FitBit Garden: A Mobile Game Designed to Increase Physical Activity in Children

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ABSTRACT
In this paper, we present the design and deployment of a mobile game titled "FitBit Garden" that encourages children to be physically active by representing the activity levels tracked via a FitBit pedometer in a garden ecosystem. The garden flourishes and grows as children and their parents take positive actions in the real world to improve the child's physical activity. These actions are then manifested into the virtual world via the mobile app. The paper presents the design of the intervention, the methods developed to collect and analyze data and the results of the usability study to determine form, function and acceptability of the intervention.

CCS CONCEPTS • Software and its engineering → Software organization and properties → Contextual software domains

KEYWORDS: Mobile, Design, Games, Obesity, Physical Activity

1 INTRODUCTION
Recent years have seen a sharp increase in obesity rates among children and adolescents in the United States. The National Health and Nutrition Examination Survey (NHANES 2013-14) indicates that a quarter of preschoolers (2-5 years) and one third of school age children and adolescents are obese or over weight [1]. There are also significant socio-economic and racial disparities evident and Native American, Latino, African American children seem to be disproportionately affected by the current obesity epidemic. 48.9% of Native American children are overweight or obese [1]. Obesity has been associated with an increased risk of cardiovascular diseases and Type II Diabetes leading to significant long-term morbidity [2]. Poverty leading to lack of affordability and access to healthy food are some of the major factors that account for high overweight and obesity rates. In addition, children and adolescents who are highly acculturated to an American lifestyle have poor eating habits with greater dependence on fast food and spend less time on exercise and physical activity [3].

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Obesity in childhood has been associated with subsequent obesity in adulthood leading to health disparities and increased cost of healthcare. The prevalence rates for obesity in the United States is well documented, however the incidence rates are not known, one approach to tackle this problem is to introduce interventions at an early age such that incidence of obesity can be curtailed.

2 METHODS
2.1 Design
Fitbit Garden is a novel in-home smartphone application that encourages Physical Activity (PA) by having family members compete in building the best looking garden. The plants and the entire garden ecosystem are automatically generated when the daily, weekly and monthly PA goals set by the player are reached. Ability to customize the garden is possible by completing the goals and collecting the rewards. The design of Fitbit Garden builds on complementary theories and ideas from behavioral science, avatars, game design and goal-setting. Developed by Fisher and Fisher [4] the information, motivation, and behavior skills (IMB) model, serves as the theoretical foundation for this design (Figure 1).

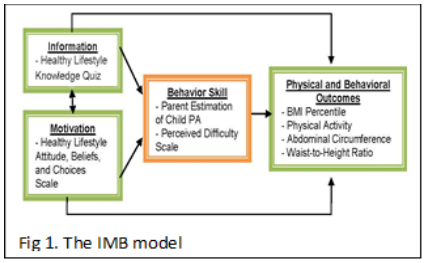

Fig 1. The IMB model

It is an empirically supported, partially mediating model in which information (e.g., for skills building) and motivation (e.g., supported intentions to make healthy choices) result in behavioral skills (e.g., choosing the right activities) for initiating and maintaining preventive health-related behaviors (e.g., increased child PA). Fitbit Garden satisfies the following design principles originating from the IMB model:

2.2 Application development
The mobile application development draws from our previous windows application that was aimed at improving PA estimation skills of parents [5]. The design followed a user centered approach also termed Player Centered Design when used to design games [6].

The objective of the application was to increase the PA levels in infants by increasing motivation in children and improving participation by parents. The design of the application builds on the IMB model (Figure 1), in which information (e.g., for skills building) and motivation (e.g., supported intentions to make

healthy choices and child's intentions to succeed in the game) result in behavioral skills (e.g., parental skills to estimate, incorporate and monitor child's PA) for initiating and maintaining preventive health related behaviors (e.g., increased child PA). The game was designed to represent a virtual garden where the virtual plant (avatar) is being controlled by the parent-child dyads on a mobile/tablet application. The growth of the plant avatar and the neighboring garden environment was dependent on two factors: 1) The PA levels received from a Fitbit (pedometer) device that was worn by the child at all times and 2) The PA estimation skills of the parent. Figure 2 shows the results of increased PA on the g arden environment, the red bars indicate the estimated values while the blue bars indicate the actual values. The check-ins by the parent happen every day during dinner time and the application updates the environment after the check-in is completed. The targeted time for the intervention was two weeks and the expected outcomes were to improve parent's PA estimation and goal setting skills as well as child's motivation to increase PA by performing the appropriate tasks.

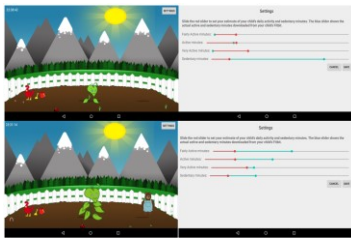

Fig 2. Game Screens

Table 1. Usability results

Usability Question	Agree/Disagree/Percentage
Using the motion detector fit into my everyday activities	9/1/90
The motion detector was easy to use	9/1/90
Using the FitBit Garden fit into our lifestyle	9/1/90
FitBit Garden encouraged my child to increase levels of activity without feeling punished when he/she was not active	9/1/90
The FitBit Garden was pleasant to look at	9/1/90
The FitBit Garden accurately represented my child's activity at each check-in	6/4/60
My home was the best place to discuss the feedback during check-in	10/0/100
FitBit garden helped my child understand how increased PA contributes to better health	7/3/70
FitBit garden helped me understand how increased PA contributes to better health	9/1/90
Did the rewards earned in FitBit garden encouraged your child to be more active	9/1/90
Did FitBit Garden educate you on how active your child needs to be on a daily basis	9/1/90
Would you use FitBit Garden again	8/2/80
My child could easily see the changes in the FitBit Garden during check-in	6/4/60
We were able to easily troubleshoot problems with FitBit Garden	5/5/50

2.3 Usability testing

A screening form [7] was used to identify and select 10 parent-child dyads who participated in the two week long intervention. Parents were screened based on availability, access and ability to use the mobile app and Fitbit devices. The intervention protocol had the following steps: 1) install the Fitbit device, mobile application at the participant's home 2) have them complete the nutrition and activity questionnaire to understand their current behavior patterns 3) measure child's anthropometric data 4) train the parents on using the Fitbit and the mobile application every day during dinner time 5) visit the home after week one, connect the device online and retrieve PA data from the Fitbit account 6) visit the home after week two and retrieve the device data, measure child's anthropometric data, give parent's the application usability questionnaire and end the study.

Table 1 shows the results of the usability survey given to parents at the end of the intervention period.

3. DISCUSSION AND FUTURE WORK

In this paper we have presented initial findings on the acceptability and usability of a smartphone app and a commercial pedometer used together as an in-home intervention to improve PA outcomes for 4 and 5 year old children. Out results indicate that such a system is acceptable and further research is needed to collect more evidence on its long term use in homes. Majority of the parents were satisfied with the use of the game and were encouraged to use it on a daily basis. There were some significant limitations with the game in it not providing instant feedback and update to the ecosystem, which was a noted concern and a system that can overcome this limitation might increase greater participation and interest. Adding continuous change and increasing incentives, challenges, levels and providing greater rewards were also requested by the participants. This study provides initial evidence in the success of in-home game based PA intervention and addressing the above stated concerns would be the goal of the next iteration of this application. The research also collected daily activity levels and anthropometric data for the participants and this data is currently being analyzed for correctness and cross-validation of the stated goals. However the validation with only 10 participants is a significant challenge and therefore as a first step this paper is only presenting the usability results and after further refinement of the application and performing a larger in-home trial cross-validation studies will be performed on all the data sets gathered from the study.

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