NUI Galway
OÉ Gaillimh

Final Year Project Report

FoodQuest

A Nutrition Education Video Game

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Contents

1. Introduction

This Final Year Project Report provides a brief overview of the author's Nutrition Education Videogame 4BCT Final Year Project to promote a shared understanding of it, reasons for creating this type of educational experience, rational behind the unique approach, aims of the project, the architecture and technology used to create the project.

"Develop a game for kids whereby the main character goes on a quest. During the quest, they will learn about proteins, carbohydrates, fats, etc. and the way to a healthier diet. You will need to have a group of children to test, once before using the game and then after playing the game (to ascertain if there is increased level of understanding)".

1.1 Summary

The author has been tasked with creating a video game to increase the level of nutritional knowledge (primarily macronutrients) in children aged 7+. Many weeks before playing the game, the player will be tested on their nutritional knowledge (macronutrients; protein, carbohydrates, etc). After completing the game, another test will be run to compare their knowledge learned from the play-through.

1.2 Gameplay

The gameplay will incorporate elements of action, adventure, and role-playing. The player will control the main character from a 2D overhead perspective. A series of monsters, each with a unique style corresponding to a macronutrient, will have to be defeated to complete the game. These monsters will be presented as boss enemies, who will be far stronger than the opponents the player has faced up to that point. The boss battles with these characters will generally occur at the climax of a section of the game, usually at the end of a stage or level, or guarding a specific objective (Polygon, 2015). The player will gain strengths as they consume different macronutrients. The player will begin the game with no knowledge of the properties of macro nutrients. Plot

The storytelling throughout the journey will be left up to the imagination of the player. The author evaluated the consequence of introducing a narrative into the game would distract from the educational message at the forefront of the core of FoodQuest. Creating an exportable environment would allow the player to fabricate their own story during the playthrough.

1.3 Mindset

The player will be intrigued to explore how each of the macronutrients (e.g. protein, carbohydrates, etc) will benefit their attributes (i.e. strength, speed, etc). This will encourage collection of different foods (for example; bread will be high in speed due to its immense natural carbohydrate level). As the player progresses through the game, their knowledge of macronutrients will increase and so will their confidence to combat the foes.

1.4 Education

The aim of this project is to apply education to an entertainment environment. The player will be informed about the various macronutrients (i.e. proteins, carbohydrates, fats, water, and fibre) along their journey.

2. Project Rationale

This project is expected to deliver a brief education of nutrition to benefit the player. To combat an increase in health issues related to the prolonged uneducated consumption of unhealthy foods, a new medium is desired to help alleviate this issue via nutritional education. Benefits upon completing this project would deliver an informative video game into the hands of children to play and throughout the journey learn about macronutrients.

2.1 The Elevator Pitch

< Pitching the author's game to an executive going to the elevator in less than 60 seconds.>

This is a game aimed at children (aged 7+) about fighting whacky bosses while being educated about nutrition. The player will experience an exciting, challenging game-based learning experience.

2.2 What sets this project apart?

Currently there are no games proven to successfully educate children about macronutrients. Almost all educational games are very simple flash games with little depth, little enjoyment derived from, and little reason to re-play. Video games in the classroom possess the potential to be innovative. This is a desire which can be met.

"We found that an entertainment computer can be used successfully in a classroom and that well-designed software can complement, and possibly improve upon, traditional teaching tools." (Lee, 2004)

Encouraging children to eat healthier foods can be painstaking as they as reluctant to try new foods.

"Two factors have been shown to contribute to rejection or acceptance of fruits and vegetables: food neophobia and 'picky/fussy' eating…. From a very young age, a child can communicate his/her likes and dislikes to their caregiver. Younger children will communicate through body language (e.g. moving away from the food offered or it away from them) or, if the caregiver is persistent at making the child eat, through non-linguistic verbalisations (e.g. groaning or screaming)" (Department of Psychology, Staffordshire University, 2008)

To engage children to a healthier diet, intervention needs to be enacted in various aspects of their lives.

"…youths' awareness of the multiple influences on diet may create opportunities for multi-faceted, ecologically-based interventions. In particular, participants stressed the importance of social influences on diet and on successful nutrition programming" (Swanson, 2012).

Video game education has been largely ignored by most of academia.

"Most educators are dismissive of video games. But corporation, the government, and the military have already recognised and harnessed their tremendous educative power. Schools have to catch up...." (Shaffer, 2005).

Video games are universally popular pastimes for children, carrying this over into the educational world is a cogent argument. Children enjoy being immersed into games in the playground, this immersion can carry over to learning.

“60 percent of children aged nine to twelve own a mobile phone. Among thirteen to sixteen-year olds, the figure is close to 90 percent” (Oksman, 2003).

“Video games still include action games, but they also include simulations, strategy, role playing, sports, puzzles and adventure. Good video game design across these genres immerses users in a rich interactive digital microworlds” (Squire, 2003).

We know educating children through animations / cartoons is a successful motivator for increasing vegetable consumption. One study in South Korea demonstrated animations as the most helpful outlet to change their eating habits.

“After education, 75.9% of the students in the nutrition-education group indicated changes in their eating habits…. most helpful medium for changing their eating habits was animations (31.0%), followed by songs (20.7%) and lectures (17.2%)” (Kim KA, 2010)

2.3 Why do we need a nutrition education video game?

Obesity is a growing issue today. With 18.4% of children at age six to eleven being obese in America being overweight (NCHS, 2017) compared to 19% of children overweight at age nine in Ireland (Mooney, 2012).

Comparing the weights of Irish children from the post-war era to the Celtic tiger found that boys aged 14 years in 1948 their average weight was 37kg, in 2002 their average weight was 61 kg, a substantial proportion of the increase in weight is seen between the 1970s and 2002 (Perry, 2008).

The prevalence of overweight and obesity had increased in all countries, rising by more than one percentage point each year during late 1980’s-2000 (Wang, 2004). Children are becoming obese at an alarming rate. The short and long-term effects, range from difficulty in movement and breathing to cardiovascular risks and type 2 diabetes. There are many programmes such as ‘Switch Off-Get Active’ (Centre for Health Behaviour Research, 2006) and ‘Food Dudes’ (Horne, 2008) in place in Ireland to combat childhood obesity. These have been widely effective at contesting the issue. Furthermore, video games are another approach to educate children about food and nutrition.

2.4 Influence #1 The Legend of Zelda

Medium: Video game

Among the gaming community, The Legend of Zelda (Nintendo, 1986) (Figure 1) was a precursor to today's role-playing video game genre. The game successfully used simplistic controls and a straightforward story to immerse the player into a vivid world. The game presented the player the tools to eliminate enemies, perfect puzzles, and traverse terrain without leaving complicated instructions to burden or hand-hold the player.

Figure 1 : Gameplay of The Legend of Zelda (Nintendo, 1986)

The boss battles of this game made it stand out amongst other titles at the time. Each boss had a unique look and would possess a set of strengths that had to be defeated by skills that the player had cultivated along the journey. A highlight of facing a new boss was the nervous excitement of walking into a boss room ready to apply your arsenal to act to whatever attacks and movement pattern this boss presented.

In modern games, the philosophy is to prevent the player for dying unless they are especially careless. That is not the case in the first Zelda game. Health is rarely dropped from enemies and conversing it the key to survival.

2.5 Influence #2 Cuphead

(Medium: Video game)

Cuphead (Studio MDHR, 2017) is a new release which has been widely accepted among the video game community. Praised for its art style and noted for its challenging difficulty it has been welcomed for its "tough but fair" gameplay. Cuphead is a run and gun platformer with gameplay centred around the boss battles with the uniquely designed opponents of Cuphead (Figure 2).

Cuphead requires the player to dodge overwhelming numbers of enemy projectiles. Focusing on a muscle memory playstyle, the player must face each boss a trial-and-error approach until they are familiar with the personality that boss's attack types and movement pattern.

Incorporating the unique style of atmosphere projected into the setting when battling with each boss into the video game, every boss is different from the last and the user must apply their skill set in approaching each. The issue of death is handled very interestingly here: the player has infinite lives, keeps weapons between deaths. Death is not a punishment to the

Figure 2: Gameplay of Cuphead (Studio MDHR, 2017)

player as it allows them multiple attempts to learn from their mistakes and apply their skills set more efficiently.

2.6 Project Aims

The main goal of this project is increase children's knowledge of nutrition. Using a game-based learning approach, the player will be educated throughout the game journey. Increasing the player's knowledge of nutrition is the main challenge faced in designing this game. With an entertaining educational experience, this game has the potential to be adopted by many schools and educational programmes anywhere in the world.

Delivering a game which a child will want to play is a critical role to execute in this project. In the past, educational games have made a reputation for having little intrigue or containing little depth. Games such as point-and-click flash are unappealing as they require little input, so the player does not feel in control. These games require the play to learn about nutrition by memory instead of by practice, such as simply displaying a piece of text with an accompanying image informing the player the benefits of carbohydrates and requiring the player to memorise that text.

In this new approach, the character's on-screen attitude will react to what a specific macronutrient does by seeing and processing the effect a macronutrient ability does. For instance, the controllable character picks up a bowl of porridge, since this food is high in carbohydrates the character will experience an increase in speed for a short time period. Another instance would see the character pick up a bag of nuts, this food being high in protein the character will experience an increase in damage in their next few attacks. The player will discover the effect of a food by observing the result of food on the character.

Since the game is aimed at children, overcomplicating the mechanics could be troublesome. Many games have featured too many abilities and items which each handle a unique situation. Nintendo's latest flagship release, *Super Mario Odyssey* (Nintendo, 2017), uses the simple mechanic of hurling the main character's hat at an object or non-playable character to take control of it. The entire gameplay is built around this single feature mapped to a single button. The player quickly learns this mechanic, applying it throughout the game therefore allowing immersion within the experience.

Anna Anthropy (DePaul University, 2017), comments on the over-complication of using a superfluous set of skills in gameplay:

"What we as creators want to avoid are orphaned verbs. An orphaned verb has no relationship to the other verbs, so the other verbs don't reinforce it, it doesn't grow and the player has forgotten about it by the time she reaches the one situation that demands it" (Anthropy, 2013)

Orphaned verbs will be avoided at all cost. The project aim is to produce a practical education packet for half a dozen macronutrients, gameplay mechanics will be based around this small group, so the role of these nutrients is clear, cohesive, and comprehensive.

3. Obesity

Obesity is defined as when a person is carrying too much body fat for their height and gender (NHS, 2018). A widespread scale to determine if a person is healthy is the Body Mass Index (BMI) and is calculated by dividing the body mass by the square of the body height. Commonly accepted BMI ranges are underweight: under 18.5 kg/m2, normal weight: 18.5 to 25, overweight: 25 to 30, obese: over 30 (NHS, 2018).

A BMI of over 30 (i.e. obese), is becoming increasingly prevalent today as more people are leading stagnant lifestyles by using motorised transport to get around and following highly sedentary careers behind desks (ref). Eating a caloric surplus (an excess in the number of calories consumed relative to the number of calories required for maintenance of current body weight), paired with inactivity, leads to rapid weight gain further resulting in obesity. The average physically active man needs about 2,500 calories, whilst the average physically active woman requires 2,000 calories / day (NHS, 2018). In contrast to this, a caloric deficit is a shortage of calories required (Bales, 2014).

"…there tends to be a progressive reduction in the demands for physical activity and it seems clear that it is the interaction among an energy-dense, high-fat diet, its ready availability and promotion, and increasingly sedentary lifestyles, which are particularly conducive to the development of obesity" (James, 2001).

Diagnosing obesity is not a simple visual test. Various symptoms are usually present paired with comparing a patient's mass to their height/gender/age. Common symptoms of obesity are: breathlessness, increased sweating, snoring, difficulty sleeping, feeling very tired every day, and back and joint pains (NHS, 2018).

3.1 Obesity in Children

A standard definition of an overweight child is not as universally clear as it is with adult obesity, as each country's populace have significantly different physical developing childhood factors. As an example, "…the World Health Organization body mass index (BMI) cut points for overweight and obesity are much higher than those of the International Obesity Task Force. One recent Czech study found that using the International Obesity Task Force cut-off, about 15 percent of 5-year-old girls were overweight; by the World Health Organization cut-off, only about 3 percent were overweight" (Monasta, 2011). However, research conducted in 2000 using 97876 males and 94851 females (from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States) from birth to 25 years of age recommended that childhood obesity be calculated using the body mass index scale: "5-18% for overweight and 0.1-4% for obesity" (Cole, 2000). Compare to the adult obesity calculated with the body mass index scale: "20% above or below the mean for that height category…considered to be overweight or underweight" (Nuttall, 2015).

In 2014, the Organisation for Economic Co-operation and Development (OECD) found from surveying 249,796 individuals in various countries of Europe, North America, South America, and Asia who suffered economic hardship ended up cutting healthier foods out of their budget, instead buying cheaper food loaded with more calories, sugar, and fat (OECD, 2014). These types of foods lead to weight gain, a path to obesity.

According to the Body Mass Index, a 10-year-old boy of average height (142cm) who weighs 46kg would have a BMI of 22.9 kg/m2. This would place the boy in the 95th percentile for his BMI. (ref) This boy would be considered as obese. The BMI for children is as follows (University of Texas Medical Branch, 2009) (Figure 3).

- Underweight: BMI < 5^{th} centile
- Normal weight: BMI > 5^{th} and < 85^{th} centile
- Overweight: BMI > 85^{th} < 95^{th} centile
- Obesity: BMI > 95^{th} centile
- Severe obesity: BMI >99^{th} centile

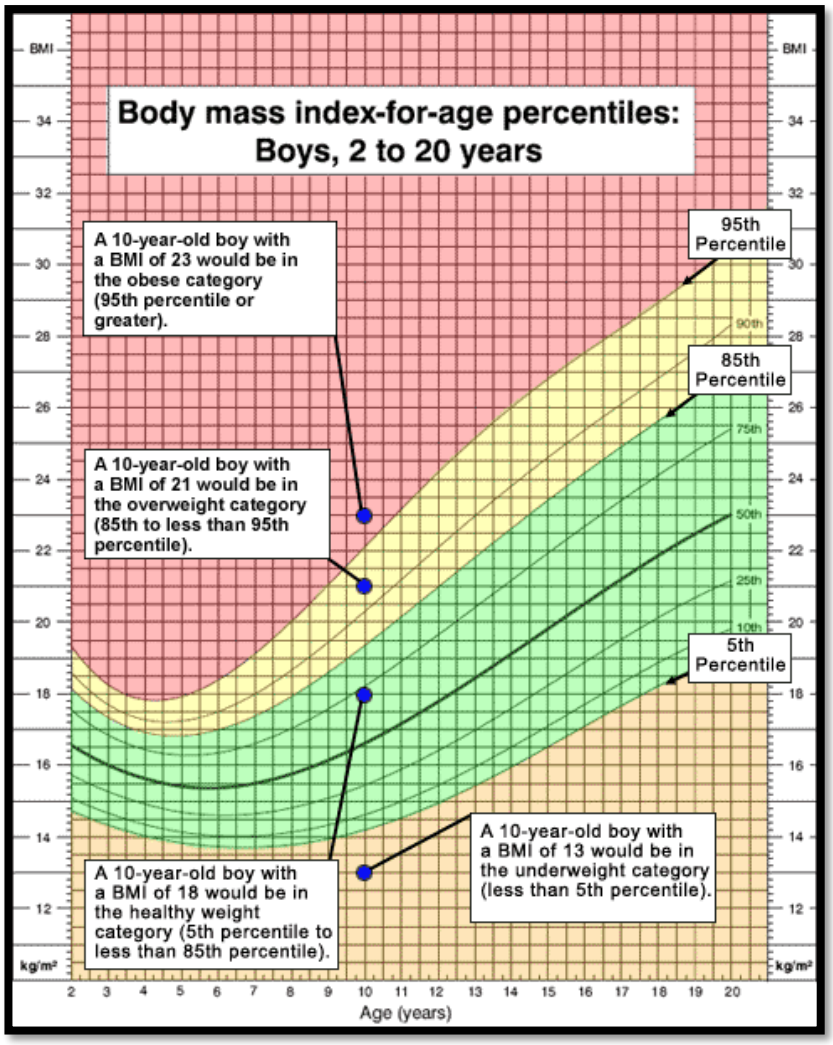


Figure 3: BMI Percentiles for Boys ages 2 to 20 years. The different percentiles are illustrated with a unique colour (University of Texas Medical Branch, 2009)

Figure 3 shows the data from 29 countries for the years 2001 to 2002 and 2013 to 2014 regarding the percentage of children aged 15 years who are overweight. As can be seen, in 2013-2014, Ireland was comparable to the OECD average of 15.5% (OECD, 2017). While significantly lower than the percentage of 15-year olds in the United States (31%) and Canada (24.5%) who are overweight, Ireland's childhood overweight demographic is an issue which needs to be addressed.

Research conducted by the International Taskforce on Obesity Standards found that in Ireland, over 20.4% of 1st class girls aged 6-7 years are obese compared to 13.2% of all boys aged 6-7 years. This seems to be a trend as the age range increases; 24.8% of 4th class girls, in comparison to 14.5% of 4th class boys are obese, whilst 22.9% of 6th class girls compared to 18% of boys are obese. Averaging out he years, it means that16.9% of all 1st class pupils; 20.2% of all 4th class pupils and 20.6% of all 6th class pupils are obese(HSE, 2017). "Over 20% of children overweight or obese, with some encouraging signs of stabilization", "more girls than boys are overweight or obese across all ages" and "those attending DEIS schools tend

to have higher levels of overweight and obesity and the gap becomes wider as children get older" (HSE, 2017).

Note: DEIS, Delivering Equality of Opportunity in Schools, is an Irish national programme aimed at addressing the educational needs of children and young people from disadvantaged communities (An Roinn Oideachais agus Scileanna, 2011).

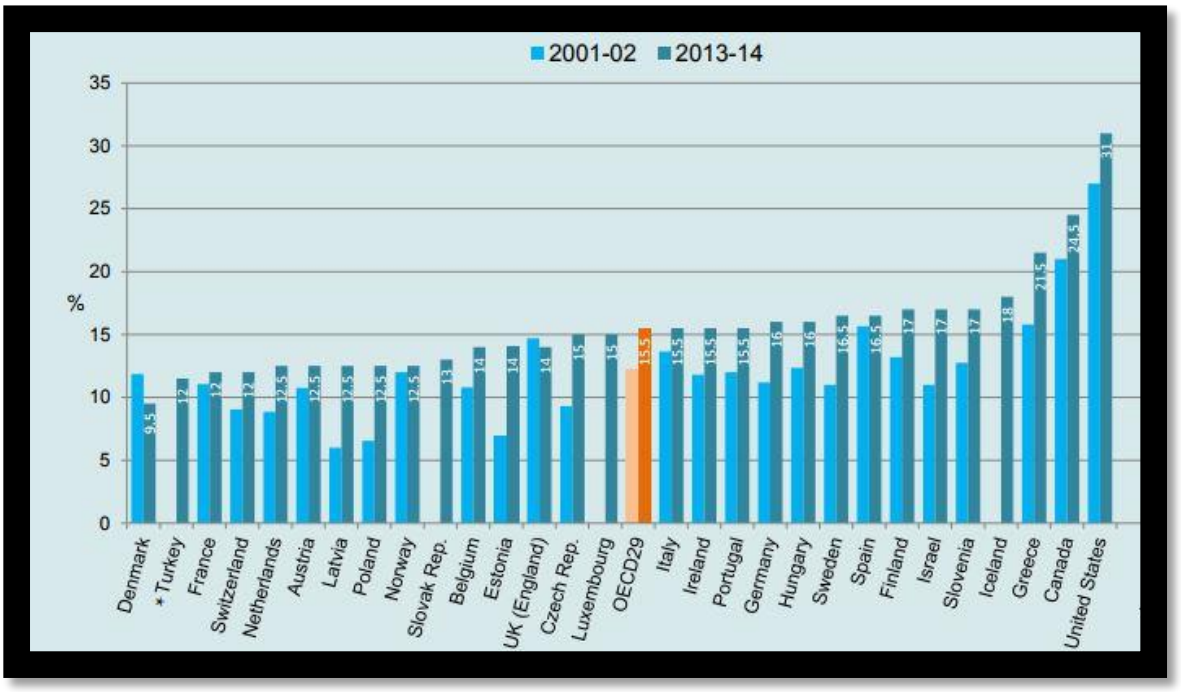


Figure 4: Self-reported overweight, including obesity, in children aged 15 years. X axis shows countries, Y axis shows percentage of 15yr olds overweight (OECD, 2017)

3.2 Reflections

Obesity is a growing issue today in Ireland and across the developed world. We know childhood obesity restricts future opportunity available to the child. Leading causes of obesity is an energy-dense, high-fat diet, its ready availability and promotion, and increasingly sedentary lifestyles, which are particularly conducive to the development towards obesity. The problem of obesity in children can be reduced through various approaches. Implementation of wide spread prevention can be educated. It will however take time, money, and a combined effort on the part of many people. The obesity level is rising in Ireland rather quickly in relation to the rest of the developed world. Ireland has the foresight as a recently emerging wealthy nation to use the opportunity to reduce this issue using technology, studies, data, and the actions other nations have taken upon this issue.

4. Effects of Obesity

Obesity is a serious, chronic disease that can have a negative effect on many bodily systems. People who are overweight or obese have a much greater risk of developing physical, mental and/or social conditions (Standform Health Care, 2018). Further, obesity has serious financial implications for both the individual and society in general.

4.1 Physical Conditions

Physical fitness is a state of health and well-being and, more specifically, the ability to perform aspects of sports, occupations and daily activities.

- Cardiovascular Risks: Increased blood pressure, changes in left ventricular mass, hyperglycaemia and hyperinsulinemia.
- Asthma: Breathing difficulties. Flare-ups (periods of swollen airways), airway remodelling (lungs become scarred, asthma medicines do not work as well, and less air is able to move through your airways) (Lung_Org, 2018).
- Foot Abnormalities: swollen ankles, disproportionate limbs. Further leads to issues in other parts of the body ex knees and hips.
- Type 1 & 2 Diabetes: organ (eyes, skin), digestive system, and immune system damage (BetterHealth, 2018). In general, people with diabetes either have a total lack of insulin (type 1 diabetes) or they have too little insulin or cannot use insulin effectively (type 2 diabetes) (WebMD, 2018).
- Psychological Distress: “Obese individuals overestimate or distort the size of their body more, are more dissatisfied and preoccupied with their appearance, and tend to avoid more social interactions because of their appearance than normal weight individuals” (Friedman, 2002).

4.2 Mental Conditions

Obesity can have highly destructive effects on mental wellbeing and self-image issues. “Negative health consequences that may result from the unique interaction of weight status and body image include physical inactivity, eating disorders, and dysfunctional exercise” (Voelker, 2015) . Physical appearance / health is a key factor is maintaining a healthy life.

Overweight and abdominal obesity are common problems in persons seeking treatment for mood disorders such as; depression, anxiety, post-traumatic stress etc. (M.Scott, 2008). Conversely, mood disorders are common in persons of all ages seeking treatment for obesity. Certain mood disorders are associated with weight gain (McElroy, 2004).

4.3 Social Conditions

Obesity can inhibit the success of an individual in society: “anti-fat bias and weight discrimination…. may further contribute to unhealthy lifestyle behaviours and reduced quality of life for many obese individuals who are at high risk for chronic disease” (Chambliss, 2003).

An analysis of the 2008-10 National Adult Nutrition Survey, showed that women who were obese had significantly fewer years of school completed (0.3 years on average), were less likely to be married, had lower household incomes, and had higher rates of poverty. For men, the only statistically significant correlation was for marital status (SafeFood, 2008). “Emerging evidence demonstrated that overweight and obese workers face stereotypical attitudes from employers and disadvantages in hiring, wages, promotions, and job termination because of their weight” (Puh, 2009).

4.4 Financial Implications of Obesity

In the Republic of Ireland, healthcare costs increased by approximately 10% in the overweight group and by approximately 30% in the obese group (SafeFood, 2008). This equates to an estimated annual cost of approximately €1.64 billion euro (SafeFood, 2012). In 2012, the main drivers of direct healthcare costs in the Republic of Ireland were cardiac disease (44%), type 2 diabetes (9%), and colorectal cancer (12%) (SafeFood, 2012). "Overweight and obesity account for somewhere between 1% and 9% of total healthcare costs…. Healthcare costs include: In-Patient, Out-patient, General Practice, Drugs and prescribing costs" (Dee, 2014).

Meanwhile, in the USA, 9.1% of the total health expenditure was directed towards obese patient related practices and between 0.6% - 4.6% of the total health expenditure in other countries (SafeFood, 2008). Other financial implications of obesity relate to labour productivity and human capital accumulation

Labour Productivity

Labour productivity is the amount (volume) of output per unit of labour input (an individual). It is measured from several inputs such as; hours worked, workforce jobs, and number of people in employment (OECD, 2018). As of 2017, Ireland has one of the highest labour productivity levels in the world; at €140 per hour worked. (OECD, 2018) In comparison, other similar countries such as the United Kingdom and the USA are at €100 per hour worked (OECD, 2018).

A higher rate of obesity can lead to a lower labour productivity rate. "…increasingly high levels of overweight and obesity among the workforce are accompanied by a hidden cost burden due to losses in productivity" (Goettler, 2017). Lowering the productivity comes from effects to the inputs (hours worked, workforce jobs, number of people in employment). All of these factors are directly affected when an individual suffers premature morality. The largest group susceptible to it is the obese demographic:

The largest effect of obesity on morbidity was for white men: a white male aged 20 years with a BMI over 45 could be expected to have 13 years of life lost the equivalent of a 22 percent reduction in remaining life years (Hammond, 2010).

Human Capital Accumulation

Human Capital Accumulation is the measure of the economic value of an employee's skill set. It corresponds to any stock of knowledge or characteristics the worker has (either innate or acquired) that contributes to his or her productivity (Acemoglu, 2017). A study was conducted by the National Longitudinal Survey of Youth in the city of Philadelphia USA in 2009 for a list of covariates including family structure and educational attainment, respondent health, smoking status, alcohol consumption, and region on respondents aged 14 to 17 concerning the effects of obesity on grade progression and drop-out rates. Fifteen-year-old males in the 90th percentile or above for BMI are 3.3 percentage points more likely to drop out in the following year than their counterparts in the second and third BMI

quartiles; 16-year old females in the 90th percentile or above are 12 percentage points less likely to complete a higher grade in the IV model (Levine, 2010).

4.5 Reflections

Child obesity has detrimental effects in the short, and long term. A consequence of child obesity is higher rate of adult obesity throughout life via habits, preferences, and psychological cravings. Reduction in obesity will increase the quality of a child's future life in not only physical; but in mental, social, and financial terms. Physically, a higher rate of limiting conditions such as asthma, foot abnormalities, diabetes, and heart disease. Mentally, highly destructive effects on mental wellbeing and self-image issues. Socially, inhibit success in society via negative stereotypical attitudes from employers and other members of society. Financially, via increased healthcare costs, loss of labour productivity, and a lower human capital accumulation. Combatting obesity will associate a healthier lifestyle which prevails functional physical ability, stronger mental health, greater job opportunity, and a successful social life among other improved aspects in life.

5. Combatting Childhood Obesity

"Childhood obesity rates have grown at a very high rate in the past three decades. Although it is highly recommended that school age children get at least sixty minutes of moderate to vigorous activity per day, many physical education programs are being cut drastically" (White, 2007).

However, there is no one solution to childhood obesity. Rather, a series of steps should be implemented into the routine of a person early in life, so they can become discipline with methods to tackle weight gain factors. Exercise, diet, positive encouragement from parents, and social environment are pillars of promotion of healthy lifestyle; "…parents serve as models and reinforce and support the acquisition and maintenance of eating and exercise behaviour" (Lindsay, 2006).

To address the childhood obesity crisis, various programmes such as Switch Off – Get Active and Food Dudes have been introduced in schools. "Sustained interventions are likely to be required at several levels – at an individual level in schools and community settings to effect behavioural change, and in sector changes within agriculture, food manufacturing, education, transportation, and urban planning. Each intervention may have minimal effects when assessed in isolation but can constitute significant components to an overall strategy" (World Health Organization, 2012).

Furthermore, the integration of obesity awareness into school's curriculums can be effective practice to improve diet and exercise habits as seen in the 'Food Dudes' (Horne, 2008) and 'Switch Off-Get Active' (Harrison, 2006) programmes. The following programmes are highly successful in their methods to address obesity in children. The findings and results are highly informative.

5.1 6.2 'Switch Off–Get Active'

'Switch Off-Get Active' (Centre for Health Behaviour Research, 2006) was a controlled health education intervention which was carried out in 2003 is a cost effective, teacher-led intervention that could be incorporated easily into Irish school structures. Introduced in nine schools in the South-East region of Ireland; its primary goal was to replace the old curriculum of SPHE (Social Personal and Healthy Education). The main objective of the study was to reduce screen time and promote physical activities as low levels of physical with high levels of television viewing lead to obesity in children. (Harrison, 2006)

The programme was broken into 10 steps (Harrison, 2006):

1. *Healthy lifestyles*: Exploration of the meaning of health and its relationship with lifestyle
2. *My time*: Self-monitoring of leisure time with emphasis on physical activity and screen time
3. *Intelligent television viewing*: Exploring TV viewing habits and encouraging selective viewing
4. *Switch Off–Get Active diaries*: Explaining the activity points system used to encourage the substitution of activity for screen pursuits
5. *Television turnoff*: Planning for a night without TV
6. *Benefits of physical activity*: Exploring social, mental and physical benefits of being active
7. *New games*: Introducing fun, non-competitive street and playground games suitable for small and larger groups
8. *Barriers to increased activity*: Identifying barriers to increased activity and ways of overcoming these barriers
9. *Local activity opportunities*: Identifying local activity opportunities
10. *Poster and slogan competitions*: Advocacy of increased activity and decreased screen time by children

Table 3 Changes in control and intervention groups from baseline to post-intervention

	Control group		Intervention group		Adjusted difference (95%CI)	*p*-Value
	Pre	Post	Pre	Post		
MVPA (30 min blocks/day)	3.04 (0.41)	5.14 (0.33)	3.11 (0.37)	5.94 (0.30)	0.84 (0.11–1.57)	0.03
Screen time (30 min blocks/day)	5.97 (0.25)	5.18 (0.27)	5.90 (0.48)	4.68 (0.57)	–0.41 (–0.93–0.12)	0.13
Self-efficacy (0–20)	12.5 (0.4)	13.3 (0.4)	12.2 (0.5)	14.2 (0.2)	0.86 (0.16–1.56)	0.03
BMI (kg/m^2)	19.2 (0.4)	19.3 (0.4)	19.0 (0.2)	18.8 (0.3)	–0.08 (–0.38–0.22)	0.63
Aerobic fitness (laps)	34.6 (1.6)	46.2 (1.2)	37.2 (3.7)	49.6 (2.5)	1.7 (–3.5–6.9)	0.55

Adjusted difference is the difference between control and intervention groups post-intervention adjusted for baseline value; pre and post values are mean (S.E.) and reflect clustered sampling.

Figure 5: Further information on 'Switch off get active' programme participants. Figure illustrates the change pre- and post-intervention in respect to screen time, body mass index, aerobic fitness (Harrison, 2006)

Table 2 Comparison of control and intervention groups at baseline

	Control	Intervention	*p*-Value
Children (*n*)	130	182	
Girls (*n*)	55 (42%)	80 (44%)	0.81
Age at baseline	10.3 (0.8)	10.2 (1.2)	0.52
% Overweight[a]	32%	35%	0.70
% With bedroom TV	51%	57%	0.43
% With ≥4 TV sets in home	38%	46%	0.22
MVPA (30 min blocks/day)	3.04 (0.41)	3.11 (0.37)	0.67
Screen time (30 min blocks/day)	5.97 (0.25)	5.90 (0.48)	0.64
Aerobic fitness (laps)	34.6 (1.6)	37.2 (3.7)	0.52

Figure 6: Information on 'Switch off get active' programme participants involved in the control group and intervention group. The diagram highlights the weight and screen activity of the children (Harrison, 2006)

The pilot intervention was very successful in showing an increase of physical activity, also a desire to purse physical activity. It has proven that the supplementation of a health education curriculum with specific lessons and activity-modification techniques can be effective to reduce vulnerability to obesity.

5.2 6.2 'Food Dudes'

The 'Food Dudes' (Horne, 2008) programme is an initiative to encourage and maintain healthy eating habits in children by encouraging consumptions of fruits & vegetable during school lunch times.

In the pilot programme, the participants were 4- to 11-year-old children attending two primary schools in Dublin during 2008. The control condition and were similar in terms of size; 228 and 207 pupils. The programme was divide into two phases.

Phase 1 (16 days): The children watch a DVD episode starring the "Food Dudes", who provide influential role-models to imitate. The kids are then given a portion of fruit and vegetable and rewards are given to whoever is finished.

Phase 2: Support for eating fruit & vegetables is cut down on, a classroom wall chart used to record consumption levels which earn rewards and Food Dudes certificates

The programme resulted in long-lasting seen the increases of fruit and vegetable consumption in children of primary school-age (4-11 years). Great increases in consumption seen in the children who at the start, the poorest eaters of fruit and vegetables. At a 12-month follow-up, parents in the experimental school and their children consumed significantly more lunchbox fruit and number of vegetables. The critical success of the Food Dudes programme came from the children enjoying consuming fruits and vegetables. Parents were ecstatic as this increase of consumption carried over to eating habits at home.

The baseline characteristics of the control and intervention children are presented below (Figure 5) and changes in control and intervention groups from baseline to post-intervention

(Figure 6). Post-intervention values for screen time were not significantly different, values for BMI and aerobic fitness similar between intervention children and the control children.

5.3 6.3 Reflections

Technology has been demonstrated in the past to effectively alternate behaviour in children regarding consumption of healthier foods and attitudes toward voluntary physical exercise. As integration of programmes into a school's curriculum, such as allowanced time slots for vigorous activity. Positive encouragement in the home, having a parent who engages in healthy eating and regular exercise. These key interventions to a child's social environment will plant the seed for routine behaviours and habits to combat obesity

6. Educational Games

Nutrition educational games are scarce. 'FoodChamps' (FoodChamps, 2018) is the only notable video game found online. A series of flash games designed to educate children about vegetable and healthy eating (Figure 7(a), Figure 7(b)). The game mechanics use point-and-click mini games to present the information to the children.

Figure 7(a): Food Champs Title Screen (FoodChamps, 2018)

Figure 7(b): Food Champs Gameplay (FoodChamps, 2018)

The most significant challenge facing game designers targeting children's audiences is the incredible range of abilities of any given target audience…. a child who picks up your game may be experiencing this genre of game, games in general, or even interactive technology for the very first time. The next child who picks up your game may have already played dozens of other games" (Fisher, 2014). There are many aspects to designing an engaging game, such as aesthetics, motivation, conflict, linear/non-linear hybrid, storytelling, error forgiveness and Winning Using Skills Acquired & Rewarding Accomplishment.

To develop a successful nutrition education game many components, must be addressed such as; aesthetics, motivation, conflict, etc

6.1 Popular Educational Games for Children

The Oregon Trial (Gameloft, 1974) is a widely renowned educational-entertainment video game from the 1970's. It is recognised as one of the first successful video games to become adopted into the classroom. The game features a journey across the historic migration route in North America during the 1830's. The game is a historical teaching of the way of life; bringing the player on a time capsule journey experiencing large-wheeled wagons, historic landmarks (Big Blue River, Fort Kearney, Chimney Rock, Fort Laramie, Independence Rock), and the treacherous fates which the early settlers faced;
measles, snakebite, dysentery, typhoid, cholera, and exhaustion.

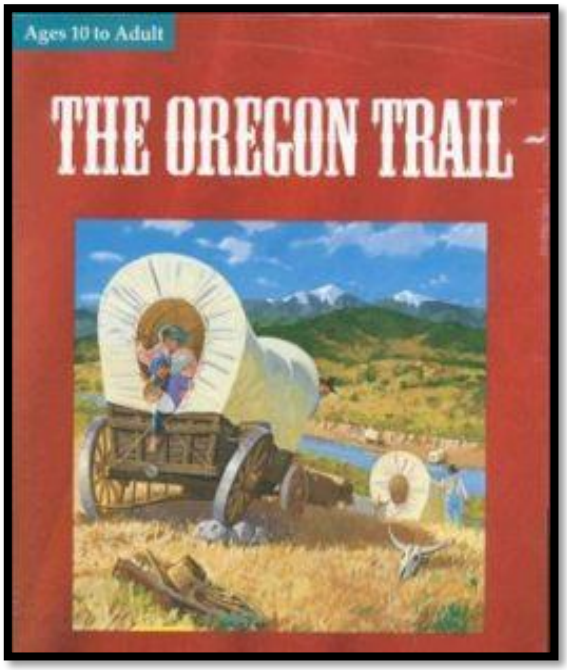


Figure 7 : The Oregon Trail Cover Art (Gameloft, 1974)

The game had a large re-play value as the player would make multiple attempts to achieve the highest score by choosing a different approach. Whether it be an alternate profession or hunting more.

The Magic School Bus (Scholastic Corporation, 1994) is a classic video game. It has been used in schools around the world and widespread across Ireland. This game, and its other entries in the series, were featured in the IT lab in the author's primary school. It is an educational-entertainment video game designed to educate through entertainment. This is achieved by sending the player on a journey through various experiences which they would not experience every day, such as; traveling to different planets in the solar system to learn about astronomy or exploring the inside of the human body to become introduced to the workings of human anatomy.

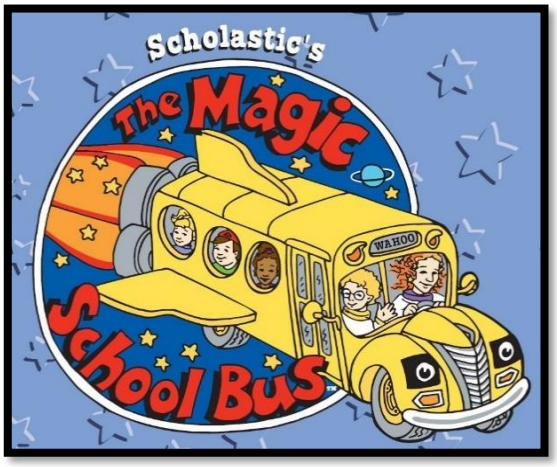


Figure 8: The Magic School Bus Cover Art (Scholastic Corporation, 1994)

The games in the series ran on windows machines with very little processing and visual power required. This allowed widespread use since most schools have older computers. The point-and-click gameplay of the titles was very intuitive and friendly to children who weren't as technological adjusted since at the time not everyone had a home computer.

Brain Training (Nintendo, 2005) is a routine video game, designed to be played a little bit every day. It was the first Nintendo DS title to require the device to be held sideward, this made the game feel as if you were writing in a little pocket journal or a notebook. The title quickly rose to fame as the Nintendo DS became the fastest selling video game platform of all time. Accessibility of bold new gaming ideas was available on this device, especially since it had been adopted by young children.

The game featured various types of puzzles, such as Sudoku to test the user's mental problem-solving capabilities. At the end of these tasks the user is graded and presented their brain age. The user was encouraged to focus on certain areas, such as mental maths, to try again and improve their score.

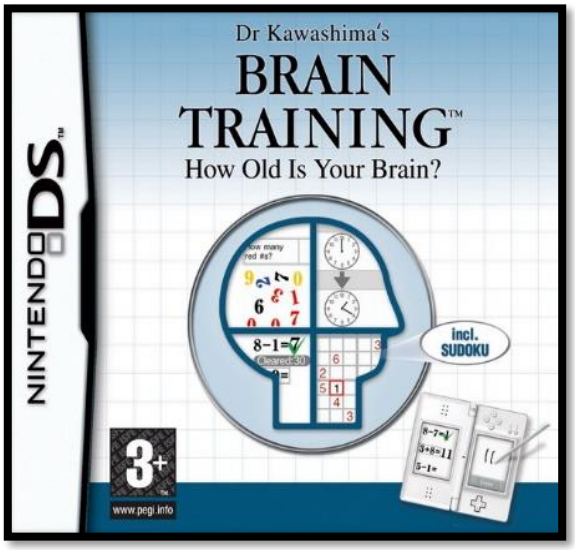


Figure 9: Brain Training Cover Art (Nintendo, 2005)

The author's favourite practical application of the video game was in a study in Scotland. 600 school students played 20 minutes of Brain Training every day before beginning their day of studies. A test was ran before they began playing the games and then afterward. The group which had been playing showed an increase of 50% in their test scores. Completion time of the test also decreased (BBC, 2008)

6.2 Aesthetics

Aesthetics is how artists imagine, create and perform works of art; how people use and enjoy art; what happens in their minds when they look at paintings, listen to music, or read poetry.

By themselves, aesthetics have the power to pull people into the game. Visuals are a powerful means of engaging players and helping them immerse into the game experience. (Majumdar, 2016). Animated presentations can promote learning under certain conditions, and they also demonstrate a successful application of interactive graphics in the design of cognitively based practice activities (Rieber, 1990).

"Visual arts promote learning in early childhood education because they enable the child to form mental images of things in the environment thus enriching their perceptions. In that case, visual arts provide the child with an opportunity to explore his/her sensory perceptions including hearing, seeing, touching, smelling and manipulating things in the environment to establish universal truths about them" (Ko, 2014).

6.3 Motivation

Intrinsic motivation is a key developmental aspect for self-motivated learning. "It is driven by an interest or enjoyment in the task itself and exists within the individual rather than relying on external pressures or a desire for consideration" (VWM, 2017). Children sometimes focus their attention intrinsically; when they are interested in assembling a Lego playset, the pleasure of playing complex playground-games with friends or crafting an image

while drawing a picture. These can all be difficult things tasks to complete but the motivation behind accomplishing them allows an intense execution. (Oudeyer, 2007) contends that motivation.

“Has been argued to be a crucial mechanism for open-ended cognitive development in humans”. (Kaitila, 2016) recommends that a video game which is fun, simple, and short will engage a child’s interests. “It probably goes without saying that one key to retaining a child’s attention is to keep it short. Nothing ruins the fun of learning more than boredom. Twenty minutes is all you’ve got” (Kaitila, 2016).

6.4 Conflict

For a game to be interesting there should be some sort of conflict to present a challenge for the player to overcome (Boller, 2017). The challenge could be a physical obstacle, combat with another player, or a puzzle that must be solved. “...electronic games require active engagement in environments, which supports discovery, observation, trial and error, and problem solving” (Dickey, 2005).

6.5 Linear / Non-Linear Hybrid

Linear gameplay can sometimes be a simple and trudging story that you can do little to make fun. At other times, it can be a thrilling experience. It is “… gameplay that nudges you along in the right direction with no allowance of real exploration” (Bui, 2010). Non-linear gameplay however, breaks the shackles of this restriction: “….put you smack dab into a living, breathing world where they can do whatever they please with no real guidance other than a story they can progress when they want to” (Bui, 2010). Meanwhile, a linear/non-linear hybrid this has been seen in the colossal success of 2007’s Mass Effect (Bioware, 2007). In this instalment, the player is given a choice on how to execute their mission. By giving freedom of choice to the player, it introduces non-linearity into a game that is largely linear.

To give create a non-linear experience, the decision making should be given back to the player via three mediums: multiple solutions, order, and selection. These elements give the player a chance to take a unique approach to situations and make real change during their experience playing a game.

Multiple Solutions: Not every player will think of the same way to go about solving a situation, and, given that these alternate solutions are reasonable, any challenge must have multiple ways for the player to overcome it (Rouse, 2005) .

Order: Giving the player choices of different puzzles to solve allows them to put aside a troubling puzzle and go work on another one for a while. After completing the second puzzle, the player may return to the first, refreshed and revitalized, and thereby have a better chance of solving it (Rouse, 2005).

Selection: Allow the player to pick and choose which challenges they want to overcome. Say that between point A and point B in a game there lies a series of three challenges, X, Y, and Z. Completing any of these challenges will allow the player to proceed. The advantage is that

if the player finds challenge X to be insurmountable, he can try challenge Y or Z (Rouse, 2005)

6.6 Storytelling

A storyline is critical to a game, as it gives it context and purpose. An interesting storyline can invest and motivate a player to seeing the game through to the finale, whilst an uninteresting storyline can have negative repercussions with the player potentially becoming disinterested and disengaged.

“An advantage as well is the opportunity to arouse the interest and engage students by using applications of digital storytelling. For example, the suggested application for history class, the introduction of the subject-matter can be done by first letting student virtually visit the museum or site about the subject-matter. After visiting students can visualise better how things were and could become more engaged by the stories they have heard.” (Gils, 2005).

“The challenge to designers is how to tell a story and still permit the player to affect or possibly change the story, depending on choices made throughout the game” (Dickey, 2005).

6.7 Error forgiveness

Error forgiveness refers to tolerating faults, blunders, snafus when the player is introduced to a new mechanic in the game and is learning effective use of the mechanic. Making errors is an integral part of everyday life. Error forgiveness is important as countless variables can cause a player to make an incorrect move, paying attention to situations such as slips, lapses, and mistakes (NIKOLOV, 2017) during designing to appropriately assign a degree of error forgiveness.

- *Slips* occur when people perform an action and the result is not what was intended due to misstep (e.g. pressing two buttons at once) (NIKOLOV, 2017).
- *Lapses* refer to brief failures of concentration, memory or judgement (e.g. children can be distracted by environmental stimuli) (NIKOLOV, 2017).
- *Mistakes* can occur when the user has incorrect knowledge or an incorrect assessment of a situation. The game should provide guidance or allow the player multiple attempts (e.g. misunderstanding of game mechanics like jump distance or enemy weakness) (NIKOLOV, 2017).

6.8 Winning Using Skills Acquired & Rewarding Accomplishment

Winning using skills acquired and rewarding accomplishment are pillars of the new wave of Gamification (BunchBall, 2018), giving players achievements for accomplishing certain tasks or hitting certain milestones. If the reward is given for the completion of a game section to a certain standard of proficiency, it will encourage the player to perform their very best.

“The gamification model, integrated into educational applications and processes, may include badges, showing different levels of achievement, leader boards, progress bars and

meters, points and other rewards that can be earned" (Su, 2014). Used effectively the player will study the info presented on the level to increase performance, otherwise the player will become completely bored with obtaining a reward.

6.9 Reflections

Education via a video game can act as a small piece in this struggle. We know past educational video games a have been proven to be successful.

The proper steps in implementing this kind of video game must be followed to have an effective, enjoyable, engaging experience for the player.

7. Architecture & Technology

The Nutrition Education Videogame will comprise of the following:

7.1 Architecture

Figure 11 is a brief illustration of Unity's architecture.

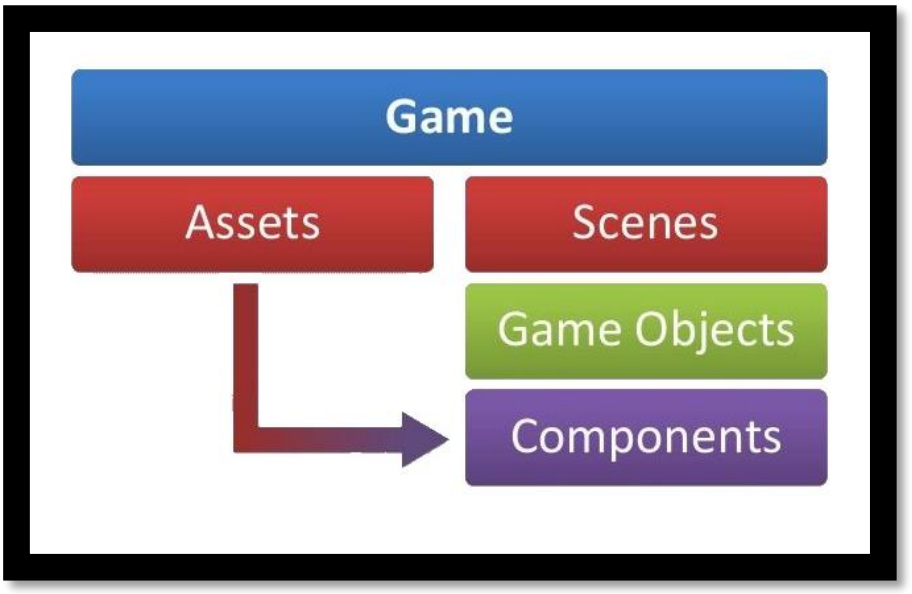


Figure 10: Architecture of Unity

7.2 Technology

Unity (Unity Technologies, 2018)

The Unity game engine is a development tool for creating video games for computers, consoles, and mobile devices. This engine supports 2D graphics, which is suitable for my project idea and is contains the tools for a satisfactory development experience. The product features a free version for new developers such as students or hobbyists.

Paint.net (Brewster, 2018)

This application is a very basic graphics editor programme. Contains support for layers, unlimited, special effects, and a wide variety of useful and powerful tools. I will use it for editing and image or photos that will be needed in the project.

GitHub (Github, 2018)

GitHub is a repository hosting service for computer code. Since the game will have to be shared/accessed easily, placing the project on GitHub will allow the user to obtain the latest version easily.

Renoise (Müller, 2018)

Renoise is a digital audio workstation. This application will be the pillar of development for the various sounds within the game. Many circumstances, actions, and various elements of the game world need an accompanying sound. Video games are full of a dynamic cast of melodies. Such as; background music, artefact collisions, accomplishment, player death, footsteps, etc. Online libraries of loyalty free sounds/music will be also implemented

Tiled (Lindeijer, 2018)

A level editor (also known as a map, campaign or scenario editor), Tiled is software used to design levels, maps, campaigns, etc. and virtual worlds for a video game. This software enables hassle-free world design for overlaying image sprites.

Tiled2Unity (Barton, 2018)

Tiled2Unity is a free utility with one goal in mind: Easy exporting of Tiled Map Editor TMX files into your Unity projects. Tiled2Unity takes your Tiled files and creates Unity prefabs from them that are easily placed into a Unity scene.

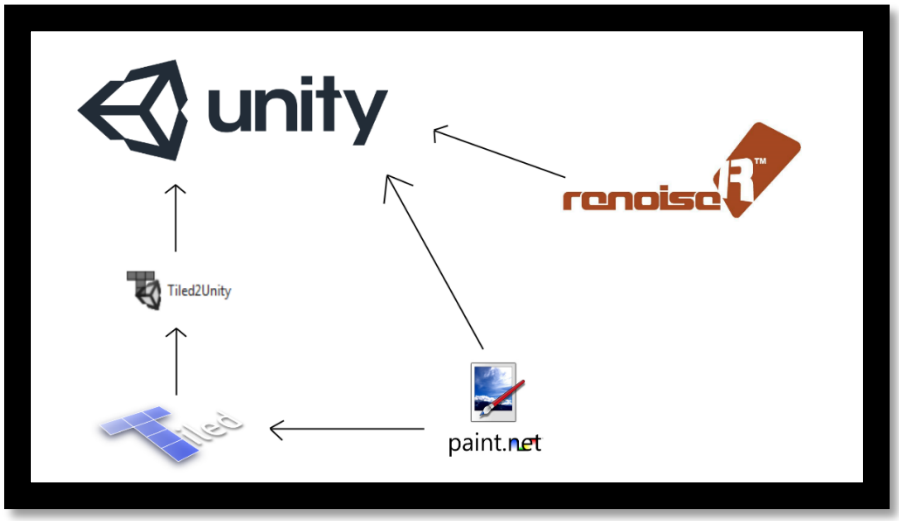


Figure 11: Overview of Project. Various software components showing their contribution towards other components

8. FoodQuest

'FoodQuest' is the title of the nutrition education videogame. This chapter will describe and present all the factors which contribute towards the execution of the game.

8.1 Development

Before launching head first into development, a list of requirements was fabricated then listed in the form of priority, having the highest importance at the top of the list. A Sprint of 2-4 weeks was decided up to be ideal. Implementing any new feature or issue was added to the backlog and returned to another time. This was highly practical as main features were live and running straight away, whereas the lesser importance one would be touch upon later.

Using the agile approach during final phases of development there was a reduced number of bugs present due to this wonderfully iterative nature of agile. Testing the application was only a minor time allocation during the development period as the end of each sprint, rigorous testing had taken place. Unity also uses an approach of testing every new feature immediately, this is used at almost every single feature implementation as Unity allows the game in development to be played within the development environment at the click of a button.

Below (Figure 13 and 14) show the Unity development environment. This is presented in two separate images to allow easier understanding of the features. A 'Game' window shows the current view which the player would have during a real playthrough, we see the UI elements and character on screen here. The 'Scene' panel shows all the GameObjects, listed in the 'Hierarchy' panel, currently in the current scene "village1". The "Inspector" panel shows the currently selected GameObject, in this case it is "Player(Clone)", providing us with various components attached to this GameObject and their details such as its Transform, Sprite Renderer, Rigidbody2D, etc.

Creating the levels for each scene was propelled using Tiled (Lindeijer, 2018). Seen in Figure 15, this application allows the construction of maps using individual squares of sprites. (The sprites used are elaborated upon in section 8.4). When a level was completed it was simply exported to be supported for the Unity environment using another application Tiled2Unity (Barton, 2018).

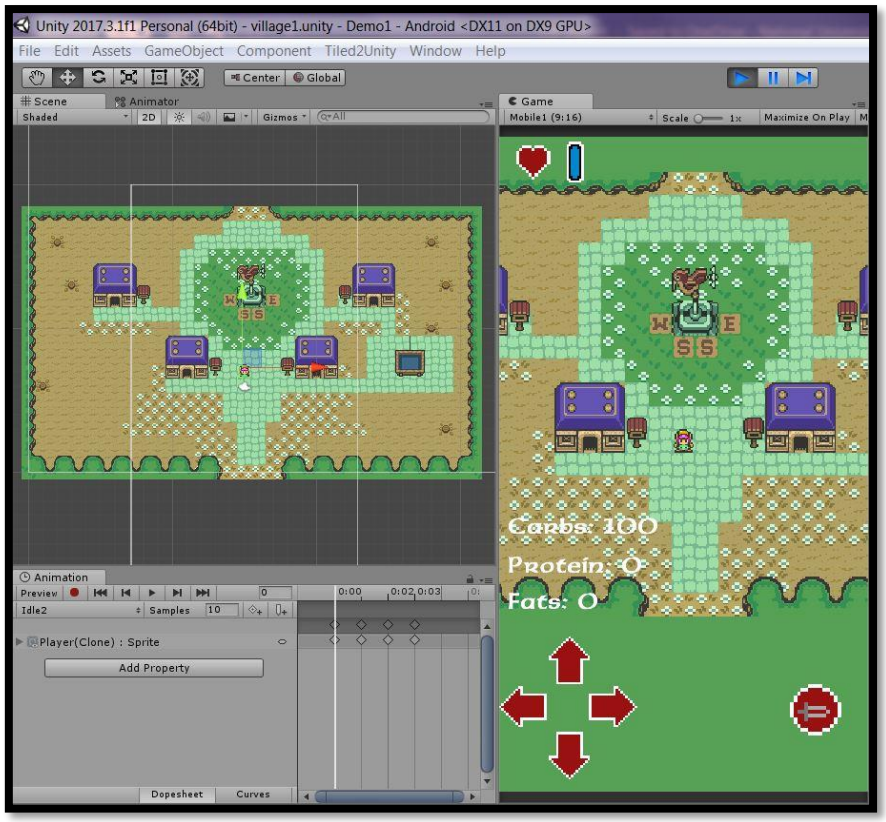


Figure 12: Unity Development View (a)

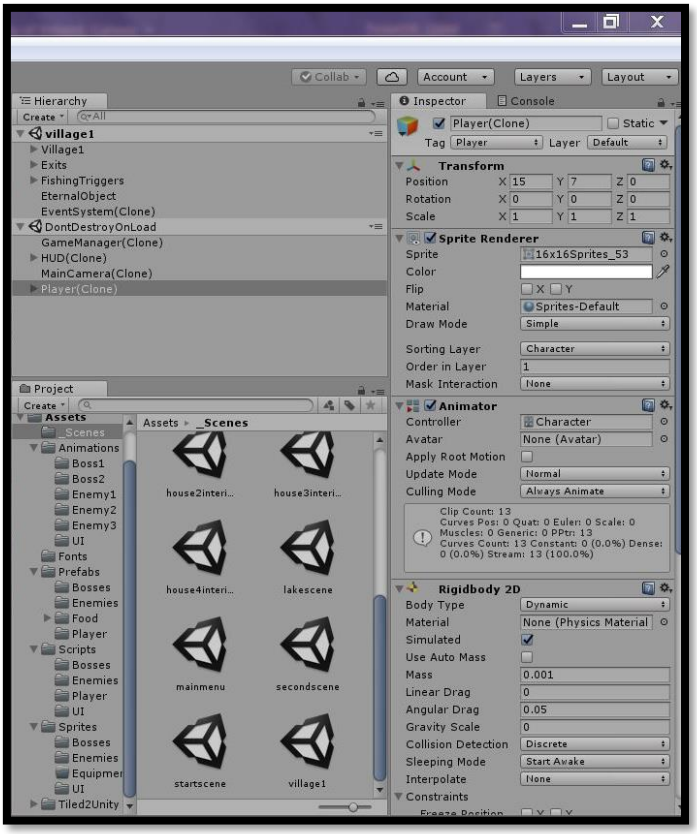


Figure 13: Unity Development View (b)

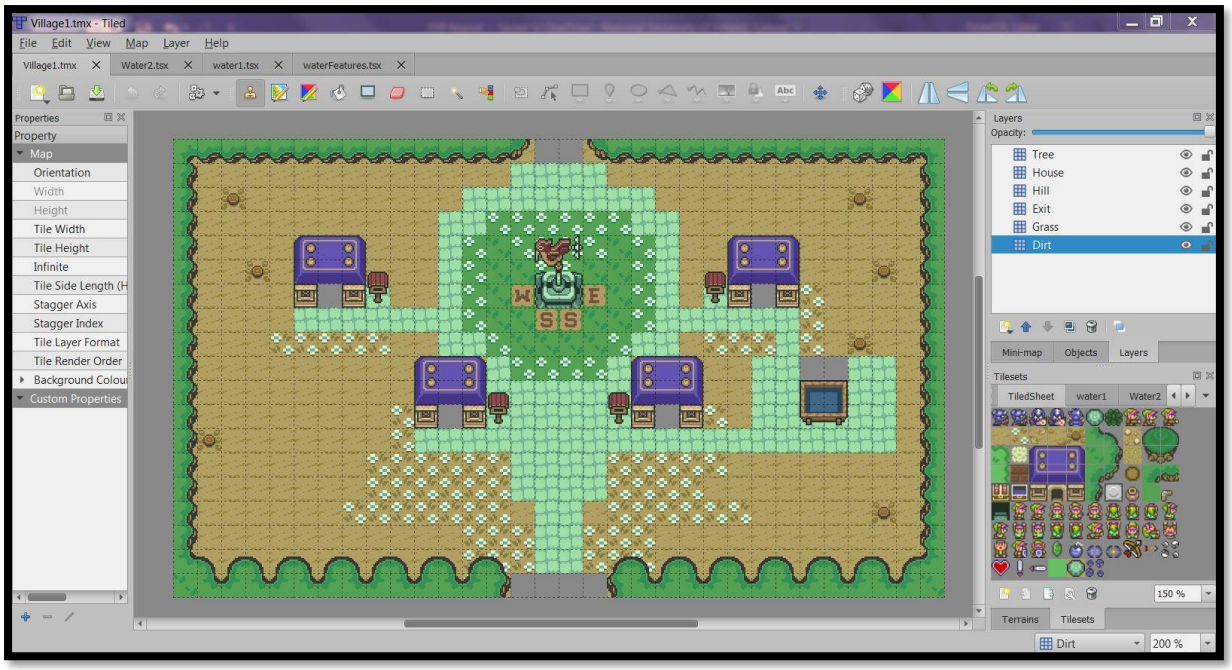


Figure 14: Tiled Development View

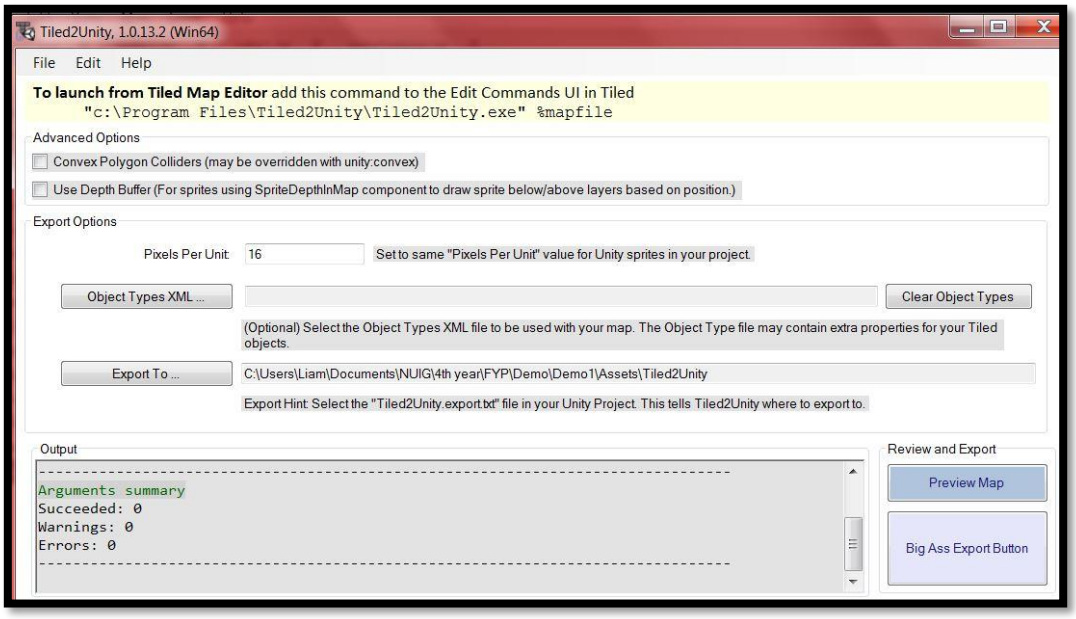


Figure 15: Tiled to Unity Export View

8.2 Accessibility

Unity supports various platforms to export the developed game onto. Windows, WebGL, Android, Facebook, etc. Since this game is targeted towards children, allowing it to be playable on an Android device is desired.

The game is exported from Unity to an Android Package (APK) file, this package file format used by the Android operating system for distribution and installation of mobile apps and middleware. APK files can be installed on Android powered devices just like installing software on PC. When a user downloads and installs an Android application from either an official source (such as Google Play), or from some other (unofficial) site, they are installing an APK file on their device. Since the FoodQuest exported APK file is not published on the Google Play store, installation is enabled it by changing the setting "Unknown sources" in the Settings menu.

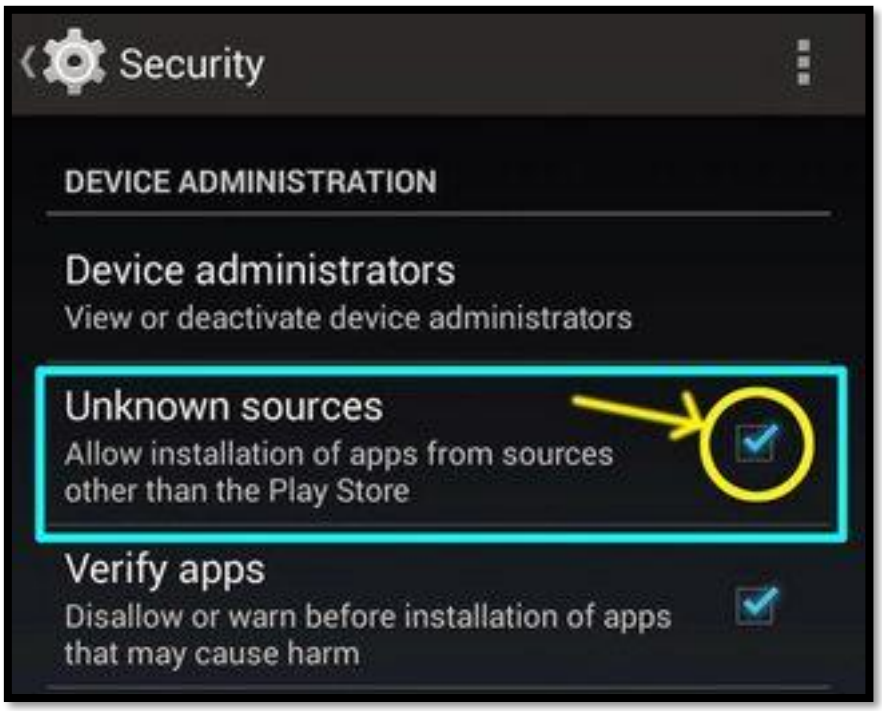


Figure 16: Unknown Sources activaion on Android platforms

8.3 Art Style / Assets (Player, Enemies, World, Music)

When deciding upon the art style for FoodQuest, inspiration was drawn from old video games using 8-bit graphics such as The Legend of Zelda (Nintendo, 1986). The assets used to populate the world of FoodQuest were all sources from community / fan-made sprite websites many of these sprites have been heavily edited by the author and various sprites were created originally for FoodQuest.

This section showcases various sprites used to create the animations. Using the style of keyframe animation, only a few sprites are required to replicate a believable movement style. Many of the characters use as little as a 3-Frame Run cycle.

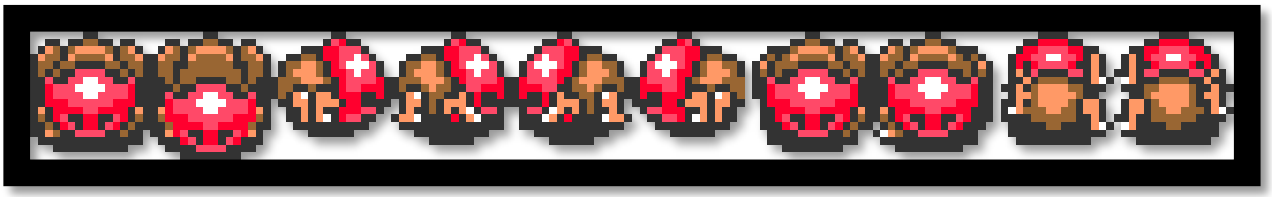


Figure 17: Sprite Sheet for Enemy1. From left to right we can see keyframes for attacking, movement, idle, vulnerable animations

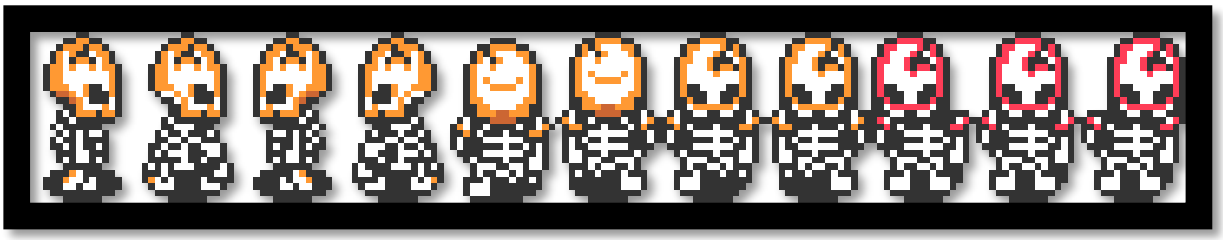


Figure 18: Sprite Sheet for Enemy2. From left to right we can see keyframes for idle, movement, attacking animations

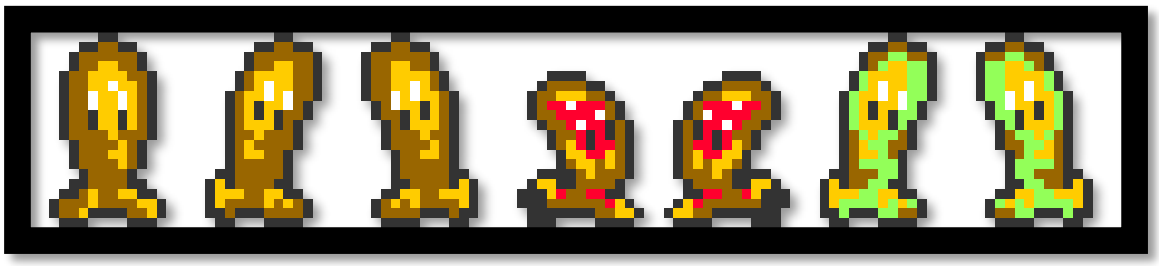


Figure 19: Sprite Sheet for Enemy3. From left to right we can see keyframes for idle, movement, attacking, vulnerable animations

Figure 20: Sprite Sheet for Boss1. From left to right we can see keyframes for idle, movement, vulnerable, attacking animations

Figure 21: Sprite Sheet for Boss2. Each row contains keyframes for idle, vulnerable, then attacking animations

Figure 22: Sprite Sheet for Character keyframes and Various World items such as: weapons, terrain, buildings, etc

Figure 23: Sprite Sheet for Collectable Food

8.4 Code

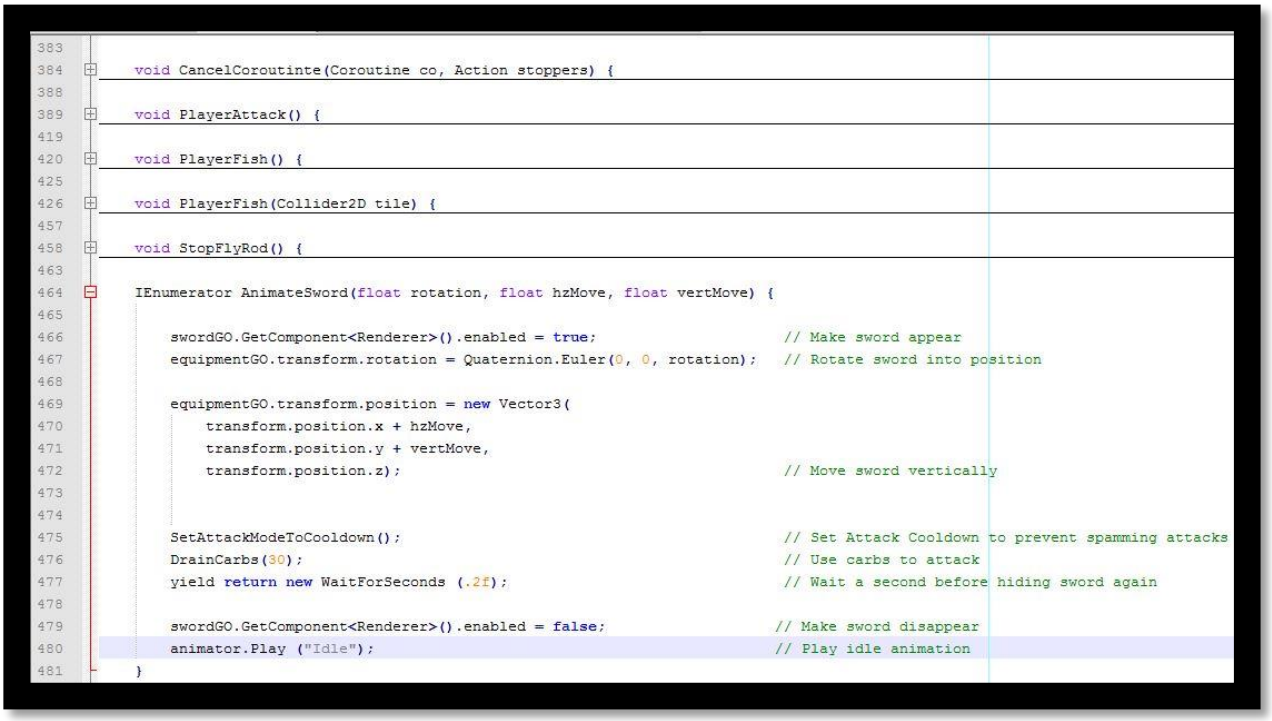
To run the game via Unity many scripts are required for various operations such as, player controllability, enemy AI, user interface operation, scene swapping, persistent game objects, etc. All the code was developed within Notepad++ (Ho, 2018), tested using the Unity compiler (Unity Technologies, 2018), is written in C# (Microsoft, 2018) using numerous functions and features form the Unity Scripting API library (Unity Technologies, 2018).

Below is a list of all the scripts used to execute FoodQuest.

- EventSystem.cs
- HUD.cs
- Player.cs
- FishingTrigger.cs
- MainCamera.cs
- TouchControls.cs
- Enemy1.cs
- Enemy2.cs
- Enemy3.cs
- Boss1.cs
- Boss2.cs
- MenuControls.cs
- MoveMenuBackground.cs
- ScreenFade.cs
- Loader.cs
- CollectableItem.cs
- GameManager.cs
- ItemManager.cs
- SoundManager.cs
- ExitLevel.cs
- LoadCollectableItems.cs

```
166    IEnumerator AttackPlayer() {
167
168        CancelInvoke("SwapDirection");
169        direction = Vector2.zero;
170
171        DisableRagdoll();
172        DisableVunerable();
173        DisableMoving();
174        EnableAttacking();
175        SetAttackModeToCooldown();
176        animator.Play ("Enemy2Attack");
177
178        float time = 0;
179        RuntimeAnimatorController ac = animator.runtimeAnimatorController;  //Get Animator controller
180        for(int i = 0; i<ac.animationClips.Length; i++) {                    //For all animations
181            if(ac.animationClips[i].name == "Enemy2Attack") {                //If it has the same name as attack animation clip
182                time = ac.animationClips[i].length;
183            }
184        }
185
186        yield return new WaitForSeconds(time * 2f);                          //wait for animation to finish then switch off attack mode stuff
187
188        DisableAttacking();
189        EnableRagdoll();
190        EnableVunerable();
191        EnableMoving();
192        EnablePredator();
193    }
```

Figure 24: Code snippet from enemy2.cs showing the AttackPlayer () coroutine function



```
383
384    void CancelCoroutinte(Coroutine co, Action stoppers) {
388
389    void PlayerAttack() {
419
420    void PlayerFish() {
425
426    void PlayerFish(Collider2D tile) {
457
458    void StopFlyRod() {
463
464    IEnumerator AnimateSword(float rotation, float hzMove, float vertMove) {
465
466        swordGO.GetComponent<Renderer>().enabled = true;                    // Make sword appear
467        equipmentGO.transform.rotation = Quaternion.Euler(0, 0, rotation);  // Rotate sword into position
468
469        equipmentGO.transform.position = new Vector3(
470            transform.position.x + hzMove,
471            transform.position.y + vertMove,
472            transform.position.z);                                          // Move sword vertically
473
474
475        SetAttackModeToCooldown();                                          // Set Attack Cooldown to prevent spamming attacks
476        DrainCarbs(30);                                                     // Use carbs to attack
477        yield return new WaitForSeconds (.2f);                              // Wait a second before hiding sword again
478
479        swordGO.GetComponent<Renderer>().enabled = false;                   // Make sword disappear
480        animator.Play ("Idle");                                             // Play idle animation
481    }
```

Figure 25: Code Snippet from Player.cs showing the AnimateSword () coroutine function and other collapsed functions

8.5 Level Design and Layout

When developing a game within Unity, the individual levels are seperated into ‘Scenes’ (Unity Technologies, 2018). FoodQuest map layout was designed to accommodate the player’s decisions, drawing inspiration from Japanese Role Playing Games (Wikipedia, 2018) such as The Legend of Zelda (Nintendo, 1986) where the individual Scene has multiple exit and entry points and a multitude of branching paths for the player to follow.

Below (Figure27) shows the global world layout of FoodQuest. The gold star shows the first scene where the player spawns at the start of the game and the two red X’s signify the boss locations.

The local Scene layout is also showin n (Figure 28 and 29), here we can see multiple entry and exit points to several difference scenes marked with red circles.

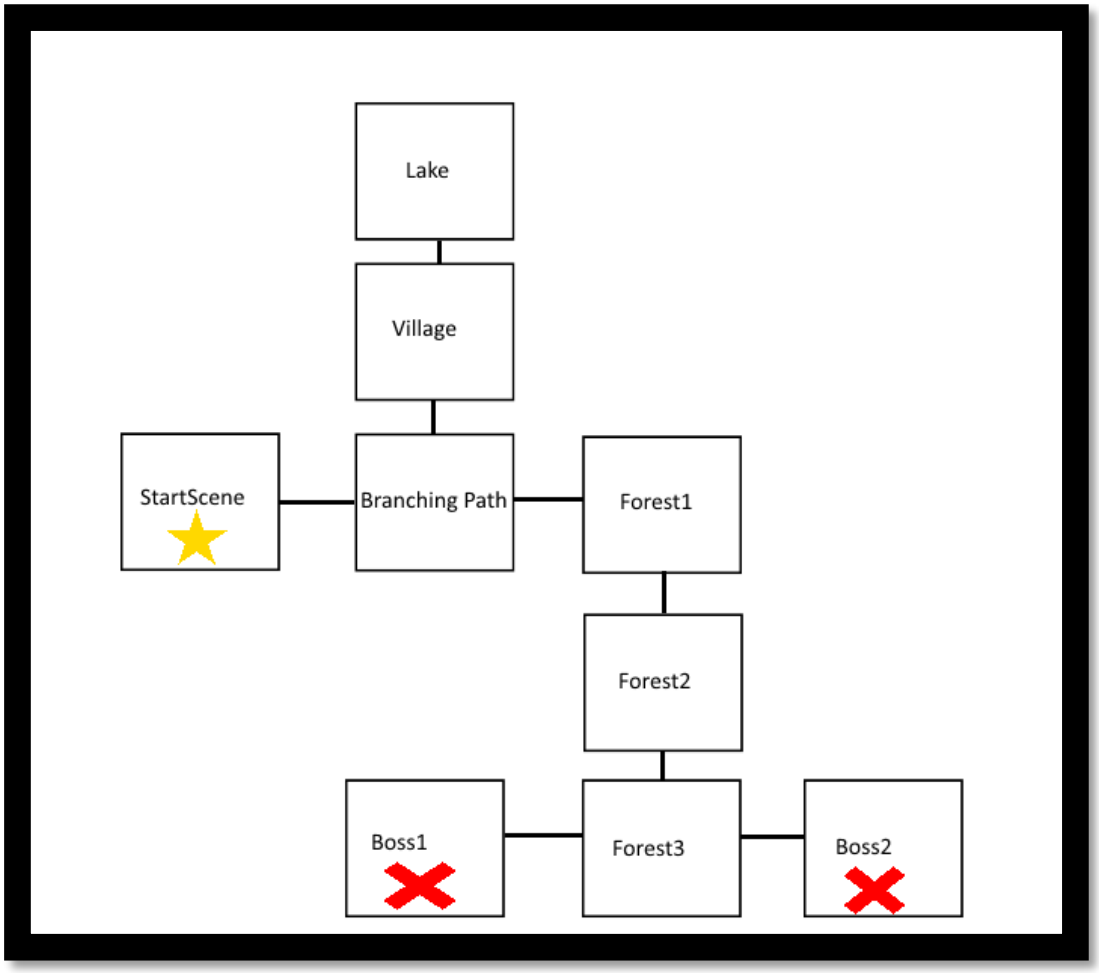


Figure 26: World Layout of FoodQuest

Figure 27: Scene view of the Village scene. Red circles shows usable entrances to access other scenes

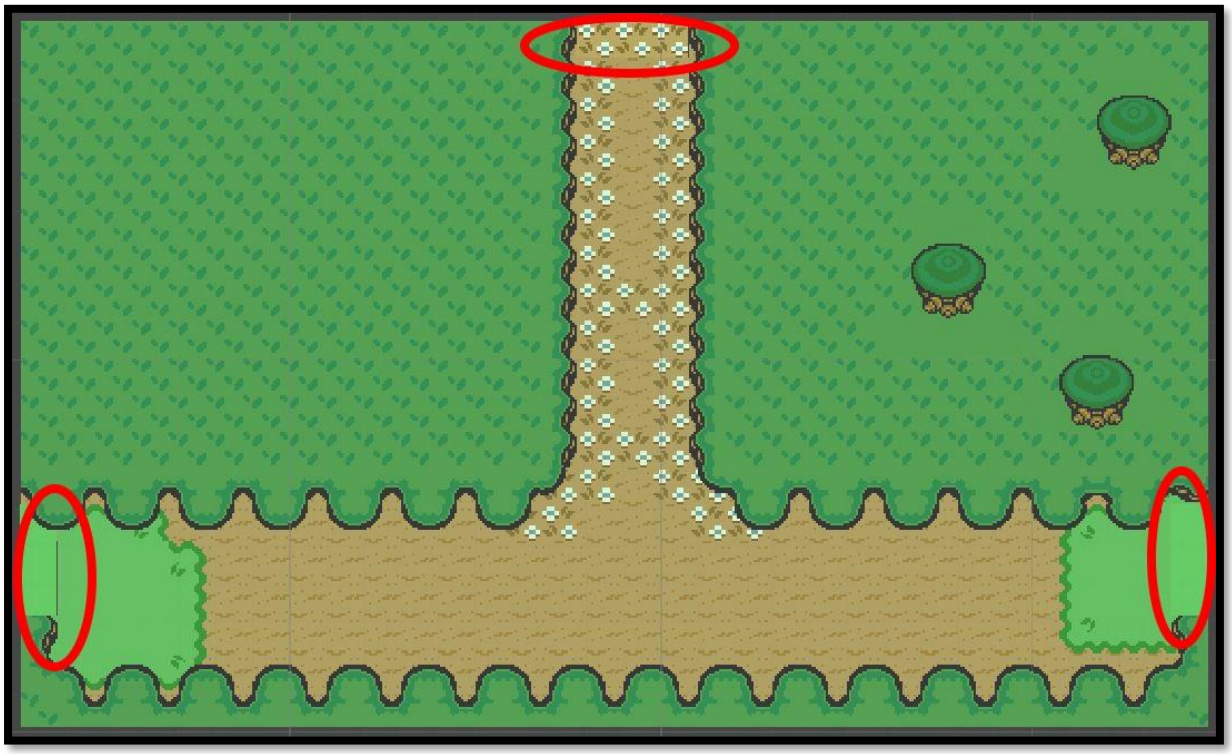


Figure 28: Scene view of the Branching Path scene. Red circles show usable entrances to access other scenes

8.6 User Interface, Game Controls

FoodQuest was developed for a touch-input Android platform with a 9:16 aspect ratio as it is the most common aspect ratio found on Android devices (1080x1920 is a resolution with this aspect ratio).To accommodate this, suitable user interface elements had to be created to suit the style of game, be intuitive for children to use, and be not obstructive to the viewing experience. Figure 30 shows the UI elements and Figure 31 shows the elements during the gameplay.

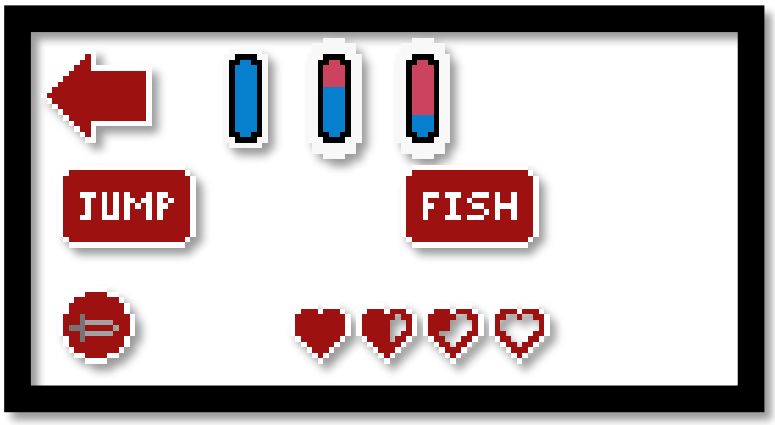


Figure 29: Sprite Sheet for User Interface

Figure 30: Game View of the UI elements

9. Testing

As aforementioned, this project was developed using the Agile methodology for planning purposes. This meant that the project was vigorously tested at the end of ever development cycle, known as a sprint. When the author implemented a new feature, it was tested in Unity make sure that it did not disrupt any of the existing functionality.

9.1 Devices

The following devices were used to test the operation of the game on the android platform.

OnePlus 5 - 1920x1080 resolution, Android Version 7.1.1

Huawei MYAL11 - 1280x720 resolution, Android Version 6.0.1

OnePlus X - 1920x1080 resolution, Android Version 6.0.1

Due to restraints in what the developer had available to test the device on the application could only be tested on the hardware mentioned in the previous section. This meant that the application was not tested on a tablet device or a device with an Android above 7.1.1. Yet due to the 2D design and low resource nature of the game, the Android application was able to run as expected on all the hardware that it was tested on. Stability of the application was highly satisfactory. There were also no issues using the touch inputs across all devices.

9.2 Test Group

A group of three children were used for the trial stage of this project. Appropriately different aged participants of 13, 9, and 7 years old made up the test group.

To determine the educational effect of playing FoodQuest, this test group would have to undergo two stages of examination. Pre-play knowledge test and a post-play knowledge test. These tests were delivered via the form of a questionnaire. Keeping in mind the FoodQuest is aimed at children, the questionnaires are brief and simple to fill out.

Before playing the game, the test group were given a questionnaire (table below) to complete. This was intended to determine the basis of their nutrition knowledge. After playing FoodQuest, another questionnaire (table below) was given to complete to determine knowledge gained.

Below are the answers provided by each of the participants in relation to the presented question. Age of the participant is provided to differentiate individuals in the test group.

Results of Pre-Play Questionnaire

Participant X	Age	Q1 Selected Choice(s)	Q2 Correct Choice(s)	Q2 Incorrect Choice(s)
Participant 1	13	1,2,3,4,5	2,3	1,4
Participant 2	9	2,3,4	3	1,2,4
Participant 3	7	3	(none correct)	1,2,3,4

Results of Post-Play Questionnaire

Participant X	Age	Q1 Selected Choice(s)	Q2 Correct Choice(s)	Q2 Incorrect Choice(s)
Participant 1	13	1,2,3,4,5	1,2,3,4	(none incorrect)
Participant 2	9	1,2,3,4,5	1,3	2,4
Participant 3	7	1,2,3	3	1,2,4

Comparing the results obtained from these questionnaires, it is striking the contrast shown in knowledge during the pre-play and during the post-play evaluation. We can see that Participant 1 obtained the greatest knowledge from their playthrough of the game. Unfortunately, the same cannot be said for the remaining two in the test group. Participant 2 and Participant 3 showed only a mild increase in their understanding of macronutrients.

Participant 3 showed little to no knowledge of macronutrients before their playthrough. Afterward they demonstrated a mild increase. This is a highly positive

A clerical error between the questionnaire and FoodQuest is the representation of the carbohydrate macronutrient, within the game it is referred to as ‘Carbs’ whereas within the questionnaire it is referred to as ‘Carbohydrate’.

These results and the possible ways to ratify the identified learning gap within FoodQuest will be reflected upon in the next section.

Pre-Play Questionnaire

Instructions

Before playing the video game please fill out this page to the best of your ability. Take your time and follow the instructions at each step carefully.

Part I: Title

1) Place a tick ✓ beside a word if you have heard of it before

1. Protein ☐
2. Fats ☐
3. Water ☐
4. Fibre ☐
5. Carbohydrate ☐
6. Macronutrient ☐

2) Place a tick ✓ beside the food which has a high content of the unique word

1.	Protein:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐
2.	Fats:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐
3.	Fibre:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐
4.	Carbohydrate:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐

Figure 31: Pre-Play Questionnaire containing the questions asked and the selectable answers

Post-Play Questionnaire

Instructions

After playing the video game please fill out this page to the best of your ability. Take your time and follow the instructions at each step carefully.

Part I: Title

1) **Place a tick ✓ beside a word if you have heard of it before**

   1. Protein ☐
   2. Fats ☐
   3. Water ☐
   4. Fibre ☐
   5. Carbohydrate ☐
   6. Macronutrient ☐

2) **Place a tick ✓ beside the food which has a high content of the unique word**

1. Protein:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐
2. Fats:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐
3. Fibre:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐
4. Carbohydrate:	Cheese ☐	Apple ☐	Chicken ☐	Potato ☐

3) **If there is anything else you would like to say about the game, please write it down in the space below**

_____

_____

_____

_____

Figure 32: Post-Play Questionnaire containing the questions asked and the selectable answers

10. Conclusions

The goal of this project was to create an educational video game to increase children's knowledge of nutrition. Using a game-based learning approach, the was educated throughout the game journey. Increasing the player's knowledge of nutrition was the greatest hurdle faced in designing this game. Any child who would pick and play FoodQuest would benefit even the smallest knowledge increase of macronutrients.

Child obesity has detrimental effects in the short, and long term. A consequence of child obesity is higher rate of adult obesity throughout life via habits, preferences, and psychological cravings. Reduction in obesity will increase the quality of a child's future life in many aspects. FoodQuest has taken steps towards tackling this issue via an engaging medium. This project has attempted to satisfy the longing for a successful educational game. Rational for this project has been cemented within the enjoyability of the gameplay and overall atmosphere the game provides.

As an entertaining educational experience, this game has the potential to be adopted by many schools and educational programmes anywhere in the world. Continued development of titles containing the main features of FoodQuest; pleasing aesthetics, motivating gameplay, non-linearity, player choice, etc, would be implemented to refine the educational game experience.

10.1 Future Refinement

From an educational game aspect, the project did exceed triumphantly, there are a few key features which were not implemented, and the author believes would have solidified the knowledge gained from FoodQuest.

Behavioural Changes

The player would be intrigued to explore how each of the macronutrients (e.g. protein, carbohydrates, etc) would benefit their attributes (i.e. strength, speed, etc). For example; bread would be high in speed due to its immense natural carbohydrate level. As the player progresses through the game, their knowledge of macronutrients would increase and so would their confidence to combat the foes.

Detailed Explanation of Macronutrients

Currently the game does not provide a factual explanation of a macronutrient's purpose. Perhaps implementing a diary with paragraph entries with missing words the player must fill out to complete the sentence which would enable progression to the next area.

Difficulty Selector

Since the game is to be played for its educational purpose, a difficultly level selector would be implemented; normal difficulty and simple difficulty. Simple difficulty would make supplies surplus (food would give the player points in different fields, such as strength and speed, which would diminish through player actions for instance; attacking would depreciate strength and walking dwindles speed) and opponents easier to defeat.

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