



## PROGRESS-BASED STRATEGY FOR USER ENGAGEMENT IN MHEALTH PARTICIPATORY SENSING

Syarulnaziah Anawar<sup>1</sup>, Saadiah Yahya<sup>2</sup>, Zakiah Ayop<sup>1</sup> and Andita Suci Pratiwi<sup>1</sup>

<sup>1</sup>Faculty of Information and Communication Technology, Universiti Teknikal Malaysia Melaka, Durian Tunggal, Melaka, Malaysia

<sup>2</sup>Faculty of Computer & Mathematical Sciences, Universiti Teknologi Mara, Shah Alam, Malaysia

E-Mail: [syarulnaziah@utem.edu.my](mailto:syarulnaziah@utem.edu.my)

### ABSTRACT

For a long time, outcome-based strategy is used as a basis of health standard in wellness program. However, in the case of mHealth participatory sensing the strategy is not always pertinent because the user of the platform is not limited to patient only, but also by a person who used the system for wellness maintenance, and by the stakeholders that collect and analyze information. To improve community's engagement on health wellness and maintenance, we propose myCommHealth that emphasizes on progress-based strategy. myCommHealth is an open data collection platform using mobile devices and allow community and stakeholder to collect, analyze and submit or share health related The objective of this paper is two-fold: First, to explore the design principle behind progress-based strategy for user engagement in mHealth participatory sensing system. Second, to propose myCommHealth, a proof-of-concept prototype that incorporate intrinsic incentive, feedback, and self-monitoring tools to improve user participation in wellness and health-maintenance campaign.

**Keywords:** progress-based, user engagement, mHealth, participatory sensing.

### INTRODUCTION

As observed, non-communicable diseases (NCD) which are related to unhealthy lifestyle cause a high proportion of deaths particularly in Malaysia. Realizing this, it is important to promote early self-risk assessment and shifted research focus towards health wellness and maintenance. The main challenges in implementing the wellness policy that have been identified are: (1) insufficient evidence-based for policy makers for decision-making (2) Community's low engagement on health wellness and maintenance. (3) Wide gap between community's knowledge and behaviour.

To address these challenges, we design myCommHealth, a mHealth participatory sensing system as open data collection platform using mobile devices and allow community and stakeholder to collect analyze and submit or share health related information. myCommHealth is initiated for organization and authorities to run mHealth participatory sensing campaign in community. It allows participants and stakeholders to monitor health-related activities, NCD monitoring, and coaching.

The objective of this paper is two-fold: First, to explore the design principle behind progress-based strategy for user engagement in mHealth participatory sensing system. Second, to design myCommHealth, a proof-of-concept that incorporates intrinsic incentive, feedback, and self-monitoring tools to improve user participation in wellness and health-maintenance campaign. This paper is organized as follows. Section 2 explain the main concept in user engagement and review some related work. In section 3, the design insight and guideline of progress-based strategy to improve engagement is presented. Finally, we present system architecture and the proof-of-concept implementation of

our prototype in Section 4. Our work of this paper is summarized in the last section.

### BACKGROUND AND RELATED WORK

The concept of engagement in computer system has emerged from the literature in the past years. Laurel in 1993 [1] define user engagement as:

"The state of mind that we must attain in order to enjoy a representation of an action" so that we may experience computer worlds "directly, without mediation or distraction".

Jaques [1] further suggest that user attention is maintains and encourages especially through intrinsic incentives. Attfield *et al*, [2] add that user engagement emphasizes on positive quality of user experience particularly on interaction and technology's captivation. The quality of user experience depends on the depth of user participation achievement based on experiential attribute [3].

Acknowledging issues of degrading quantity and quality of data collection in participatory sensing, a framework [4] of incentive mechanism in the direction of engaging and motivating participants contributing data in participatory sensing applications. The work focuses on the impact of flexible selection of incentive mechanism towards different type of: (1) interest of individual user, (2) characteristics of individual user, and (3) properties of applications. To the best of our knowledge, this framework is the first to hypothesize the association of engagement construct towards higher quality and quantity of data participatory sensing. However, it has to be borne in mind that this framework is not empirically tested

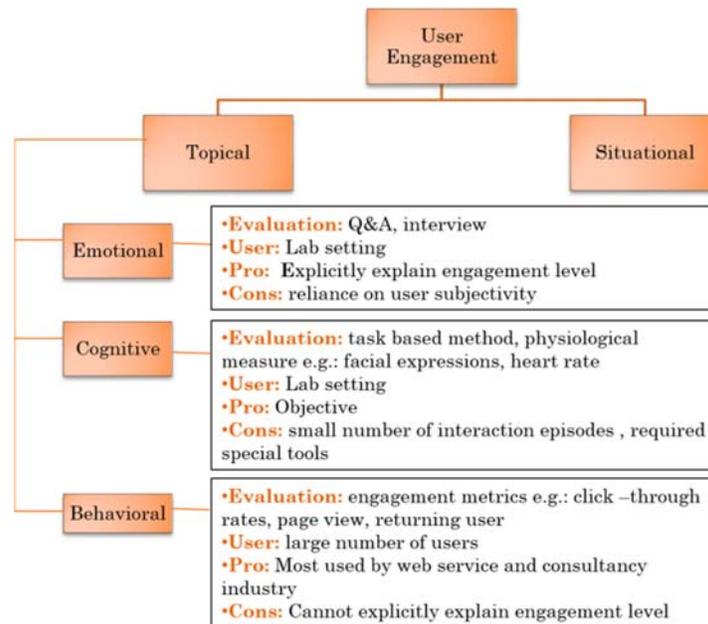
In 2013, Vreede and Nguyen described a model [5] of user engagement in Crowd sourcing. They define user engagement in the context of crowd sourcing as the quality of effort online users devote to open collaboration



activities that contribute directly to desired outcomes. Based on engagement measurement in web analytics [6], the quality of effort is quantified by the degree of participation, duration spent, and self-perceptions of engagement by users. According to them<sup>5</sup>, user will high likely prolong participating and making meaningful contribution if they are personally interested in the topic regardless the importance of the issue.

There are two types of user engagement [7] as summarized in Figure-1, topical and situational. Situational engagement is usually short-lived, context

dependent and environmentally activated. It is a kind of engagement that is based on the novelty of topic, which enough to trigger curiosity, and the salience of content. Topical engagement is developed through experience and emotions which give individual emotional, cognitive and behavioral quality. User is said topically interested when they are addressing important life themes (emotional), participating in events which are outside their deep emotional range (cognitive) and perform an action beyond typical expectation (behavioral).



**Figure-1.** Summary of user engagement classification.

In Table-1, we present our proposed variables to measure user engagement based on our synthesis of literature in mHealth participatory sensing. We then mapped the engagement variables into empirical studies of mHealth participatory sensing design. The engagement variables that we extracted based on the literature are:

a. **Goal:** The appropriateness of accomplishment was evaluated and then the number of appropriates served as the indicator for quality of participation.

- b. **Loyalty:** The quantity of participation is measured by the frequency input by the participants.
- c. **Contribution:** Participants effort to improve standard participation requirement set by campaign manager.
- d. **Activity:** Number of activities engaged by a user.
- a. **Duration:** Period of a campaign set by campaign manager.
- e. **Social:** Level of cooperativeness and competitiveness with other campaigns' participants.

**Table-1.** Mapping of engagement variables onto empirical studies [8-12] of mHealth participatory sensing design.

Empirical studies	Engagement variables					
	Goal	Loyalty	Contribution	Activity	Duration	Social
Consolvo <i>et al.</i> , 2009 Physical Exercise	√	√		√	√	√
Hicks <i>et al.</i> , 2010 Physical Exercise				√		
Kawasaki <i>et al.</i> , 2013 Physical Exercise		√	√	√	√	
Mamykina <i>et al.</i> , 2008 Diabetes	√	√		√		
Mattila <i>et al.</i> , 2010 Weight-loss	√	√		√	√	
Oliveira <i>et al.</i> , 2010 Medication		√			√	
Harrison <i>et al.</i> , 2012 Mental health			√	√	√	
Freyne <i>et al.</i> , 2012 Weight-loss	√			√	√	

### DESIGN INSIGHT AND GUIDELINE

For a long time, outcome-based strategy is used as a basis of health standard in wellness program. However, in the case of mHealth participatory sensing the strategy is not always pertinent because the user of the platform is not limited to patient only, but also by a person who used the system for wellness maintenance, and stakeholders that share information.

To improve community's engagement on health wellness and maintenance, the design principles of myCommHealth emphasizes on progress-based strategy. We adopt a progress-based incentive [13] into our system to provide a self-adjusted approach in order to achieve health goals and intrinsic incentives. Using this strategy, the public who previously believe the health standard unfeasible and not medically appropriate, may engage in myCommHealth as a medium of behavioral intervention in order to improve their health. This is particularly important because what is seen as "progress" may vary among the participants. Some participants may view participation in wellness activities as adequate progress while others may deem progress as achieving a tangible health goal [14].

The proposed design guideline of our progress-based strategy is adapted from study on user preferences for mHealth applications [15]:

a. **Incentives and feedback** - In Progress-based strategy, all participants will equally get an opportunity to earn incentives regardless of how far away they are left behind the recommended standard. In the context of present study, intrinsic incentive is the reward gain by a participant that should be met in order to motivate participant to stay participating and

accomplishing user goal. We believe that intrinsic value can be a strong motivator, particularly when extrinsic motivation is put at minimum level. For example, a participant may continue contributing data and participating in a health campaign because they find the task given is challenging and would like to feel a sense of mastery once they are able to accomplish campaign's goal. Thus, intrinsic is said as a booster for sustainable engagement for participants in a participatory sensing campaign.

b. **Self-monitoring** - Another key concern in application design is self-monitoring support tools like goal setting, reminders and feedback, and decision support were considered attractive. The ability of participant to set, manage, and monitor their progress toward health goal was an important intrinsic incentive for using self-management tool. Then, the accomplishment rate for the goal is calculated. The concept of goal setting and reminders is potentially valuable to help adhere to some domain particularly in medication compliance, stress management, and prevention and cessation campaign. Customization of prompts and reminder schedule is considered necessary. The reminder must be timed to be convenient to the participants. Random reminders, or having to remember to complete assessment after every meal (without reminder), were also felt to be problematic

We previously [16] suggest that self-monitoring operates by enhancing focus on the desired engagement variables of the participatory sensing application, goal, participation, duration, and activity.



- Goal Settings:** This work recommends progress-based variables for goal settings instead of outcomes-based model which is based on health practice standards. In myCommHealth, participant sets an adjusted target and the apps will provide feedback for inappropriate targeted goal using guidelines suggested by Blackburn *et al*, [17] until they attain a realistic goal. This offers all participants an opportunity to accomplish goals even if it does not meet the health standard.
- Participation:** Participation represents the number of inputs or data that were taken by a participant. It can be compared over different time intervals that make up the data collection period. myCommHealth offers submissions per daily, weekly, fortnightly, or monthly.
- Duration:** Only data from participants who record two or more weights spanning a period of at least one month is accounted for collection to exclude unreliable health data.
- Activity:** Currently, myCommHealth offers several function where participant might join only one

activity or many. The more activities, the higher time spent for interaction, and the better experience for a user with the application.

## IMPLEMENTATION AND PROOF OF CONCEPT PROTOTYPE

myCommHealth is an upscaling of our previous project, w8l0ss [16]. Project myCommHealth is a mHealth participatory sensing system which is initiated for organization i.e., service provider, to run a wellness-program. It allows participants to record their activities that contributed to wellness and health maintenance. The activities include BMI and Weight-loss management, Dietary and calories intake management, Wellness activity, Diabetes and Blood pressure tracker, and Health club information. This project is developed for Android mobile user and an open database web platform. Figure-2 shows myCommHealth system architecture.

The design of the system can be seen in Figure-3. We developed Self-Monitoring tools and Reminders as our approach to effectively promote health-related activity.

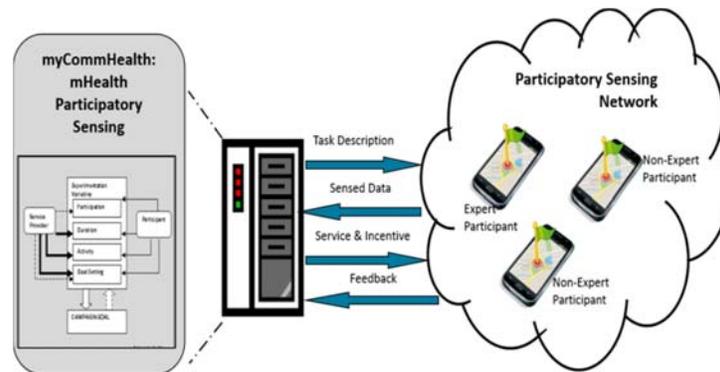


Figure-2. myCommHealth system architecture.

**Self-Monitoring and Reminders.** Users keep an activity journal in which they can record daily health-related activities, whether or not it counts toward a goal. The initial of the user self-monitoring starts with setting up their goal body info and user profile. The journal interface is similar to the goal-setting interface: the user navigates to the activity, taps to add data of their daily activity and saves it.

**Reminders.** myCommHealth provide the user with prompts (or pop-up reminder?) to journal activities and health related data, as well as a persistent reminder in the form of ringtone plus notification flash message on top of the mobile screen. User may set these reminders twice daily, and can be timed to be convenient to the user.

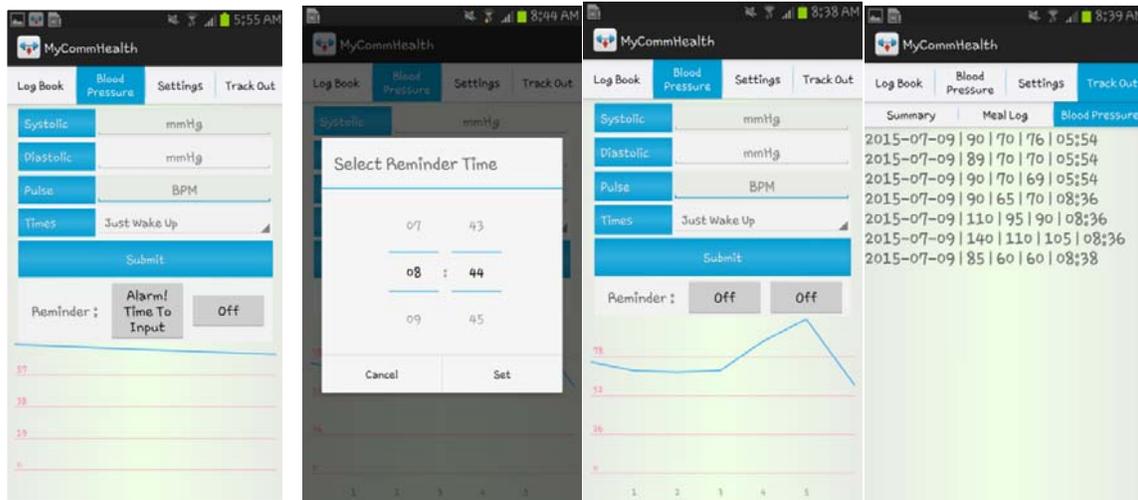
**Viewing Progress.** myCommHealth support self-monitoring in a variety of ways. From the Blood Pressure screen (Figure 3, bottom left), a line chart shows the detail of information which inputted in Blood Pressure page. The Graph shows the progress of user's blood pressure

information within the set duration. Detail Blood Pressure readings can also be seen in Track Out page (Figure 3, bottom right).

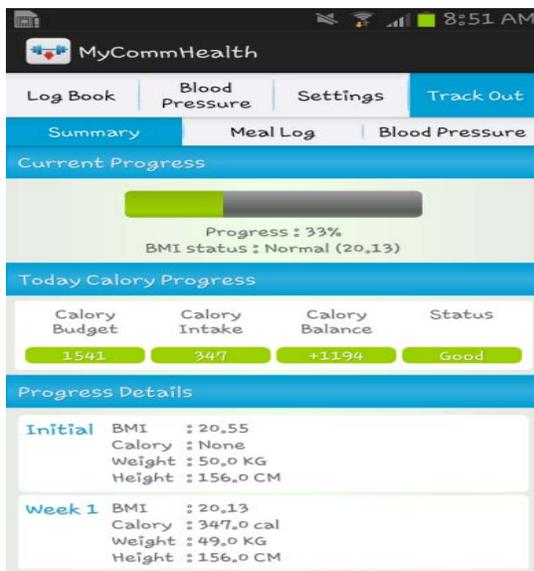
From the Track Out page, Summary tab (see Figure-4) will show:

1. Current Progress: the bar will shows percentage of user current progress to achieve weight-loss target.
2. Today Calory Progress: it shows user calory budget, user calory intake and user calory balance which is it will change frequently following user meal log.
3. Progress Detail: it shows user health progress from user's week start and each week of data submission.

Every time user inputting in Log Book section, the information will be sent and displayed in Meal Log page.



**Figure-3.** MyCommHealth application. Top Left: Blood pressure monitor. Top Right: Reminder setup page. Bottom Left: viewing blood pressure progress within the time duration. Bottom Right: Track out blood pressure readings.



**Figure-4.** Summary page.

## CONCLUSIONS AND FUTURE WORK

This paper explores the concept of user engagement in mHealth participatory sensing and identifies the design principle behind progress-based strategy to promote user engagement in myCommHealth. myCommHealth is a proof-of-concept that incorporate intrinsic incentive, feedback, and self-monitoring tools to improve user participation in wellness and health-maintenance campaign.

We are currently performing data collection using a qualitative data analysis methodology. We perform interview with 20 participants as respondent after they have used myCommHealth for two (2) weeks. The collected data will later be analyze using Atlas.ti, a qualitative data analysis software. The finding will be

validated using the statistical validation on the data collected in myCommHealth database.

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