# Obesity Management in Children on an iOS Device

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***Abstract*- The main objective of this paper is to create an application that makes use of gamification principles in order to teach and guide children and teens towards a healthier life and encourage them to lead it. The application also allows users to track their overall progress and it instructs them on how to proceed. While doing so it gives them tips and facts about improving their lifestyle. The application also tries to apply gamification techniques like having a sense of competition and providing feedback so that tasks like exercise are more engaging. To evaluate the application, a group of people made use of the application as they saw fit, for a period of time. The gamification techniques used were successful in giving them the desired experience. With the competitive element between friends encouraging them to make more use of the application and the tips and facts helping them towards a healthier lifestyle. The biggest concern was that the application did not encourage the users to keep using it as much as we'd liked.**

***Keywords-obesity; healthy; iOS; gamification; lifestyle***

## I. INTRODUCTION

The problem of obesity is a growing concern that has reached epidemic scales in most developed countries within Europe and the United States of America [16], [18]. Recent studies show Malta as having the most obese adult and child males in Europe [1], [2].

The biggest concern is that obesity puts children and teens at risk of developing more serious health issues, which are normally seen at an older age [17]. It is also a strong indication that the child or teen will be obese once adulthood sets in.

This helped motivate us into trying to find our own solution to the problem; so we set out to develop an iOS application that would help the users tackle obesity. With current smartphone devices, the application's potential is endless, even more so since current generations spend so much time playing some kind of game on some type of device or console [19].

After reviewing various publications and current technologies, we came up with the ***My Lifestyle App*** for the iOS. It makes use of gamification concepts like using a points and a leader board system in order to engage users and help them maintain healthier lifestyles. The application also attempts to challenge and teach users so that they can lead a healthier lifestyle.

Once we developed the application, we also had a group of people trying out the application for a period of time before evaluating it. After they evaluated it, we analysed all the results and came to a conclusion.

In this paper, we give a short analysis of different papers that we reviewed with regards to current technology used for nutritional purposes and different gamification concepts. We then move on to stating our aims and objectives and how we plan on designing our proposed application in order to reach these objectives. From there, we move on to the Implementation stage. There we give a detailed outlook on how the application was developed. Finally, we give a report of our findings before coming to our conclusion. In the conclusion, we try to summarise our findings and state different ways of how we plan on improving the application for future reference.

## II. LITERATURE REVIEW

The literature review was split into two main sections. The first section revolved around papers, publications, and applications regarding technology that is being or will be used in helping to improve ones nutritional values and help to combat obesity. The second section was with regards to gamification and the different techniques that can be used in order to make mundane and tiring tasks more fun, engaging and meaningful.

### *A. Technology and Nutrition*

The basis of how we plan on tackling obesity, as said by Tsai et al. [*3*] is to modify the two main modifiable aspects of an obese or overweight person's life. These aspects are their diets and their physical inactivity. So, we sought out to examine the different technologies that were able to help in improving these aspects of someone's life in some way or another.

With the advancements in smartphones, monitoring food intake has become much easier, where various systems allow you to scan barcodes and retrieve the item's nutritional values very easily. Yet, for this to function properly, we need to have large amounts of data stored in large online databases, with food items for all kinds of societies since different societies will have different brands and different food items. This would also make the application more dependent on an Internet connection, which might not always be available. It might also have efficiency issues in order to retrieve certain information from the database, so it will need to be optimized to enable quick searches.

Although such a system would allow an application to tell you what kind of food you would need during the day, and what's good and what's not, simply allowing them to monitor themselves still would not be enough. This is mostly due to the fact that even if you simply scan an item

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to input it's nutritional values, some users will still either forget or not bother to input the items, which would result in the application giving them bad instructions. Therefore, we will also need to teach the user about why and how they should eat healthier, so that they would not necessarily need to monitor their food intake. Instead they will know what is good for them and what's not.

One way of teaching nowadays is through games, and this is becoming especially common in younger generations. One simple example can be seen in [*4*], where Piziak et al. make use of a Pictorial Bingo Game, which would help teach children about healthy foods, either through riddles instead of calling up numbers like in a normal bingo game or by simply showing them the image of a healthy food item for them to cross out on their bingo card. Piziak et al. also conducted a study about how effective such a method was. Parents of the children were asked to state if they saw a change in their child's eating habit after using the game, and they reported some good results. Parents stated that they saw an increase in vegetable consumption, also showing that children were actually learning about their food in a fun and enjoyable way. In a different publication (Yien et al. [*5*]) they developed a course that made use of different games to teach children about different ways of living a healthier life. The course was split into 4 sections, with each section making use of a different computer game. It included sections like learning about food for psychological and physical needs, where they learnt about the different food groups within the food pyramid. An illustration of the food pyramid can be seen in Figure 1.


Figure 1. Food pyramid indicating the six main food groups
Source: [*6*]

They also learnt about how certain environmental factors that came into play when eating healthy foods. They learnt about eating less fast food and about eating alternative, healthier foods. Their last lessons involved a one-day diet where they monitored what they consumed for a whole day, so that for a single day they were more aware of what they were actually eating. After this one-day diet, each subject compared their personal lifestyle to that of a healthy lifestyle in order to see how they were doing. They also learnt about how they can improve their lifestyle, by making use of certain rules to develop a healthier example of living.

So, by making use of simple games to teach children, it can have very positive effects. Yet, as mentioned earlier, we not only want to teach our users about healthy eating, we also need to find ways of how to help increase our users' physical activity during the day. Different means were researched, like use of active video games and use of smartphones and other technologies, which can hopefully have some effect on a child or teen's level of activity.

With regards to active video games, there were two publications that generated the most interest in order to help us design our application. Both these papers conducted studies on the use of active video games and on how effective they really are. The first publication is by Maddison et al. [*7*] and they conducted a controlled study with regards to active video games used by children, where they had advised their intervention group to perform a minimum of 60 minutes of moderate to vigorous exercise every day. The children involved (both control and intervention groups) would also be monitored three times during the entire study. At the start, half way through and at the end of the study period, a series of tests were conducted to see if there was any improvement in the children's Body Mass Index (BMI) and other aspects. The study resulted significant difference in the BMI percentile of the intervention group against that of the control group. With the intervention group losing an average of 0.33% of their BMI, whereas the control group averaged a loss of 0.08%. Yet in our second paper by Baranowski et al. [*8*], they conducted a more naturalistic study, meaning that there was less intervention within the subject's life. They simply gave their subjects a Wii console together with some active games and let the children use them in any way they wanted, without any kind of instructions being given to them other than what the video game itself instructs them to do. This study gave conflicting results when compared to the paper by Maddison et al. [*7*]. They came to a conclusion that when the children were given a more natural setting, they either did not play the games that they were given or they compensated by being less active during other times of the day.

Here, we can see the conflicting result where when given the more natural setting, children were not making much use of the active video games. This resulted in no significant improvement on the overall health of the subjects [*8*], unlike what we saw in the more controlled setting, which is more unrealistic [*7*].

As for smartphone devices, we can make use of the device's in-built sensors like an accelerometer, a gyroscope, and Global Positioning System (GPS) to help track the device and the user's movement. So, with such a device there is great potential to create great applications that can help increase the user's physical activity. Such an application can be seen in [*9*], where Arteaga et al. developed an application that recommends third party health and fitness apps that it deems suitable for that particular user. Such an application works by first making use of the Big 5 Personality Theory to help get an idea of what kind of applications and tasks the user would mostly like to perform. Then, when the application recommends a certain application for the user, the user can accept or decline the recommendation, thus helping the app to continue learning about the user in order to better tailor the apps for him/her.

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From all the publications, it was very evident that by making use of smartphone technology, we are able to give the user a better interactive experience, and we are able to track their daily activity without having to be too intrusive in their daily routine, yet still manage to be part of this routine. The device is also a great medium to help teach our users about healthy living.

### B. Gamification

Gamification is the art of adding game mechanics to a system in order to make it less tedious and more enjoyable to use. Such a technique is ideal for making exercise seem less tedious and more like a game where you can compete against your friends. With our gamification techniques, we aim to achieve a Rate of Flow [*10*], a theoretical state developed by Mihaly Csikszentmihalyi, where the user is balanced between a state of anxiety and boredom. It is at this particular state that we are the most concentrated on performing a certain act, making the task feel easy and effortless to perform.

In order to achieve this rate of flow and have a successfully gamified application, we tried to find what makes a successfully gamified system and what we should avoid from doing. We saw various frameworks and theories about how and what needs to be done in order to reach our goal. With all the different theories we analysed, they all came down to the Mechanics, Dynamics, and Aesthetics of the system, also known as the MDA Framework [*11*]. The Mechanics of the system or the application are the individual aspects and background workings of the application. It includes the rules, conditions, game states, and user representation of the game or the system. The Dynamics of the game take into consideration the game's interaction with the user through the different mechanics during run-time. It does so in order to react to the user's inputs, enabling the user to make use of the mechanics. The dynamics also considers how intuitive the application is for the user and it also enables consistency within the application, which is important in order to give the user a good experience. The final aspect is the Aesthetics, which helps to evoke the desired emotions that we try to create with the mechanics and the dynamics of the system. These are the means by which the user will give his/her input and how he/she will receive feedback from the application.

By making use of this framework when gamifying our system, we will be able to give our user a more engaging experience. It will also help to give the application more meaning, which is essential if we want our users to keep on using the application.

From the publications that we reviewed we were also able to come up with the kind of gamification concepts that we can use within our application. One aspect is social integration within the application. This means that we make use of social networks like Facebook, so that users can share their progress and all their achievement on the social network for all their online friends or other app users to see, like and comment so that they could help encourage the users in reaching their goal [*12*]. Another aspect is the feedback system. Here, we would make use of a points system so that for every achievement or completion of a task we give the user an amount of points, thus giving the user an indication of how well or poorly they are doing. Also, by making use of the user's total points we can create a global leader board that would introduce a more competitive aspect. This would help to motivate our users by making them compete against their friends, thus resulting in them making more use of the application.

What we would not want to happen is to have the application be meaningless for the user. Such a thing happened to the Foursquare system that would allow the user to claim mayorship of certain destinations, which they would often visit. The concept of being a virtual mayor of a real destination did not really give the user much meaning. This is why, back in 2012, they completely redesigned the system and went from a game oriented application to a recommendation application, which it was intended for in the first place.

After reviewing some publications on successful and unsuccessful gamified systems, we came to a conclusion that whenever we need to gamify any system, our aim has to be that we try to fully immerse the user in the system. For this to happen we need to give meaning to the system, so that the user is actually doing something with purpose. Without having some form of meaning, users will get bored and stop using the system or the application.

## III. AIMS AND OBJECTIVES

The main objective behind the development of this application is to help users engage in a healthier lifestyle by making use of a mobile app on an iOS device. The application will specifically target children and teenagers between the ages of 12 to 19 years. Since not a lot of time is available in order to have a full trial where we can see whether or not the application makes any significant difference, we will only be aiming to get our users on the right track towards leading a healthier lifestyle.

To make the application more fun and engaging for our users we will be making use of gamification in order to help teach and guide them in maintaining a healthier lifestyle. Other than simply teaching them about healthier choices, the application will also try to challenge the user to perform certain tasks that will increase their physical activity, tasks include walking instead of taking the bus, going out for a quick run, taking the stairs instead of an elevator and so on. Therefore, we will be using the iOS device to challenge our users in real life instead of in a virtual environment.

In order to achieve our goals, we try to apply gamification techniques like using a points feedback system to help encourage the user and a leader board system to create a sense of competition. We also incorporated a social aspect to the game by giving users the ability to share their current progress on their Facebook accounts.

Hopefully, by making use of these concepts we are able to engage the users and have them feel a great sense of achievement by having completed the challenges set out for them.

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## IV. DESIGN

While designing the application, we kept in mind that we wanted to be able to give the user the necessary functionality, but this shouldn't mean that its aesthetic qualities should suffer. First of all, the application will be designed using XCode (https://developer.apple.com/xcode/) and it will be optimized for use with the iPhone/iPod Touch running iOS 6.1 or later, allowing us to make use of the accelerometer and Global Positioning System (GPS) sensors found on the devices.

To start making use of the app, we will need certain information from the user in order to give him/her the appropriate instructions. The information needed will allow us to calculate the user's BMI, their ideal weight and Resting Metabolic Rate. The application will also request Facebook permissions so that the application is allowed to post on behalf of the user.

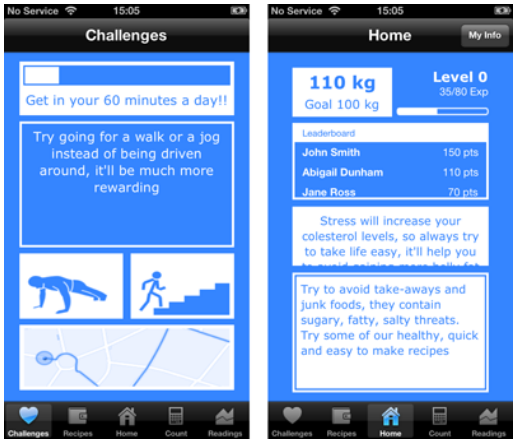


Figure 2. Application screenshot showing the Challenges and Home Sections, together with the other three sections shown in the tabbed navigation bar
Source: Gary Hili - 2013

The application design is split into five sections, fitting the iOS's tabbed navigation controller as seen in Figure 2, so that we can display all of our content in the different sections for the user to easily navigate through. These sections are the following:

- Home Section – This is the first view seen by the user. It contains a progress bar together with a summary of how the user is doing. It also has an area with some tips and facts about eating and living healthier. An important aspect of our gamification techniques can also be found here, since we included the overall leader board, which displays the top ten users.
- Recipe Section – This section includes a list of healthy, easy to make, tasty recipes for every time of the day that the user can enjoy. It also gives the user the possibility of sharing an image of what they prepared on the social network, by doing so they will also be earning points.
- Weight Readings – Used to track the user's progress in terms of their weight and height in order to get an idea of the user's current Body Mass Index. Here, users will be able to get a more visual representation of how they are doing by having a scatter graph instead of a list of numbers with their past weight.
- Calorie Counting – It allows the user to track the calorie content of the food they consume and calculate the caloric burn of the exercise or physical activity that they perform. By inputting such information, the application will be able to instruct the user on how to proceed by first calculating their current caloric balance.
- Challenges Section – This is a very important section within the application. Here the application will be tracking the user while he/she is performing certain exercises that the app can track. These exercises include push-ups, stair climbing, walking or running. In this section, the application recommends certain exercises depending on the time of day and the amount of exercise performed so far in the day. Users will then be given certain amount of points depending on how well they perform during each challenge.

By having the user make use of these different sections we will be able to help them achieve their goal of leading a healthier life.

## V. IMPLEMENTATION

When we implemented the application, we made use of the Model-View-Controller design pattern, which has the advantage of separating the data and the information from the user, resulting in cleaner, reusable code and a more efficient application.

### A. Controller Layer

The Controller layer is where the application communicates from the front end to the back end of the application. Classes in this layer don't have much logical computation performed in them. In our implementation, some of the controllers do perform some of the more complex operations within the Challenges section of the application.

- In the Push-Up challenge, the controller will receive accelerometer data every time the push up button is touched.

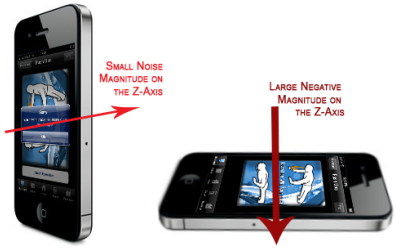


Figure 3. Use of accelerometer to detect the device's orientation
Source: Gary Hili - 2013

The purpose of this is to detect the device's orientation, as seen in Figure 3, so that it can help detect if the user is cheating by not having the device lying face up but instead he/she is holding it in their hands.

- The Stair Climber challenge also makes use of the accelerometer sensor. In this challenge, the controller is constantly receiving information from the accelerometer.

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The controller then calculates the magnitude of the three axes of the accelerometer and if a certain threshold is reached that will be counted as a step. It continues to do this until the user either chooses to stop or the challenge has been completed.

- In the final challenge, the Walk/Run Challenge, the application makes use of the devices GPS tracking capabilities in order to track the user's route, speed and distance. The Walk/Run Challenge also consists of one of the biggest disadvantages within the application. This is the fact that the current version isn't capable of tracking the user once the device's screen has been locked.

Other than the above-mentioned algorithms, the Controller will mostly handle any data being sent by the model layer and any user interactions that are made with the view layer and require some kind of processing.

### B. View Layer

The View layer contains all the aesthetic properties of the application. It is this layer of the application that the user will interact with and be given feedback. Implementation of this layer was relatively easy since we made use of the XCode storyboard feature, so designing and connecting the different views was quick. Designing the look of the application still took some time in order to achieve the best possible aesthetic appeal. While designing this layer we tried to make use of a simplistic approach, using a monochrome design with contrasting colours throughout the application. This simple approach was used in order not to overwhelm the user and so that the emphasis can remain on the content of the application yet still be appealing to the user. One of the more complex views was the Weight Readings Section since here we had to include the CorePlot Library [*13*] in order to design the view.

Most of the maintenance of the view layer is done by the iOS itself, so the main job of the views is to simply fire actions each time a user interacts with that view so that any listening methods can perform the necessary action.

### C. Model Layer

As for the Model layer, this is the backbone of the application, where all the logical and mathematical calculations are being made. At this layer we have all the data controller classes together with the classes that manipulate this data before being sent to the controller layer in order to be sent to the view layer. The data controllers are used to load and save data in XML format. They are able to either load the necessary data from the application bundle or the devices document directory and they also have basic array manipulation methods that allow other classes to make use of the loaded data. We use the data controllers at various points within the application. They control the challenge difficulty levels, the list of recipes and the handling of weight and calorie count entries amongst other tasks. This layer also makes use of algorithms that help determine what tasks should be recommended or what instruction should be given to help the user. In order to give the necessary instructions to the user, we have certain classes that take the available data and calculate the BMI, Resting Metabolic Rate (RMR), the caloric balance and so on, storing these values for other classes to use. So, these values are then called by another class, which uses them to determine what kind of instruction to give the user. By using BMI and the caloric balance, the application will tell the user how they are doing during that day, instructing them to eat or exercise more, or whether they are overdoing it and eating or exercising too much. The model layer also instructs users on what kind of exercise they should perform. The algorithm used to tell the user what challenges to perform makes use of the time of day together with how much exercise they've performed so far during that day. The main reason why we used this approach is because our main age focus is 12 to 19 years of age, and at these ages they are spending 9 months out of 12 in school, so they are more likely to be home at certain hours, and at school at others. Hence, in the mornings and the evenings the application will be suggesting the Stair Climb challenge since it might be too early or too late to actually go out for a walk. As for the Walk/Run Challenge, it's mostly encouraged after school, maybe walking back home or to some after school activity. As for the push-ups they are mostly being used as a way to working your body and not be sitting down all day, so we create this easy challenge where they don't really need to go out. Being such a low calorie burning exercise, the application would not be recommending it as much as the other challenges. Figure 4 shows what kind of challenge is being recommended during a certain period of time. Taking into account the amount of time spent exercising during the day, the algorithm will no longer recommend the Walk/Run Challenge. Instead it recommends the Stair Climb Challenge, which is easier to perform indoors in a shorter period of time.

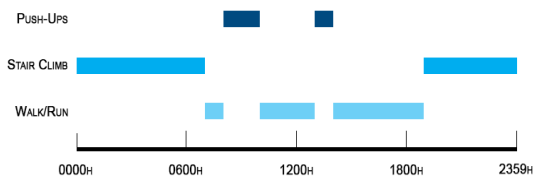


Figure 4. Gantt chart of the times each exercise is suggested
Source: Gary Hili – 2013

The instruction being provided also makes use of positively reinforced statements because certain studies (Woolfard et al. [*14*]) had shown that making use of such messages makes the users feel better about themselves, boosting their self-esteem.

The last thing the model layer is handling is the social integration of the application and any network related functions. This includes retrieving and setting data on the leader board being used in the home section.

Implementation of the artefact took longer than expected since we were new to technology. However, the resulting application was very satisfactory and once testing of the

application's features were performed, the beta evaluation of the artefact could commence.

## VI. Results and Evaluation

In order to evaluate the application, we first conducted a 20-day trial period, where a group of 25 users were asked to use the application as they saw fit and then evaluate it by filling in a questionnaire. Each user's points throughout this period were also being tracked so that we were able to evaluate how much they actually made use of it.

The aim of the application was to help our users in order to start leading a healthier life, so we tried to improve the users' eating habits by teaching them about healthier alternatives and giving them the possibility of tracking their food consumption for them to be more aware of what they eat. We also tried to increase their physical activity by making use of the different challenges and encouraging them to exercise more during the day. To make it all the more enjoyable we implemented gamification concepts that motivated our users to compete against one another and encourage one another.

The users that evaluated the application did not have any severe problems of obesity. 52% were female and the rest male, with 76% between the ages of 19-21, 16% were between the ages of 16-18 and the rest were over 25 years of age. Although most of the users were not within the age group the application was targeting, their input was still valuable. The reason being that they are able to express themselves better about how the application is helping them and how it can be improved.

In order to evaluate the application they were given a questionnaire, which regarded the use of the gamification concepts within the application. It also regarded how well the application helped the user with regards to their diet and exercise, and finally they were asked to report any bugs or future work they'd like to see.

With regards to the use of gamification, users found the points and leader board techniques to be very helpful and it made them want to use the application. The biggest reason was because of the competition it evoked, which was motivational for them. The social integration factor wasn't as successful as we'd hoped it would be. We had included this feature since in recent years we have seen an increase in how people are constantly posting and sharing statements about their lives on such online networks. With our application, users did not really make much use of this feature, resulting in the majority (68%) not even realizing that using it would earn them more points, yet 70% of those that did not realize this said that they would've made more use of it if they had realized it gave them extra points. Another important aspect of a gamified system is the application's intuitiveness and ease of use, which is highly dependent on the aesthetics of the application. We had 96% of the users finding it very easy to use, while the other 4% gave a neutral opinion on the matter.

Next, the users were asked about how the application helped them increase their physical activity. Most of the users liked all the three challenges that we provided but they were not used as much as they were liked. This meant that the challenges were not effective in helping our users lose weight, but were helping in keeping the users engaged with the application. For example, 80% of the users liked the Stair Climber Challenge, 92% of the users even said that having an application that tracks their exercise is great, yet only 40% of the users said that they made use of Stair Climber challenge on a daily or almost daily basis. The same scenario can be seen throughout the three different challenges (as seen in Figure 5).

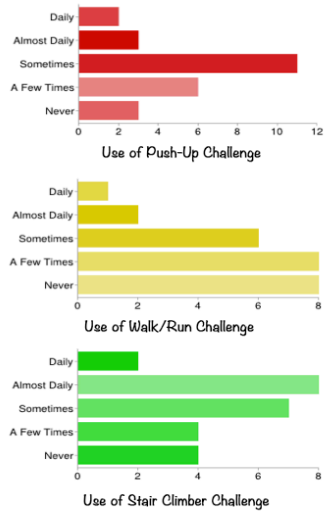


Figure 5. Bar charts showing usage of challenges
Source: Gary Hili – 2013

Then the users were asked about how the tips and facts given to them about living healthier managed to help or in any way affect them. The tips were found to be very helpful and easy to remember as well, with most of the users having recited a tip or a fact that they had read while using the application. As for the calorie counting aspect of our application, we saw that tracking the user's food consumption wasn't very effective. A small percentage said that it was easy to use, yet the majority said that they either did not use it or they couldn't bother to search the web to see how much calorie an item contains. Some users also suggested that we try to make this easier by adding a way that the users can actually search their food's nutritional values and add it to their list.

In the final part of our evaluation, we analyzed the data recorded by keeping track of the users' points throughout the 20-day period. As one would expect, some users made more use of the application than others. Our biggest concern was that even for a small period of time, users were not making use of it daily, with some users even showing long periods of not making any use of the application. By the last 6 days of the trial period, about 90% of the users had stopped making use of the application entirely. Around half way through our trial period, we introduced an update to the application, which handled some bugs that we had found. After making this update available for the users we could see a slight overall increase in the usage of the application even though no new visible content was released.

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What we were able to conclude from this was that we were not able to retain the users as much as we'd liked. When we asked some of the more active users why they think this happened various responses were given. Yet most of them stated that they had moved on to another application that was capable of giving them more detailed reports with regards to their current performance and is capable of giving them detailed reports on their personal computer as well.

By making use of gamification, we were able to successfully motivate our users so that they'd make more use of the application by competing against their friends. We also managed to help them learn about ways to lead a healthier life. However, we still were not able to retain the user's interest for a long enough period to make a significant difference in their lifestyle. Other pitfalls with our application included our food tracking implementation, which, although easy to use, isn't able to tell the user the nutritional values of a food item. The application also lacked in the social aspects, since users did not really make much use of the social networking features.

Even if we had some negative results from the evaluation of the application, we still managed to get some results that have helped us get a better understanding of how we can fix and improve the application in order to benefit our users and make a significant difference in the lives.

## VII. Conclusion and Future Work

Our aim when we started this project was to develop an application that would help obese children and teenagers start leading a healthier lifestyle.

Although we managed to make a small difference in the lives of our users, room for improvement can be evidently seen, most of all we would need to introduce a better way to track the users' caloric consumption. This can be done using various ways depending on how technology will move forward. One way is to use large databases with different choices that the user can search for. Another way would be to introduce edible RFIDs [*15*], which could contain such information directly on the RFID or via an online database. The application also needs to introduce background processing in order to improve the application's exercise tracking capabilities.

Some other possible ideas were also mentioned in the user evaluation of the application. This included the introduction of more challenges, which would give a better variety. The users also said that one kind of additional feature could be the ability to upload images of their workouts.

We were able to successfully design and implement our application, using gamification concepts throughout in order to help teach the user about healthier foods and motivating them to increase their physical activity. After having analyzed all our findings, we were able to come up with a possible way forward that would improve the application in general. Most of all, it will improve the user retention and hopefully have the users make more use of the application, maybe even on a daily basis.

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