TeenPower: A new obesity prevention strategy to e-empower and engage teenagers through gamification techniques applied to a self-monitoring mobile application

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Abstract - Adolescent obesity has reached epidemic proportions, being critical to find effective prevention strategies. The TeenPower project was developed to promote healthy behaviours and prevent adolescent obesity through an mHealth platform. An Android application was created to meet the goals of the project. This application is to be used by adolescents, mainly for self-monitoring and educational purposes. The Android application has already been deployed and is currently being used in a pilot project, by real users. A natural enhancement is the development of an iOS version of the app to reach even further users and extend the intervention area. Besides, adopting new and improving existing gamification strategies is essential to promote and accomplish positive behavior that changes outcomes and engages users.

I. INTRODUCTION

Obesity is considered the most significant health challenges facing today’s youngest generation [1] and it is associated with serious health and physical consequences in childhood as well as an increased risk of premature death and disability in adult life [2]. The prevalence of overweight and obesity among children and adolescents have risen dramatically so that in 2016, 18% of the global population of children and adolescents (10-19 years) had overweight [3].

According to the Childhood Obesity Surveillance Initiative - COSI Portugal 2016, Portugal is one of the European countries with the highest prevalence’s of overweight/obesity [4]. This is a significant concern for the Portuguese National Health Service that believes that it is urgent for health care providers, insurers, philanthropic organizations and schools to invest in obesity in following areas of action: treatment services to support people affected by obesity/overweight; early intervention to improve treatment success; implementation of prevention programs/strategies to reduce the need for treatment [5].

Prevention is known as a viable way to contain the epidemic percentages of overweight/obesity and nutritional surveillance data are essential to effectively design, implement and evaluate policies and strategies to combat obesity [2]. Overweight and obesity cannot be solved through individual action alone. Comprehensive responses are needed to create healthy environments that can support individuals in making healthy choices grounded on knowledge and skills related to health behaviors.

In general, these results reinforce the need to create and implement an intervention/prevention program which we named “TeenPower: e-Empowering teenagers to prevent obesity” and it was implemented in schools in the district of Leiria, Santarém and Castelo Branco, in Portugal. Briefly, the TeenPower project lays in a healthcare technology system that empower adolescents to make healthier choices and manage more effectively their health [3]. Working for the success of the project is a multi-disciplinary team that is making its contribution in several scientific areas such as Multimedia and Arts Design, Healthcare, Information Technology and Sports. Essentially, the TeenPower project focuses on the analysis of effective responses to a serious public health problem (obesity/overweight) based on e-Therapy.

Digital behaviors change intervention programs are associated with a more rational use of health services by helping patients and caregivers in the decision-making process and promote changes. This interventions are usually achieved using various technologies such as websites, smartphone apps or wearable devices [3]. Since the smartphone ownership among teens is growing and they are one of the highest users of technology, about 23% of teens aged 12-17 years own a smartphone and 88% of them have mentioned access to a smartphone or laptop/computer on a daily basis the need of a m-Health platform like TeenPower was reinforced [1].

The TeenPower mHealth platform is composed by two main software applications: An Android mobile application which is to be used by teenagers and provides health related content and self-monitoring tools to e-empower teenagers to prevent obesity; and a web based Backoffice to support health professionals to access and update contents available on the teens’ mobile app, and to analyze their usage and self-monitoring data. The mobile application is structured as a game that enrolls the teen in a journey while inciting obesity prevention behaviors [4],[6].

This paper mainly describes the technical aspects of the development and implementation of the TeenPower mobile application. Describes the current state of the application (a first version of the application) that is already available for users in the Google Play Store [7] and presents all the new additions to the system that are in progress, from the technological point of view.
II. TEENPOWER MOBILE APPLICATION

The TeenPower mobile application plays a crucial role in the TeenPower project itself. The application target audience are teenagers and they are using the app already. We created an attractive virtual environment, with a game-based learning approach, where their engagement is rewarded. In short, the user assumes the role of a customized avatar that can explore different scenarios available in the TeenPower map.

A. Functionalities and Design Considerations

The application is composed by three main modules which are used transversely by four pre-defined scenarios. The three main modules are:

- **The self-monitoring module**, which allows the teen to register data regarding sleeping hours, meal intake, physical activity (step count, abs and push-up counts) and biometrics data (height, weight - body mass index - and waist circumference); Historical registered data can also be seen through interactive charts;
- **The educational resources module** that showcase contents like videos, leaflets, histories, manuals, diets, links, suggestions, interactive contents, quizzes, and challenges;
- **The social interaction module** that includes private chat with colleagues and health professionals and discussion forums.

Throughout the application, in the self-monitoring module the user gets feedback about his progression of health behaviors and biometric data; and receives positive reinforcement. The user can also analyze and interact with the historical registered data through interactive charts that reflect his weekly and monthly progress [4].

The four pre-defined scenarios are Home (includes Kitchen and Bedroom), Gym, Park and Library (Figure 1).

![Figure 1. TeenPower Map.](image)

The “Home” scenario presents the user with the Kitchen and the Bedroom. He has access to food suggestions (clicking on the fridge), can insert the meal intake (clicking on the avatar) and register sleep information (clicking on the bed).

The “Gym” not only allows the user to watch exercise related content (clicking on the bike) but also supports a section for registering weight, waist and body mass index (Figure 2 - right). The “Park” presents the recorded steps and expended calories for the week as well as exercise related videos (Figure 2 - left).

![Figure 2. TeenPower Gym and TeenPower Park.](image)

The “Library” is a content (data) repository and presents multimedia and encouraging health related leaflets to pass information to the user.

At this time, the user isn’t rewarded for his engagement. This was the initial version that was implemented and has the critical aspects of the system in order to meet the functional objectives. The self-monitoring functionalities are essential to evaluate the effectiveness of the intervention program and that’s why they were, from the beginning, the priority.

B. An Overview of the Architecture

The TeenPower application has been developed in Android in accordance with the android development guidelines using Android Architecture Components and following the Model-View-ViewModel (MVVM) [8],[9] design pattern in order to isolate business logic from user interface logic. This is presented in Figure 3.

![Figure 3. Teen Power Android Application Design Pattern [4].](image)

Each activity (user interface layer) only handles presentation logic and data presented in view consists of LiveData objects [10] inside a View Model. Then, activities have Observers that act as listeners that listen for changes in data which can trigger updates in view. The function of the View Model is to retrieve data either from the in-app database using a Data Access Object (DAO) or from the TeenPower database by making a request to the TeenPower API. The data generated by self-monitoring modules are stored in an in-app database that was created using Room Persistence Library [11] that provides an abstraction layer over SQLite in order to avoid repeated connections to an external database (like the database housed in a backoffice server) which can
be beneficial when the user is connected to high latency networks.

Volley HTTP [12] and GSON Libraries [13] are used to make HTTP requests to the API and parse JSON encoded entities contained in the responses into existing model classes in the application.

Additionally, the application interacts with two external systems:

- Google Firebase: in the initial version of the app, the app only takes advantage of the Firebase Cloud Messaging Service (FCM) [14]. Thus, providing the sending of push notifications to the mobile applications whenever the user uses features from the social interaction module;
- Google Fit [15] to count the user’s daily steps and the calories expended in the process. Google Fit gives information based on context retrieved from the user’s smartphone. Users are only required to sign in to a google account, so that context information recorded can be associated with a google account.

III. A NEW PROPOSAL

The TeenPower project is already being implemented, essentially, in schools so the application is already being used by real users/teenagers. Since the application became available and the intervention program started, members of the TeenPower team had weekly contact with the users. This has given us a new perspective (as developers) and has given rise to new ideas, new improvements and encouraged the development of new additions to the system.

A. The iOS Version

The iOS version of the TeenPower application has always been a goal. Apple’s iOS it’s the second most popular mobile operating system in the world [16] and with a version of the TeenPower app available to Apple users, the project can meet its goals: reach a higher number of teen users. So, the first enhancement is to migrate the app to Apple’s iOS in order to widen the project focus and consequently increase the number of users of the application. From the technological point of view, a new operating system means compliance with new development guidelines.

The goal is to create an app with the same exactly functionalities as the Teen Power Android app and with similar layouts, providing the same experience to end users, regardless of the platform they are using. Thus, at the presentation layer there are no expected significant changes.

The development of the iOS version of the app has already begun and the priority involves the development of all the user functionalities: user login, persistence, user profile and user model/entity.

B. Gamification: The Way to Engage

Furthermore, both versions (Android and iOS) will benefit from one of the critical aspects to improve the user engagement: an actual gamification strategy. “Gamification has been a predominant focus of the health app industry in recent years” [17] because “the idea of using game-thinking and game mechanics to solve problems and engage audiences isn’t exactly new. To further engage audiences, we need to consider reward structures, positive reinforcement, and subtle feedback loops alongside mechanics like points, badges, levels, challenges, and leaderboards” [18]. We envision that the main challenge will be to apply gamification techniques to the application in order to promote and accomplish positive behavior change outcomes, using the existing design elements.

Hereupon, some new features have already been developed in the scope of gamification:

- The Reward System

We implemented a simple way to reward the user: users can accumulate points by using the modules of the app (self-monitoring, social, educational). Basically, a number of points were assigned to a set of tasks that are considered important. Thereby, every time the user performs those tasks, he will win that number of points. The number of points are shown to the user in specific screens of the application and every time the user gain points he sees an animation in those screens. Every user starts with 10 points and earns points according to the information in Table 1.

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Scenario</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Click in fridge to see food suggestions.</td>
<td>Home: Kitchen</td>
<td>5</td>
</tr>
<tr>
<td>Click in one of the food suggestions.</td>
<td>Home: Kitchen</td>
<td>10</td>
</tr>
<tr>
<td>Register hydration.</td>
<td>Home: Kitchen</td>
<td>20</td>
</tr>
<tr>
<td>For each meal recorded.</td>
<td>Home: Kitchen</td>
<td>10</td>
</tr>
<tr>
<td>Register sleep hours.</td>
<td>Home: Bedroom</td>
<td>20</td>
</tr>
<tr>
<td>Register activities before sleep.</td>
<td>Home: Bedroom</td>
<td>10</td>
</tr>
<tr>
<td>For each forum access.</td>
<td>Menu: Forum</td>
<td>5</td>
</tr>
<tr>
<td>For each post in forum.</td>
<td>Menu: Forum</td>
<td>10</td>
</tr>
<tr>
<td>For each biometric register.</td>
<td>Gym</td>
<td>5</td>
</tr>
<tr>
<td>For each physical activity register.</td>
<td>Gym</td>
<td>15</td>
</tr>
<tr>
<td>For each access to media contents.</td>
<td>Gym, Park, Library</td>
<td>10</td>
</tr>
</tbody>
</table>

Currently, the points are shown to the user as shown in the Figure 4.

Figure 4. User points in the red circle and progress visualization in yellow circle.

- The Wall of Fame and Badges

The user has access to the ranking of the game, in which the first ten positions are displayed. The ten users with the highest score and their own position and score are listed. The
user with more points has a badge with the inscription "The best score" (Figure 5).

- Progress Visualization

The user can also visualize his progress through status bars (Figure 4, - yellow circles). There are five status bars to show progress in hydration, hunger, tiredness and physical condition. These bars are dependent on the user’s usage of the self-monitoring throughout the day: the hydration bar is linked to water glasses consumed; hunger bar is linked to meals inputted during the day; tiredness bar is dependent on the number of hours slept; physical condition bar is dependent on the daily steps. Quotas for these bars are adjusted for gender and reference values defined by health professionals.

We believe that the progress visualization encourages teenagers to input their habits in the app.

IV. CONCLUSION

TeenPower arises from the need to create and implement an intervention/prevention obesity program to target adolescents’ nutritional, health, fitness and social habits. Currently, an Android version of the mobile application is already deployed and is being used by real end users in a pilot project implementation. A natural enhancement to the project is the provision on an iOS version of the application, targeting iPhone users and broadening the intervention area. Another relevant improvement appears as the definition of new gamification strategies that will lead to the engagement of users.

Our hope is that these new additions will bring new users and keep current users engaged and healthy.

REFERENCES


