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ON THE DEVELOPMENT OF A DIETARY CASUAL GAME FOR DISEASE MANAGEMENT

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Abstract
In order to help people manage their health goals more accurately, a casual and educational game that will assist people in making the right meal choices known as ServeBest was developed. ServeBest was built on a hybridized technology principle to encourage learning, give room for reflection, and boost the speed and accuracy at which users make their meal choices. Persuasive principles were adopted to motivate users. Object Oriented Hypermedia Design Method (OOHDM) was adopted in the design of the system. The system was implemented using HTML, CSS, JavaScript and PHP. ServeBest takes into consideration popular diets in Nigeria. The system was tested by 30 participants. 97% of the participants affirmed that ServeBest increased their nutrition knowledge while 93% recorded that playing ServeBest led to out-of-game reflection. Playing ServeBest had a positive impact on the participants' blood sugar level.

Keywords: *Persuasive game, behaviour change, casual games, hybrid Technology, goal-setting theory.*

Introduction

Several people in Nigeria are suffering from different kinds of diseases. Most diseases are nutrition related. One of such nutritional disease is diabetes mellitus. Diabetes mellitus is a metabolic disorder of multiple aetiology characterized by chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both [1]. Research has shown that correct food choices can tremendously aid in the management of this disease. A good number of research have suggested that most chronic diseases and health issues that worries the health care unit such as diabetes, can be stopped through dietary change, and that choices of food and their effect is of great importance to health researchers [2] and [3]. It has been shown that the risk of some severe diseases can be decreased when a person establishes healthy eating habits and choices, while some severe disease can be increased by unhealthy eating [4].

In order to help people make healthy meal choices, many hospitals now provides books that contains meals and their nutritional value for diabetic patients, yet people still persist in eating unhealthy meals. This may be because the information provided lacks substance and is voluminous to read. This inability to read the books provided and the proliferation of smart phones led to the development of games using persuasive technology. Persuasive technology is a term used to portray technologies that change human behaviour and attitude in an intended way without deceiving or forcing them [5]. Research has shown that persuasive technology encourages people to engage in healthy living. Many persuasive technology interventions have been proposed based on helping people to choose the appropriate diet that is consistent to their health need. Researchers in the field of persuasive technology have developed variety of systems that induce dietary al change in human to promote well-being. Some of these systems which are in the form of games are built on a fast technology principle which has the limitation of imposing some in-game time related constraints, that is it allows little or no room for reflection. Several other persuasive dietary change systems do not consider quantity of the meal or diet as a determinant. A good example of such game is the OrderUp [6].

In addition, most systems developed to induce dietary change in humans' are built based on one-goal-fits-all methodology instead of a goal-based technique. Lastly, most researchers applied their intuition in developing persuasive system; no researcher has applied change models in this regard.

Therefore, the aim of this work is to design and implement a persuasive nutrition game to change dietary in Nigerians by applying change model so as to develop a nutrition casual persuasive game known as ServeBest that aids making healthy meal choices using change model; introduce food quantity and activity level as a determinant in making healthy meal choices among patients and implement and evaluate the developed system to assess its impact on the health of several patients. This work will help people to make correct food choices for their health management. The implication of this is that it will improve the health of several Nigerians, thereby reducing the rate of mortality. It will assist dietician in recommending correct food choices for the management of individual health issues of Nigerians. In the absence of dieticians the system can help patients to know the proper food to take. In addition, this work will assist stakeholders in the health domain to create awareness on the correct food intake in the right quantity for several patients.

Related Works

National mindless eating challenge (NMEC) is a mobile phone-based health game. The purpose of this game is to encourage healthy eating[7]. NMEC system was implemented using suggestion, comparison, reward, customization and personalization persuasive strategies. In NMEC game, a player is expected to care for a virtual plant or pet. The player follows a variety of healthy eating recommendations. At the start of the game, an initial eating goal and sub goals are selected by a player. Tasks that are relevant to player's eating goal are assigned to the player. The player is allowed to disable some features of the game if need be. Players are evaluated (assessed) at the end of each month and suggestion on how to achieve their goals in subsequent month is given. A player can also compare with others after receiving a reward.

Cullen et al. [8] came up with Squires Quest!, a persuasive game that helps increase children consumption of fruits, juices and vegetables (FJVs) and thus reduce the rate of diet-related diseases. This persuasive game was implemented using reward, simulation, competition, comparison and personalization strategies. In the game, players play the role of a squire whose task is to help the king and queen defeat invaders who are planning to destroy their kingdom by damaging the fruit and vegetable crops. The task for the squires are to learn to a high degree of proficiency the skills needed to make fruit, juice, and vegetable (FJV) recipes to provide energy for the king and his court, with goals related to eating more nutritious FJVs. The players get awarded with point based on goal obtained. The number of points earned determines the level of their knighthood. The game also provides a simulation of the physical environment.

Right way café is a persuasive game that promotes healthy eating and physical activity [9]. At the start of the game, the player produces a representative avatar using the player's personal information such as age, name, height, weight, body frame, and gender. With the specified information, the game provides healthy eating suggestions with regard to daily calorie consumption and ideal weight. The task of a player is to manage the avatars daily calorie consumption and physical activity to ensure it reaches ideal weight. The winner of the game is the player that best manages in a healthy manner the avatar's daily diet. The weight change is simulated at the end of each week.

Packy and Marlon is an adventure game that helps teenagers manages their type 1 diabetes. The goal of the players is to keep their illness under control by monitoring blood sugar [10]. In the game, both players need to successfully manage their insulin and food intakes, in order to win. At the start of the game, players can set insulin option and monitor the movement in blood glucose with respect to their choice.

Bronki the Bronchiasauraus is a game aimed at disclosing asthma management talent to children with asthma [11]. The game presents two animated characters and players are tasked with helping

the characters manage asthma by avoiding triggers such as smoke while the players go on a quest, checking breadth strength, using inhaler properly and taking medication as prescribed. The player health decision in the game determines the character health outcome. The player with the best health outcome wins the game. Spiro Game is a game for making spirometry in children easier [12]. Spirometry is often used for patient with lungs diseases, such as asthma. Spirometry is the measurement of the volume of air that a person can move in and out of the lungs, using a spirometer. Spiro Game helps a child co-operate well during spirometry. It teaches a child how to control the child's breathing during spirometry by making the child control a simulated caterpillar that crawls to an apple with their breath. OrderUp is a casual persuasive game where a player acts as an attendant in a hotel. The task of the player is to recommend a healthier food option to the customers [6]. Points are gained by the player when the player recommends quickly the healthiest food option.

MealBox is a persuasive casual game for health intervention [13]. The application is a web based multiplayer application. In this game, a group of people visit a restaurant with the sole aim of selecting the most appropriate meal with respect to their individual health goals. This system captures five different health goals- hypertension, diabetes, renal failure, obesity, and general well-being. MealBox is built on a slow technology principle. A number of persuasive principles and change theories were employed in the development of this game. The game consists of 12 rounds that are played in 6 days that is, 2 rounds per day. In each round, a player is presented with three different meal options from which the player is expected to choose the most appropriate.

Materials and Methods

We developed ServeBest, a dietary game for disease management using XAMPP server Version 5.5.0.0, MariaDB Database Engine; Hypertext Preprocessor (PHP) Scripts Version 5.4; Hypertext Markup Language (HTML) Version 5.0, Cascading Style Sheet (CSS) Version 3.0 and Dreamweaver GUI. We adopted a hybrid methodology. The methodology was derived from the combination of the Structured System Analysis and Design Methodology (SSADM) and Object-Oriented Hypermedia Design Methodology (OOHDM). The investigative phase of the SSADM was deployed as the paradigm for systematic study in order to obtain information on the current trends in the research area of dietary games. The information obtained necessitated the definition of a high-level model (HLM) for the system as shown in Figure 1. Using this HLM, a navigational context schema of the system (Figure 2) was designed. ServeBest was administered to thirty (30) participants to determine the effects of playing the game on them and assess the impact of the system on the participants. ServeBest was also evaluated by a pharmacist who administered the game to thirty (30) diabetic patients. These patients were divided into two (2) groups – moderately active group and sedentary group made up of fifteen (15) participants.

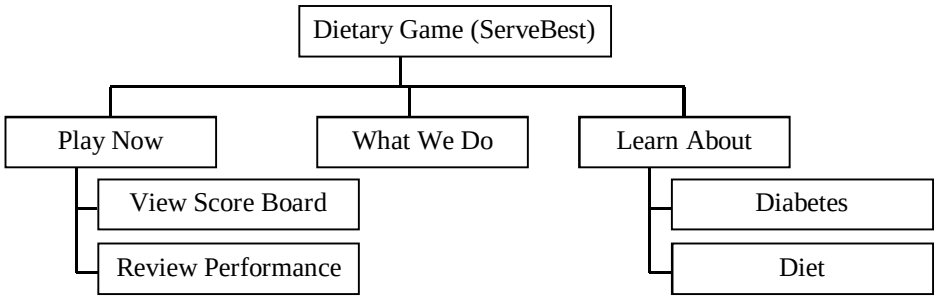

Figure 1: High Level Model of the New System

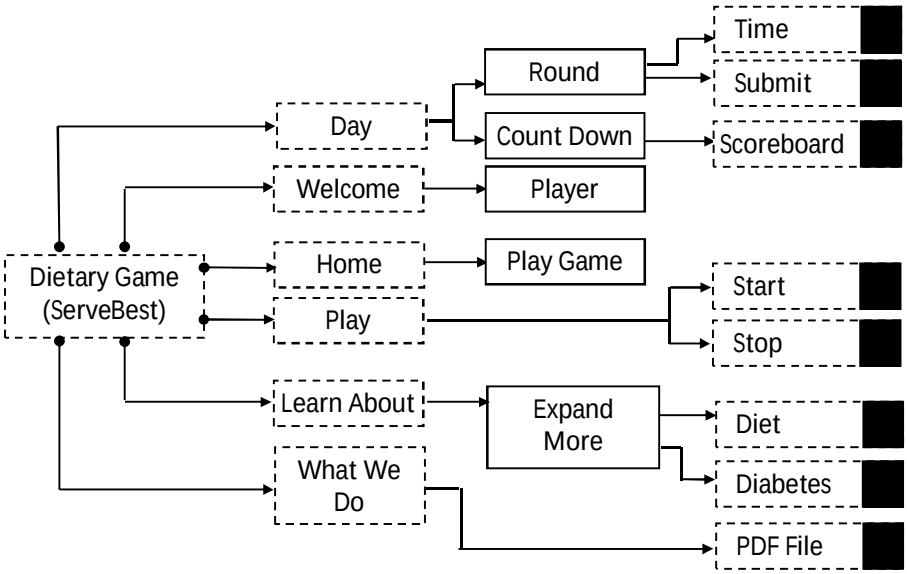

Figure 2: Navigational Context Schema of the New System

The New System: ServeBest

In this work, we designed and developed a persuasive game that induces dietary behavioural change using hybrid technology. The game is known as ServeBest. Studies have shown that games can be effective approach to trigger behaviour change in an intended manner. This approach is preferred because it is natural and common amongst the target users. In ServeBest, players assume the duty of waiters in a restaurant and a player's goal is to suggest as fast as possible healthier meals to customers in line with customers health goal. Serving customers quickly with correct meal choices allows the player to retain the player's employment in the imaginary setting. This fictional setting was chosen because the American Diabetes Association have proved that knowledge on making healthy diet choices when eating away from home is an essential skill to build. The intended users of the system are Nigerians because the rate of diabetes and other diseases are on the increase. Researchers have always stressed the need for interventions to address these health issues. The system is tailored to incorporate various meals from major ethnic group in Nigeria.

In ServeBest, a player has to serve ten customers' that come sequentially into the restaurant. At the beginning of the game, each player has salary to be zero naira. When a customer enters the restaurant, the player is presented with four foods (meals) options chosen at random. Meals are presented at random to ensure that players cannot predicate the combination pattern of meals and pass the information that no meal is generally good or bad as a particular meal that is good in this round might not be in the next round depending on the nutritional value of other option. Research has shown that the real power of any decision making system is not in it representation scheme but in the fact, rules or knowledge it possess. Rules and fact comes from different sources

and one very important source is from an expert. As such, the health and nutritional values of different meals presented in the game are gotten from an expert (a dietician). Consulting a dietician has thus shown that different meals having the same taste may have different nutritional value which depends on their content.

A game session is made up of 40 rounds, of which a player plays 10 rounds in a day. The player earns 200 naira for selecting the best meal, 100 naira for second best choice, 50 naira for third best and earns no money for selecting the worst choice. Highest possible amount a player can earn in a day for selecting all correct meals is 2000 naira. When the game starts, the player is given 15 seconds to select a meal among four options or the customer will become annoyed and leave. In this case, the player loses all the points associated with that customer. After the first round, the player moves to the second round and so on until the player gets to the tenth round which is the last round for the day. After the tenth round, the player can view the players result as well as the correct meal choices to the entire questions. On completion of the tenth round, players must wait for the dawn of a new day before the players can continue the game. The slow aspect allows players to reflect, discuss with folks and research on meal choices in line with the chosen health goal.

The system changes human behaviour using the goal setting theory, knowledge attitude behaviour theory, and reinforcement model. The introduction of meal quantity shows that eating a healthy meal is not sufficient enough to achieve the desired aim but eating a healthy meal in the right proportion. ServeBest also uses the reward, competitive, comparison, and praise strategies. The knowledge attitude behaviour theory states that as players learn healthy meal choices, that there is a high tendency of changing their behaviour. The advantage of using hybridized technology is that it encourages learning, reflection, and increases speed and accuracy at which players select the best meal option. The game can run on any web enabled device.

Results and Discussion

The results are shown in Figure 3 to Figure 8. Figure 3 is the screenshots of the dietary casual game for disease management – ServeBest.

ServeBest was given to thirty (30) volunteer participants to use. These participants were interviewed before the game and after playing the game. The effects of playing the game are represented in Figure 4 and Figure 5. Twenty nine (29) participants representing 97% of the users recorded that playing ServeBest increased their nutrition knowledge, while one (1) participant representing 3% of the users did not respond as to the effect of ServeBest as shown in Figure 4.

In Figure 5, twenty eight (28) participants representing 93% of the users recorded that playing ServeBest led to out-of-game reflection while two participants representing 7% of the users affirm that ServeBest did not give room for reflection. The slow attribute of ServeBest is the main component that triggers reflection. Slow part of the game allows participants time to research more about their current health goals. The participants also recorded that the feedback they got after playing the game (ServeBest) facilitated learning and been able to view the score board served as a motivation to learn more.

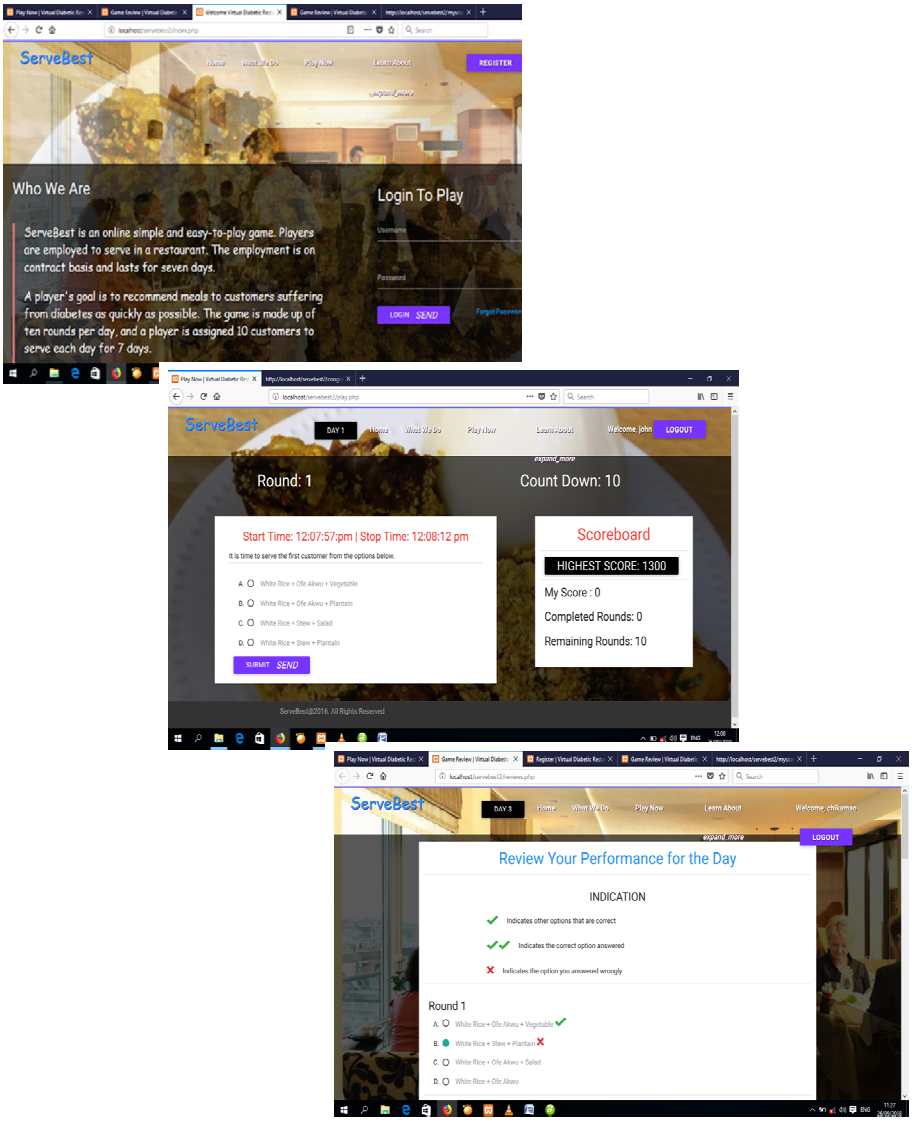

Figure 3: GUI screenshots of ServeBest System

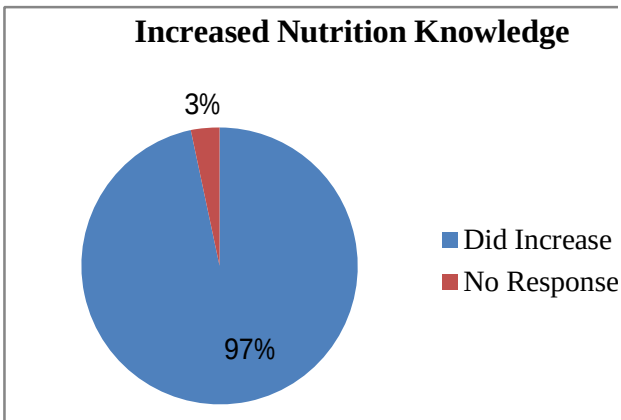

Figure 4 (2): Result for Increased Nutrition Knowledge

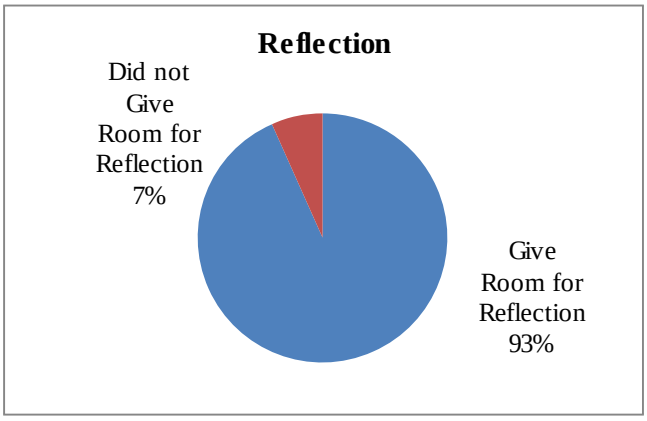

Figure 5 (3): Result for Reflection

A pharmacist helped to evaluate ServeBest. The pharmacist introduced the ServeBest to thirty (30) diabetic patients. Before the patients started playing the game, the pharmacist took and recorded the patient's blood sugar level. The thirty patients that were used to evaluate the system were asked to supply their blood sugar level during registration. On completion of the game, the patients were given a space of three week to completely change their dietary behaviour after which the patients were required to enter their new (current) blood sugar level in mmol/L. The new blood sugar level was also recorded by the pharmacist. The type of test required to get the new blood sugar level was the fasting blood sugar test. In this type of test, patients were required not to eat or drink anything before checking their sugar level. The thirty patients were made up of fifteen sedentary and fifteen moderately active patients.

Figure 6 depicts the chart for the sedentary participants. The chart shows the previous blood sugar level before playing the game and current blood sugar level after three weeks of completing the game. From the chart, the current blood sugar level was less than the previous blood sugar level for the entire participants. This shows that playing the game had great positive impact on the participant's blood sugar level.

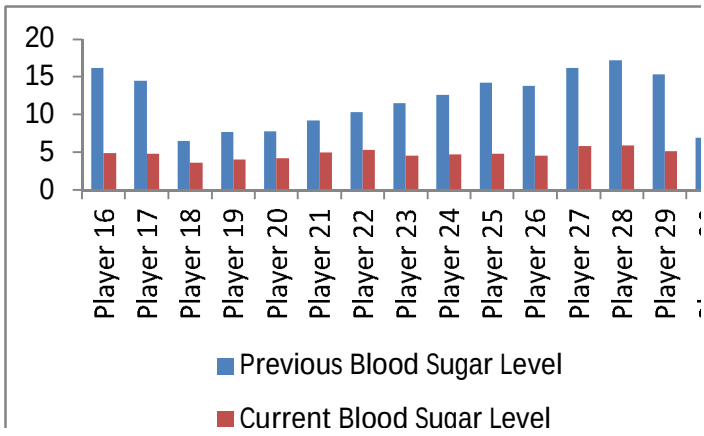

Figure 6: Result for Sedentary Participants

Figure 7 depicts the chart for moderately active participants. From the chart, the current blood sugar level of the entire participants is less than the previous blood sugar level. This shows that 300g is the ideal quantity of meal for moderately active participants and playing ServeBest has led to a positive dietary behaviour change in the participants. The current sugar level of the entire

participant after the game fall between the range of 3.5 and 6.1 mmol/L which was equivalent to the normal blood sugar level of a humans which is between 3.5 and 6.1 mmol/L.

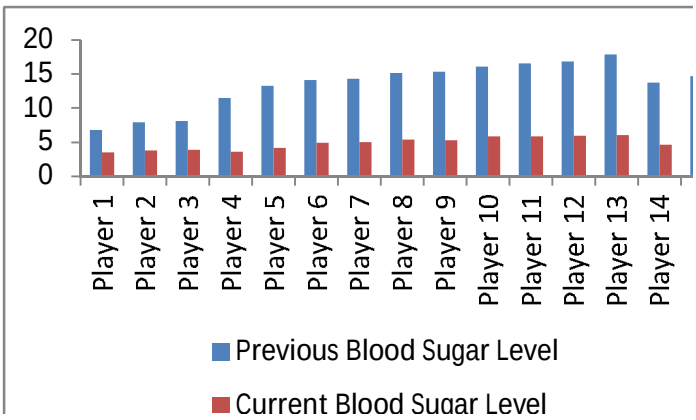

Figure 7: Result for Moderately Active Participant

Conclusion

In this work, we developed a fast and slow dietary game for disease (diabetes) management to encourage learning, give room for reflection, and boost the speed and accuracy at which users make their healthy meal choices. This dietary game is known as ServeBest. ServeBest increased the nutrition knowledge of participants and made them have time to reflect. This shows that playing the game had great positive impact on the participant's blood sugar level as it led to a positive attitude change toward healthy eating.

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