majority of these frameworks explain how the concept of motivational affordances to use ICTs can be laveraged through gamification. Deterding [11] developed a conceptual model for situated motivational affordances of game elements that

was inspired by SDT. Nicholson [34] proposed a framework for meaningful gamification and emphasized on integration of these four core concepts through user centred design; (1) organismic integration theory (sub theory of SDT); (2) situational relevance and situated motivational affordance; (2) universal design for learning; (3) player generated content. The aforementioned initiatives suggest the potential of gamification in assimilating the core constructs of SDT to enhance user experience.

Deterding et al. [12] situated work in gamification relative to similar initiatives in HCI and game studies which go back as far as early 1980s. Their work suggested that gamification brings gameful experiences and whereby gamification can be viewed as a game depending on the context of users and within gamification. They further explained how gamification can result into an experiential "flicker" between gameful, playful, and other modes of experience and engagement. Since the goal of gamification is different from games, recent literature tends to consider gamification more of a user experience rather than a gameful experience[48].

2.3 Characteristics of Gamification Users

Since gamification borrows its design elements from games, it is important to understand types of users in gamification to appropriately tailor a gamification intervention. For instance in online games there are three main components which are of users' interests, achievement, social, and immersion components, and interest in any of these features is determined by demographic information such as age, gender, etc [53]. There are users who are interested with socializing more than anything else, or there will be users who are interested in achievements etc. Orji et al also [37] emphasized tailoring of persuasive games targeting health to gamer type. Another study found out that players/users with high "Game Identity Strength" (GIS)- the degree in which players define gaming as part of the social identity, reported higher competence, autonomy, and relatedness, and in addition these hardcore players reported higher levels of persistence in playing compared to heavy and casual players [33]. In our work we didn't focus much on these aspects of gamer types but we point out some of the findings that exhibit these characteristics of gamer types.

2.4 Personal Health Apps and Gamification

The use of gamification in health and fitness apps is gaining popularity [31]. A recent review on persuasive technologies literature found unprecedented increase in the number of studies with applications that use gamification, and several of these studies targeted health behaviour change [18]. General approaches on how to design such systems have been proposed with ideas coming from both HCI[26] and persuasive technologies fields [15, 36, 35].

The HCI community is focusing more on how to design personal informatics to motivate change in behaviours in areas such as energy saving, health, etc. One of the first gamified personal apps for health to be published in HCI literature is ***"Fish'n'Steps"*** [30]. Within the app there was a fish bowl of whereby a fish gets excited depending on the level of activity of the user. Social cues from the app made its users respond to it as if it was a physical being.

Another app was ***"Ubifit"*** [22]. In this app there was a garden that represents accumulation of physical activity. A garden could consists of flowers of different types which represent various activities such as cardio etc. This information was collected through an activity sensor and transmitted to a mobile phone of where a user would document an exercise type. The garden was being displayed as a screen saver.

Arteaga [2] also presents a mobile persuasive application for to motivate kids with loss weight issues.The application is designed with games that allow users to select the game they want to play according to their personality. Another mHealth diabetes app namely ***"bant"*** that uses gamification incentives showed an improvement in the frequency of blood glucose monitoring in adolescents with type 1 diabetes.

Most of these apps have been implemented with motivational affordances to motivate a beneficiary user (be a teenager or an adult) alone hence it is challenging to motivate ongoing use in the context where a beneficiary user has to to rely on an intermediary user to interact with his/her personal data. The phenomenon of young people providing support to adults on technological related problems is quite prevalent in both HCI and ICTD literature. Factors that influence help-seeking and giving behaviours have been pointed out as group orientations towards tasks, unfamiliarity with technology, social rapport, the sense of being accountable etc.[47, 40, 21, 38]. However the aforementioned literature is limited to general use of technology and it has not focused on specialized technology such as persuasive technologies of which on ongoing use is vital for their intended purpose. Kumar and Anderson [24] have also studied existing information structures for dissemination of mobile content on maternal health to rural women, and emphasized on the role children and youth in facilitating access. However the suggested approach relies solely on tendency of children to feel obliged to care for members of their families or communities. However, in the context of personal informatics, frequency of usage is very dependent on what sort of information is collected. Frequency of usage of personal informatics 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 [13]. Relying solely on innate intrinsic motivation of intermediaries may pose challenge into availability and hence results into intermittent usage which may hinder cognitive flow which is essential for self-reflection. In our previous encounters, we have observed that children have tendency to get annoyed when their parents are too reliant on technology related tasks. This kind of behaviour can introduce negative experience on the side of parents. For instance, in a study by [21] about informal help, parents were sometimes hesitant to seek help from their children to avoid negative experiences, (i.e being bashed for being nagging parent and too reliant). Therefore, due to nature of usage of personal informatics that target health domains (i.e physical activity, diet), it is important of how one can enhance engagement of intermediaries to feel that they are part of the process.

In our work, we designed a system that utilizes gamification to motivate an intermediary and beneficiary users to work together in sustaining ongoing use of a system. The use of gamification has been studied in tasks such as image annotation[32],crowd reporting[6], etc. Gamification has also been explored in the context of education in developing regions [19, 4] but has only seen limited exploration in the context of mobile health for development. However, Dimagi, a company that develops mobile interventions for use by front-line workers, including community health workers, has

recently started exploring the use of gamification to incentivise self-learning on mobile phones[1].
The intermediated information task for health in our context is different as it is more complex than the aforementioned tasks as there may be two users collaborating to engage with a user interface with the goal of one user assisting another user with his/her health information needs. In this context an intermediary user might be a passive user of health information and a beneficiary user is a recipient/beneficiary of health information. This study builds from our previous study [20] which designed a system iteratively and evaluated it with end users to get qualitative feedback. The aforementioned study suggested that a familial relationship is the key to implementations of such interventions. However, this work didn't isolate the effect of gamification from natural tendency of intermediaries to care for the people close to them. We argue that gamification adds value on motivation to use the system beyond existing intrinsic motivation that is built based on existing familial relationships. We extend this work by exploring on the effectiveness of gamification in facilitating usage through intermediary users in such interventions.

3. METHODS

3.1 Participants' Demography

Participants for this study were recruited from low-income suburbs of Langa and Athlone in Cape Town, South Africa. The recruitment was facilitated by one research assistant and her field worker, who were residing in Langa and Athlone respectively. A convenient sampling technique was applied as it was challenging to get participants who were willing to be part of the study for six weeks. The recruitment criteria were: (1) participants should be adults who are willing to commit to this study for six weeks; and (2) each adult participant should be have a partner intermediary, preferably a child of an adult participant. We observed from our previous qualitative study that, when a pair consists of a parent working with his/her child; the child may have a tendency to put more value to an intervention compared to when a a parent and child are not related [20]. Putting value to a behaviour regulation can foster the *identified and integrated regulations* during the process of behaviour internalization as proposed by Ryan and Deci [43]. Rationale for a behaviour regulation is one of the facilitating social factors for its internalization [8].
A total of 14 adult participants with mean age of 44.21 years (S.D of 9.99 years) were recruited. The youngest adult participant was 26 years of age while the oldest was 60 years of age. Thirteen of these adult participants were females. The reason for this gender imbalance was due to the fact that we were used convenient sampling to get participants, hence, women were more easily accessible and eager to participate than men. Also in our previous study[20] we recruited many women and fewer men. Despite this, having more women could help in having a better understanding of intermediated interactions in resource constrained environments. Sambasivan et al[47] pointed out how women in low income communities are likely to face insurmountable barriers that affect direct access to ICTs due to existing social hierarchies hence they are likely to benefit from intermediated interactions. Also a study in India [24] used a feminist reflexivity approach to explore how patriarchal structures and social conventions constrain women in accessing information, and how these women leverage help within communities to navigate their way out. Therefore, having more women in our studies is beneficial towards exploring complex social structures that influence the way technology is being accessed in low income communities. In addition to this, studies have also indicated that in countries such as South Africa, women with low social economic status are more at risk of obesity compared to their counterparts with high social economic status [20]. Hence, women from low income communities are more likely to benefit from an intervention of this type.
The education level of these adult participants was between Grades 7 and 12 (primary and secondary school), implying all of them could read and write. Each adult/beneficiary participant elected one of their children/grand children to work with. The two members formed a pair and were required to work together in using the "Family Health App" to self-monitor the wellness of an adult member of a pair (a beneficiary user). The average age of children/intermediary participants was 15.42 (S.D=2.06) years. The youngest intermediary participant was 12 years of age while the oldest one was 20 years of age. The number of females and males intermediary participants/users were equal. Prior to be part of this study all adult participants signed consent forms and also all children participants signed assent forms which were also signed by their respective adult participants. This is a justification why we selected kids who were family members. Perceived interest/enjoyment in gamification tends to diminish with increasing in age [3] and this suggests that young people are the perfect choice for intermediaries. We limited selection of young intermediary users to family members. We borrow the idea of using family members from a study [20] that revealed the importance familial relationships to the success of such interventions.
We compared two versions of the "Family Health App". The first version of the app was simply a logbook/journal (Figure 1) that allows each pair of users to self-monitor both steps graphs and nutrition components of food consumed by a beneficiary user. The second version consisted of logbook features with an added gamification component (Figure 2). A gamification component consisted of a leader board (points' score board), badges, avatars, message board, activity and usage gardens, and aquarium. The rewards were earned based on efforts in usage of the app, number of recorded meals consumed by a beneficiary user(and what is the percentage of fruits and vegetables in those meals), and number of steps walked by a beneficiary user. For instance number and size of fish might be determined by both usage of the app and a badge of which itself depends on steps. In addition, both versions of the systems implemented SMS reminders and feedbacks. For instance, in gamification children can be reminded that recording more fruits and vegetables from their parents will give a better garden for their pair/team. A full description of a gamified application together with its design process is explained by Katule et al. [20]

3.2 Experiment Design

[1]Bhavsar, M (2014). Dimagi Social Apps. YouTube. Released 30 June 2014. Accessed 9 September 2016. https://www.youtube.com/watch?v=M55aVJkHIco

Figure 1: An example of a meals' pie chart in the logbook app

Figure 2: Examples of badges in a gamified app

The experiment applied a "within-group" design of whereby, the same group of participants were exposed to different experimental conditions in to minimized the effect of confounding variables. In our case, examples of confounding variables that could be controlled with this experiment design are such as: variation in motivation levels of both beneficiaries, and intermediaries; technology operational skills of both beneficiaries , and intermediaries; education level of both beneficiaries; and beneficiaries; and etc. The advantage of using the "within-group" design is that it minimizes the sample size hence cutting down the cost of running experiments, and it also increases the power when using student t test with repeated measures. However by using this design approach another problem is introduced, and that is the learning effect. In order to minimize the impact of the learning effect on any experimental condition, each pair of users was randomly assigned to either one of the two experimental sequences (GL or LG groups). The LG group started with logbook and finished with gamification. The GL group started with gamification and finished with logbook . Each group had 7 pairs of users. In this way the learning effects from the two experimental conditions are expected to cancel each other.

3.3 Data collection and Analysis

Prior to data collection each pair was given an android phone (Samsung GT-S5300) installed with both a native link to a web app and native pedometer app. The phones were supposed to be handled by adults. We allocated 1.3 GB of data to use for 6 weeks. Also,each adult received ZAR 240 (approx. US $20) as a compensation for transport and their time for the duration of the study. The data bundle was also an incentive to both members of a pair as they could use it for other purposes.

The experiment lasted for 6 weeks (October 2015 to November 2015). For the first 4 weeks, the LG and GL groups were in logbook and gamification respectively. After switching, for the last 2 weeks, the LG and GL groups were in gamification and logbook respectively. The explanation of why four weeks in phase 1 and two weeks phase 2 is based on two reasons. Our plan was to divide time equally in three(3) weeks intervals, but phase one had extended to four(4) weeks instead of the three(3) weeks we had initially plan for and this was because we couldn't schedule a midline assessment immediately after the end of the third week since participants were not available hence we extended experimental switching until after the assessment. We also couldn't extend the experimental period in phase two to have the same number of days as phase 1 because it was approaching December and it was going to be tricky to gather participants as some would have travelled for holidays. These are some of the unforeseen challenges that can affect the rigour of a research design in resource-constrained environments. In order to minimize this problem of inequality on our findings, on assessment of usage, we only use a relative amount with respect to the number of days in which participants were given access to a particular experimental condition. This has no effect on either motivation to use any experimental condition since both logbook and gamification were both present in both phases. The effects on motivations due to different durations are expected to cancel each other.

We collected data through a triangulation of usage logs, intrinsic motivation inventory(IMI) questionnaires, and interviews. We developed the IMI questionnaires with guidance of materials found on a "Self-Determination Theory"[2] website which is maintained by researchers working on the theory including Richard Ryan and Edward Deci[10] whom were early pioneers in developing the theory. These questionnaires were pretested in one of our early pilot studies.

A questionnaire of was administered to children and it included sub-scales for the three basic psychological needs, together with perceived enjoyment. Usage was measured by counting the number of sessions from each version of the system. A new session was defined as when an activity has been detected in the absence of any activity in the past one hour or more. We computed the relative number of sessions 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. Therefore, we use number of sessions per day which is obtained using Equation 1. Usage comparison between logbook and gamification excluded four pairs of users because they had various technical problems that hindered their full participation in both experimental conditions. The list of pairs that were excluded and reasons for their exclusion are summarised on Table 1.

$$y = t_{i\,n}/d_{i\,n} \tag{1}$$

where:y is number of sessions per day, $t_{n\,i}$ is total number of sessions for pair "n" in experimental condition "i", and $d_{n\,i}$ is total number of days on which experimental condition "i" was available for pair "n".

4. FINDINGS

4.1 Usage Trend

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

Table 1: Pairs with technical problems

Pair	Group	Problem
Pair A	GL	App not loading
Pair B	GL	Miss-allocation of data bundles.
Pair C	LG.	Pedometer never transmitted data.
Pair D	LG.	Pedometer stopped transmitting data.

The usage of the app in a period of six weeks for all fourteen pairs is shown on Figure 3. During the first few weeks the usage was high as the result of the app being new to most participants. As time went by usage started to drop. Therefore, high usage at the beginning was as the result of the novelty effect. Before the fifth day, fewer people (4 pairs) had tried using the app. Many people who had not used the app started using it on the fifth day, this explained why there is sudden peak on that particular day. Comparison

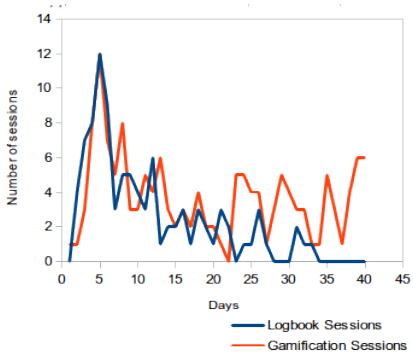

Figure 3: Total daily number of sessions from the two experimental conditions.

of usage between logbook and gamification 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). We used log mean because we transformed the original data to have a normal distribution shape on the differences between number of sessions per day. What this finding suggests is that there was an indication of a significant increase in frequency of daily usage when pairs where in gamification condition.

4.2 User Experience

Most of the time, usage of the app was controlled by intermediaries in proximate enabling and proximate translations[47]. Children proved to be more skilled in cellphones than their parents. Familiarity with different smart-phone based apps indicated that children were significantly familiar with more apps on average compared to their parents. Hence, they didn't face difficulties in familiarizing with interventions' phones. Firstly, we present user experience findings through aspects of mediators to app usage. Secondly and foremost, we present the findings on effectiveness of gamification in supporting the three basic psychological needs of competence, relatedness, and autonomy.

4.2.1 Mediators of App of Utilization

Some of the observed factors in influencing usage were: (1) phone effect; (2) presence of gamification; (3) help-seeking initiated by beneficiaries.

Reciprocation of unlimited access to the phone

A beneficiary user (parent) was a custodian of the intervention phone, meaning the phone was supposed to be carried around by a beneficiary user most of the time. However, the phone exchanged hands between a parent and child. This made some children to utilize these phones for their own needs such social media and games. Children borrowed phones from their parents because: (1) they didn't have phones at all or their phones were limited in functionality; and (2) to utilize available data bundle on phones of which they used it more often compared to their parents.

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

Effect of competition

Intermediaries were competing each other on the leader board and talked about their points whenever they physically met.

> *"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*

In some cases, the competition fostered a close collaboration between intermediaries and beneficiaries. For instance, in some cases intermediaries stated explicit goals of winning against other teams to their team mates (beneficiaries) while in other scenarios, intermediaries attempted to encourage their respective beneficiary participants to do things that are advantageous in winning.

> *"When I see other people trying to come above me [on the leader board]. I hand over the phone to my mum 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*

The notion of competitions also had an effect on intermediary users who were in logbook condition prior to being switched to gamification at a later stage. These users were already aware that they will be switched to gamification at

some point of usage, therefore some of them took an extra initiative to engage with the app during logbook condition with premise that once they are switched to gamification it will give them enough scores to lead in gamification. An example of this situation during logbook is that of "*Siyamthanda*". She emphasized on winning while their pair was still in Logbook condition. This explained by a narration from the beneficiary participant below.

> *"Most of the time she used to say that 'we must win this"'*
>
> —***Kefiloe**, a female beneficiary from Langa, 26 years old*

There was a variation in motivation of intermediary users as some of them exhibited interests on interacting with other users through the app while others were more concerned on dominating others in competitions.

> *"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 use social features on the app in order to interact with others. This entailed commenting on rewards from their peers as highlighted on excerpts below.

> *"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 most conversation happened outside the app context, and therefore the relatedness brought by the app overlapped in between logbook and gamification conditions.
There were incidences of whereby some pairs cheated the rules of gamification in order to win. For instance, in one scenario, there was a pair of a which a mother was working with her daughter. In their case, not only the beneficiary user 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 walked enough steps. They did this to accumulate more steps than other pairs.

> *"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 had more points than you [points referring to steps]"*
>
> —***Celine**, an intermediary*

In the aforementioned scenario of *Celine* and her mother, this pair attempted to violate one of the rules which required only a beneficiary user to carry around the mobile phone that had a pedometer app. This is an example introjected regulation in self-monitoring behaviour of whereby participating members are influenced solely by competition with others.

Requests from beneficiary users

Not all usage of the app was initiated by intermediaries alone. There were instances of whereby intermediary users got into the app after receiving requests from their respective beneficiaries. These requests came through in both experimental conditions (Logbook, and Gamification). Therefore, app usage was also as the result of fulfilling these help-seeking requests but at times they also served as reminders to intermediary users. For instance on the case of *Kelvin* as explained by his mother.

> *"I would remind him. Kelvin did you go to that app really? 'Yes mum I am going to it now'. [This happened during gamification condition]"*
>
> —***Aziza**, a female beneficiary from Athlone, 35 yrs old*

A different way of looking at how gamification fostered a sense of collaboration between intermediary and beneficiary users is through requests by beneficiaries. Request initiated by beneficiaries interested in gamification indicated a sense of collaborative ownership in using the app. For beneficiaries that felt engage with gamification, the way requests were phrased in gamification condition was different from logbook condition. In logbook condition, beneficiary user would use a statement such as "*how am I doing on this?*" while for those beneficiaries that were interested in gamification, a beneficiary user would use a statement such as "*How are we doing on this?*". The former indicates authority by beneficiaries users while the latter indicates a more collaborative approach which is not authoritative and it can promote autonomy of intermediary users.

> *"I would always ask him [Kelvin] where are we. Are we first? And what badge do we have? Where are the others? How far is Simon[Another intermediary] then? How far is that one? 'No mum we are on top. We are first. We are the champions'[This is during gamification condition]"*
>
> —***Aziza**, a beneficiary user*

> *"I always start the conversation. Because I always want to make sure if he records because I can't use it. It was difficult for me to use it.[Authority of beneficiary in logbook condition]"*
>
> —***Samela**, a female beneficiary from Athlone, 43 yrs old*

From the two aforementioned excerpts, it is shown that, one is more inclusive meaning that the request promotes collaboration, while the other one is a directive from a beneficiary user which doesn't consider whether an intermediary user is interested or not. In such directives, some intermediaries felt their autonomy was being violated. For instance, there were requests issued at times when intermediary participants were either studying for end of the year exams or engaging in a different task. In such cases, intermediaries felt it was not the right time to fulfil those requests as they were interrupting tasks that that were considered to be important (with higher priority) or more interesting. In such situations, intermediary participants felt that their parents were nagging them. For instance, in a scenario of an intermediary participant in logbook condition, **Lunga**, a male aged 17 years from Langa, felt annoyed when his mother insisted

they should get into the family wellness app while he was busy using social media through the intervention's phone. Another 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. She also felt the app was not that exciting as she said "*The app was okay at 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.

4.2.2 SDT Support for Intermediaries

Despite higher frequency of usage in gamification condition reported above, the trend on average perceived enjoyment in logbook condition appears to be higher than in gamification condition for both age groups (age >= median(15.5) or <15.5) (Figure 4). The reason behind this trend is that not all intermediary participants had a positive user experience on utilizing gamification. We observed two factors that contributed to this. The first factor is that there were pairs that had usage problems as we have seen on Table 1 above. Among those four pairs, the user experience was severely bad in the intermediary users from pairs "A" and, "C".
For pair A, the app demotivated the intermediary because it was not stable and it was always failing to load and resulted into termination of usage after two days.
For pair C, the pedometer never transmitted a single reading to the server but this pair continued to use the app throughout the logbook condition. An intermediary user from this pair was close to an intermediary from pair D which also experienced problems with pedometer but not so severe like for Pair C. Therefore, an intermediary user from pair C continued use the app although the steps never got transmitted to the server because of direct steps comparison. Steps for pair C could still be viewed directly from a native pedometer app as raw numbers. The two intermediary participants from pairs C, D shared their progress about steps walked by their respective beneficiary users whenever they met. This explained why the pedometer problem didn't affect the usage of the app by the intermediary user from pair C while in logbook condition. After pair C was switched to gamification, the inability of the pedometer to transmit steps to the server resulted to a negative user experience to the intermediary user from this pair. This also happened to pair D but it didn't affect much the motivation of this intermediary user as the pedometer was working until one week before switching of experimental conditions. Steps played a role in achievement of rewards. Intermediary user from pair C had done a lot of efforts with expectations that their pair will be rewarded once switched to gamification condition. This finding about expectations was shared by another intermediary user from pair E who was living close to the two intermediaries from pairs C and D. She was concerned about the gamification system as she worried that the system was not fair because her peers had done more efforts compared to her but she was ahead of them and she didn't understand why was it the case. She was referring to what she had observed during logbook condition, therefore she was expecting the efforts of her peers to transmute into rewards after they were both switched to gamification condition. As the result the problems on pairs C, D had a multiplier effect on the perceived enjoyment of this intermediary user from pair E hence her motivation to use the gamified app and this affected her trust on the credibility of the gamified system.

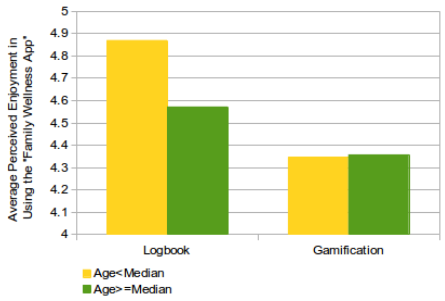

Figure 4: Intermediaries' average perceived enjoyment in using the app versus age group (Logbook and Gamification).

Gamification condition didn't harm motivation of only intermediary users with severe usability problems (from pairs A, C) as there was also another scenario on two other intermediary users from **Pairs F**, and **D**. These users had used the app more often while in gamification compared to when they were in logbook but had both reported lower scores in competence when they were in gamification compared to when they were in logbook. Upon reviewing their performance on gamification, it was observed that these two users never attained any advancement in badges despite their efforts during gamification. The reason for this is that their beneficiary users were not walking enough steps. As badges were earned in combination of both the app usage and average number of steps walked by a beneficiary user, then the absence of rewards harmed their enjoyment to use the gamified app. We attribute this negative experience to failure of our gamification system to match challenges with abilities as efforts of beneficiaries differed hence challenges didn't match with individual intermediaries' abilities. In addition, also a Leader-board can play a role in demotivating those users that are at the bottom but it can foster aspects of relatedness for all users [46].

Table 2: Comparison of 10 intermediaries' scores on sub-scales of perceived competence (PC), perceived autonomy (PA), and perceived relatedness (PR) in using the "Family Health App

Mean	Logbook	Gamification
PC	M=5.23; SD=1.02	M=5.96; SD=0.66
	t(9)=-3.495; p=0.0068 ; 95% CI= -1.204 to -0.258	
PA	M=3.95; SD=0.86	M=3.96; SD=0.94
	t(9)= -0.027; p= 0.98; 95% CI= -0.596 to 0.582	
PR	M=4.22; SD=0.63	M=4.37; SD=0.9
	t(9)= -0.719; p=0.49; 95% CI= -0.622 to 0.322	

We then compared the ability of the two versions of the app to afford the three basic psychological needs. In this comparison, we excluded pairs A, C, F, and G due the reasons we have stated above. The results for this comparison is

shown on Table 2. Perceived competence of intermediaries in using the "Family Health App" was significantly higher in the gamified condition than in the logbook condition. This means a gamified system gave intermediary users challenges and these challenges motivated an increase in frequency of using the app. There were no significant differences on both perceived autonomy and relatedness.

4.2.3 Unintended Internalization of Self-Monitoring Habits

As the result of helping, there were some intermediaries who perceived benefits as an unintended effect. These intermediaries believed that the app had also helped them in eating healthy. Therefore, these individuals had put value in self-monitoring beyond just helping their parents to live healthy.

> *"The app was very useful and very convenient. In many ways it helped me. It shows me what I was eating and that. The information I was putting on the phone it was mostly hers. But we eat the same food and the same amount of food"*
>
> —***Kelvin**, an intermediary*

Although there was some perceived value in self-monitoring of behaviour, regulation was not fully integrated as it still relied on external rewards. For instance, Kelvin, an intermediary user together with his mother engaged with the app more often during gamification but their usage dropped in logbook condition despite the fact that Kelvin appreciated the app to also be helping him in eating healthy. Therefore, this form of internalization can be can categorized on identified regulation as the behaviour is perceived as valuable but it is not fully integrated with individuals core beliefs and values.

5. DISCUSSION

Existing literature on utilization of young people in families and communities for dissemination of health information doesn't consider of ways on which these intermediaries could be engaged in order to enhance participation beyond reliance on natural tendencies of caring for their families or community members. Our approach brings the element of gamification which is considered as adding user experience in order to increase engagement of intermediaries in the task of self-monitoring. We compared a self-monitoring app supported with gamification and without gamification to understand if gamification increases engagement of intermediaries. Since the same group of intermediary users used both version of the system, the variation in innate motivation as result of caring will have the same effect in gamification and logbook conditions.

In the next subsections, mediators of usage such as availability of phones, the novelty effect, requests by beneficiaries, and gamification are discussed . In addition, also strength and weakness of gamification are discussed relative to our context of intermediary users.

Availability of intervention's phones to intermediaries

In our previous study, beneficiaries who had no parent to child relationship dominated use of the intervention phone even in cases of familial relationships such as auntie and niece, and these beneficiaries handed over phones to intermediaries only in cases were help was needed [20].

In this study, all relationships between intermediaries and beneficiaries were parent-child bonds, hence, it was easier for majority of the parents to trust their kids with their intervention's cellphone. The phenomenon of sharing phones had an effect on mediating negotiation for interaction initiated by beneficiaries. Some of the parents were lending their intervention's phones to their kids to access social media sites and games. In return, intermediaries (children) fulfilled requests from their beneficiaries (parents).

A phone served as a catalyst for existing relationship between a parent and child. Having access to a phone while providing help to beneficiary participants can be viewed as an act of reciprocation of benefits. Some intermediary participants had installed games,and other apps on intervention's phones. This 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 [14]. Therefore, sharing of phones enhanced autonomy of intermediaries. This kind of sharing nurtured the permissive environment for help-seeking behaviours. It was observed in cases where intermediaries had to borrow phones because of better functionality or availability of data bundles.

However, not all phones were accessible by intermediaries. Some beneficiary maintained busy schedules hence in these cases there were less contact with their respective intermediary users. In such scenarios, the app was used less frequent. This brings another issue of maintenance of flow and spatial arrangement of users and technology. Having a technology in possession of beneficiaries, can affect timely feedback to intermediaries in cases where beneficiaries are not within vicinity. Timely feedback is one of the important aspects of cognitive flow. Flow in information design can be viewed as support for self-consciousness with the goal of fulfilling ones' overall satisfaction [7]. This means timely reflection is important in flow. In this context, we have two layers of reflection of which one involves intermediaries, and another one involves beneficiaries. It is challenging to support timely feedback in such a context. On using gamification, most intermediaries will be interested to continue using the system even without the presence of their beneficiary users. Therefore, there is a need to understand how best one could spatially arrange the system in order to optimally support timely feedback to both intermediaries and beneficiaries. The design issue in this case is to ensure reflection for the two sets of users is optimal. Intermediary can continue to access the system when beneficiaries are not around, and also beneficiaries can continue to receive feedbacks through mechanisms that are easily accessible to them i.e. SMS feedbacks etc.

Novelty effect

One of the challenges of measuring the impact of gamification is the interference of the novelty effect. A study by Koivisto and Hamari [23] found out that perceived enjoyment and usefulness of the gamification tend to decline with use, suggesting that users might experience novelty effects from the service. In our case the novelty effect appeared to affect both logbook and gamification. The novelty effect explains for the high usage at the beginning as shown on Figure 3. Utilization of gamification appeared to be steady towards the end. However, there is a need to study the long term effect of utilizing gamification in this context.

Gamification

In most cases, gamification engaged only intermediaries except for fewer cases of beneficiaries who were also enjoying gamification. Therefore, intermediary users were the main users of gamification and in fewer occasions some beneficiaries interact with gamification through intermediary users. Availability of game design elements increased the frequency of intermediary users to engage with the app during the day. Also, from the findings it is evident that gamification created an ambiance for competitiveness, meaning that it provided support for intermediary users to evaluate their performance or competence in assisting their respective beneficiary users. On relatedness, participants' face to face interactions affected the ability to isolate the effect of social features provided by gamification, as these face to face interactions entailed participants discussing about what has been happening in the app regardless of what experimental condition they were in. Our gamification design didn't reach its full potential as it appeared not to add value on autonomy of intermediary users.

One the main weaknesses of the gamified system is that it didn't give users more flexibility in customizing user interfaces according to their needs. The only support for flexibility was provided through avatars. Most users changed their avatars during gamification and this shows users might be interested to have more power to define themselves. For instance one user explained that avatars were important to her. She saw the avatar she selected as a representation of herself. And at the same found it amusing to see what avatars were picked by intermediaries from other teams. Through avatars, these users embodied their identities. Allowing users to create or change avatars is an example of how an ICT system can afford autonomy [54].

Another weakness with the gamified app was its inability to support intermediary users in defining goals and selecting the level of gamification/challenges that matches their skills. Their performance relied on skills of beneficiaries to the great extent. Hence, failure of a beneficiary user resulted into failure of a team which eventually affected motivation of intermediary users.

Flexibility is very important because skills of users and interests on game elements vary. For instance, in our context, some participants were motivated by achievements while others showed the desire to interact with others by commenting on their fitness gardens, and aquariums. Same aplies with skills. This variation in interests and skills exhibits differences in intermediary users' traits. The importance of tailoring persuasive games according to personalities of players has been emphasized[37]. For instance, Arteaga [2] designed a study involving motivating teenagers to exercise using persuasive health games, each player selected a game that matches their personality. In the absence of competition from other members, users that focus on achievements are likely to be demotivated. While in the absence of members who want to interact, a user who likes to interact with other may be demotivated

Due to a small sample size, it was difficult to have many users with similar characteristics under one experimental sequence. For instance, those who liked interaction with others, were not on gamification at the same time and hence received no responses from the rest. A study on social motivation to use gamification put an emphasis on the importance of having a larger network of users who are committed to the same goal because this has advantages of providing users with a better possibility of receiving recognition from others, get exposed to more social influence, and receive more reciprocal benefits from the use of gamification [17].

Therefore, to address the aforementioned shortcoming a larger study is required. In addition, a prototype needs to be improved with several iteration in the field in order to enhance autonomy of intermediary users. 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. [16]. To also make the app more enjoyable, it is feasible for intermediaries to also generate their own data such as steps to be integrated as part of the competition. This can also enhance the ability of users to challenge their skills. This idea is supported by findings that show how some members of pairs took turns in utilizing the pedometer. Also findings indicated that it is possible for intermediary users to benefit from nutritional information while in the process of recording food consumed by their parents. This technique will support internalization process through identified and integrated regulations as intermediary user are more likely to put value to a self-monitoring behaviour.

Usage Initiated by Requests from Beneficiaries

Motivation as the result of informal comparison of steps observed in the previous study [20]; was not common this time as beneficiaries had less direct interactions (face to face discussions) between themselves [20].Therefore, motivation was as the result of two sources and these were; (1) perceived usefulness on instrumental value of the intervention; and (2) gamification. Variation in motivation of beneficiaries had impact on the overall participation on the intervention. Beneficiary users can be grouped into highly motivated beneficiary (HMI) and less motivated beneficiary (LMI). Intermediaries that were highly interested in the app tended to go an extra mile in driving the conversation that led to intermediaries executing tasks on the app, while less motivated beneficiaries were more passive (i.e the initiative to interact was driven by their intermediaries). An example of a passive beneficiary user is provided on the excerpt below.

> *"She [her mother] won't say anything about the app and I must ask how is the app. Me and my mum were not really talking. I was like, okay do you like to use the app? and that is how we started talking about the app "*
>
> —***Sophia**, an intermediary*

Therefore, interest on beneficiaries add value to an intervention.

6. CONCLUSIONS

Gamification appears to increase engagement of young intermediary users to assist adult beneficiary users in interacting with a personal health informatics. This study has demonstrated that it is feasible to utilize motivational affordances that encourage on going use through intermediary users. There are some challenges with our prototype as didn't provide much support for autonomy and cognitive flow. Cognitive flow was affected on untimely feedback due

to unclear spatial arrangement of technology and user, and lack of ability to support intermediaries users in defining their goals and applying skills in attaining those goals. In addition, this study is limited in sample size hence it fails to take advantage of network effect which is a mediator for exploiting the power of gamification. In addition we faced a myriad of challenges such as intermittent connectivity that affect generalizability of these findings. Ramachandran and Goswami [42] have also highlighted how doing research in ICTD context poses challenges to the rigour of research design. This is one step towards exploring the feasibility of engaging intermediaries through gamification. There are many unexplored issues such spatial arrangement of technology and users; i.e an optimal arrangement for technology design to support flow to both intermediaries and beneficiaries. These issues need to be looked into by future studies.

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