

QATAR UNIVERSITY

COLLEGE OF ENGINEERING

A NUTRITION GAME-BASED TECHNOLOGY SOLUTION TO INCITE CHILDREN

TO TAKE DAILY BREAKFAST FROM HEALTHY FOOD

BY

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## ABSTRACT

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Title: A Nutrition Game-based Technology Solution to Incite Children to Take Daily Breakfast  
-  
from Healthy Food

Supervisors of the Project: Prof. Jihad, Mohamad, Jaam and Dr. Noor, Ali, Al-Maadeed

Many children in Qatar are going daily to school without taking their breakfast. They buy, however, unhealthy food from their schools, nearby shops or restaurants, which results in many health problems, like obesity and teeth decay. To overcome this problem, we propose a learning system that incites children to take their breakfast before going to school. The system is composed of two main components: 1) a video game and 2) an informative tool. The system enhances the children knowledge about healthy food with breakfast and shows the importance of exercising to have a healthy life. The game aims to develop children's eating habits and help them to maintain ideal weight and become healthier. On the other hand, the diet informative component aims to help parents to select the right food for their children based on their health conditions. According to the assessments carried out on children of age 6 to 12, the results show that most of them intended to change their eating life style after playing the game. This shows that the proposed solution is promising and may have a significant impact on children's health.

**Keywords:** *Nutrition Game; Obesity and Overweight; Healthy Food.*

## DEDICATION

*I am dedicating this work to my daughter “Noor” because she missed me a lot during the creation of this project as well as my Mom for her help and support taking care of my daughter during my long hours of absence from home.*

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## CHAPTER 1: INTRODUCTION AND BACKGROUND

### 1.1. Introduction

The rapid spread of fast food restaurants in the state of Qatar and their alluring advertisements make the children and adolescents in the country obsessed with their attractive food. Therefore, parents commonly report that their children are going daily to school and neglecting to take their early breakfast at home. They prefer to buy junk food or snacks from schools or nearby restaurants when they feel hungry. In fact, breakfast is considered as an important meal for children's body, especially for their proper growth as it provides the body with the energy required to start the day properly [1]. Recent works showed that people who are eating early breakfast are less likely to be overweight compared to those who skip this meal. Typically, when the child goes to school without having this meal or eating unhealthy food, he/she loses his/her concentration in the class, which degrades his/her level of understanding. Besides, eating consistently unhealthy food causes a dramatic effect on children's health because it includes nutrients that do not meet the needs of human cell activity [1]. The best nutrition affects human life in its quality and longevity besides reducing the risk factors related to nutrition diseases [2]. Therefore, weight management is a key component of good health [1]. Chronic diseases started and aggravated mainly from unhealthy eating such as unbalanced nutrition and overeating [3].

A new report published by the U.S. Centers for Disease Control and Prevention's National Center for Health Statistics showed that 34 percent of adolescents eat fast food on daily-basis and 12.4 percent get their daily calories from unhealthy food. Many diseases

are rampant in society among children because of bad eating habits and staying physically inactive. [4]

A recent statistical report on childhood obesity from Hamad Medical Corporation in Qatar on 2009 mentioned that around 70 percent of school children are taking junk food as their daily meals. In addition, 33 percent of them are skipping their breakfast while 80 percent do not get the recommended daily amount of fruits and vegetables. [5]

A recent study conducted in Qatar University on 2014 shows that 42.6% of school children are overweight and obese. This figure shows 3.6% increase over the study conducted by Childhood Culture Center on 2009. [6]

Another survey conducted earlier in Qatar shows that two out of three children take fast food at least once or twice a week. Moreover, 90 percent of the children take unhealthy snacks between their meals, which results in 28 percent of children being obese. According to international association of obesity study in 2009, Qatar had the highest obesity rate of young boys in the region. [7]

The obesity is the major impact resulting from eating unhealthy food, which is considered as a visible health issue that reached epidemic proportions in developing countries [8]. It puts humans at risk to more than 30 chronic health conditions like, asthma, type 2 diabetes mellitus (DM), coronary heart disease, tooth decay, cardiovascular, hypertension, dyslipidemia, kidney diseases, and cancer. The obesity is growing dramatically among children due to many factors that fall under environmental and individual factors [9]. Scientifically, the main cause of obesity and overweight is the

increase of the energy intake from foods and beverages than the expended in physical activities [1]. Unhealthy food contains more energy/calories than allowed. Moreover, the modern technology replaced the required physical activities at home, work, and transportation, for example, escalators replaced stairs, cars replaced walking, etc. Therefore, eating unhealthy food and lack of exercise are considered as main factors in obesity and overweight problems. The current treatment methods used nowadays, like modern surgeries of stomach, are giving a good weight loss, but in short term with a big risk on human's health [10]. To lose and maintain weight in long term, we need to increase human's motivation to change their eating behavior [10]. Educating children on healthy food becomes highly important topic to protect their health from diseases that affect the society.

Children and adolescent are gaining autonomy in choosing their food they would like to eat at the same time they may not have adequate information about it [11]. It seems that they need to be educated and guided on their food choices to fight obesity and all other diseases results from unhealthy eating [11]. Therefore, parents should play an important role in developing their children food preferences to help them grow up strongly and be physically active in school. They should prepare the breakfast and sit with their children to have it before going to school. However, this approach is rarely used because nowadays mostly both parents are working and do not have enough time to adopt it. A new approach should be then implemented to overcome this social challenging problem that greatly affect the society.

## 1.2. Motivation

Science has proven that the method of indoctrination is not effective in educating children especially when you are trying to change the things they like. Modern learning approaches involve child into interactive activities that have educational goals aiming to show them the impact of their actions.

Due to the wide spread of games on mobiles and tablets, several children spend most of their time playing on these technologies. These technologies offer the elements of excitement and challenge to the children beside the ease of use. In 2010, Kaiser Family Foundation institution in America made a survey on 2000 child from age 8 to 18 to measure the number of hours they spend in front of screens (mobiles, video games, etc.). They found that the average time the child spend is 7 hours and 38 minutes per day, which in fact represents a huge number of daily life. [12]

Another study carried out by Childhood Cultural Center in Qatar on 2016 about electronic games and their impact on children and young people's behavior. It shows that the proportion of children who play electronic games reaches 85% per day. Moreover, it estimates the rate of hours the children spent daily on electronic games, which exceeded 3 hours. [13]

From this study and many other similar global studies, we can recognize that most of children are addicted to electronic games. What if we could harness these games to teach children rather than be a waste of their time?

In reality, games can be an efficient fun tool to educate children and expand their knowledge by involving them into educational activities. There are many evidence in current educational literature that says employing a technology in educational processes results in improving learning outcomes [14]. The educational games aim to teach children with satisfying their fundamental needs such as playing, exploring and having fun [14]. Considering that playing and learning are a good combination of digital technology known as an important task in learning process [15]. That's why engaging education with technology has a great number of implications on children.

Since most of children have strong attachment to electronic games, they spend several hours a day playing video and mobile games. Most of the available online and mobile health games are English-based and contain food types that do not suite Qatar's local culture and Islamic religion. This inspired me to tackle health-related problems by creating a comprehensive nutrition system.

### 1.3. Project objectives

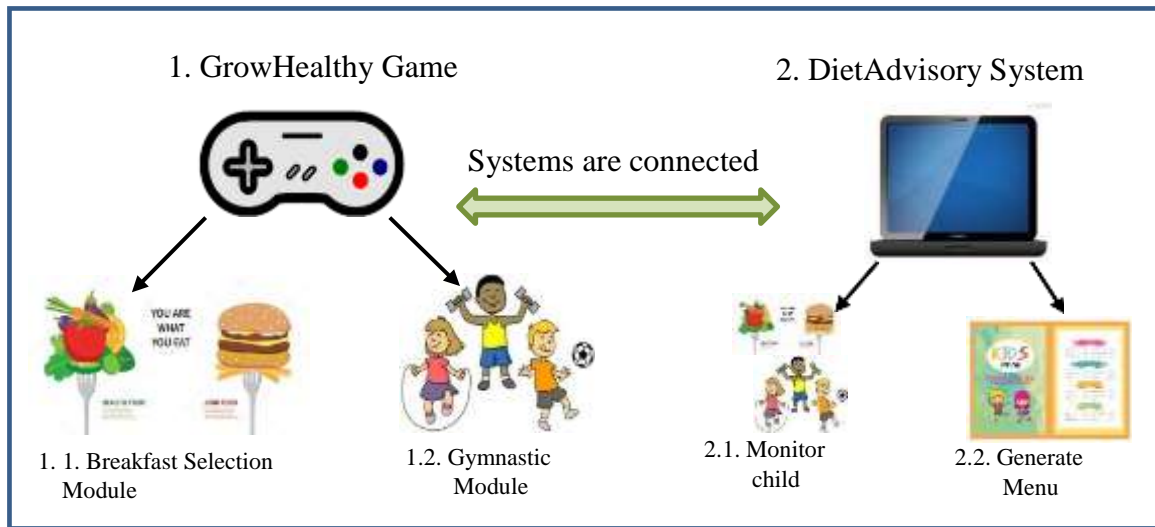
The main goal of developing a comprehensive nutrition system is to incite school children to take their daily breakfast from healthy food and increase the awareness of nutrition facts among society. The system focuses on the following objectives:

1. Play the game as usual, but with learning objectives.
2. Gain awareness on the importance of breakfast and healthy eating.
3. Learn about junk and fast food and their impact on health in short and long terms.



4. Improve child's choices of food items by listening to healthy advices offered in the game.
5. Instill the concept of sport in society by encouraging children to do physical exercise every day.
6. Help parents to understand the nutrition recommendations for children based on scientific nutrition information to offer them the best choices for breakfast.
7. Help parents to know the food items that their child likes.
8. Create a simple and feasible approach that can be adopted easily by children

The proposed system architecture can be summarized in Figure 1 below. It composed of: i) 3D video game called 'GrowHealthy' adopted to Qatar's society and intended to teach children the importance of taking healthy breakfast before going to school and playing daily sports, and ii) a web-based diet advisory system for parents called 'DietAdvisory' that dynamically generates daily breakfast menu according to child's health condition and monitors child's activities on the game. Both systems are detailed in Chapter 5 below.



*Figure 1. System Architecture*

#### 1.4. Outlines

The report consists of the following chapters:

**Chapter 1: Introduction and Background**, shows an overview about the problem and the objectives of the project along with the motivation behind creating the system.

**Chapter 2: Literature Review**, presents the related works of similar systems and technologies.

**Chapter 3: Nutrition Theories and Terminologies**, describes some nutrition theories and terminologies used in the proposed system.

**Chapter 4: Proposed System Design**, shows the system design along with the USDA database used in the diet advisory system.

**Chapter 5: Proposed System Implementation**, describes the implementation of GrowHealthy game and DietAdvisory system in details.

**Chapter 6: Evaluation and Testing**, presents the assessment conducted in the game to evaluate it.

**Chapter 7: Conclusion and Future Work**, shows a conclusion of the report with an explanation of future work.

## CHAPTER 2: LITERATURE REVIEW

### 2.1. Introduction

Globally, many institutions care about children's health and try to implement many applications to help children of certain age to eat healthy food. Plenty of online healthy food games are freely available on the internet and categorized by children's age group, for example, British Nutrition Foundation offers a website called "food a fact of life" that has several games for different age groups. In addition, "The adventure of Spoti" is an online interactive game that targeted children from age 6 to 10 years, who have Down's syndrome disability [16]. This game focuses on educating the children on food to reduce the childhood obesity using a series of healthy food activities and physical activities [16]. Beside online games, many research projects have been conducted in gaming area trying to reduce the obesity of children using different approaches.

### 2.2. Related works

Anna Mansour et al. [8] proposed a system called "MunchCrunch", which is a heuristic-based health game that intended to help adolescent of certain age to balance their eating habits by learning about healthy and unhealthy food. The game asks the player to answer simple questions prepared from each category of virtual food pyramid. Moreover, it offers a collaboration between team players by discussions and sharing information. This adds a value of entertainment to the game making it more competitive and motivates players to learn more about healthy food. This game uses a screen with buzzer buttons and

involve two teams to have a physical race between them to answer the question by pressing on buzzer buttons.

S.J. Lentelink et al. [9] implemented a healthy weight serious game that aims at fighting obesity and overweight. The goal of this game is to prevent and treat overweight and obesity by applying physical exercises in order to achieve and encourage healthier lifestyle. The game defines a step-goal for each player depending on his/her BMI score, age and average number of daily steps her/she performed. If the weekly goal is achieved, the player will be rewarded and going to the next level as well as the avatar losing weight and becoming slimmer. From technical side, it is a 2D game developed on mobiles that uses Android platform. Furthermore, it uses a step-counter algorithm that calculates the number of steps the player performs every day. This game supports multi-players where they can race against each other by presenting their position on racetrack according to the number of weekly steps they completed. The overall rate of this game was 7.5/10 from all the players, which in turn gives a good indication about how the game is useful and attractive.

Eman Almonani et al. [16] proposed a mobile game approach that prevents childhood obesity using persuasive technology. MACO is a mobile-based game composed of two components: courseware and game. The courseware module educates children about healthy and unhealthy food by showing images with a piece of information and suitable time to eat. It also teaches children the importance of physical activities on children's health by displaying images of active, overweight and obese children before and after doing the

exercises. The game module asks the child to select healthy food from a list of healthy and unhealthy items to earn points accordingly then play exercises such as jumping and running. Technically speaking, MACO is a 2D game built on mobiles with simple look and feel based on cartoon images.

Hawazin Badawi et al. [17] introduced a diet advisory system for children using biofeedback sensor. The proposed system uses biofeedback sensor attached to a child shoes to monitor his/her physical activities and measure the energy spent during the activities. These activities can be enhanced to give better results by providing suitable diet recommendations based on the child health condition and preferences. The algorithm implemented here calculates the daily expended energy of a child using accelerometer sensor and then give him/her healthy food diet based on the energy expenditure, vitamins and allergies. Finally, the results are shown to parents through their smart phones or computers.

Joongsin Park et al. [18] presented a new mobile game that promotes healthy choices for snack foods called “SnackBreaker”. The main idea behind this game is to select the proper healthy snack among different food types. The game consists of two parts; Elimination Tournament and True-False quizzes. In the first part, the game is continuously offering two choices of snacks where the players can choose from them until the winner is announced. During the gameplay, some nutrition information is displayed to players about snacks in a purpose of education and help on making the right choice. The second part of the game shows True-False questions about the nutrition information. The authors

conducted a study on 38 participants, which show that 36 percent of them willing to change their eating habits, while 55 percent express their satisfaction on the nutrition information provided by the game.

Nora Ptakauskaite et al. [19] proposed a game to promote healthy eating and support social innovation in children. The game is intended to support the National Health Service's (NHS) change4life initiative. This game offers a series of workshop activities to children from age 7 to 12, where they can do a handcrafted game design. It uses a co-constructive approach that allow children to act as valuable informants for the design. The patterns emerge from this study proven that the children understand the concept of healthy eating. Moreover, it provides a sort of questions about children's favorite sweets with pros and cons of playing video games.

J.P. Pollak et al. [20] introduced a "Time to eat" game that targets the seventh and eighth grade students. The idea behind this game is to design a pet care game, which is part of foreign culture. The player can choose among various pets (worm, dinosaur, etc.) and name it. The pet is communicating with the child through email by sending reminders to eat healthy breakfast before going to school. The game prompts the child to take a picture of his meal and submit it. Then, the user will receive a score ranging from -2 to 2 based on what he eats and the healthiness of his food. Technically, the game is a 2D game that is accessed using mobile browser.

A. Rodríguez Isasi et al. [21] created a serious game that helps children with Intellectual Disability to understand healthy eating habits. This project focuses on kids who suffered from Down syndrome and aims to educate them on healthy eating. The application is composed of two games. The first game is “how to make Salad”, which allows the child to create a salad plate by choosing the right food items between two different choices. The second game allows the child to select the food he/she likes for breakfast among variety of healthy and unhealthy items. The system will check the healthy food and give messages about unhealthy food selected. The application is tested among many children and the results were positive and encouraging. From technical point of view, it is a 2D game implemented in Apple IOS using Xcode and SQLite to run on iPhone devices.

Xiaocheng Li et al. [22] presented a healthy eating system using a web data mining technique that tracks eating habits of a person and recommends some types of food that improves his/her health and avoid illnesses. The proposed system is composed of three main components: data acquisition of eating habit, data mining, and recommendation of health eating. The system proposes a website where the people can choose their meals as if they were in a restaurant. Then their meal will be saved into the database and associated to further useful information by means of a mining algorithm for extraction. Finally, the system gives some recommendation for each user. Technically, this system is a web-based system implemented using various techniques, like data warehouse and data mining.



### 2.3. Conclusion

This chapter presents an overview of related works to the problem of educating children about healthy eating using games. Most of the methods presented are not suitable for the local culture of Qatar and Islamic religion because they are English-based and mainly based on foreign food items. Moreover, most of them are interacting with virtual pets, while this concept is not used locally. From technical side, most of the presented work are in 2D platform and don't have an animated character, which decrease the level of entertainment for the kids. Furthermore, some of the presented games have native base implementation (either Android or Apple IOS), which in turn limits the number of users who will use it. Therefore, a game that takes into consideration the local tradition and culture of children, the adoptability to any portable device, and the highest level of entertainment should be developed along with the correct nutrition information.

## CHAPTER 3: NUTRITION THEORIES AND TERMINOLOGIES

### 3.1. Introduction

Most people are getting energy from their food without caring about the calories suitability for their health. Human bodies need certain amount of nutrition daily to maintain their health state. 'Calorie' is determined as a measurement unit of energy in food and presented as Kcal (kilo calories) unit. People need a minimum number of calories to take daily which is called Basal Metabolic Rate (BMR). The BMR is affected by many factors of human body such as, gender, age, muscle body content, fat body content, and other internal body changes. The bad behavior on daily nutritional intake will lead to health problems such as malnutrition, overweight or obesity. [23]

### 3.2. Terminologies

Reference to the book [1], the daily calories needed differ from person to another depending on his/her gender, weight and height. Many variables have to be calculated to identify the calories required for each child as follows:

#### 3.2.1. *Body Mass Index (BMI)*

The BMI is a measure of weight adjusted for height. It is used to determine if the human is underweight, healthy, overweight, or obese using the following equation [1]:

$$BMI = \text{weight (Kg)} / \text{height (meter)}^2 \quad (1)$$

### 3.2.2. *Categories of BMI*

The Center for Disease Control and Prevention (CDC) produces an enhanced version of children growth charts. It uses a survey data and statically smoothing procedures in order to present children's BMI by their age in charts. These types of charts are recommended to use in clinical purposes by health care centers to monitor growth and identify potential health or nutrition related problems. [24]

Figure 2 below shows the BMI chart for boys from age 2 to 20 in percentile [24], while Figure 3 shows BMI chart for girls in the same age [24].



Figure 2. BMI chart for boys from 2 to 20 years old.

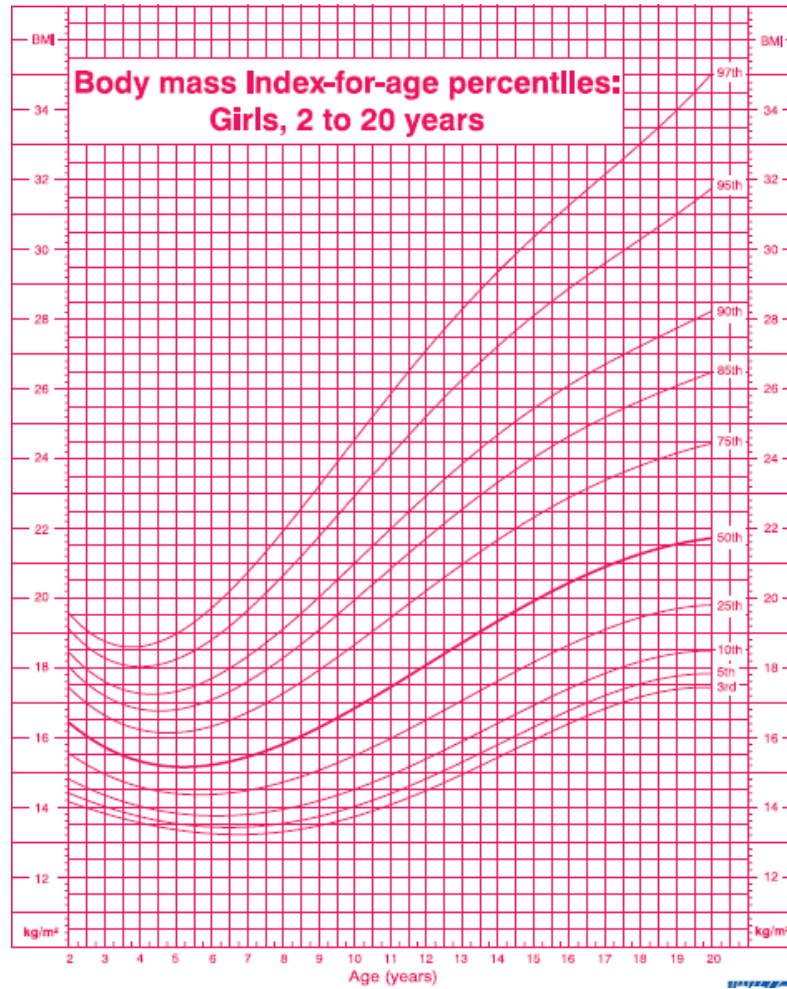


Figure 3. BMI chart for girls from 2 to 20 years old.

Based on the above charts, I constructed the following tables to use them in the system to easily categorize the children from age 6 to 12 based on their BMI.

Table 1

*BMI category ranges for boys*

Age	Underweight	Healthy	Overweight	Obese
6	$\leq 13.2$	$\geq 13.3$ and $\leq 17$	$\geq 17.1$ and $\leq 18.2$	$\geq 18.3$
7	$\leq 13.2$	$\geq 13.3$ and $\leq 17.2$	$\geq 17.3$ and $\leq 19.1$	$\geq 19.2$
8	$\leq 13.3$	$\geq 13.4$ and $\leq 18$	$\geq 18.1$ and $\leq 20$	$\geq 20.1$
9	$\leq 13.4$	$\geq 14$ and $\leq 19$	$\geq 19.1$ and $\leq 21$	$\geq 21.1$
10	$\leq 14$	$\geq 14.1$ and $\leq 19.2$	$\geq 19.3$ and $\leq 22.1$	$\geq 22.2$
11	$\leq 14.1$	$\geq 14.2$ and $\leq 20.1$	$\geq 20.2$ and $\leq 23.1$	$\geq 23.2$
12	$\leq 14.3$	$\geq 14.4$ and $\leq 21$	$\geq 21.1$ and $\leq 24.1$	$\geq 24.2$

Table 2

*BMI category ranges for Girls*

Age	Underweight	Healthy	Overweight	Obese
6	$\leq 13.1$	$\geq 13.2$ and $\leq 17.1$	$\geq 17.2$ and $\leq 18.4$	$\geq 18.5$
7	$\leq 13.1$	$\geq 13.2$ and $\leq 17.3$	$\geq 17.4$ and $\leq 19.3$	$\geq 19.4$
8	$\leq 13.2$	$\geq 13.3$ and $\leq 18.1$	$\geq 18.2$ and $\leq 20.3$	$\geq 20.4$
9	$\leq 13.3$	$\geq 13.4$ and $\leq 19.1$	$\geq 19.2$ and $\leq 21.4$	$\geq 22$
10	$\leq 13.4$	$\geq 14$ and $\leq 20$	$\geq 20.1$ and $\leq 23$	$\geq 23.1$
11	$\leq 14.1$	$\geq 14.2$ and $\leq 20.4$	$\geq 21$ and $\leq 24.1$	$\geq 24.2$
12	$\leq 14.3$	$\geq 14.4$ and $\leq 21.4$	$\geq 22$ and $\leq 25.1$	$\geq 25.2$

### 3.2.3. Basal Metabolic Rate (BMR)

BMR represents the number of calories burned when human is resting for 24 hours doing nothing. On other words, it represents the minimum energy required for the body organs in order to function. There are many equations to calculate the BMR; GrowHealthy game uses ‘Harris and Benedict’ because it is latest and precise equation [25]. The BMR calculation differs from boys to girls according to theories. Equation (2) below calculates the BRM for boys and equation (3) calculates it for girls:

$$BMR = 66.5 + (13.75 * weight (kg)) + (5.003 * height (cm)) - (6.755 * age (years)) \quad (2)$$

$$BMR = 655.1 + (9.563 * weight (kg)) + (1.850 * height (cm)) - (4.676 * age (years)) \quad (3)$$

### 3.2.4. Physical Activities

Physical activity represents the activity level of children per day engaged with a representative number. It differs based on the theory used in calculating the BMR. Therefore, ‘Harris and Benedict’ physical activities table was used in this project as shown below.



Table 3

*Physical Activity Levels*

---

Activity	Boy/Girl
Sedentary (Non-active)	1
Low Active	1.6
Active	1.31
Very Active	1.56

---

*3.2.5. Daily Calories*

The daily calories or daily energy represents the number of calories needed per day. It can be measured using the following equation [1]:

$$\text{Daily Calories} = \text{Physical Activity} * \text{BMR} \quad (4)$$

### 3.2.6. Food Pyramid

The USDA food pyramid is a diagram in a form of pyramid that specifies the optimal number of serving from each food group to take every day. It composes of five basic groups which are: Grains, Vegetables, Fruits, Milk, and Meat and Beans. The amount of food that must be eaten every day is constructed from an elaborate study by USDA nutritional experts and provided at the bottom of each group in the pyramid.

Figure 4 below shows the recent USDA food pyramid, which is used in the DietAdvisory system.

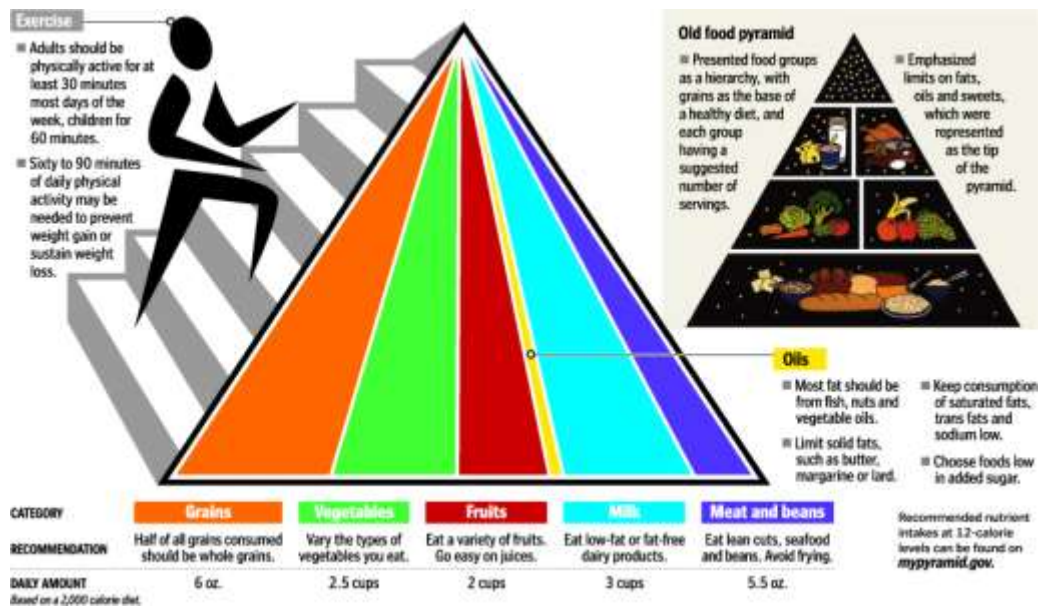


Figure 4. USDA Food Pyramid.

### 3.3. Conclusion

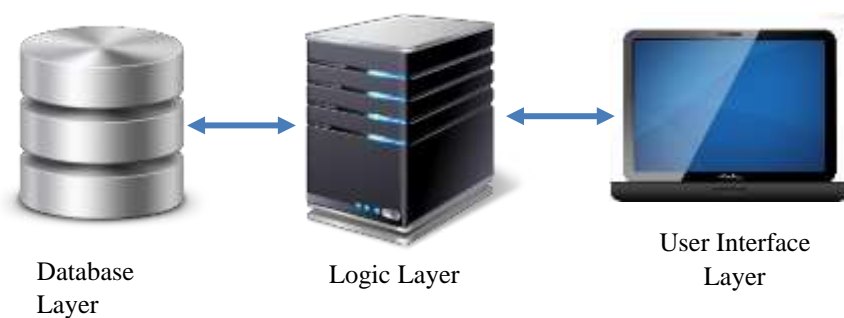
This chapter defines the nutrition concepts and calculations used in GrowHealthy game and DietAdvisory system in order to control child's weight and health. Using correct and up-to-date nutrition information with a support of nutrition doctor gives a significant value to the implemented system. Most of the games seen in literature review are not based on correct nutrition facts, which degrade their level of credibility.

## CHAPTER 4: PROPOSED SYSTEM DESIGN

### 4.1. Introduction

In the design of GrowHealthy game, the guidelines proposed by Cugelman (2013) were followed, which consist of the following: (1) Clearly define the game goal; (2) give feedback to players continuously; (4) Strengthen reinforcement; (5) Show progress; (6) Enhance social impact; (7) Have fun when playing. These guidelines are similar to those proposed by (Gartner, 2011), which are: (1) Encouraged feedback; (2) Simple rules to play; (3) A compelling narrative; (4) Challenging and achievable tasks.

The proposed system architecture is composed of three main layers: Database layer, Logic layer, and User Interface layer as shown in Figure 5 below [21]. Each layer is described in details in the following sections.



*Figure 5.* High level design.

Further to system operations, Figure 6 below shows the flow chart architecture of GrowHealthy and Figure 7 shows the flow chart of DietAdvisory.

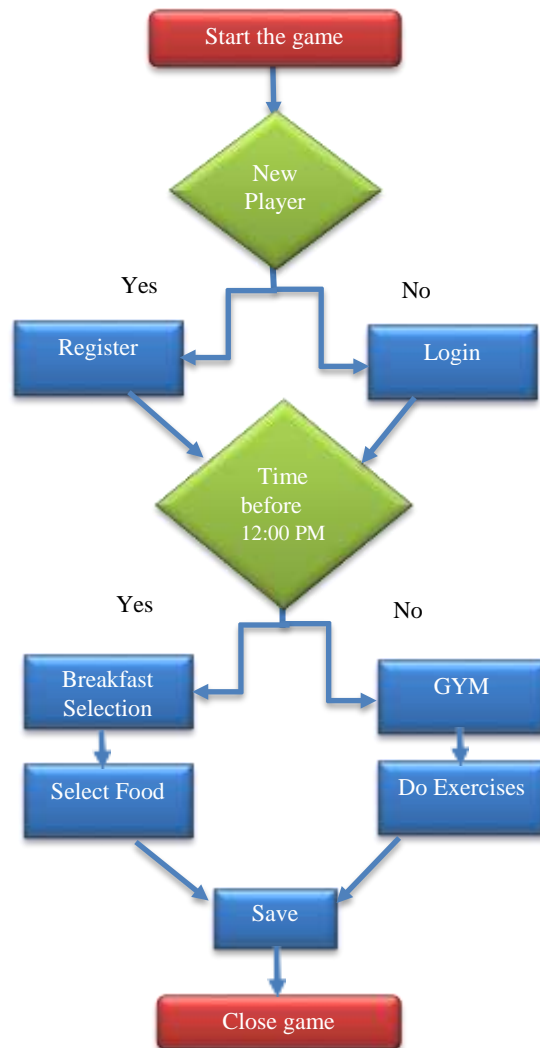


Figure 6. GrowHealthy game flow chart diagram.

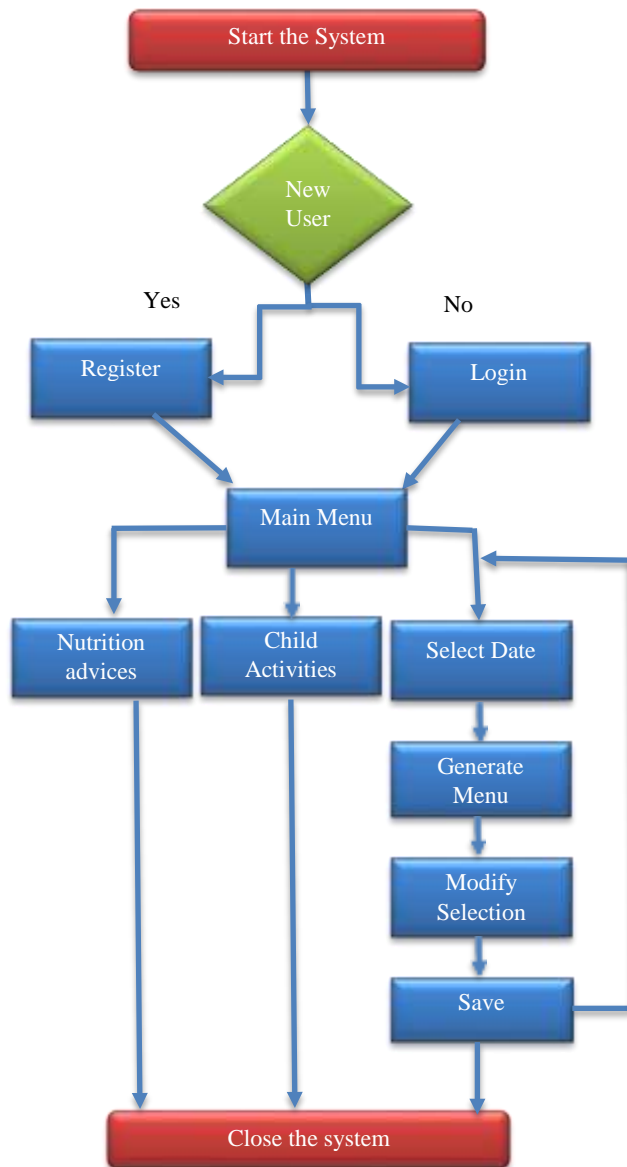


Figure 7. DietAdvisory system flow chart diagram.

## 4.2. Database layer

This layer is implemented in GrowHealthy game using SQLite and Microsoft SQL Server (MSSQL). The SQLite saves player's information and activities offline on player's device (PC or mobile). Once the internet is established in player's device, the data will be saved into MSSQL database for further processing by DietAdvisory system that only uses MSSQL database. Figure 8 below shows the Entity Relationship (ER) diagram of GrowHealthy game and DietAdvisory system.

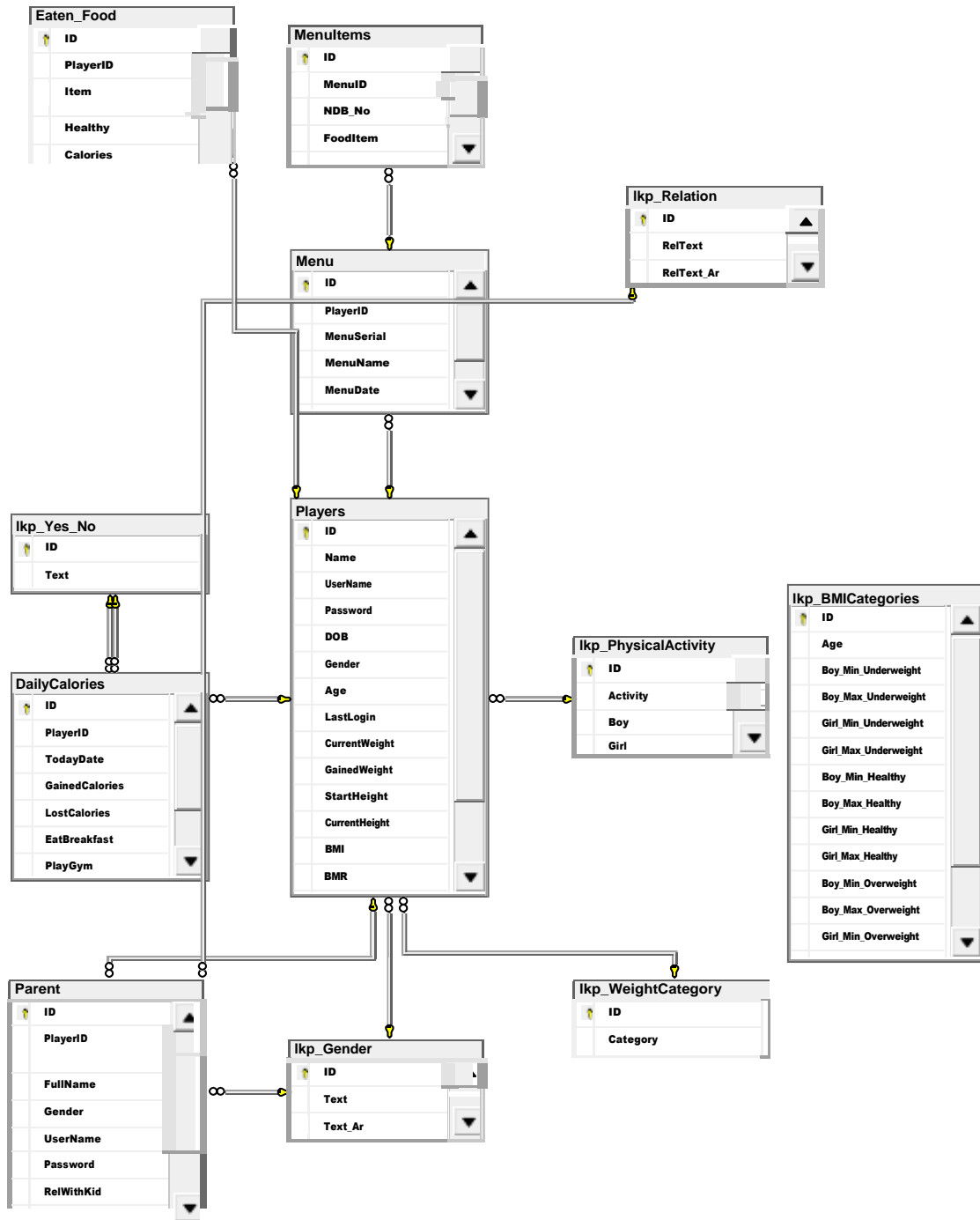


Figure 8. GrowHealthy game and DietAdvisory system ER diagram.



#### *4.2.1. Food Dataset*

The dataset used in the diet advisory system is “USDA National Nutrient Database”, which is considered as the major source of food composition in the United States. It uses a collection of 8,789 food items categorized under 25 food groups. Each food item is showing its nutrients, calories, weights and measures extracted from the published “Agriculture handbook 8”. The database contains some tables that describe the food items by showing its name and the related characteristics, like raw or cooked, color, etc. [26]

Categorizing the food items under groups and showing their weights and measures facilitates our work to follow the USDA recommendations in food pyramid. Generally, the database is well organized, easy to understand and descriptive [26]. Figure 9 below shows the ER diagram of USDA national nutrient database.

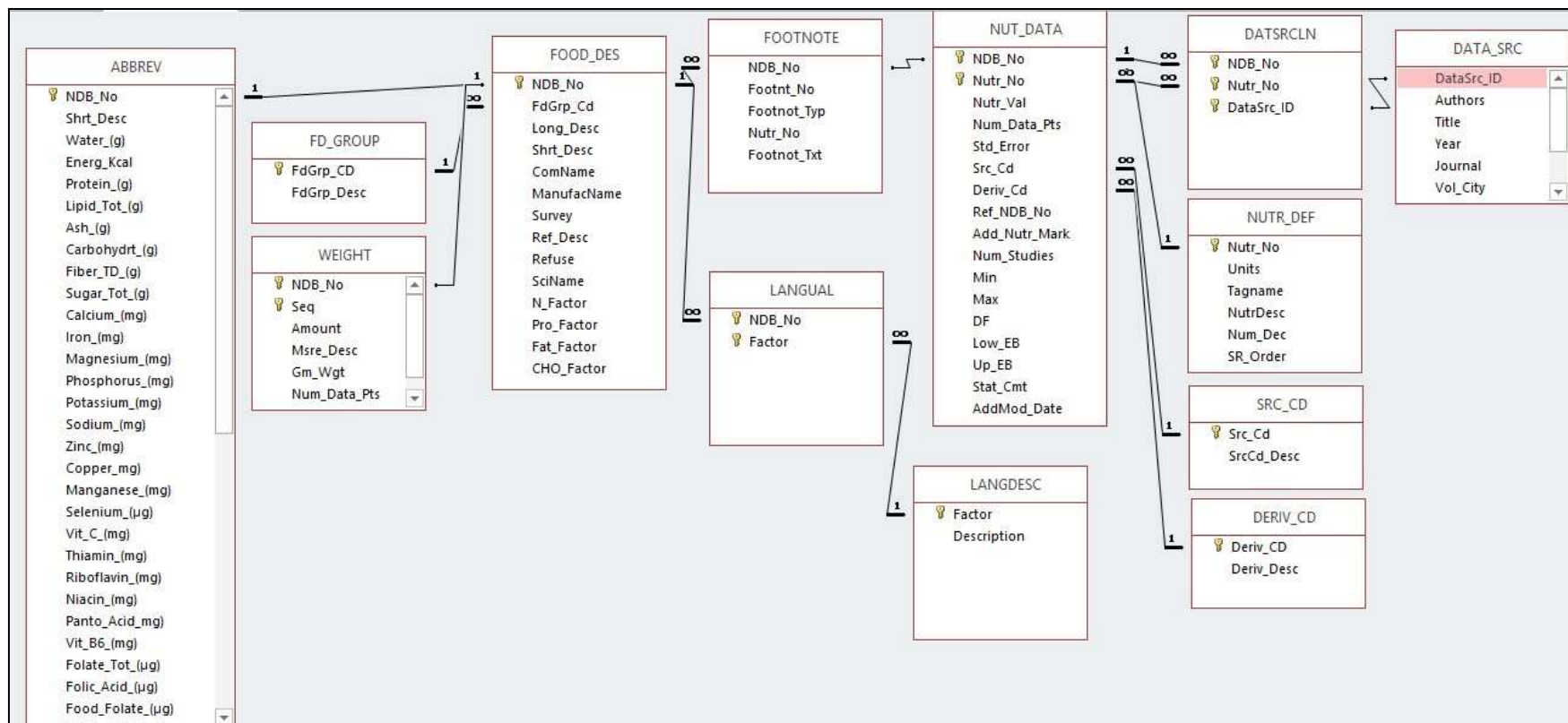


Figure 9. USDA national nutrient database ER diagram.

Although it was decided that the USDA database will be used for this project, unfortunately it couldn't be used directly as it is for many reasons described below:

- 1) The number of groups in USDA dataset exceeded the number of the main groups recommended in the food pyramid.
- 2) The food items offered in the dataset are related to the US culture, which means many of them are not suitable for the local culture of Qatar.
- 3) The food offered is for any meal, while our system focuses only on breakfast meal.

To overcome the above problems, some operations are performed on the database and application layers in order to make the dataset clean and better suited for the needs of the systems in this project. Following the food pyramid, we can see that there are only five main groups which are: grains, vegetables, fruits, milk, meat and beans. Therefore, the dataset was analyzed and it was found that the first problem occurs because some groups in the dataset are actually sub-groups from the main groups. Nevertheless, some groups are found in the database cannot be considered as sub-groups of any, like Snacks, Baby Foods and others; It was named 'No-group'. As a solution for the first problem, the sub-groups are gathered based on their main group in the application level and discard the No-group items when querying the database.

To solve the second problem, a manual cleansing was done on the data by adding a flag to the items that suits the local culture of Qatar and excluding the rest while querying

the data. In parallel with second solution, manual flag also took place to mark the appropriate food for breakfast to be retrieved while querying the data.

### 4.3. Logic and User Interface layers

The logic layer represents the implementation of the proposed system. GrowHealthy game is implemented using Unity software and C# programming language. In contrast, the DietAdvisory system is a web-based application that is implemented using ASP.net and C#. To describe the system using logical operations, Figure 10 and Figure 11 below show the use case diagrams of GrowHealthy game and DietAdvisory system, respectively. These operations are detailed in the next chapter.

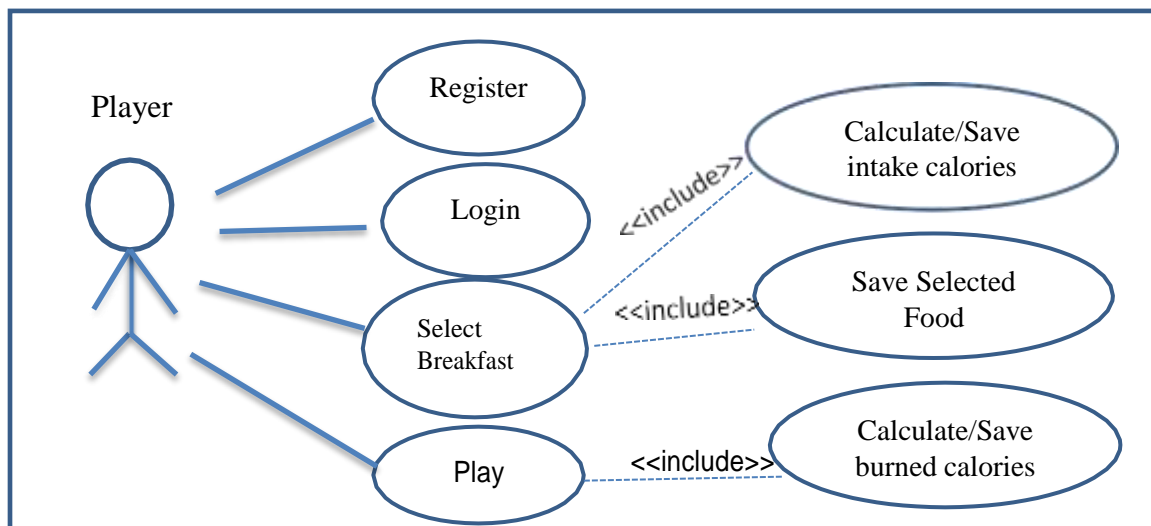


Figure 10. GrowHealthy game use case diagram.

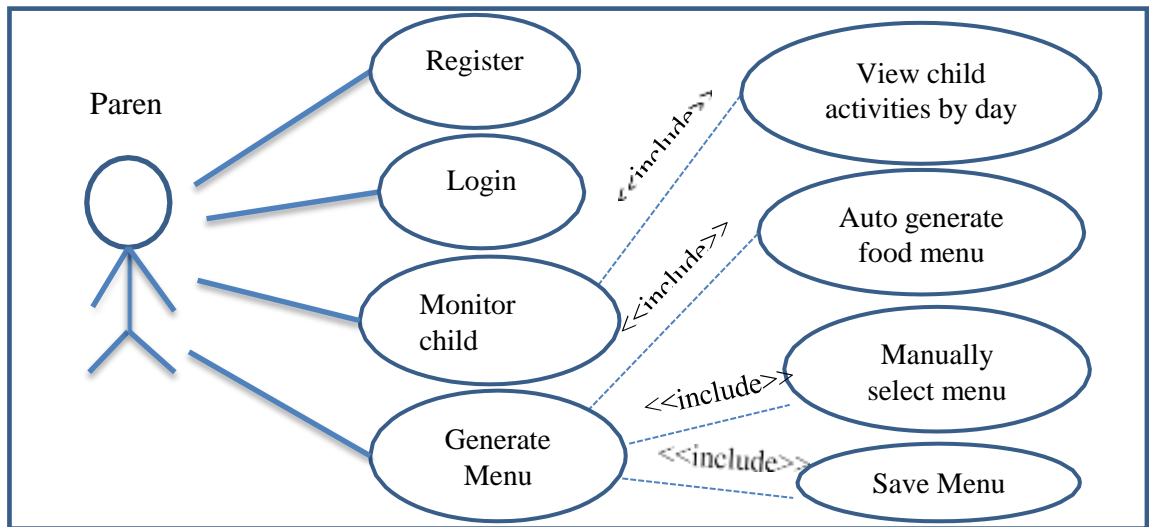


Figure 11. DietAdvisory system use case diagram.

To have a clear understanding of system operations, we will present the most important algorithms used for each system. Algorithm (1) below used in GrowHealthy game to calculate the daily calories needed for each child based on his/her weight, height, age, and gender then save its values in the database for further processing. This algorithm will run only one time once the child register his information.

**Algorithm (1):** *calculate\_DailyCal* (Object: Player)

---

**Input:** Player is an object that holds child information like: weight, height, age, and gender, which will be used in the calculation

**Output:** number of daily calories required for the child

---

**Begin**

1.  $BMI = \text{Player.weight} / (\text{Player.height} * \text{Player.height});$  *//calculated number*
2.  $BMICat = \text{checkBMICat}(\text{Player.age});$  *//retrieve the BMI category object of child's age from lkp\_BMICategories table in the database that contains different ranges of categories (underweight, healthy, Overweight, and Obese) for boys and girls*
3.  $\text{PhysicalActivity} = \text{checkPhysicalActivity}(\text{Player.PhysicalActivity});$  *//check the physical activity figure using lkp\_PhysicalActivity table in the database*
4. **if**  $\text{Player.gender} = 1$  **then** *// if the child is boy*
5.  $BMR = 66.5 + (13.75 * \text{Player.weight}) + (5.003 * \text{Player.height}) - (6.755 * \text{Player.age});$
6. **if**  $(BMI \geq BMICat.boys\_Min\_Underweight \ \& \ BMI \leq BMICat.boys\_Max\_Underweight)$
7.  $\text{Child\_BMICat} = \text{Underweight};$
8. **else**

```

9. if (BMI >= BMICat.boys_Min_Healthy & BMI <=
    BMICat.boys_Max_Healthy)
10.     Child_BMICat= Healthy;
11. else
12.     if (BMI >= BMICat.boys_Min_Overweight & BMI <=
    BMICat.boys_Max_Overweight)
13.     Child_BMICat= Overweight;
14. else
15. if (BMI >= BMICat.boys_Min_Obese & BMI <=
    BMICat.boys_Max_Obese)
16.     Child_BMICat= Obese;
17. end
18. else // if the child is girl
19.     BMR= 66.51+ (9.563* Player.weight) + (1.850* Player.height)
    - (4.676 * Player.age);
20. if (BMI >= BMICat.girls_Min_Underweight & BMI <=
    BMICat.girls_Max_Underweight)
21.     Child_BMICat= Underweight;
22. else
23. if (BMI >= BMICat.girls_Min_Healthy & BMI <=
    BMICat.girls_Max_Healthy)

```

```
24.         Child_BMICat= Healthy;
25.  else
26.     if (BMI >= BMICat.girls_Min_Overweight & BMI <=
           BMICat.girls_Max_Overweight)
27.         Child_BMICat= Overweight;
28.  else
29.  if (BMI >= BMICat.girls_Min_Obese & BMI <=
           BMICat.girls_Max_Obese)
30.         Child_BMICat= Obese;

31.  end
32. end
33. DailyCalories= PhysicalActivity* BMR;
34. Save(Player.ID, DailyCalories, BMI, BMR, Child_BMICat);
    //save the calculated variables in Players table in database
```

**End**

---

On the other hand, Algorithm (2) shows the implementation of auto-generate menu in DietAdvisory system. It uses the daily calories of child calculated previously and



the USDA pyramid recommendations. The extension of this algorithm is that the parent can change food item from auto-menu with respect to the constraints of food calories and weight. Also, he/she can disable one or more food groups and re-generate the menu with respect to disabled groups.

**Algorithm (2):** *generate\_Menu* (Object: Player)

---

**Input:** Player is an object that holds child information stored in the database

**Output:** a list of menu food items

---

**Begin**

1.  $\text{GRAINS} = 42.5;$  *//constant variable that shows the allowed number of grams in grains group*
2.  $\text{VEGE} = 0.625;$  *//constant variable that shows the allowed number of cups in Vege group*
3.  $\text{FRUIT} = 0.5;$  *//constant variable that shows the allowed number of cups in Fruit group*
4.  $\text{MILK} = 0.75;$  *//constant variable that shows the allowed number of cups in Milk group*
5.  $\text{MEAT\_BEAN} = 38.975;$  *//constant variable that shows the allowed number of grams in meat and bean group*
6.  $\text{Breakfast\_Cal} = \text{Player.dailyCalories} * 25 / 100;$  *//number of allowed calories in the breakfast, which is 25% of child daily calories*
7.  $\text{Active\_groups}=5;$  *//number of active groups*
8.  $\text{Cal\_Group} = \text{Breakfast\_Cal}/\text{Active\_groups};$  *//the allowed number of calories for each food group*

9. ListGrains= *getGrainList(GRAINS, Cal\_Group); //get the grains food list from USDA database using the constraints 1) weight of food is less than or equal to **GRAINS** constant and 2) food calories are less than or equal to **Cal\_Group** constant*

10. ListVege= *getVegeList(VEGE, Cal\_Group); //get the vegetable food list from USDA database using the constraints 1) weight of food is less than or equal to **VEGE** constant and 2) food calories are less than or equal to **Cal\_Group** constant*

11. ListFruit= *getFruitList(FRUIT, Cal\_Group); //get the fruit food list from USDA database using the constraints 1) weight of food is less than or equal to **FRUIT** constant and 2) food calories are less than or equal to **Cal\_Group** constant*

12. ListMilk= *getMilkList(MILK, Cal\_Group); //get the milk food list from USDA database using the constraints 1) weight of food is less than or equal to **MILK** constant and 2) food calories are less than or equal to **Cal\_Group** constant*

13. ListMeat= *getMeatList(MEAT, Cal\_Group); //get the meat food list from USDA database using the constraints 1) weight of food is less than or equal to **MEAT\_BEAN** constant and 2) food calories are less than or equal to **Cal\_Group** constant*

14. GrainFood=*getRandom(ListGrains) //get random food item of grains food list*

15. VegeFood=*getRandom(ListVege) //get random food item of vegetables food list*

16. FruitFood=*getRandom(ListFruit) //get random food item of fruit food list*

17. MilkFood=*getRandom(ListMilk) //get random food item of milk food list*

18. MeatFood=getRandom(ListMeat) *//get random food item of meat food list*

19. Save (Player.ID, GrainFood, VegeFood, FruitFood, MilkFood, MeatFood);

*//save the menu items for the child*

**End**

---

Moreover, the User Interface layer represents the PC or mobile interface, where the child can access GrowHealthy game. It also represents the web pages in the DietAdvisory system, where the parents can monitor child activities and generate food menu. Furthermore, the Graphical User Interface (GUI) of GrowHealthy game is chosen carefully to attract children and engage them with the game. More clearly, 3D games were chosen because they are popular, recent and child-friendly. Additionally, the DietAdvisory system uses kid's GUI for some reasons, which are: 1) parents should feel that the system is special for their children, 2) allows children to use the system with their parents to help them in selecting the food items for breakfast, and 3) teaches children with their parents the right nutrition information and pushes them to apply advices.

#### 4.4. Conclusion

This chapter describes the architecture of proposed system and the technology used in each layer. Detailing the database layer by showing the Entity Relationship diagram of the proposed system and describing the USDA nutrition food database gives a clear understanding of system core. Moreover, the algorithms listed in logic layer helps technical audience to benefit from this system. The concept behind the selection of the look and feel, which is described in user interface layer, helps the audience to have a complete picture of the proposed system.

## CHAPTER 5: PROPOSED SYSTEM IMPLEMENTATION

### 5.1. GrowHealthy game

“GrowHealthy” game is an Arabic-based game that uses an animated avatar called ‘Noor’ who represents the child and shows his activities during the day. The game is composed of two main modules, breakfast selection and gymnastic. In the breakfast selection module, the child can select the appropriate food from local environment and learn about the selected items and how much calories they add. Due to the importance of sport and its impact on child’s health, the game linked the food with physical activities by adding a gymnastic module, where the child can do some exercises with the avatar. The two modules will add or drop daily score to the child according to his food selection and the exercises performed. Generally, we need to show an avatar looks more energetic and full of joy after eating healthy breakfast and performing exercises.

First, the game shows an introductory page that introduces the avatar and defines the game target as shown in Figure 12 below.



Figure 12. Introductory page in the game.

If this is the first time that the child enters the game, he should press on “العب الجديد” button (means “New Player”) to register his information. In this step, the parent must intervene to help the child to enter his personal information, like name, age, gender, weight, height, and the preferable user name and password as shown in Figure 13.

The registration page features a light green background. On the left, there are three dropdown menus: the first is labeled 'نوع النظام:' (System Type), the second 'هل تعاني من مرض الحساسية' (Do you have an allergy?), and the third 'هل تعاني من مرض السكري' (Do you have diabetes?). Below these are input fields for 'User Name' and 'Password'. On the right, there are input fields for 'Your Name', 'Age', 'Weight', and 'Height', with labels 'الاسم:', 'العمر:', 'النوع:', 'الوزن:', and 'الطول:' respectively. Below these are labels for 'اسم المستخدم:' (User Name) and 'كلمة المرور:' (Password). At the bottom, there are three buttons: 'إغلاق اللعبة' (Close Game), 'عودة' (Return), and 'تسجيل' (Register). On the far right, a 3D character with a pink and white floral headpiece, glasses, and a blue outfit is standing.

Figure 13. Registration page in the game.

The registered information will help the system to calculate the appropriate daily calories required for the child using the equations mentioned in Chapter 3 earlier. GrowHealthy game allows different players to access the game independently. Every player will have a unique account and record in the database, so he/she can log in using his/her credentials as shown in Figure 14.





Figure 14. Login page in the game.

#### 5.1.1. First Module: Breakfast Selection

After a successful login, GrowHealthy game will check the local timing on player's PC/mobile and then open the breakfast module if the time is before 12:00 PM. This feature stresses the concept of healthy breakfast in children's minds and encourages them to eat their breakfast before going to school. The character 'Noor' in this module goes to the dining room every morning to take her breakfast. The child plays the role of feeding the avatar by selecting the food he/she likes among different selections of healthy and unhealthy items. Whenever a selection is made, the corresponding number of calories will be presented on the screen and added to the player calories intake for today. The player will learn that the calories are the fuel of the body and excessive number of calories will require heavy exercising to avoid obesity and other diseases.



Figure 15. An informative screen telling the child to start eating the meal.

Based on the consultation of our nutritionist, it is recommended that the breakfast contains maximum 25 percent of the total daily calories, while the lunch should not exceed 45 percent and the dinner should be limited to 15 percent of the required daily calories. In fact, children who are unable to dispense on snacks, will be left with 15 percent of daily calories for snacking.



Figure 16. Different food with healthy and unhealthy Items.

The character gives some advices about healthy and unhealthy items as a series of audio records with speech bubbles before the child starts selecting. The child will get 10 points score when he/she selects healthy items and the total calories gained from the selected foods should not exceed his/her allowed daily calories for breakfast. If he/she selected unhealthy items or the calories exceeded his/her allowed number, it will decrement the score until reaching minus. Once the child finishes eating, the total calories he/she consumed, the items he/she selected, and the gained score will be added to his record. This information can be used later by a nutritionist to examine the child's eating behavior and healthy life style.

### 5.1.2. *Second Module: Gym*

The gym module will not start until afternoon because a meal should not be directly followed by exercises as per the advice of our nutritionist. In this module, the child will be asked to follow the avatar movement and gestures while exercising. To simplify the exercises, we only consider some of the important exercises for humans, which are walking and jogging, and limit it to thirty minutes per day. Based on our nutritionist advice, jogging exercise should interfere with walking exercise for short distance, so after each five-minute walking, there is one-minute or less of running.

Each day has a predetermined goal to achieve and a score is recorded. The child is challenged gradually. Based on most nutrition books and researches, physical exercise is recommended to be five days during the week. Therefore, the child will gain a high score in a week when he completes the gym module for five times or more.

During the exercise, the game shows the number of calories that the child gained at morning and his current weight plus calories burned counter. The calories burned is calculated based on sport walking machine. It shows that eleven calories are burned after three minutes in speed 3, which is considered as a walking exercise for children. By dividing the burned calories by minutes, it results with 3.67 Kcal burned per minute. For jogging exercise, the sport machine shows that fifteen calories burned after three minutes in a speed 4.1. By applying the same division, the number of calories burned in jogging exercise is 5 Kcal per minute. Table 4 below shows the number of calories burned daily when the child completed this exercise.

Table 4

*Burned calories of physical activities by time*

Physical Activity	Duration (hours)	Consumed Calories
Walking	0.25	91.75
Jogging	0.5	25
Total	0.30	116.75

To avoid boredom and tiredness, a list of random kids' music plays on the background during the exercise. The soft music helps the child to have fun while exercising and forget the tiredness. The child is allowed to have one-minute break for five times during the exercise whenever he feels tired and would like to relax for a while. The break shouldn't exceed one minute; if it exceeds, the counter will start from the beginning.



Figure 17. Gym module (second module).

The amount of daily gained and lost calories will be saved for future analysis. When the weekly goal is achieved, the child will be rewarded by creating a party for him that shows his name and the great achievement he did as shown in Figure 18. Thus, the child can feel proud of himself and encourage other children to play the game. Parents can give the child a physical award after achieving his goal, so it will make him/her engaging with the game and love to play it in a daily base.



*Figure 18.* Party Reward.

## 5.2.Diet Advisory System

Due to lack of awareness in health guidelines and the best diet to follow for the child, it became necessary to educate parents on the correct nutrition concepts. This motivates me to create a comprehensive system that combines the game with the diet advisory system for parents. The DietAdvisory system is a web-based system aims to guide parents to select the best food for their child based on the nutrition equations explained in Chapter 3 earlier. The parent should register his/her information along with child's information, if the child doesn't register in GrowHealthy game. In case the child registered in the game, the parent should type child's username in the registration page. This operation

is required to link the two systems. After the parent register successfully, he/she can log in using his/her credentials to enter the system as shown in Figure 19.

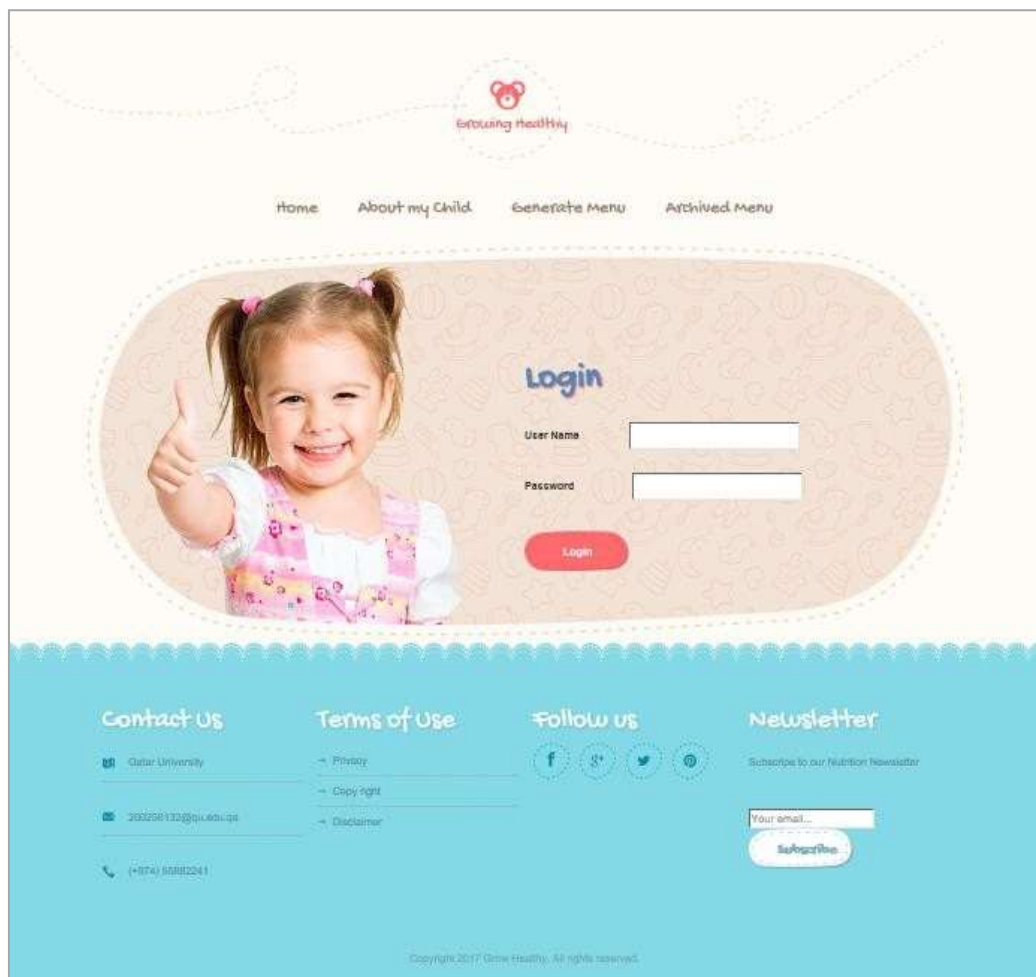


Figure 19. Login Page for advisory system.



After a successful login, parent can see some information about the game and the importance of breakfast for child's health as shown Figure 20 below. This page will be updated continuously to educate parents on nutrition facts by showing recent nutrition advice and recommendations.



Figure 20. Home Page for advisory system.

From this system, parent can monitor the daily activities of child over the game by seeing the list of food items he/she selected, the intake calories and the burned calories as

shown in Figure 21 below. This feature allows parent to know the favorite food items for their children.

The screenshot displays the 'Child's Activities' page. At the top, there is a logo with a bear and the text 'growing healthy'. Below the logo is a navigation menu with links: Home, About my Child, Generate Menu, and Archived Menu. The main heading is 'Child's Activities'. There is a 'Filter By Date:' section with a date input field set to '12/18/2017' and a 'Search' button. Below this is a table with the following data:

Item	Calories	Healthy	Columnist
Ice Cream	192	<input type="checkbox"/>	19-12-2017
Cake	167	<input type="checkbox"/>	19-12-2017
Donuts	121	<input type="checkbox"/>	19-12-2017
Hamburger	232	<input type="checkbox"/>	19-12-2017

Below the table, there are three summary statistics:

- No. of items eaten Today: 4
- No. of healthy items: 0
- No. of unhealthy items: 4

At the bottom of the main content area, there is a summary bar with two rows:

Intake Calories	594
Logit Calories via activities	10

The footer contains four sections: 'Contact Us' with Qatar University and email '2002501132@qu.edu.qa'; 'Terms of Use' with links for Privacy, Copy rights, and Disclaimer; 'Follow us' with social media icons for Facebook, Google+, Twitter, and YouTube; and 'Newsletter' with a subscription link and an email input field.

Figure 21. Child's Activities in Advisory System.

The main goal of this system is to help parents especially mothers to choose the right food items for her child. Therefore, the system offers a feature to generate breakfast menu from all food groups mentioned in the food pyramid in Chapter 3. The system will query a diversity food items from USDA nutrient database based on some constraints listed below:

- i) The total calories of selected items should not exceed 25 percent of child's daily calories.
- ii) The food selected should follow the USDA recommended quantity from each group.

In addition, the system gives more flexibility to parent to change the items that his/her child doesn't like or unavailable. By pressing on 'Change' button under certain group, it will open a popup page containing a multi-checklist of food items belonging to that group with the calories bound by the constraints above. A parent then can choose the items that his/her child likes and the system instantly counts their calories to prevent exceeding the calorie limit.

Moreover, a parent can delete any group because a breakfast menu is not supposed to be inclusive of all food groups, for example, meat and beans group is not preferred to be in breakfast meal. When deleting a group, the calories corresponds to that group will be distributed over all remaining groups. Deleting a group is bounded by a constraint that there should be at least one group in the menu.

The parent can also generate multiple number of menus and keep user's preference

of deleted groups to generate menus based only on active groups. Furthermore, the parent can reset groups to default, means activate all groups, and re-generate menu. After preparing the menu, the parent should save it for further use by the game. This feature allows parent to choose menu for today or upcoming days using interactive calendar. Figure 22 below shows an auto generated menu for child with his daily calories, breakfast calories and menu calories.

**MyPyramid** For Kids  
Eat Right. Exercise. Move Fun.  
MyPyramid.gov

**Grains**  
Make half your grains whole

**Veg. tables**  
Eat 7 your veggies

**Fruits**  
Eat an fruit

**Milk**  
Get your calcium-rich foods

**Meat & Beans**  
Eat less with protein

**Suggested Menu Start**

<p><b>Grains</b> 1/2 cup whole wheat bread 1/2 cup whole wheat spaghetti protein</p> <p>Change Delete</p> <p>90</p>	<p><b>Veg. tables</b> Coles, sweet, white, frozen, broccoli, cut up, cooked, boiled, drained, with oil</p> <p>Change Delete</p> <p>34</p>	<p><b>Fruits</b> Apple juice, calcium or lemon, unsweetened, with added ascorbic acid</p> <p>Change Delete</p> <p>40</p>	<p><b>Milk</b> Yogurt, fruit variety, nonfat</p> <p>Change Delete</p> <p>90</p>	<p><b>Meat &amp; Beans</b> Turkey breast, low salt, prepackaged or deli, sandwich meat</p> <p>Change Delete</p> <p>100</p>
---	---	--	---	--

**Calories:**

<b>Your Child's Needed Calories</b>	2300
Needed Calories for breakfast	576
Menu Calories	404

Another Menu    Reset Menu    Select This

Figure 22. Generate Menu in Advisory System.

## CHAPTER 6: EVALUATION AND TESTING

### 6.1. Introduction

As an assessment to GrowHealthy game, two rounds of assessment were conducted with Edison International School. We used a questionnaire in both rounds, which is determined as a ‘conventional social research method’ of getting users’ opinion and measure their satisfaction about the proposed system. The first round was used to get the feedback and evaluation on the game in order to enhance it. Then, the second round was executed after reflecting some of the comments and feedback from round 1. Usually the surveys conducted worldwide are using a statistical approach that consider the sample as the whole population of that sample. Therefore, the sample used in the 2 rounds are representing the children in Qatar.

### 6.2. Round 1

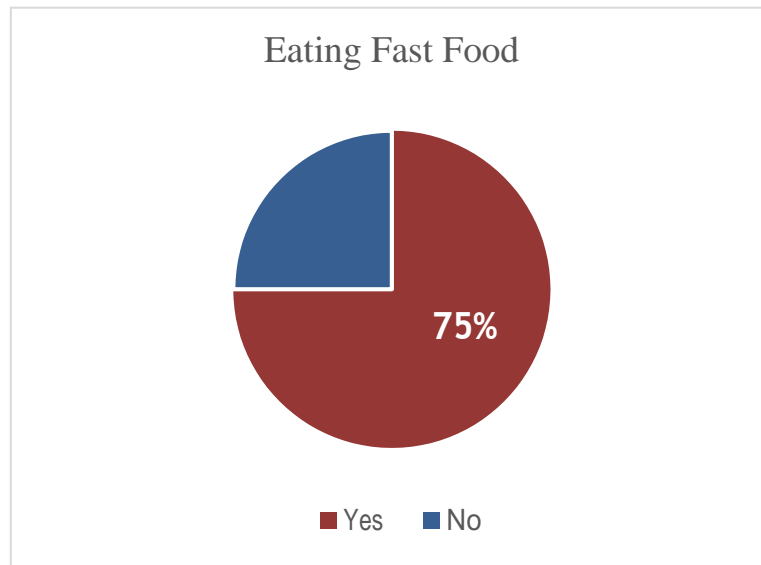
In this round, the school assistant manager randomly distributes the game on children from age 6 to 12 to play at home for a week. Then, a survey (attached in Appendix A) was sent to parents to get their feedback about the game and measure how it effects child’s eating style. We received only 6 evaluated surveys after week and a half. Due to time constraints, we assumed that this is the project sample. In this evaluation round, we used the following list of criteria to evaluate the game, where most of the answers are stick to yes-no questions:

- 1) Child eats unhealthy food.

- 2) Child found difficulties in understanding the game
- 3) Child enjoy the game
- 4) Child is overweight or has a lack of activities
- 5) GrowHealthy game is useful for the child
- 6) Child spent time on game
- 7) The preferable game module
- 8) The impact of GrowHealthy game on child

After analyzing the results, it shows that 75 percent of these children are eating fast food and they are overweight. Moreover, parents of all sample reported that GrowHealthy game is useful for their children. Figure 23 below presents the number of children who eat fast food compare to children who eat only healthy food.





*Figure 23.* Children who are eating fast food.

Fifty percent of children found moderate difficulties in understanding the game, while the rest didn't face any difficulty. This means we need to know and measure the difficulties found to see how we can enhance it in the future. In contrast, 100 percent of children reported feeling so excited when playing the game.

In addition, half of the sample spent more than 10 minutes in front of the game, while the second half spent from 5 to 10 minutes. This shows that children love playing the game and they are excited. Furthermore, 50 percent of children like breakfast selection module while the rest like gym module as shown in Figure 24 below. This proves the success of achieving entertainment in both modules.

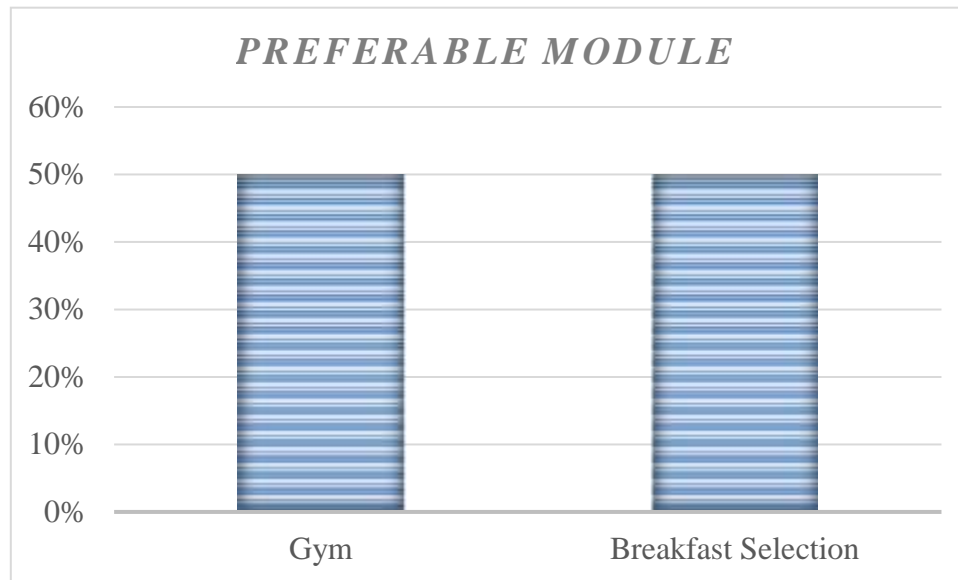


Figure 24. GrowHealthy game preferable module.

Moreover, half of the parents reported that this game had a significant impact on their child eating behavior and his/her physical activities, while the second half saw that the game has a moderate impact on their child. The last point proves that the game succeeded in achieving its goal. Table 5 below shows children answers in this round.

Table 5

*Measurement matrix of children who play the game – Round 1*

#No.	Age	Gender	Eating fast food	Enjoy Playing?	Difficulty to understand the game	Overweight / Obese	Time spent in playing (minutes)	Is it useful for the child?	Which Module the child like?	Impact on child eating habits
1	6	Girl	Yes	Yes	Moderate	Yes	10 to 30	Yes	Gym	Moderate
2	8	Boy	Yes	Yes	Moderate	Yes	5 to 10	Yes	Gym	Big Impact
3	11	Boy	No	Moderate	No	Yes	10 to 30	Yes	Breakfast	Big Impact
4	11	Boy	Yes	Yes	No	No	5 to 10	Yes	Breakfast	Moderate
5	11	Boy	Yes	Moderate	Moderate	Yes	5 to 10	Yes	Breakfast	Moderate
6	12	Boy	Yes	Moderate	No	Yes	10 to 30	Yes	Gym	Big Impact

### 6.3. Round 2

Round 2 aims to measure the improvements implemented from first round comments and the impact of GrowHealthy game on education. The time period between round 1 and round 2 is seven months during which the game was improved. In round 2, Qatar University invited two classes of second and third grade (7 and 8 years old) to do an assessment for GrowHealthy game in university campus. The following is a list of criteria used in the survey (attached in Appendix B), which help us in gathering children opinions about the game.

- 1) Child enjoy the game
- 2) GrowHealthy game increases child's motivation
- 3) Child likes GrowHealthy game than reading
- 4) Child likes GrowHealthy game than listening
- 5) Child likes Breakfast selection module
- 6) Child likes GYM module
- 7) Child eats unhealthy food
- 8) Child found difficulties in understanding the game
- 9) The impact of GrowHealthy game on child

The sample in this round increases to fifteen children and the answers (attached in Appendix C) range from (1) ‘Strongly Like’ to (5) ‘Strongly Dislike’, which gives a precise and accurate value to measure.

After analyzing the results, we found that 99 percent of the sample reported that they strongly like the breakfast module, while only one percent likes it. This gives a good indication that this module is favored by children. In contrast, 66.7 percent reported that they strongly like the gym module, while 13.3 percent likes it and 20 percent were neutral. Figure 25 below shows the engagement of children for each module.

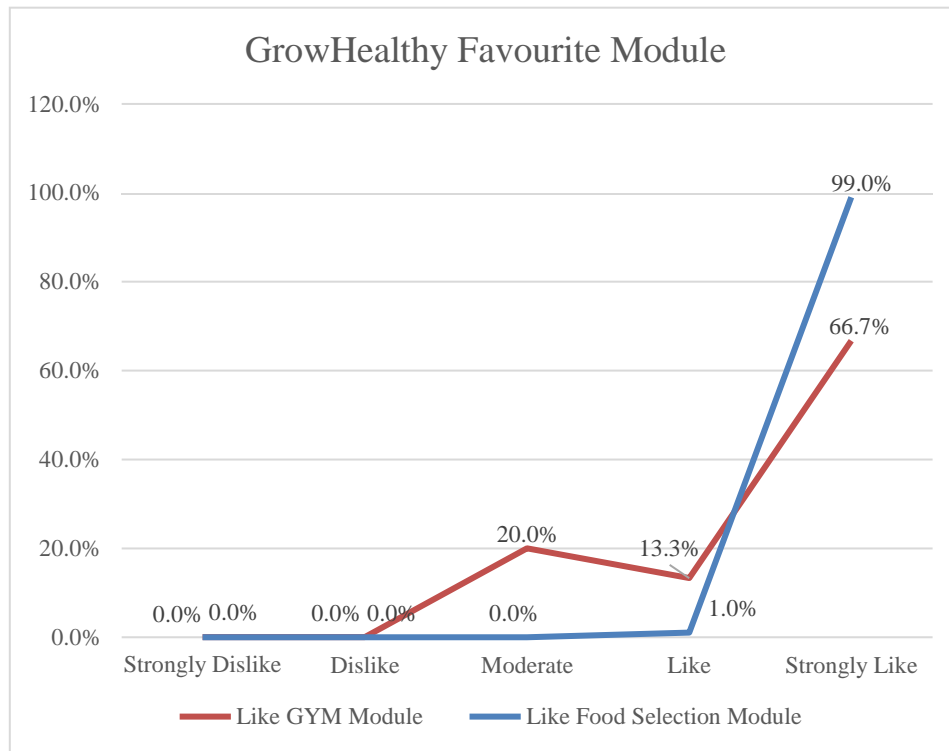
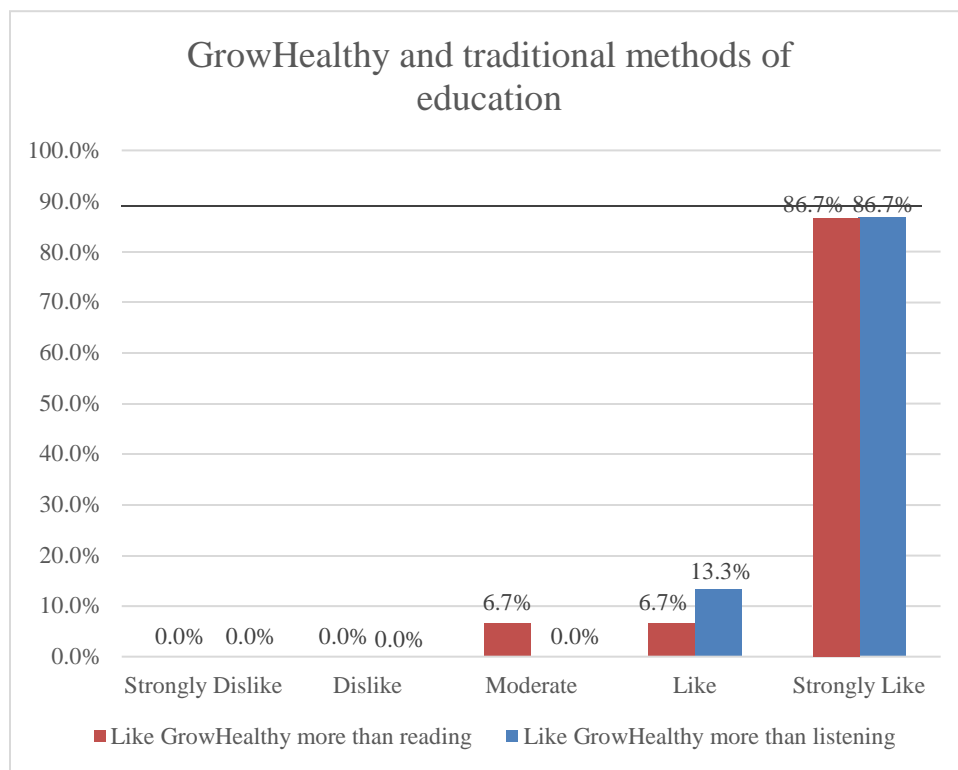


Figure 25. GrowHealthy game favorite module.

Measuring the difference between traditional methods of education, such as reading and listening with modern educational ways, such as GrowHealthy game according to preference of children is one of the most important goals in this round. The analysis shows that 86.7 percent indicated they strongly prefer the game more than traditional reading process, while 6.7 percent likes playing more than reading and 6.7 percent are neutral. Regarding the traditional listening process, the analysis shows that 86.7 percent prefers the game than listening, while 13.3 percent are neutral. Figure 26 below shows children's

opinion in how they are liking and learning from the game more than traditional methods of education.



*Figure 26.* Comparison between GrowHealthy game and traditional methods of education.

Moreover, the study shows that 80 percent of the sample are eating unhealthy food, while 20 percent are eating healthy food. Fifty percent of children who eat unhealthy food

are taking it into daily basis, while 25 percent are taking it into weekly basis and the remaining 25 percent are taking it into monthly basis. 83.3 percent of these children are intended to change their eating life style, while 16.7 percent refused to change. The following figure compares the intension to change eating style after playing the game between round 1 and round 2.

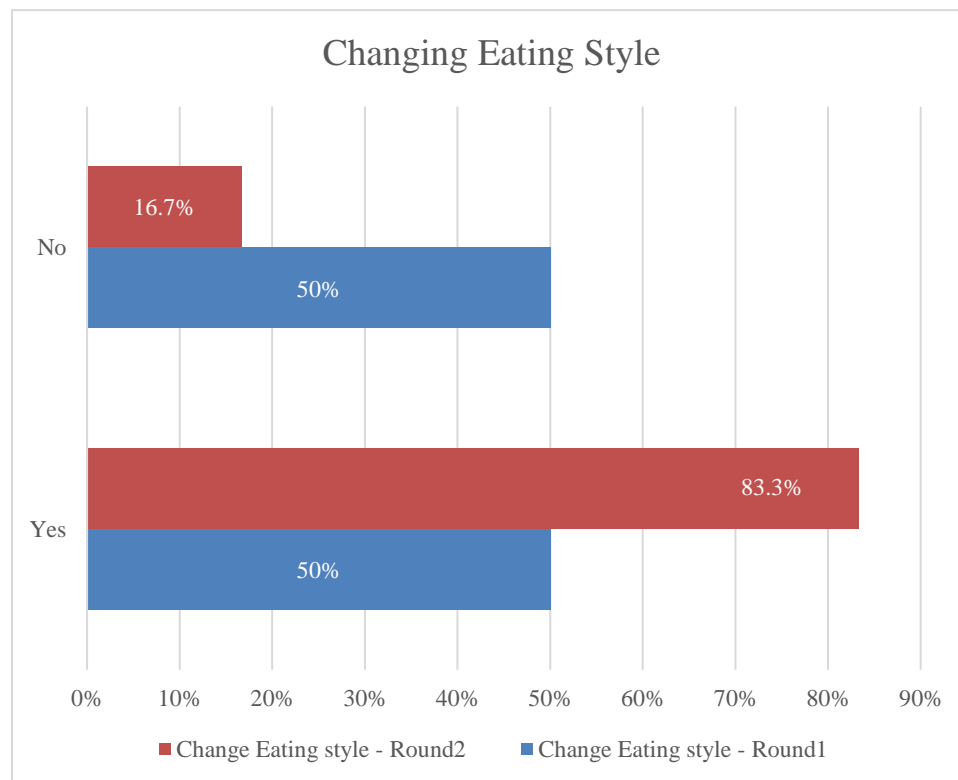


Figure 27. Intention to change eating life style between round 1 and round 2.



From this figure we can see that the intension of changing the bad eating life style is increased in round 2, which achieves the desired goal. Overall, the study shows that all the children are strongly engaged with the game with minimum difficulty in understanding and playing the game, but with high educational impact in raising children's motivation to eat healthy breakfast. This study proves that this game achieves its desired goals.

## CHAPTER 7: CONCLUSION AND FUTURE WORK

### 7.1. Conclusion

Nowadays, educating children on healthy eating becomes an important topic due to widespread outbreaks of unhealthy food in Qatar. Children represent the future of the society; therefore, their health must be taken into account. Stop eating fast food can't be achieved in individual level alone. The community, media, governments and food supplements should work together to encourage healthy eating and physical exercises among children. Qatar already passes a big step on this by allocating a day for sport to its population. They encourage them to freely do exercises in all public gardens that provided with all sports devices and games.

Moreover, they encourage healthy eating in this day by distributing fruits and healthy food on public. But this day comes once a year and the children need to be always educated on healthy eating. Therefore, I tried to combine educational process with children's addiction factor, games, to achieve the highest degree of efficiency in education.

The game developed will help children from age 6 - 12 to get their early breakfast from healthy food. The assessment phase applied in this project helps in measuring the satisfaction of parents on children's eating habits as well as getting a proper feedback for future enhancements to achieve its goal.

## 7.2. Future work

The future work planned for this project is to add more features to the modules, adding new module and enhancing the diet advisory system. In breakfast module, we need to show the food on the table everyday based on the menu selected by parent. In addition, we need to add more exercises on the gym module, so we can have a diversity on the exercises offered. These exercises can also be changed according to health status of each child. Additionally, the change on weight should appear on avatar's body so he/she can become fat or slim. Moreover, we need to apply a dieting system, weight loss or weight gain. Furthermore, we need to create a new module which is a race between two avatars, 'Noor' and a fat avatar 'Reem'. This module will enrich the game and motivates the child to become healthier when he/she sees that overweight or obese character will never take the lead in the race.

More enhancement is needed in the diet advisory system, like creating a control panel to add latest nutrition advices so the parents are updated all the time. Also, apply some of these advices in the system. To make it more clinical, we can add a feature called 'Ask the doctor' that allow the parent to communicate directly with nutrition doctor with minimum fees.

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## APPENDICES

### Appendix A: Assessment survey 1

\* 1. اسم الطفل

\* 2. عمر الطفل

\* 3. وزن الطفل

\* 4. هل يتناول ابنك الوجبات السريعة؟

- نعم  
 لا

\* 5. هل تحب ابنك لعبة صحتي هي طعامي؟

- نعم  
 لا

\* 6. هل استمتع طفلك باللعبة؟

- استمتع جدا  
 إلى حد ما  
 لم يستمتع قط

\* 7. هل يعاني طفلك من السمنة أو قلة الحركة؟

- نعم  
 لا

\* 8. هل وجدت اللعبة مفيدة بالنسبة لطفلك؟

- نعم  
 لا

هل وجد طفلك صعوبة في فهم اللعبة؟ \* 9.

- وجد صعوبة بالغة
- صعوبة إلى حد ما
- لم يجد أي صعوبة

كم مرة كان يلعب طفلك اللعبة؟ \* 10.

- يوماً
- من مرتين إلى 3 في 5 أيام السابقة
- مرة واحدة
- ولا مرة

كم يستغرق طفلك من الوقت أمام اللعبة في المرة الواحدة؟ \* 11.

- من 10 دقائق إلى نصف ساعة
- من 5 إلى 10 دقائق
- أقل من 5 دقائق
- دقيقة 0

أي نموذج لعبه طفلك أكثر؟ \* 12.

- لعبة تغيير الطعم
- لعبة الصلة الرياضية

هل كان للعبة تأثير في سلوك الطفل من تناول الأطعمة الصحية وممارسة الرياضة؟ \* 13.

- نعم ، تأثير كبير
- إلى حد ما
- لا ، ليس هناك أي تأثير

ملاحظتك عن اللعبة. 14.

كيف يمكننا تحسين اللعبة من وجهة نظرك. 15.






*Appendix B: Assessment survey 2*

Section I: General Information

Please, answer the following questions:

Name:	
Age:	
Gender	<input type="checkbox"/> Male <input type="checkbox"/> Female

Section II. Usability of the system

No.	Statement	Strongly Like 	Agree 	Moderate 	Disagree 	Strongly Dislike 
1	Do you like the game "صحبي في طعامي"					

2	Do you like Food selection module?					
3	Do you like Gym selection module?					
4	I prefer reading than playing the game					
5	I prefer listening than playing the game					
6	The game raised my motivation					

Section III. General Questions

1. Do you eat unhealthy food like Burger, Daunts, ice cream, etc.?

Yes       No

2. If you eat unhealthy food, how many times you eat it?

Daily       Weekly       Monthly       Never

3. After playing the game, will you intended to change your unhealthy eating style?

Yes       No

4. Do you face any difficulty in playing the game?

Yes       No

5. Would you like to play this game daily at home?

Yes       No

*Appendix C: Assessment round 2 answers*

Table 6

*Measurement matrix of children who play the game -Round 2*

#	Age	Gender	like the game	Like Food Selection Module	Like GYM Module	Like reading more than Game	Like Listening more than game	Game raised motivation	Eat unhealthy food
1	8	Male	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Dislike	Strongly Like	Yes
2	7	Female	Strongly Like	Like	Strongly Like	Strongly Dislike	Moderate	Strongly Like	Yes
3	8	Female	Strongly Like	Strongly Like	Like	Strongly Dislike	Strongly Dislike	Strongly Like	Yes
4	7	Female	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Dislike	Strongly Like	Yes
5	7	Female	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Dislike	Strongly Like	No
6	8	Female	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Dislike	Strongly dislike	No
7	8	Female	Strongly Like	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Like	Yes
8	8	Female	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Dislike	Strongly Like	Yes
9	7	Female	Strongly Like	Strongly Like	Moderate	Strongly Dislike	Strongly Dislike	Strongly Like	Yes

Table 7

*Measurement matrix of children who play the game -Round 2 (cont.)*

#	Age	Gender	like the game	Like Food Selection Module	Like GYM Module	Like reading more than Game	Like Listening more than game	Game raised motivation	Eat unhealthy food
10	9	Female	Strongly Like	Strongly Like	Moderate	Strongly Dislike	Strongly Dislike	Strongly Like	Yes
11	7	Female	Strongly Like	Strongly Like	Like	Like	Strongly Dislike	Strongly Like	Yes
12	9	Female	Strongly Like	Strongly Like	Moderate	Strongly Dislike	Strongly Dislike	Strongly Like	Yes
13	8	Female	Strongly Like	Strongly Like	Strongly Like	Moderate	Moderate	Strongly Like	No
14	9	Male	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Dislike	Strongly Like	Yes
15	7	Female	Strongly Like	Strongly Like	Strongly Like	Strongly Dislike	Strongly Dislike	Strongly Like	Yes

Table 8

*Measurement matrix of children who play the game -Round 2 (Cont.)*

#No.	Age	Gender	How many times eat unhealthy food	plan to change eating style	Game is difficult	like to play game at home
1	8	Male	Weekly	Yes	No	Yes
2	7	Female	Monthly	Yes	Yes	Yes
3	8	Female	Monthly	Yes	No	Yes
4	7	Female	Weekly	Yes	No	Yes
5	7	Female	Never	Yes	No	Yes
6	8	Female	Never	No	No	Yes
7	8	Female	Monthly	No	No	Yes
8	8	Female	Daily	No	No	Yes
9	7	Female	Daily	Yes	No	Yes
10	9	Female	Daily	Yes	No	Yes
11	7	Female	Monthly	Yes	Yes	Yes
12	9	Female	Daily	Yes	Yes	Yes
13	8	Female	Never	Yes	No	Yes
14	9	Male	Weekly	Yes	No	Yes
15	7	Female	Weekly	Yes	No	Yes