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Utilizing Gamification Approaches in Pervasive Health: How Can We Motivate Physical Activity Effectively?

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Abstract

Persuasive health systems such as wearable trackers and mobile applications can facilitate self-reflection on one's physical activity. The gamification approach incorporates game design elements with persuasive systems to encourage more physical activity. However, some investigations have shown that using gamification to promote physical activity could have contradictory effects. To explore the conflicted findings in more detail, we designed and studied *FitPet* – an interactive virtual pet-keeping mobile game focused on encouraging physical activity. In a six-week field study, its effectiveness was evaluated and compared with two other gamification strategies, the goal-setting strategy and the use of social communities. Findings are that the social interaction strategy was the most effective intervention among these three. Contrary to prior research, goal-setting was not found to be as effective at providing motivation compared to social interaction. Although *FitPet* failed to promote significantly higher levels of physical activity, participants enjoyed this approach and provided design insights for future research: implementing social components and more challenging gameplay.

Keywords: gamification, motivation, self-reflection, physical activity, goal setting, pervasive technology.

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1. Introduction

A sedentary lifestyle is a contributing factor to chronic disease. Regular physical activity is critical to everyone's physical and psychological health, regardless of his or her normal, overweight, or obese weight categories [13]. According to the U.S. Centers for Disease Control and Prevention， despite the importance of physical activity, many adults in North America do not get enough exercise [17]. One method for substantially improving the quality of life is to perform a physical activity, which can both increase mental and physical health and reduce the potential risk of potential chronic diseases. Although many people may recognize that performing regular physical activity is essential for health, many are not physically active on a regular basis.

Tools such as mobile devices and wearable devices have been shown to help people manage their health and wellness. Of particular interest are technologies that are designed for activity tracking and promoting behavior change in everyday life, such as the *FitBit*, *Jawbone UP*, *Nike FuelBand*, etc. These technologies hold the potential to assist with counteracting the lack of regular physical activity by motivating people to develop and maintain a healthier and more active lifestyle. These systems capture and measure activity-related parameters and present the measured data to people in various ways, including gamification approaches.

Gamification is considered to be far more powerful than typical transactional engagement strategies [3] and has the potential to engage people emotionally. Gamification

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techniques – points, virtual rewards, levelling up, badges, peer obligation, social currency, missions, and challenges – are relatively new, with early signs showing great potential for lifestyle improvement [10]. Gamification approaches have become popular in recent years and are utilized as a design strategy in applications for promoting healthy behavior changes [3]. Nevertheless, some researchers have also criticized certain gamification strategies for their ineffectiveness in providing incentives, for instance, group sharing did not motivate people's physical activity as expected [9] [14].

In light of the criticism and controversy surrounding gamification and a relative lack of rigorous studies evaluating its effectiveness, in this paper, we developed a research prototype based on a game idea – *FitPet*. Next, we set out to evaluate the effectiveness of the *FitPet* approach and compared it with two gamification methods – goal-setting and social interaction – in a six-week field study. We explored how the incentives and their sub-components worked as motivators for promoting increased physical activity amongst participants. Results showed that the effectiveness of the goal-setting strategy relied highly on the individual's personality and context. Social interaction was the most effective approach regarding promoting more physical activity. Although *FitPet*'s game-based approach was not successful at encouraging significantly more steps than the control group, participants accepted and enjoyed the general game concept and idea. This study provides an in-depth way to understand better the complexities of promoting motivation, along with insights for designing gamification strategies that encourage and support health behavior change.

2. Related Work

Due to the low cost, high penetration, and integration in individual's everyday life, mobile phones, wearable health sensors, web applications, and social networking tools hold great potential for supporting people as they strive to adopt and sustain health-encouraging behaviors.

Many technologies enable an individual's access to personal information through web-based resources, pedometers and other wearable sensors, and smart phone Apps. In this section, prior and current technology solutions for commercial and experimental purposes are introduced and reviewed, and how those solutions and information were visualized for personal informatics is discussed. Last, the influence of those technology solutions have had over participants' behavioral and motivational changes is discussed.

Methods for encouraging physical activity and related behavior changes like self-monitoring, goal-setting tasks, and social competition, have been and continue to be incorporated into the design of persuasive systems. Approaches that provide incentives vary from virtual and physical rewards as elements to full digital games and gamification. Several research findings showed adverse effects as a result of using specific gamification techniques (such as goal-setting and social interaction). Yet they did not articulate the contexts that may have contributed to the effectiveness, for example, when to use social sharing and communications for encouraging activity [4][11][15]. Therefore, it remains unclear whether certain gamification approaches are effective in the context of promoting physical activity, or what aspects of gamification contribute the most to effectiveness.

Although in Kuru et al.'s study [18], they summarized four major characteristics for designing engaging experience with physical activity tracking product: connectivity, curiosity, personalization, and motivation. For one thing, the researchers did not include or investigate the impact from social communication and interaction aspects because they mainly focused on the relationship between participants and the products. For another, the affordances of the commercial products they tested in experiment settings did not maintain game features. Moreover, connectivity, curiosity, and personalization sometimes have a causal relationship with motivation. Connectivity and personalization are the characteristics that the intervention tool can provide, while curiosity and motivation are in line with one's personality and self-efficacy. Therefore, it requires further investigation about how inner motivation impacts other outside products' characteristics, also from gamification aspect, which has been neglected by researchers in [18].

We discuss the related work based on which gamification strategies were adopted and how the incentives appear to have worked as motivators for physical activity. From the reviewed literature, a single research prototype usually deploys more than one gamification strategy at the same time. Implementing multiple gamified approaches together make it challenging to assess which strategy contributed the most to findings. Figure 1 shows an overview diagram of all the development process of all research prototypes discussed in this section according to chronology order.

2.1. Goal-Setting Strategy

Goal-setting is considered to be the primary technique for facilitating reflection and behavior change. Although both goal-setting and real-time feedback are utilized in numerous non-game and non-gamified situations, they are regarded as game elements by some researchers [7]. Many research studies incorporate goal-setting in the research prototypes as the primary or singular strategy to promote physical activity. In research [2], Bravata et al. identified that an additional significant motivator for increasing physical activity is setting a step goal. They reported that participants who were given either a fixed or personalized step goal tended to have more steps than who were not. In Houston [5], participants were asked to set a daily step goal based on their baseline level. UbiFit [6] also deployed goal-setting, where people need to set a primary and an alternate weekly physical goal each week. In the first and second study of StepByStep [16], participants were asked to set up their active minutes goals regarding active minutes, either a fixed one or an adjustable one based on experimental group conditions. However, the drawback of goal-setting is that individuals tend to give up

and feel frustrated when their goals are not achievable during the goal-setting task period. Zuckerman et al.'s [16] study revealed that goals had been shown to be effective when they are crucial to the individuals, especially for self-set goals rather than assigned ones [19]. People receive positive feedback as they progress towards goal completeness after they set attainable goals.

2.2. Social Communication and Collaboration

In *Houston*, a research prototype and a study designed by Consolvo et al. [4], groups of friends wearing pedometers could share each other's goals and progress as well as motivational messages via mobile phones. The study revealed that sharing activity-related information resulted in social pressure to meet one's goal, beat a friend, or not have the lowest step count. Similarly, in *Chick Clique* [14], small groups of individuals shared their step counts and progress toward daily step count goals with each other via their mobile phones. However, the participants in *GoalPost* and *GoalLine* [12] were hesitant to share their activity information with others on *Facebook*. A more recent research prototype *StepByStep* [16], was designed with multiple gamification strategies: goal-setting, a leaderboard comparison, and virtual points. In their three-week field study, Zuckerman et al. demonstrated that gamified versions offering virtual rewards and social comparison were only as effective as the quantified version. In other words, the participants in the intervention group did not benefit more than those in the control group. The authors concluded that the specific gamification incentives and mechanics used in *StepByStep* [16] were ineffective.

In a close reading of how the social interaction happened, two different mechanisms of communication and collaboration were identified from both prior studies and this study. One type of mechanism is the passive involvement. In *Fish'n'Step* [9] and *StepByStep* [16], participants interacted with strangers who they almost know nothing about in a relatively large group, and their physical activity data were ranked together in a public digital leaderboard. In *GoalPost* [12], participants shared their activity information on Facebook. In these situations, individuals maintain a passive way of communicating within the study group or with others outside the group: there is no real-time collaboration or synchronous feedback and no actual social interaction going on.

Social communication, competition, and collaboration have been implemented in applications for lifestyle improvement as one of the most effective gamification approaches so far. These findings were demonstrated in *Houston* [4] and *StepStream* [11], where participants who experienced the social features had more physical activity and more progress towards their goals. In other studies like *Fish'n'Step* [9], *GoalPost* [12] and *StepByStep* [16], there are conflicting results of similar social gamification strategies. Participants in these study groups reported negative feelings and privacy concerns about sharing personal information and having social interaction with others. In this study, we found that the goal-setting strategy was less useful and helpful for promoting awareness or motivation of a higher level of physical activity as suggested in prior studies [6] [12].

The other type of social interaction is the active engagement: the dynamic communication and collaboration were taking place inside the group, especially when acquaintances or loved ones were involved. In *Houston* [4] and *StepStream* [11], people engaged with the social interaction that the prototype was allowed, most likely because the ones they followed were mainly their friends, instead of strangers.

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2.3. Avatar Visualizations and Digital Games

Fish'n'Step [9] uses personal goals, social influence, and a non-literal, aesthetic display to promote physical activity, especially more steps. A participant's step count is linked to the emotional states, growth, and activity of his/her virtual fish in a virtual tank – a tank that includes the fish of others. The fish tank is displayed both in a public kiosk in an office and on personal websites for an individual progress view. The study results showed that when a fish avatar was not aesthetically pleasing, participants stopped looking at the tank and some even stopped using the system altogether. The concepts of using a virtual avatar to represent physical activity data were further studied in Consolvo et al.'s *UbiFit* Garden system [6]. It is a system which uses small sensors and a mobile display to visualize people's physical activity. It uses virtual flowers and butterflies to represent participants' physical activity levels and goal completeness.

Games are also deployed in persuasive technologies and utilized together with trackers to promote physical activity. Yet the effectiveness of current research prototypes seems to be less powerful than simpler systems like *UbiFit Garden*. For example, a map-based game called Intro [1] records steps from a mobile phone's accelerometers; on the virtual map, players' locations are determined by their step count. In a one-week study, participants rated the app to be motivating and appealing. But the effectiveness regarding physical activity improvement was not formally evaluated. Similarly, *The American Horsepower Challenge* is a location-based competition game aimed at increasing students' physical activity [15]. Students wore pedometers whose data were later converted into a web-based game later. The goal of *The American Horsepower Challenge* is for one school's students to win a virtual race against students in other schools. However, Xu et al. [15] reported finding a drop in the number of steps to below the baseline level. The *FitPet* study differs from the prior study that this is an interactive mobile game with game mechanics, economics, and dynamics.

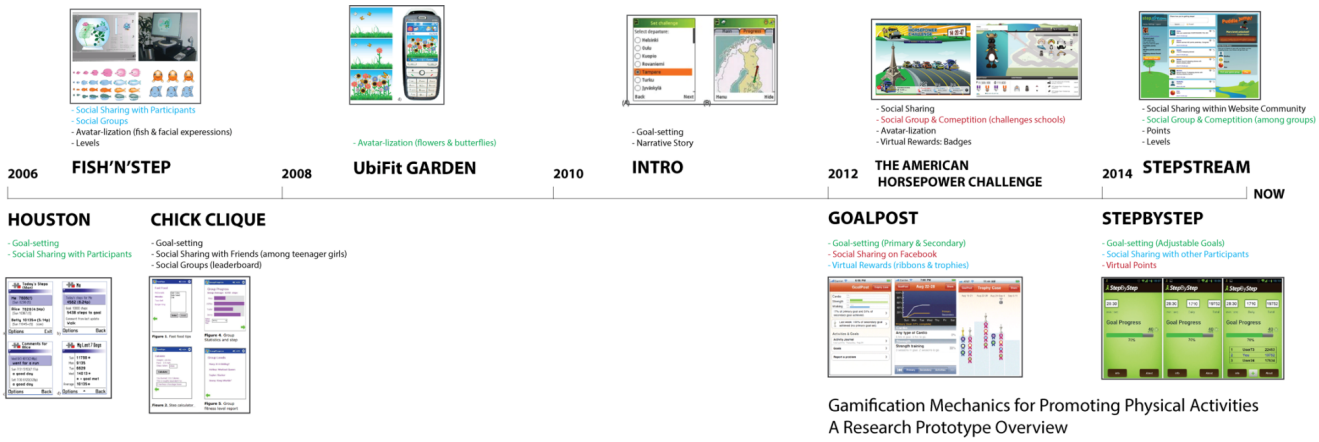

Figure 1. An Overview of the Prototypes Mentioned in Related Research

3. Motivational Models for Encouraging Behavioural Changes

Desired changes can be achieved without a significant disruption of one's current lifestyle. For example, studies have demonstrated that individuals who walked at least 10,000 steps a day were more likely to maintain their desired weight [19] and sugar level in the diet.

Individual behaviour change, including physical activity, has become a subject of active investigation in the areas of cognitive science and clinical psychology. One of the most popular theoretical models by psychology community of how changes happen is the Transtheoretical Model (TTM) introduced by James Prochaska [20]. TTM argues that individuals change their behaviour gradually, by advancing along a series of steps. These steps vary from pre-contemplation in which individuals have not realized the need for change, to termination in which the new behaviour has become so habitual that there is no longer any danger of relapse.

TTM has been successfully used to design interventions for undesirable behaviours, like alcoholism, smoking, and domestic violence [21], and to motivate an increase in exercise and other types of physical activity [22] [23] [24]. However, traditional techniques inspired by TTM rely on significant clinical resources for individuals who seek the change. There is a need to develop more innovative and cost-effective intervention programs that supplement or replace meetings with a therapist [24].

In TTM, six steps are considered to be crucial to the behaviour changes. As interpreted in prior research by Lin et al. [25] (Lin et al. 2006), the six steps are "1) Pre-contemplation: individuals have no recognition of the need to change and, consequently, no intention to take action; 2) Contemplation: intention to take action within foreseeable future (next six months); 3) Preparation: intention to take action within immediate future (next thirty days and having taken initial preparatory steps); 4) Action: practicing new behaviour for three to six months; 5) Maintenance: continuing commitment to sustaining behaviour; 6) Termination: overt behaviour will never return, and there is complete confidence that one can cope without fear of relapse". For an exercise program, termination means that the behaviour is so ingrained that external reinforcements are no longer necessary.

Therefore, in this research, we divided the participants into TTM levels, and they were assessed both before and after the six-week study using TTM definitions.

4. The Field Research – Goal-setting, Social Interaction, and *FitPet* Mobile Game

4.1. Introduction to *FitPet* Mobile App

To investigate what motivates people the most to increase their physical activity, we created a mobile game called *FitPet*. *FitPet* was built as a mobile application that is available on both Android and IOS platforms. The goal of this research prototype is to provide a non-intrusive and gamified system that can be used in people's daily routines. Steps are used as the parameter to assess a player's overall activity level. The game's flow chart is shown in Figure 2, and the pet's growth rule is illustrated in Figure 3.

The gameplay and main game concept of *FitPet* – to take care of the digital pet by taking care of oneself – were inspired by *Tamagotchi*. *Tamagotchi* was conceived by a Japanese mother for her children, since limited space precluded the introduction of a live pet into the household [8]. Once the game is turned on, the virtual animal is hatched from an egg and grows up. To sustain it and maintain its health, the *Tamagotchi* required virtual care, when necessary, in the form of sleep, a regular supply of food and drink, washing, playing, teaching, scolding and medicating. The virtual pet's progress and needs could be assessed any time by pressing a button calling for a report that included its weight, age, temperature, the extent of its hunger and thirst, mood and the like. Similar gameplay was

implemented in *FitPet*, in a more flexible way so that attending to the virtual pet was not too intrusive or overwhelming for the adult players.

To motivate players to engage with the pet more frequently and to grow an emotional attachment to the pet, individuals' daily progress towards their goals was mapped to the development of the virtual pet in two ways. Firstly, the daily step count could be converted to game coins, and then the players could use their coins to play with and feed their pet, and provide medical help when the pet is sick. Secondly, the growth level of the virtual pet is related to the accumulated total steps and the player's daily step goal. The general idea of the mobile application is to take care of one's pet by taking care of oneself.

The step, coin trade, and play game economics, growth level and goal rule, and visual design are the key mechanics, dynamics, and aesthetics implemented to encourage more engagement from the players with their virtual pets. In addition to the detection of walking, *FitPet* also supports real-time feedback of players' physical activity and compares it with pre-set activity goals. The player can name the pet and set up a daily step goal. It was designed with adjustable goals so that players could change their goals based on their needs.

The mobile phone's accelerometer is used for measuring the step data. In a pilot study, we tested the accuracy of the step-counting algorithm in different settings, such as idling, walking, running, etc. The reliability of the algorithm was evaluated and compared with the step data collected by the *FitBit* device. The average level of detection accuracy compared to the *FitBit* was around 110-120% while running or walking. A notable limitation with the game design platform is that the application needs to run in the background on a user's mobile phone so that it can calculate and store the physical activity data. As such, we asked all participants to keep the program running in the background during the study's intervention period.

Figure 2. The Flow Chart of *FitPet* Mobile App

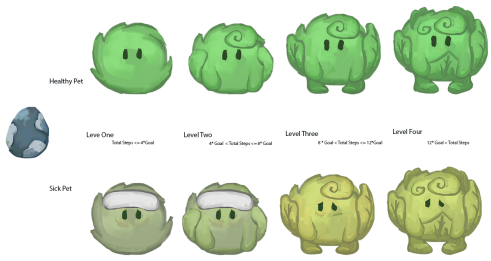

Figure 3. The Growth Levels and Health Conditions of the Pet

4.2. Study Details

The goal of this study is to compare the effectiveness of three gamification approaches for health behavior promotion: goal-setting, social interaction, and the interactive mobile game *FitPet*. In this section, we describe the study procedure and details.

Participants

To assess the effectiveness of three gamification strategies, we recruited 23 participants (8 females and 15 males) inside and outside the university, all of whom either have a full-time job (office job) or are full-time university students. Convenience sampling was used to select the participants. In the pre-test phase, background research was conducted with each; we collected the participants' general information (gender, age, and job types), exercise and physical activity levels, familiarity and experience with the relevant technology, and desires to change activity levels. All participants resided in the Greater Vancouver area. Before their participation in this study, 5 (21.7%) of the participants used either mobile applications or health trackers to self-monitor personal data. Only one participant had taken part in a research study promoting physical activity several years ago. None of the participants had a specific daily or weekly steps/activity goal. Seven of them have a general long-term goal of fitness, such as losing weight, gaining muscles, running longer and faster, or staying active and healthy.

Procedures

The six-week field study consisted of three phases. All experiments conducted under this study received ethics approval, and all participants were required to sign a consent form. Figure 4 shows the study procedure and its timeline.

(i) Two-week Pre-test Observation: Before the pre-intervention stage, participants were asked to fill in a questionnaire about their daily lifestyle, physical activity level and routines and familiarity with technologies and games. During this phase, the participants were given a *FitBit* wearable device worn on the wrist. The participants were asked to wear the *FitBit* as much as possible. The participants were also encouraged to maintain their regular lifestyles. At the end of the pre-intervention phase, steps data were collected from the participants' FitBit accounts. The baseline levels (average steps) were then established for each. Finally, in the interview, the participants were asked to set up individual goals for the next phase. After the pre-intervention phase, all participants were asked to take a 20-minute interview regarding their experience of the wearable tracker.

(ii) Two-week Intervention: During the experimental phase, the participants were randomly assigned to one of the three conditions: control group (the goal-setting task with *FitBit*), social group (the goal-setting task and social activities with *FitBit*), and *FitPet* group (the goal-setting task with *FitPet*). The control group has the *FitBit* step data and the goal-setting task. The social group was asked to complete social activities (Website Community and Mobile Challenges) in addition to the goal-setting task. While the *FitPet* group could still wear their FitBit (for capturing data), they were instructed to focus on the mobile app *FitPet* and to not pay attention to FitBit anymore. The *FitPet* group also had the goal-setting task. Participants were instructed to start goal-setting and they were given the freedom and flexibility to adjust their goals based on their personal schedules and daily routines. In this phase, all participants were encouraged to set and try to achieve their individual goals. They were asked to update and sync their data with a mobile phone or PC every day. After this intervention phase, again, all participants were again asked to have a 20-minute semi-structured interview regarding their experience and behavior changes.

(iii) Two-week Post-test Observation: At the end of week 4, the goal-setting, social interactions, and *FitPet* game interventions ended. However, the participants were asked to adopt the most helpful methods to keep themselves motivated and to stay physically active. All participants were encouraged to keep wearing their FitBit for an additional 2 weeks. All of the interviews were audiotaped and then transcribed by the researchers. All of the interviews and questionnaires were coded according to categories that emerged during the study's analysis. After the interviews, open coding was adopted to analyze the qualitative results. For the same question, for example, annotated answers from the participants within the same study group were listed together and compared. Finally, codes were developed from the annotated answers and summarized into different categories using axial and selective coding to draw out the main themes.

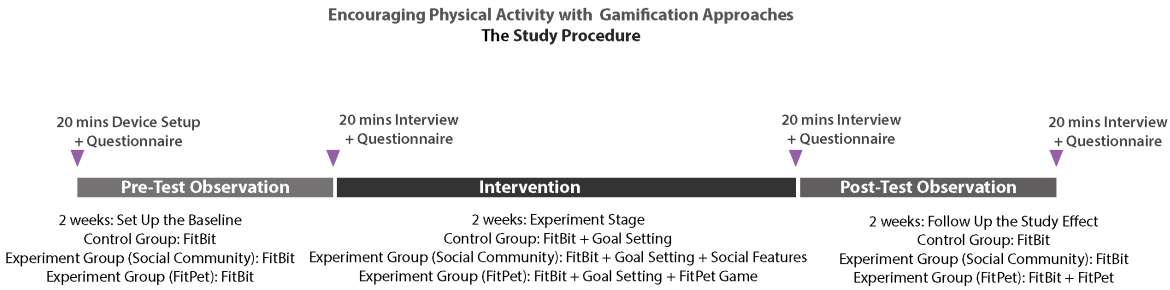

Figure 4. The Six-week Field Study Timeline

4.3. Study Results

In this section, we reveal our study results and analyse them according to our field study interviews. The study used a between-subjects design; a participant either belonged to the control group, the social group, or the *FitPet* group. Time was a within-subjects factor, as every participant's daily step was measured after each study phase. Therefore, to evaluate the effectiveness of the three gamified conditions, a Two-way Mixed-ANOVA test was conducted to compare before-intervention and after-intervention changes in step counts. The independent variables were the intervention conditions (goal-setting, social Website Community and *FitPet*) and time phases (pre-intervention and post-intervention). The dependent variable was the step count data collected throughout the six-week study.

Participants' Background Data

In the pre-test phase, background research was conducted with our participants, regarded their general information (gender, age, and job types), exercise and physical activity levels, familiarity and experience with the relevant technology, and desires to change activity levels. Results are summarized in Table 1.

Before their participation in this study, 5 (21.7%) of the participants used either mobile applications or health trackers to self-monitor personal data. Only one person had taken part in a research study promoting physical activity, which occurred several years ago. As for goal-setting, none of the participants had a specific daily or weekly steps/activity goal. Seven of them have a general long-term goal of fitness, such as losing weight, gaining muscles, running longer and faster, or staying active and healthy in general. Out of 23 participants, 11 had experience with a *Tamagotchi* and played with it over period ranging from 1 month to 2 years, all of which do not have one during the study period.

Figure 5 shows participants' familiarity with technology. Light, intermediate, heavy, and extreme heavy are used as the terms to describe participants' usage of technology. Originally in the questionnaire, participants were asked to rate their usage of particular technology on a 0 to 100 visual analog scale. The range 0 to 24 was classified to light, 25-49 as intermediate, 50-74 as heavy, and 75-100 as extreme heavy. From the results, all participants are either heavy (5) or extreme heavy (18) users of Internet and Computers. For Mobile Phones, it has a similar tendency as Internet and Computers, 10 people considered themselves to be heavy users and 10 to be extreme heavy users. As for Games, most participants rated themselves to be intermediate (5) or heavy (8) users. However, for wearables, most people (14) are light users, and they are not familiar or had prior experience with this technology. To conclude, participants are more familiar with Internet and Computer usage compared to wearables. In general, participants were mostly intermediate and heavy users of games and mobile phones.

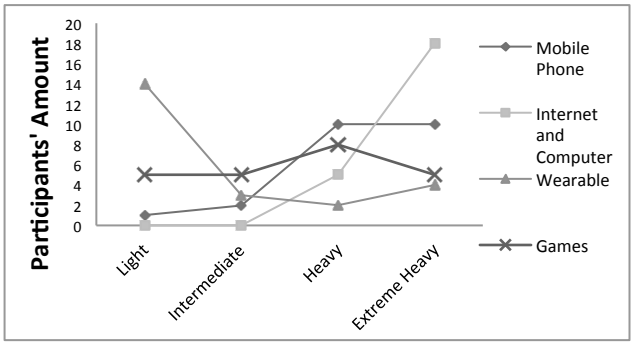

Figure 5. Participants' Familiarity with Technologies and Games

Figure 6 shows the frequency of participants' physical activity. Eight of 23 participants performed physical activity several times per week, and six people did it once a week. Three participants fell into the other three categories, seldom, several times a month and every day. It can be concluded that most participants have regular physical activity routine, but a few of them in extreme active and inactive conditions.

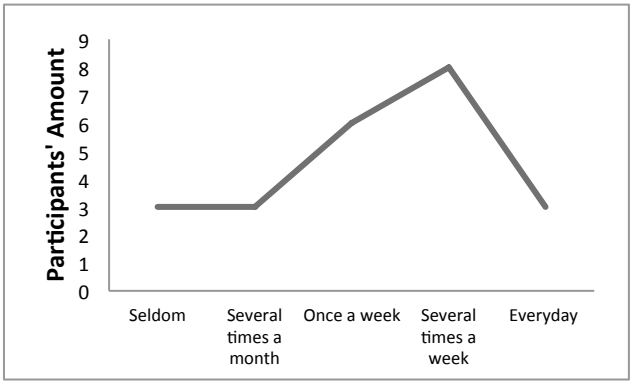

Figure 6. Participants' Frequency of Physical Exercises

Physical Activity Data (Steps)

A significant main effect of time was found, $F(2, 22) = 4.17$, $p = .02 < .05$, $r = .53$. A Tukey HSD test run on these data showed that the social group had significantly more steps than the *FitPet* group $p = .03 < .05$, and between the social group and the control group, $p = .03 < .05$.

However, there was no significant difference between the *FitPet* group and the control group. The main effect of condition was non-significant, $F(2, 22) = 2.23$, $p = .12 > .05$, $r = .20$. The results indicated that when the time at which step count was measured is ignored, the initial step level of participants in each group was not significantly different. There was a significant Time * Group interaction effect, $F(2, 22) = 5.31$, $p = .02 < .05$, $r = .33$, indicating that the changes of step count in the groups were significantly different from each other. Specifically, there was a significant increase of steps in the social group.

In the social group, the post-test step count was significantly higher than pre-test step data, $p = .03 < .05$. Also, in the post-test analysis, significant differences were found between *FitPet* group and social group. The social group had a significant increase of steps over *FitPet* group, $p = .04 < .05$. The tests revealed no other differences. These findings indicate that the social group was significantly more effective than the goal-setting control group and the *FitPet* game group (Figure 7).

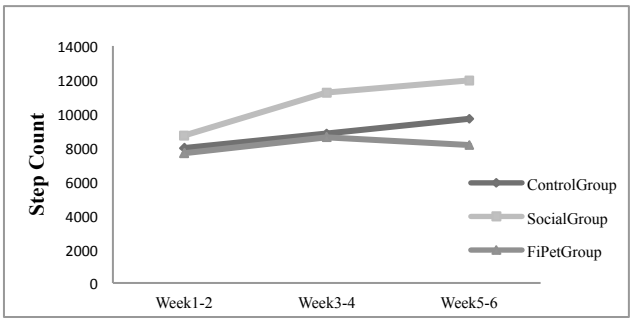

Figure 7. Physical Activity Changes of Three Groups during the Six-week Field Study

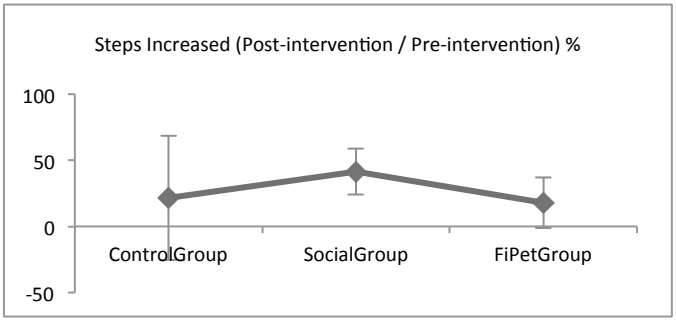

Figure 8. Steps Increased: Percentages of Three Conditions after Intervention Compared to Pre-intervention Phase

These findings indicate that the social group was significantly more effective than the goal-setting control group and the *FitPet* experimental group. LS means test results are shown in Figure 10.

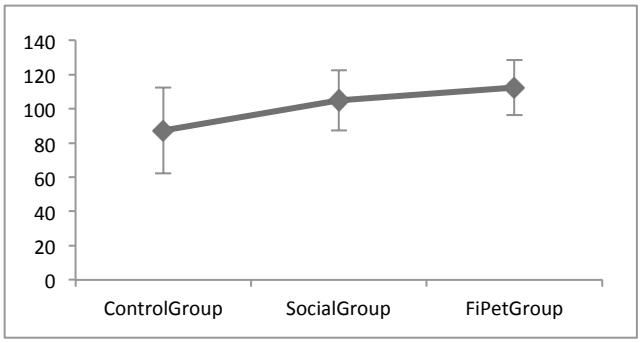

Figure 9. Goal Completeness: the Percentages of the Three Study Conditions

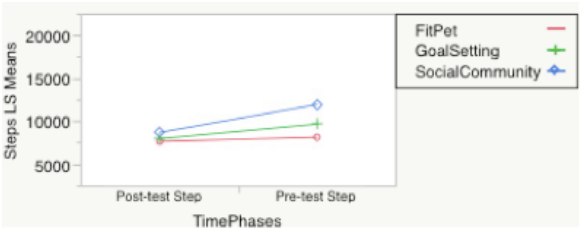

Figure.10 LS Means of the Three Conditions

Motivation and Behaviour Changes Data

In the study, participants were interviewed and were categorized into different activity and motivation levels. Table 1 demonstrated all participants' changes of activity level before and after the study, with step changes and goal completeness data. Levels are defined below and are based on the TTM model (Lin et al. 2006) (Munson and Consolvo 2012):

Level 1: Ultra Casual (Pre-contemplation): a minimum amount of reported physical activity; no attention or motivation to take action regarding physical activity.

Level 2: Casual (Contemplation Stage): low level of reported physical activity; intention to take action; little motivation for being active.

Level 3: Transitional (Preparation Stage): a certain level of reported physical activity and initial steps taken towards actions; indications of motivation to be active.

Level 4: Hardcore (Action and Maintenance Stage): change in behavior occurred in the past; an active level of physical activity with motivation.

Level 5: Ultra Hardcore (Termination Stage): an active level of physical activity; complete confidence in coping without fear of relapse; strong motivation.

Table 2 shows the engagement situation of each participant in the study activity group, as well as the Mobile Challenges they participated in. Although most participants neither posted in the activity community nor discussed with others (about their questions, physical activity conditions, and so on), they joined lots of Mobile Challenges and tried most of the social interaction features.

Interview Results

From three semi-structured interviews, participants' experiences and evaluations using different approaches (goal-setting, social Website Community and Mobile Challenges, and game-based mobile app), are summarized in this section.

In this subsection, we introduce how participants set up their goals during the study and how they perceive the effectiveness of this approach. Goal-setting acted as a motivating factor for promoting activity for 10 out of the 23 participants. However, for three individuals, neither the step count nor step goals made a great deal of sense for them. Although the health tracker could make participants more aware of their stride length and how many steps they took per km as P02 mentioned,

"Healthy and fit are what made my body and mind feel better. I do not really care if step count is a certain number."

On average, each participant set 1.8 daily step goals. Four participants in the social group were "hardcore" (regarding motivation and physical activity); they have "training days" and "resting days." Therefore, they have multiple goals depending on the workout schedule. Twelve of the overall participants normally started with an attainable goal, and then raised the bar if they could make it, or modified it. Thirteen of twenty-three set their goal so that it was not too high to reach, but still required particular effort to meet that goal to not feel bad. Three participants had no time for exercising or physical activity, owing to their responsibilities for work and taking care of their family. They mostly tried to find their maximum steps for activity and tried to stick to the same goal without changes.

Seven out of 8 individuals from the social group reported they enjoyed having social interaction with others, but these were limited to the Mobile Challenge activities and not the Website Community. All 7 mentioned that the type of social communication and interactions that happened in the Mobile Challenges had a significant influence on their motivation to perform physical activity.

All participants enjoyed and liked the Social Mobile Challenge feature. One participant observed that the people in the Website Community group did not talk enough so the overall engagement declined. By comparison, the Mobile Challenge component was thought to be more fun, enjoyable, and effective in motivating physical activity by all 8 participants.

P05 said,

"Challenges are more effective because of their limited timeframes and reminders of what everyone is doing." P08 also mentioned, *"Not so much the Website group, but the Challenges since the app sends constant reminders of what is happening."*

Competition with each other did influence the participants a lot, but they also enjoyed other types of interactions as reported by 7 participants in the social group, such as encouragement, nudges, and cheer-up from others. The participants could communicate with each other, even *"make fun of each other"* (P08), and experience interesting conversations. Moreover, according to all 8 participants from the social group, members' background (physical activity routine) and the group size mattered to group members' social engagement and the motivation for staying physically active.

Engagement with the FitBit and self-monitoring faded as time went by as reported by around 1/3 of the participants. However, social features prompted participants to check their physical activity more often. The Mobile Challenges brought participants more dynamic communication, working towards a goal, and individual engagement with the participants. But the types of the Mobile Challenges were also reported to have been crucial to the effectiveness of such social gamification mechanics, e.g.,

"Although I liked it and it motivated me, the Challenges were too simple for me after the two intervention weeks. They are all about having the most steps within (a) certain timeframe, which is boring. I would prefer to try new ones" (P07).

After a few times of trying out Mobile Challenges, there were cases where participants' invitations were rejected or ignored by others. From the interviews, people said they felt too physically tired to keep themselves in a constant active state. A few participants said that they did a Weekend Warrior Challenge for two days, and they did a Weekdays Hustle Challenge next which lasted for five days. Therefore, after all seven continually active days, they were too exhausted to accept any new ones.

As for the *FitPet*, all of its 8 participants appreciated the idea of converting their healthy data to something game related. However, they stated their problems and concerns using such a mobile application and offered suggestions regarding design ideas and game mechanics. Four out of eight continued using *FitPet* in the post-intervention period. All 8 participants liked the idea of associating their health (steps) with the health of a virtual pet, which was to realize something "bigger" and not limited to oneself. But they still felt there were things missing to make them more engaged. Participants felt a certain degree of emotional investment and engagement with the pet; however, they felt it was not strong and powerful enough.

Table 1. Participants' Cumulative TTM Assessment Results with Steps Data and Goal Completeness, Pre-study and Post-study.

Group Information and ID		Pre-test Level	Post-test Level	Step Changes	Goal Completeness During Intervention %
Control Group With *FitBit* and Goal-setting	2	4	4	1213	79.73
	9	3	4	-3539	107.51

	10	3	4	-3276	70.65
	14	1	3	4801	90.77
	20	2	3	2609	79.93
	21	3	3	9222	129.59
	22	2	3	998	52.71
Experimental Group One With *FitBit*, Goal-setting and Social Interaction	1	2	3	502	77.49
	4	4	4	4735	114.48
	5	3	4	3967	102.77
	7	4	5	4956	114.8
	8	2	3	794	93.68
	13	2	3	3080	134.47
	15	4	3	1322	90.89
	11	4	4	6658	109.71
Experimental Group Two With *FitPet*, and Goal-setting	3	1	3	-1790	110
	6	2	2	-318	99.34
	12	2	2	1189	102.58
	16	2	3	1874	124.01
	17	3	4	1255	109.72
	18	2	3	1049	146.94
	19	1	2	1824	104.35
	23	2	2	-1206	100.15

Table 2. Experimental Group Two: Social Community and Interaction Information during the Intervention Stage

IID	Friends Added in *FitBit* Network	Activity Community		Challenges	
		Public Posts in Activity Community	Frequency Check Group Leaderboard	Challenges Participated	Interactions with Other Participants
1	5	1	1-2 times/week	2 Weekend Warriors; 1 Weekdays Hustle	Cheer-up, Nudge
4	7	3	3-4 times/week	2 Weekend Warriors; 1 Weekdays Hustle	Cheer-up, Nudge, communicate (conversation)
5	10	5	Once	2 Weekend Warriors; 2 Weekdays Hustle	Cheer-up, Nudge, communicate (conversation)
7	8	7	1-2 times/week	2 Weekend Warriors; 1 Weekdays Hustle	Cheer-up, Nudge, communicate (conversation)
8	7	0	Once	1 Weekend Warriors; 1 Weekdays Hustle; 1 Daily Showdown	Cheer-up, Nudge, communicate (conversation)
13	8	0	3-4 times/week	1 Weekend Warriors;	Cheer-up
15	9	0	1-2 times/week	2 Weekend Warriors; 1 Weekdays Hustle	Cheer-up, Nudge, communicate (conversation)
11	5	0	Once	1 Weekend Warriors; 1 Weekdays Hustle	Cheer-up, Nudge, communicate (conversation)

For example,

"When the pet is sick, I want to ask 'why', 'you are so well loved, you must be broke', and when it is healthy, I felt, 'good, you should be', and "I really want to touch the pet, to build connections with him." (P06)

Five participants suggested that the application should be made to run whenever they became physically active, instead of having to open the software manually. Four of them said that connecting with other wearable health trackers' APIs would also work for them to play the game. Four participants mentioned that they would prefer to have more interactions and more virtual rewards with the virtual pet besides the current gameplay. One participant who was at the self-defined "hardcore" level said,

"I feed it every day to keep it happy. (This) Does not help me promote steps because there is not enough reward in the game. (The game) Needs more (interactions) or different goals to promote my activities". "There is a mixed feeling. I like the game and idea, but I do not feel motivated enough. The game can be more challenging." (P18)

Also, four participants offered the feedback that to be more motivated and have more awareness of how the pet was doing, prompt notifications showing updates about the pet's condition would be significantly helpful, for example, "your pet needs food" in the phone's notification bar.

4.4. Study Summary

To sum up the findings from the study interviews, for the goal-setting approach, participants already had known their baseline level after the pre-test study period, but most people still did not know how they could or should set an appropriate personal goal according to their context. From the interview, some people set an "arbitrary" goal. Thus, proper guidance and professional advice are important for an individual to understand how to set goals as the goals can vary considerably.

For the two types of social interventions tested in the social group, Website Community and Mobile Challenges, I concluded from the interviews that the Website Community is a more passive way of communicating and is not as engaging, whereas Mobile Challenge was active, and offered more synchronous communication and collaboration, which participants found to be fun and engaging. Participants cared their rankings of physical activity in the Mobile Challenge leaderboard but not in the Website Community, for instance. Moreover, besides the generally used "peer competition" strategy, "peer-cheer" communication was also considered and reported to be a critical encouraging factor for the participants to feel engaged and connected. Furthermore, as summarized from the interviews, what mattered to participants' experience of social interaction were the size of the group, the background and context of its group members, and the frequency of the Mobile Challenge.

The FitPet mobile game did not perform as well as was expected. Participants liked the main design idea. However, they mentioned the game did not provide enough awareness or feedback, and it did not need much investment. The gameplay was not difficult for them, especially after a few days of adaptation. For these reasons, a narrative element or story about the mini game would improve its viability. Even for a small-scale game like FitPet, the difficulty of challenges in the game should be controlled to match players' skills. In a game like this, player experience and game flow are important because it is how people can become more involved in it, investing more effort and emotional engagement.

5. Discussions

In this section, we discuss the results of our study and how they may translate into design implications for encouraging lifestyle changes accordingly. We also compare the strategies and results of our study with past studies of a similar nature. These distinguishing results suggest implications for the design of behavior-changing prototypes. We specifically explore the cases where our data contradict prior research to understand why the difference in findings may be occurring. Thus, our goal is not to try and disprove previous studies; instead, we are attempting to show how the context and prerequisites of a specific gamification strategy affect the success of that strategy, how to use various strategies, and in what situations they might work best – as we have found, context matters when designing and using gamification approaches. The results and analysis aim at providing reflections and implications for designing interventions for health and well-being.

Customize Your Daily Goal Practically

For the goal-setting approach, though participants already knew their baseline level before the intervention phase, most people still did not know how they could set an appropriate personal goal and what their goals should be in their context. From the interview, we found that some people set a too "ambitious" or "arbitrary" goal, whereas others had more "lazy" goals – a goal neither realistic nor motivating enough to complete. Thus, proper guidance and professional advice are important for people to understand what their goals should be as the goals can vary considerably.

Regardless of the successes or the failures participants had in their goal-setting tasks, most participants set alternative or multiple goals during the intervention phase. Participants substituted their primary goals with their alternative goals when they experienced hardships in fulfilling their goals. (These alternative goals seemed to have functioned as an adaptation, which allowed participants to sustain their motivation, despite the unanticipated complexities of life.) Yet, the alternative goals of step counts were normally below participants' actual capabilities. In this case, both the primary and

secondary goals would not be motivating enough for people to keep. By way of conclusion, goal-setting was only effective for promoting awareness and activity when the person had the motivation to keep it (As one of the participants stated in the interview). To foster a sustainable motivation for people's goal, the goal should be customized to an attainable level dynamically according to personal life or work schedule and individual physical activity conditions or habits.

Design the Social Collaboration and Communication in a "peer-cheer" Way

For the two types of social interventions tested in the social group, the Website Community was considered to be a passive way of communication and was not active enough for people to engage, while participants experienced active participation, competition, and collaboration in the Mobile Challenge group. The social communication strategy in the Challenge Group offered more synchronous feedback, communication, and collaboration.

In a Mobile Challenge used in this study, participants had the option to start a Mobile Challenge, and each had the right to accept a Mobile Challenge or reject it. Besides social competition, which was usually implemented as one of the most common social interaction approaches [9] [16], being fun and able to get support from each other (what we call "peer-cheer") were compelling reasons for participants to stay engaged and to keep checked in. Furthermore, in the Mobile Challenge, members could know each other better and get more involved with the social activities and interactions because of the synchronous communication afforded by the Mobile Challenge's live chat window. Consequently, the members reported they experienced more close relationships with each other.

Lessons learned from the interviews are that besides social competition, one should consider implementing social collaboration in an engaging way. The engaging strategy can be done by: (1) implementing both "peer-competition" and "peer-cheer" features in the mobile app; (2) designing activities that are engaging and challenging; (3) designing for small groups of co-workers or family/friends; (4) providing various types of "Challenges"; and (6) supporting varying participation frequencies.

Although participants felt positive about interacting with each other in the social network, participants were concerned about their privacy if they had interacted with strangers instead of their "acquaintances." They worried that if there were all strangers in the Mobile Challenge, other members of the same social group might be less willing to communicate as frequently as they were in the study. Besides, strangers might not be reliable in participation and social communication; therefore, involving strangers in the social interaction – the Mobile Challenge in our case – might become more of a dull time instead of a fun time. In comparison, when involved with co-workers or friends, participants found more peer-pressure as well as peer-cheer from the group than with strangers. Being able to work out the Mobile Challenge together with family members and friends would also be enjoyable and fun.

Empathize Self-awareness and Foster Emotional Investment through Game Flow

The *FitPet* mobile game was not motivating enough to promote changes, which was not what we had expected in the design phase of this project. Participants liked the main design idea. However, they the game did not provide constant awareness or feedback as a wearable wristband, therefore, people had less emotional investment and attention for the virtual pet than a *Tamagotchi*. Participants' responses proved that a separate system embedding the *FitPet* Game might be more efficient in facilitating the emotional empathy for the virtual creature because they would perceive it as an object, a thing, rather than a digital game that they will never do any harm to. Moreover, people lost their interest and motivations for playing the game in the long run. We failed to provide matched game challenges that satisfy players' growing skills, and participants' increased physical activity. Therefore, the third lesson learned is that even for a small-scale game like *FitPet*, the difficulty of challenges in the game should be well arranged to match players' skills. Although participants had no problem with understanding the game concept and mechanics, the game required more attention from people than merely "observing for increasing self-awareness" as prior avatar visualization prototypes [6]. As this avatar visualization approach asks for more attention and investment from players, designers should implement more challenges that match players' skills. To provide more self-awareness for reflection, *FitPet* could have sent out regular notifications about the pet's condition and its increasing demands for players, and potentially making it increasingly harder to trade steps for game coins.

Study Limitations

Our study was, of course, not without its limitations. The weather in the Great Vancouver Area can influence physical activity to some degree as the region sees heavy rainfall at various points in time; however, all groups were subject to the same weather patterns throughout the study. Our study also did not have a *FitPet* social community condition available to compare our results to and the activity level of *FitPet* users was not as fully tracked as the *FitBit* group. Moreover, both the *FitBit* and *FitPet* App were limited regarding what types of activity they could monitor and had difficulties detecting activities besides walking and running. Finally, there is the potential that the novelty of one or more of the technologies affected users' activity levels. For this reason, longitudinal studies should be used to explore the effects of the gamification approaches further.

6. Conclusions

The lessons learned from this research can inform the design of applications for promoting physical activity or well-being behavior changes. From the analysis, we found that the social aspects are evaluated as an effective strategy if used correctly and under certain circumstances. For example, some social aspects can involve participants in an active and engaging way, such as socializing and having fun with each other. Conversely, the passive communication afforded in the Website Community has not proven very effective in promoting physical activity. Moreover, besides social competition, opportunities for positive collaborations should be considered as an important type of social interaction when designing for gamification. Specifically, social components should be implemented in a *FitPet*-like game approach, and its effectiveness should be investigated and evaluated. Furthermore, since *FitPet*-like games hold the potential to engage people and we see people's enthusiasms about making achievement in a larger context than their personal goals. More mechanics and dynamics are needed to enhance the level of players' awareness and engagement. Attending to these issues will help in the ways in which ubiquitous and persuasive technologies can be used to encourage physical activity and promote healthy behavior changes. The reflections of this research and critiques of others in the same fields helped us understand: to be effective and efficient, the context where gamified approaches are used matters. Contexts summarized from interviews are personal life schedule, individual physical activity baseline and condition, as well as preferences of social communication and taste of games. The contexts and prerequisites of what gamification strategy should be deployed, how to use it, and when, are critical to the success of designing gamification strategies for behavior changes.

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