Obesity in Children - A Serious Game

Elmedin Selmanovic*
Supervised by: Kurt Debattista,† Simon Scarle,‡ Alan Chalmers§

International Digital Laboratory
University of Warwick
Coventry / United Kingdom

Abstract

Childhood obesity is a prevalent problem in most developed countries. It can have a significant negative impact on a childs health including diabetes and cancer. Help in the preventing and reducing obesity is required. One possible method suggested in this paper is a serious game, which would increase energy expenditure during play, educate about nutrition and promote healthy eating and physical activity. Methods and ideas, informed by the related research, which were used for the implementation of such a game, are presented in this paper. Although not a complete solution in itself the game could help in the fight against childhood obesity.

Keywords: Serious Games, Obesity, Edutainment, Exergaming

1 Introduction

The prevalence of childhood obesity in advanced countries is an increasing problem. The number of obese children varies from 17% in the UK [2] and 16% in the US [21] to 12% in Australia [35]. Obesity can have negative effects on a child's health (e.g. diabetes, cancer and cardiovascular disease) and negative psychosocial impact including low self esteem and stigma [6, 7]. Moreover, in 40% to 70% of the cases, obesity is likely to persist into adulthood [24] with accompanying health risks and possible socioeconomic problems.

The causes of childhood obesity are complex and multifactorial including unhealthy eating patterns and an inactive lifestyle, both of which can be linked to increase in the time spent watching television and playing video games [6, 23]. Given that an average US family keeps its TV turned on 8 hours a day, the time a child spends in front of the screen can reach up to 55 hours per week [37]. One response was reduce the amount of TV watching, but different solutions were needed, as children did not relinquish screen time that easily [8, 11]. One possible answer to this problem would be to convert this sedentary screen time into a more active form and use it to promote physical activity and healthy eating.

The aforementioned objective could be accomplished using a game. This would fall into the domain of serious games, games whose primary function is other than pure entertainment. The aim of this paper is to show the creation process of the game that can help tackle and prevent childhood obesity.

First, definition and brief history of serious games is discussed. Related work is provided in Section 3. In Section 4, the game design and different considerations are explained. Section 5 deals with the actual implementation and examines a selection of various tools and techniques. Feedback obtained from the first game testing is provided in Section 6. The conclusion is presented in Section 7 and future work is discussed in Section 8.

2 Serious Games Background

Clark Abt published a book entitled Serious Games in 1970 (Abt 1987). This was the first time the term was used. Although, in this book, Abt was mostly concerned with card and board games, the definition which he offered is still relevant: *"Games may be played seriously or casually. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining."*

However, today, serious games do not have such a clear scope, because the majority of researchers involved tend to offer their own, somewhat, different definition. For instance, not everyone agrees that factor of fan or entertainment has to be included. While Zyda [39], Bergeron [1] and Prensky [22] think it is necessary, Stoll [31] completely rejects the idea of putting fun into the learning process. Michael and Chen [19] take a more moderate view suggesting that fun although desirable is not essential. According to Zyda [39] an additional factor that has to be considered is pedagogy, but this still needs to be subordinate to entertainment. Bergeron [1] finds it crucial that a scoring system and challenging goals are included. The

*elmedin.selmanovic@warwick.ac.uk
†k.debattista@warwick.ac.uk
‡s.scarle@warwick.ac.uk
§a.g.chalmers@warwick.ac.uk

Serious Games Initiative [14] focuses on the usage of serious games for education, training, health and public policy. Still one common idea can be taken out and used as the broad definition of serious games; those are the games whose main purpose is other than pure entertainment.

With such a broad definition the history of serious games is difficult to pin down. However, factors that affected the development of this field can be identified and include the evolution of industrial-military complex, a usage of digital technologies in medical education, expansion of the computer industry and the popularity of commercial games [1]. The first instance of serious gaming can be traced back to Edwin Link who constructed the first flight simulator in the late 1920s [16]. After this early start sporadic examples of serious games followed mostly in the military and medical fields. In the 1980s two promising disciplines of virtual reality and edutainment, which used games for non-entertainment purposes, started to expand [32]. Unfortunately, this expansion did not last long and both of these concepts failed to fulfil their early promise. Virtual reality struggled with expensive hardware, the absence of case studies, lack of attention for end user's requirements and failures to provide meaningful and functional intellectual property [32]. At the same time edutainment, the idea of education through entertainment, produced boring games no one had interest in playing [36]. Serious games have to avoid these pitfalls to succeed, especially given that, today, edutainment is considered its key part. The expansion of serious games started in 2002 with lunch of the Serious Games Initiative which tries to form connections between game industry and health, education, training and public policy projects that require its services. Serious games have a large application area including military, government, corporations, healthcare and cultural heritage. The market size of serious games is not easily determined (one of the reasons being the broad definition), but the U.S. military alone spends millions on their development annually [1].

The advantages that serious games have to offer need to be defined. What is clear is that a game's simulated environments provide the user with the opportunity to experience situations which cannot be replicated in real world due to time, cost and safety reasons [4, 30]. However, the effect that they have on players is difficult to assess because complexity of the games requires variables that are narrowly defined and conditions that are tightly controlled, resulting in research with rather limited claims [36]. Nevertheless, it has been shown that serious games can improve analytical, spatial and strategic skills, learning and recollection capabilities, psychomotor skills, visual selective attention, self-monitoring, problem recognition and problem solving, decision making, short and long term memory, social skills such as collaboration, negotiation and shared decision making [20, 25]. It is important, in this context, to recognize that not every serious game offers all of these benefits and each one should be assessed individually to determine success.

3 Related Work

There are a number of studies that support the idea of exergaming: using video games for exercises [13, 17, 27, 29]. Most of them test the amount of energy spent during play and compare the result to both sedentary screen time as well as sports activities. The active games significantly improve energy expenditure, sometimes even doubling it compared to the regular sedentary screen time, while in most cases they are still not as good as doing regular sports. A comparison which demonstrate how exergaming can come close to the real sports, shows that playing Wii Sports Tennis spends 750 kJ/hour while real bowling spends 800 kJ/h [12].

In most cases of exergaming, specialist hardware is required. The idea of connecting exercise equipment to video games is almost as old as games themselves [28]. An early commercial example is the project named Atari Puffer where an exercise bike was interfaced with a game console. After this, a series of companies started using exercise bikes for the same purpose with today's representatives: Tacx Fortius Trainer, Fisher Price Smart Cycle and Cateye GameBike Pro. Foot operated pads are another type of devices used for exergaming. One of the especially successful games that used foot operated pad was Konami's Dance Dance Revolution with 6.5 million copies sold. Successful instance of this device is Nintendo's Wii Balance Board [28]. Lastly, we have equipment that uses motion sensors for input; popular examples are: Sony's EyeToy, Nintendo's Wii Controller and Wii Nunchuk. In addition to these commercial products efforts in creating exergames have been done in academia as well [18, 38]. Sinclair et al. [28] describe considerations which need to be taken into account during exergame creation. In addition to being fun the authors state that game have to have a level of intensity corresponding to the fitness of the player.

Besides being a form of exercise themselves games were also used to encourage both physical activities and healthy eating. In order to promote physical activity, games were used as a requirement for getting more desired activities such as watching TV or playing games [10, 26]. Another strategy involved members of the group competing by using actual data from the pedometer which they were wearing during the day [3, 9]. Examples of games promoting healthy eating include commercial titles like Hungry Red Planet and research ones [34] both of which taught children nutrition skills. A framework for developing serious games can be based on four dimensions: context, pedagogy, learner specifications and representation. This framework can be extended by using output from an analysis phase and checking if the serious game solution satisfies a learning need [5].

GameFlow is a model for evaluating player enjoyment in games [33]. Eight elements ensure a game is fun to play. Concentration is the first one. A game should not distract player from the action and should not burden him with the unimportant tasks. The two elements which are closely

related are challenge and player skill, as they need to be carefully balanced all the time. Next, the player should always feel in control of their actions in the game. Clear goals have to be provided and appropriate feedback should be sent to the player. Element of immersion states that players should be deeply, but effortlessly involved in the game. Social interaction is the last suggested element.

The game described in this paper attempts to combine all the above mentioned concepts, using specialist hardware to exercise, while at the same time promoting healthy eating and physical activity.

4 Game design

Making the game successful required fulfilment of many different, and occasionally opposing, conditions. The game had to be physically engaging, informative and, above all, fun. In order to ensure that the game design is properly executed, guidelines from papers mentioned in previous section were followed [12, 5, 33]. In addition, the fact that the game was non-gender specific and aimed at children aged 8 to 12 years had to be considered. Also, the time available for producing this game was 10 months with a development team including one full time programmer and three part-time members.

The targeted age group governed the choice of the art style, shown in Figure 1, which can be described as cartoony. Characters, environment and even animation are exaggerated with a simple yet vivid colour scheme full of contrast. All edges are accentuated by hard black lines. This style is not only appealing to children but it also accelerates development by reducing time required for modelling, texturing and animation, as less precision and realism is needed. In addition, it should help keep children's concentration as no distraction is created by unnecessary details.

Figure 1: The Game's Art Style

In order to conform to idea of boosting physical activity, the main game input and most of the interaction is carried only through movement. The devices chosen to capture motion were the Wii Controller and Wii Balancing Board, as they are relatively cheap, easily obtainable, provide satisfactory supporting software and given their popularity, a user might already own one. They are used to control both the character and the graphical user interface. The expected player's movement should be bold, thereby, increasing energy expenditure and also making itself easier to capture. This in turn should reduce user errors which should then ameliorate concentration, feeling of control and immersion. Although physical activity is increased in this manner it is acknowledged that the game is not a substitute for real exercise.

The player's character is a young sorcerer (Figure 2). This choice was conditioned by the pedagogical decision of no violence and highly abstracting any notion of combat. The wizard's wand appeared to be a good option for a non-violent tool/weapon. Furthermore, movements made by a wand corresponds well to movements of a Wii Controller making control natural and helping increase immersion. Magic is also convenient way to explain some curious phenomena that happens in a game as will be shown later. In order to preserve gender and ethnic neutrality customization of the character should be allowed.

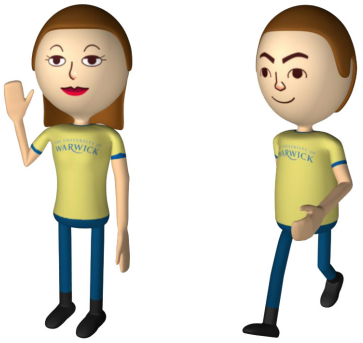

Figure 2: The Main Characters

Level design was guided by the idea of small, independent entities with a number of different yet familiar mini-games. The advantages of this approach are numerous. Firstly, a small, independent level is easily and quickly tested and, in case it does not function, it can be simply discarded. Secondly, the player is not required to complete levels in a predefined order which should increase the impression of control. Likewise, hard levels can be skipped and played afterwards when the player's skill has improved and matched the level's challenge. Lastly, mini-games should increase variety making the game more interesting and keeping the children's attention longer. Still, each mini-game has to have similar gameplay so that the player's learned skill is transferable.

One relatively straightforward solution, which encompasses the suggested type of level design, is to use islands as separate levels. Although, freedom of level selection should be allowed, it would not make sense if player could access the last stage in the beginning of the game. To

overcome this problem and balance challenge and control, the decision was made to have a number of lakes, each containing multiple islands (Figure 3). An island could be freely chosen but transition to the next lake would be locked (Figure 4) until completion of all the levels or scoring a certain number of points. The lakes could have different art themes (e.g. winter, desert, and volcano). In this setting, assets could be reused requiring only slight changes (e.g. textures). This would reduce development time while preserving variety.

Figure 3: One of the Lakes

Figure 4: A Dam Blocking the Exit

The primary vehicle for moving the character is a coracle. This means of transport fits well into the lake environment and interfaces smoothly with Wii Balance Board and Wii Controller. The controller is used for rowing action which propels the coracle forward, while direction is altered by leaning left and right on the Wii Board. This routine, which increases physical activity, has also been used in its own right for a mini-game when the player travels between lakes. To go from one lake to another a player is required to sail down the river full of obstacles (stones, logs, whirlpools) and try to collect bonuses which can later be used on the islands, or increase score (Figure 5).

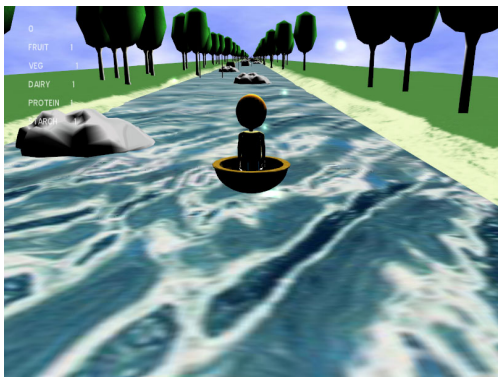

Figure 5: The River Minigame

Healthy eating messages had to be incorporated subtly, so as not to distract from the main gameplay. The first, simple idea is to place short and relevant text tips onto the loading screen. The second idea, actually, defined the story of the game. As a young sorcerer, the player is required to deliver food packages to the famine struck islanders, while two villain characters (Figure 6), for nefarious reasons, are slipping in unhealthy food in an attempt to make islanders overweight. The player needs to eliminate these unwanted packages. Two pedagogical issues had to be taken into account. Firstly, the main character cannot be modified to look overweight. Secondly, the player is not allowed to fight the villains directly.

Figure 6: The Villains

Taking above considerations into account the gameplay was defined. Upon approaching an island in a lake view the player is transferred onto it. The character still stays in the coracle which now floats above ground (due to magic) but player does not have to row anymore and only uses the leaning motion to move. An island is inhabited by the famished people and animals which add background interest. In the centre of the island is a challenge made from food packages. The ”good” food package is moved into the islanders’ barn when the player collects it, while ”bad” ones are dispatched into a skip. The opposite happens in case of the villains (bad goes to the barn and good to the skip). In this manner direct conflict is avoided. A screenshot pre-

senting the gameplay on one of the islands is shown in Figure 7.

Figure 7: An Island Level

In general, packages are separated into six categories according to food group division (e.g. dairy products, fruit, and vegetables) with one category being unhealthy food (Figure 8). Packages of each group are colour coded, reducing confusion. One of five food group members is represented on a package (e.g. fruit package would be green and could have cherries depicted on it) giving the total of 30 distinct packages.

Figure 8: Blocks Used in a Level

The goal of each level is to provide islanders with enough food packages while achieving good balance of food groups. Preserving this balance during play is important as well, because due to large amount of unhealthy food character starts to turn into stone and his movement becomes slow and lethargic. This also affects islanders and island animals that walk in the background highlighting the consequence. On the other hand, dispatching unhealthy food slows villains down. User interface always provides clear representation of current food balance and time left.

Each island is going to have a different challenge. Central idea behind challenges is the concept of "Physically Enhanced Puzzles". In such puzzles speed and direction of input motion affect the gameplay keeping the player active. Re-interpretations of classic games like Columns, Brake Out, Space Invaders and Tetris are used as a foundation of the puzzle design. They are then modified to accept motion input, collection of food packages and actions of villains. To increase variation, each of these major puzzles is then slightly altered and used on a different island.

5 Game Implementation

The minimal hardware requirements were set low, making the game accessible to more potential users. Also, the low requirements should help deploy the game into the schools with relatively old equipment. The game should run smoothly on a machine with 1GHz processor, 1GB of RAM and 256MB DirectX9 graphics card. In addition, a Bluetooth connection, which is easily obtained using a cheap USB dongle, is required for Wii Controller and Wii Balance Board. Choice for the last two Wii devices is explained in the previous section.

The time frame available for game development ruled out the possibility of creating our own game engine, while budget did not provide funds for purchasing commercially available solution. The only feasible option was usage of a freely available product. Choice was to use Ogre 3D: *"the most powerful open source real-time 3D rendering library currently available"* [15]. It is important to note that Ogre 3D is not a full game engine. It is, instead, a graphics engine used for rendering. However, it is easily scalable with a number of plug-ins provided. Another advantage of Ogre is the large user community which offers solid support and resources. For managing players input from Wii Controller and Wii Board open source libraries were used. Object movement and interaction was implemented using Nvidias PhysX technology.

Game assets and character animation were created in Autodesks Maya 2009 software. Texture production was done in Adobes Photoshop CS2. Both of these packages are industry standards and were available prior to game implementation. Exporting content from Maya to Ogre was done using OgreMax, a freely available Maya plug-in.

6 Feedback

An early version of the game was tested in a local school. Seventeen children aged 7 to 11 played the game. They were of the mixed gender (8 boys and 9 girls), ethnicity and body size. Children were divided into the four focus groups depending on a Year group. A questionnaire was given before playing the game which tested if the children knew they should eat 5 portions of fruit and vegetables a day and also asked them how many portions they ate. The results shown in Table 1 imply that although most of the children knew how many portions they need to eat majority of them did not eat this amount. Children were also

Answer	How many portions of Fruit & Veg should children eat in a day?	How many portions of Fruit & Veg do you eat each day (on average)?
0	0	1
1	0	0
2	1	1
3	1	4
4	1	5
5	12	5
6 or more	2	1

Table 1: Questionnaire Results

asked which computer games they were playing at that moment and 15 of the 17 gave specific names while two participants left this field blank.

16 of the 17 participants were positive about the game with comments like: "funny", "loved it" and "addicted to it". They would like to play the game again. They said they liked the graphics and would be happy to have the game in the school to learn about healthy eating. Some wanted to take a copy home. One girl did not like the game and found it too difficult. She said that it was "annoying".

Children offered other feedback and gave a number of useful suggestions that could be implemented in later versions. X-Box like controller, which was offered during the testing, was preferred over the balance board. As the board was challenging to use children suggested to change its sensitivity. They also said they learned about food. They learned not to eat fat/junk food and connected this with getting fat. Also they showed understanding of different food groups, but sometimes what they said was outside the game's scope (e.g. "different vitamins"). Although there was some mention of physical activity, knowledge which they obtained from the game was limited. The request for customising characters (e.g. clothes, facial features, gender, name and hair) was also expressed. One child suggested tackling the bad guys with swords to which other child responded "that would be violence", although the latter child stated previously he was playing the GTA: Vice City, a rather violent game.

Other suggestions were also brought to researchers' attention and included:

- menu options
- multiplayer option (two players helping each other)
- new levels
- save option
- changing the look of the water in the lakes
- making pictures of food clearer
- clear goals for each level
- option for inputting real-life fruit and vegetable consumption
- option for swimming around the lake
- using the labels of "good food" and "bad food".

In addition to children, four parents/carers participated in the trial. There were 3 mothers and one father, although the mothers gave most of the comments. Parents liked the game and supported the idea of using it in the school to teach children healthy diet. They stated that many cannot afford Wii Balance Board and suggested the usage of the regular controller. They also recommended making the images and text more prominent and clearer. Finally, they said that levels need more feedback, possibly speech, telling children what to do next and giving them useful messages. Parents were keen to see the game going to the next stage of its development.

7 Conclusion

Action to help fight and prevent childhood obesity is required swiftly. It could come in the form of a serious game which increases physical activity and promotes healthy eating and sports. Understanding the background of serious games was important for appreciating the large number of considerations required during development, distinguishing them from regular video games and presenting their advantages. Related work used to govern the design phase was carefully explored. Design was possible only by balancing all different constrains and making sound decisions informed by research. After finishing the design it was possible to start implementation which required new choices in terms of hardware and software. Although the development is still not complete the first trail with a focus group showed that children did enjoy playing the game. However, the true measure of the game's success can only be obtained after the game has been distributed and data, gathered during prolonged use, has been analysed.

8 Future Work

The game is still in the development phase with three months left before the end of the project. Majority of the gameplay logic has been implemented. One instance of fully functional lake with three islands is available. Motion input requires more improvement as there are the occasional problems recognizing gestures. The logic for running cut-scenes is in the late phase of development. The stage for character customization, tutorial levels and nice GUI still need to be created. A strategy for promoting physical activity is also required. There is a present need for generating more content and assets. It is planned to test the game with focus groups once more. After the game is developed it should be deployed and the data to prove its

effectiveness should be gathered, but that goes beyond the scope of this project.

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