Addressing 21st Century Food Challenge

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Contents

1. Introduction

Food waste is an extremely serious environmental, social and economic concern to the whole world. Although, food waste has been recognized has a major problem around the world, it was only recently addressed or identified as a serious environmental problem. The production stage, trading and consumption of food products are all key contributors to various environmental problems, which consequently contribute to Global Warming and Climate change (WRAP, 2009). According to Waste and Resources Action Program (WRAP), approximately twenty percent of greenhouse gas emissions are related to the production, processing, transportation and storage of food.

The global population exceeded seven billion people in 2011 and it has been predicted to reach about nine point three billion by 2050. This results in more people to feed, combined with an increase in economic development, which allows people to consume more thereby leading to a forecasted food demand increase between fifty to seventy percent by 2050 (FAO, 2012). It is therefore paramount to reduce global food waste in order to increase the availability of food for future generations. The challenge will therefore be to attend to the increase in food consumption demand through the most sustainable approach (which includes tackling it environmentally, economically and socially), which eventually provides safe and healthy food for everyone (FAO, 2009).

With this increasing demand for food, it is still surprising that about eight hundred and 68 million people around the globe are seriously under-nourished, corresponding to one in eight people worldwide. With estimates also revealing that over thirty three percent of food produced around the world for human consumption goes to food waste at the same time (Moomaw et al., 2012). The current climate change issue along with the continuous increasing demand for food consecutive increasing demand for food, coupled with climate change, is resulting into aggravated pressures on global natural resources and ecosystems, which humans rely upon. Therefore reducing the degree of waste throughout the whole food system is a step towards achieving global food security (Kearney, 2010). Global food security occurs "when everyone has access to safe, sufficient and nutritious food, which enables and maintains a healthy life" (WHO, 2011). To ensure food security is sustainable, the core principles of food security (access, availability and utilization) must be considered along with social, environmental, political and economic factors (Ingram, 2011).

1.1 What is Food Waste?

According to WRAP, "Food waste is defined as any food or even drink that is produced for human consumption that has, or has had, the reasonable potential to be eaten, together with any associated unavoidable parts, which are removed from the food supply chain" (Parfitt, 2010). This definition was proposed by WRAP in order to focus efforts on food waste prevention. Food waste most commonly refers to edible foods, which were normally intended for human consumption, but have otherwise been disposed, misplaced, or consumed by pests and also does not include the inedible portions of foodstuffs. There must however be a distinction between avoidable and unavoidable waste and also between the policy approaches to those types of waste**.** Furthermore, food waste may also be classified as food loss when incurred during the early stages of the food supply-chain, and as food waste within the latter phases (Gustavsson, et. al 2011).

In the UK, food waste is used generically as a term which encompasses all food and drinks which have been discarded through the food supply-chain, from the production of food through to its post consumption (as defined by WRAP).Food waste can also be divided into three forms of waste (Figure 1),

which include foods of personal preference (possibly avoidable), the inedible portion of food (unavoidable waste) and edible waste (avoidable waste) (WRAP, 2009).

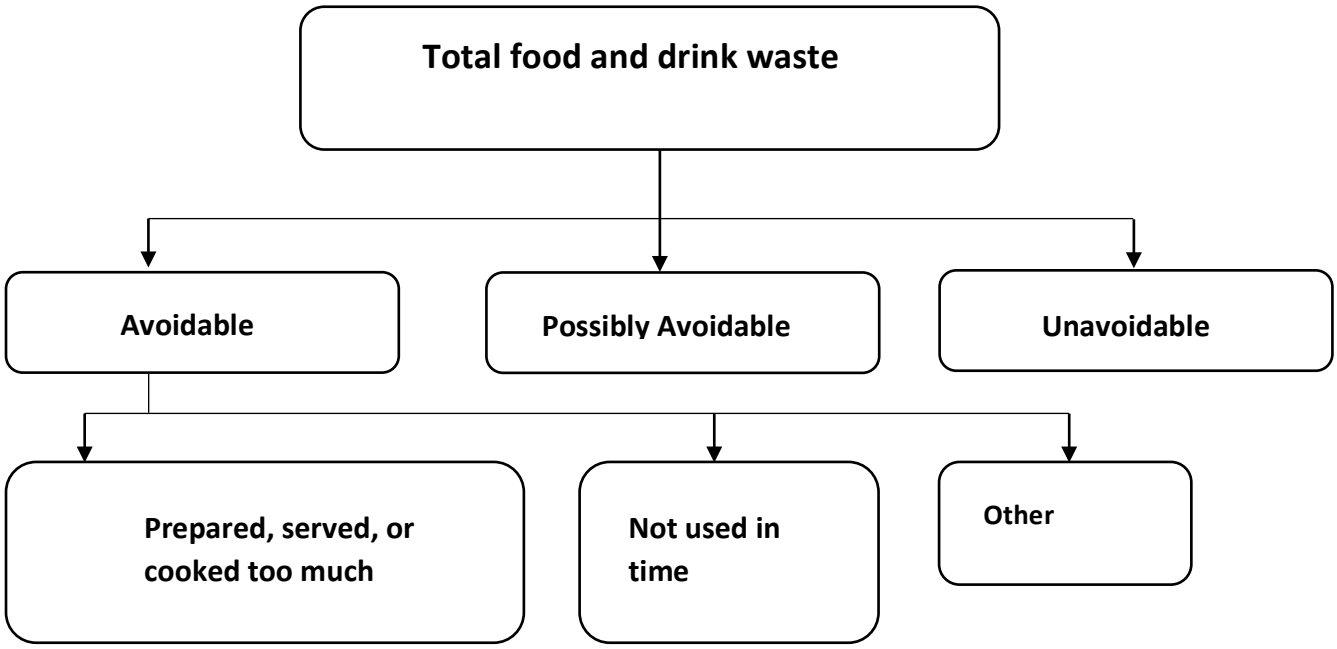


Figure 1: WRAP Classification of Household waste (WRAP, 2009). Household Food and Drink Waste in the UK.

This classification of food waste above helps investigate the patterns of food consumption and its disposal in the UK. In particular, it assists in scrutinizing the impacts of waste through the food supply chain and also in landfill decomposition.

1.2 Global Characteristics of Food Waste

Estimates have shown that about one third of the global food production is lost annually across the food supply, which equates to about one point three billion tones. An interesting fact to note is that the proportion of food not consumed within developing and developed nations is similar, although through different channels. Research shows that forty percent of total global waste is lost during early stage post-harvest and processing in developing countries, whilst conversely, the same amount is wasted during the final stages of retail and consumption (Fox, 2013). In highly developed countries, research has revealed that food waste is predominant during food consumption (Gustavsson et. al., 2011).

Estimates show that individuals waste about 95 – 150 Kg of food waste annually in developed regions such as North America and Europe. Contrastingly, in developing and low-income countries such as Sub-Saharan Africa and South/Southeast Asia, about six to eleven kilograms per capita of consumer food waste is generated annually (Gustavsson et. al., 2011). These losses show the weaknesses of commodity groups along the food supply chain and also the various challenges encountered by both developed and developing countries. This equates to about 45 – 50% of root crops, fruits and vegetables and about 20 – 30% of cereals, meats, fish and dairy. There appears to be similarities between developed and developing countries in terms of increased food intake and a higher national economic growth (FAO, 2011).

A key aspect of food waste generation can be found in the retail provision sector and in the diverse range of consumer choices, where the most persuasive and compelling retail driver is to ensure stocks (food commodities) are available all year long (DEFRA, 2006). Some key elements, which facilitate food wastage in the modern day supply chain are retail promotions unto customer's households, over production ad product-gradings (DEFRA, 2006). Retail promotions are an integral element of the retail-consumer interface, while some offer good value for money with little food waste, other promotions such as, Buy One Get One Free (BOGOF) can lead to more waste if not supported by proper storage or better education on how to cook healthily by supplying recipe ideas. These drivers of food waste will be expatiated more in detail, specifically in the context of the UK food supply chain, the role of supermarkets and consumerism (DEFRA, 2008).

2. Literature Review

2.1 Food Waste in the UK

Waste in the UK is an emerging problem. The UK currently generates around 8.3 million tons of household food waste every year (the single largest producer of food waste), the majority of which is disposed of into landfills. Generally, food waste puts a large financial implication on each household and local councils in the UK. Food wastage is estimated to cost each British household about £250 - £400 yearly, which accumulates to about £15,000 – £25,000 over a lifetime. Local authorities also spend about £1 billion a year disposing food waste (WRAP, 2011). By considering the annual cost of waste, which is at £10 million, it will not be economically feasible to waste a lot, especially with landfill tax increasing to £48 per ton from April 2010 (WRAP, 2009). The foods that are disposed of into landfills are broken down into carbon dioxide and methane gas, which are both greenhouse gases, responsible for global climate change. If the UK is to achieve their targets of reducing their carbon emissions by eighty percent in 2050, it is important to reduce the amount of food waste that goes into landfills (Hall, 2009). Estimates also reveal that methane emissions from biodegradable waste in landfill sites can contribute about forty percent of UK emissions (DEFRA, 2007). About 1 million tons of greenhouse gas (GHG) emissions is derived from the UK energy consumption annually. About twenty percent of these emissions may be attributed to the foods and drinks sector, majorly through agricultural outputs and imported goods.

2.2 Current UK Waste trends

The UK household food waste makes up about 90% of municipal solid waste generated yearly in the UK. Around 60% of this waste is biodegradable (capable of being decomposed) with food waste accounting for 25% of this, equating to 0.2 tones per household yearly (Knipe, 2005). As discussed earlier, food waste can be segregated into three forms namely, avoidable, possibly avoidable and unavoidable. Avoidable food is no longer useful because it has gone past its sell by date, although it will not cause harm to the body when consumed. The frequent causes of avoidable food wastage is that it is not used in time and it goes past its sell by date, this accounts for about 50% of food waste (WRAP, 2009). Also the preparation of excess amount of food results in about forty percent of avoidable waste. Avoidable food waste is also connected with avoided waste, although this is mainly down to personal preference. Unavoidable food waste on the other hand is produced as a spin-off of food preparation which is not edible (Figure 1). Food can also be damaged if a problem arises with the storage equipment for example a broken freezer. Some other factors which contribute to food waste include poor storage which leads to foods going off, poor planning for meals, confusion about food date labels and a lack of culinary skills. Also, an increased demand for food caused by an increased UK population results in an increased potential for waste. Research has shown that 8.3 million tons of household waste is produced annually in the UK, with about 5.3 million tons of this waste being avoidable, accounting for about 64% of avoidable waste (Table 1). This shows that there is a huge potential for food waste to be reduced drastically in the UK (WRAP, 2011).

Food Group	Weight generated (tonnes per year)				Avoidable waste (£ million per year)
	Total	Unavoidable	Possibly avoidable	Avoidable	
Fresh vegetables and salads	1,900,000	250,000	810,000	860,000	£1,400
Drink	1,300,000	430,000	<1,000	870,000	£1,600
Fresh fruit	1,100,000	520,000	81,000	500,000	£990
Bakery	800,000	<1,000	120,000	680,000	£1,100
Meals (homemade and pre-prepared)	690,000	<1,000	24,000	660,000	£2,100
Meat and fish	610,000	240,000	83,000	290,000	£1,600
Dairy and eggs	580,000	54,000	<1,000	530,000	£870
Processed vegetables and salad	210,000	<1,000	<1,000	210,000	£360
Condiments, sauces, herbs & spices	210,000	<1,000	6,000	200,000	£700
Staple foods	200,000	<1,000	<1,000	200,000	£470
Cake and desserts	190,000	<1,000	<1,000	190,000	£510
Oil and fat	90,000	5,000	64,000	20,000	£37
Confectionery and snacks	71,000	4,000	<1,000	67,000	£330
Processed fruit	30,000	<1,000	<1,000	30,000	£63
Other	*300,000*	*<1,000*	*280,000*	*20,000*	£110
Total	**8,300,000**	**1,500,000**	**1,500,000**	**5,300,000**	**12,000**

Table 1: The amount of food and drink waste by food group, split by avoidability (Adapted from WRAP 2009)

The foods that are commonly wasted in the UK are fresh vegetables and salads accounting for 23% of waste, 16% by drinks and 13% being fresh fruit. 95% of unavoidable food and drink waste comes from four food groups: fruit contributes about 33%, with a further 28% from drink, mainly tea bags. Vegetables and salads make up 17%, while meat and fish contribute a similar percentage (Figures 2 –5) (WRAP, 2009).

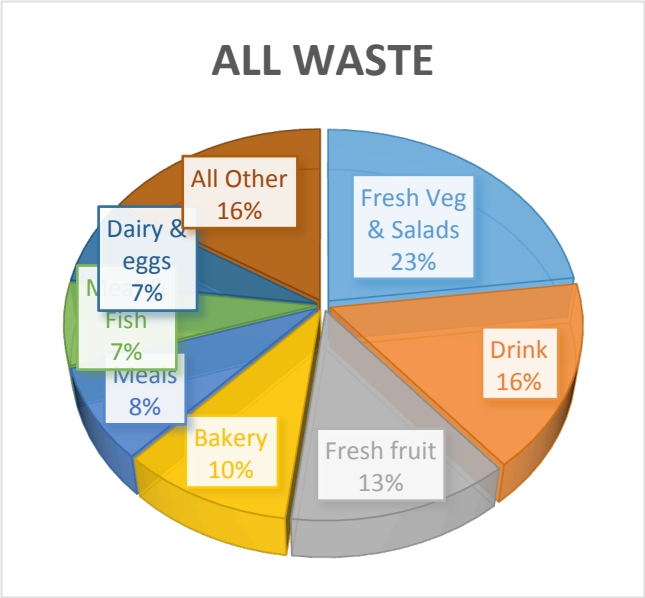


Figure 2: Proportions of weight of food and drink waste (All Waste) (Adapted from WRAP, 2009)

Figure 3: Proportions of weight of food and drink waste (Avoidable Waste) (Adapted from WRAP, 2009)

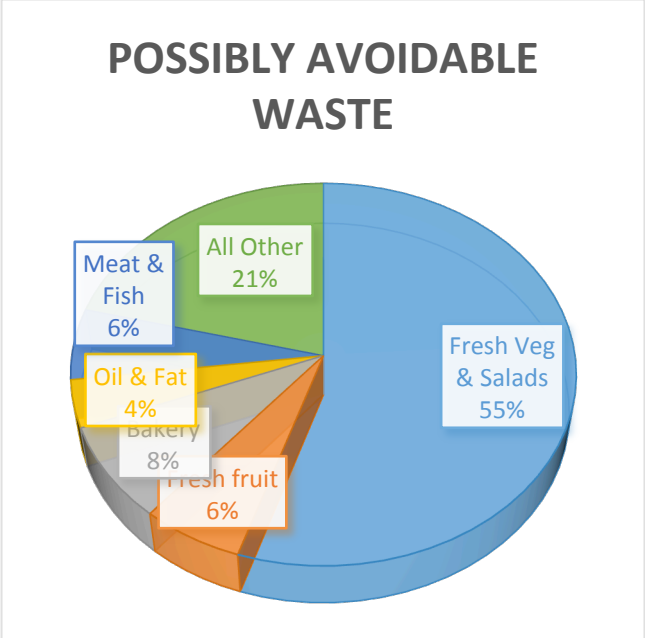


Figure 4: Proportions of weight of food and drink waste (Possibly Avoidable Waste) (Adapted from WRAP, 2009)

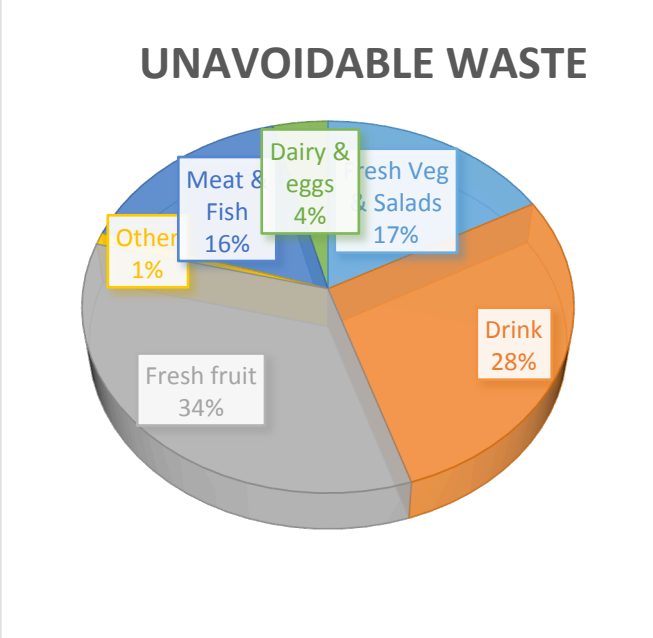


Figure 5: Proportions of weight of food and drink waste (Unavoidable Waste) (Adapted from WRAP, 2009)

From Figures 2-5, it is evident that most of unavoidable food waste emanates from fruits and drinks and the majority of avoidable food is due to fruit and vegetable becoming un-fresh.

Furthermore, when analyzing household food waste, it is important to determine which type of distinct population sub-groups or household exist and which contributes more to food waste. Households that generate the least amount of food waste are the older and professional social classes (DEFRA, 2009). This could be as a result of inflation on pensions and savings. Households that generate more waste per individual are those of families with children, whilst single-person households produce the most waste. On a wider scale, waste may be seen as a by-product of lifestyles, social norms/practices and retailer's policies on packaging sizes (WRAP, 2007).

2.3 The Role of Supermarkets in the generation of food waste

Studies have shown that UK consumers spend about £180 billion on food and drinks annually, with about £100 billion purchased from retail outlets, and about 75% from the big four supermarkets (Tesco, ASDA, Sainsbury's, Morrison's). Supermarkets have changed the relationship of consumers to the everyday products they purchase and also their perception regarding its production, packaging and marketing (WRAP, 2011). Although supermarkets have become a key player in promoting fast food lifestyle with easy access to a diverse range of food at a reasonable price, they have also implemented a structure, where millions of tons of food are wasted daily (WRAP, 2011).

The UK is one of the main contributors of food waste among European and developed countries and also has an increase in the number of supermarkets to three times within the last decade. Also, the increasing stringent regulations by government on supermarkets for quality and appearance results in huge amount of food waste. The various incentives and promotional offers by supermarkets like Buy One Get One Free (BOGOF) have further encouraged customers to buy more than they actually need, which eventually results in food going off in the food. Hence, the spontaneous purchase of food without the present need of food is often the main cause of food waste (WRAP, 2009).

In 2007, the major supermarket chains accounted for over 80% of the market share, with Tesco being the market leader with (31.4%) of the total market share, ASDA (16.7%), Sainsbury's sixteen point two percent (16.2%), Morrison's (11.1%), Somerfield (4%), Waitrose (3.9%), Iceland (1.6%) and others (25.1%) (WRAP, 2011).

Research shows that UK households dispose about 25% of the foods they purchase without even using them (WRAP, 2008). Their marketing strategies and policies, bulk purchases have generated enormous food waste, contributing to about 80% of total food waste produced in the UK. Research has shown that each UK household will save £480 yearly by not disposing consumable foods (See Table 2). Several other studies have shown that the UK has about 380 calories available to an individual, which is twice the amount of food calories essential for the nutritional needs of the population (DEFRA, 2008). Therefore we are consuming more food than what is actually needed. Elliott, 2013 show that thirty percent of all supermarket purchases in UK households go straight to the bin.

Household size	Weight generated (kg per household per year)				Cost of avoidable waste (£ per household per year)
	Total	Unavoidable	Possibly avoidable	Avoidable	
1	220	40	40	140	£310
2	290	60	50	180	£420
3	410	60	70	270	£630
4+	480	80	90	310	£720
Average UK household (2.4 people)	**330**	**60**	**60**	**210**	**£480**

Table 2: Food and drink waste by household size, weight and avoidable cost (Table Adapted from WRAP, 2009)

2.4 Management of UK Household Waste

Household waste in the UK has been managed in a variety of ways ranging from home cooking tips to maximizing the efficiency of cooking, better packaging system and new technological innovations in the treatment of collected waste. Some of the initiatives which have been implemented by governments and non-governmental organizations to reduce waste in an house hold are: War on Waste Campaign, Composting and Food Waste Digesters (FWDs), rationing (to prevent the excess use of food), reducing food proportion size, planning meals ahead, provision of advice on food storage, the employment of special recipes which uses leftovers from previous meals to avoid more food waste. If none of the above is effective, recycling or composting can also be used (WRAP, 2011).

By focusing on addressing consumer waste, we have decided as a group based on prior research to focus on food packaging/storage and also to encourage the consumer to produce less food waste. We have developed a mobile phone application (food expiry application) designed to monitor sell by dates of food at home along with a fridge magnet for convenience. It is a tactile device that enhances the incorporation of digital food monitoring into family life. This innovation we have designed will be directed to households with families and children and single households as our research has shown that they are prone to waste food in excess. This product designed will be a valuable resource to supermarkets, application developers, cooking websites/programs, industry and consumer packaging manufacturers. It will consequently elicit change in consumer and industry behavior/attitude to food. The approaches that we have used to come up with a concept, and the process of ideation, results from surveys and interviews will be discussed in detail in the subsequent sections.

3. Methods and Analysis

Throughout this research and design project we are consulting the IDEO method cards, which have enabled some of our inspirations and particularly given us ideas about which research methods to use. The four main methods that we chose as the most suitable to use, after initial literature reviews, are summarized in Table 3.

Method	Participants	Aims
Questionnaire	36 participants - 23 university students - 5 parents - 6 school students - 2 grandparents	- Gain an overview about why people from various backgrounds waste food - Find out which methods of food waste prevention consumers think will be most effective
Food Diaries	7 participants - 5 university students - 2 parents	- Gain information about the specific types of food that people waste and why - Use photography and written descriptions to explain fully what happened
Interviews	5 participants - Mother of 2 Children - University student - School student - Mother of 3 Children - Father of 2	- Gain in depth detail of why food is wasted in a variety of different households
Consumer Journey Map	1 character - Eighteen year old	- Pinpoint intervention points along the journey map

Table 3 Summary of methods used to collect the data for this research project.

Figure 6 shows the different IDEO cards used at this stage of the design process. Questionnaires would allow us to gain a broad overview of how and why food is waste in UK homes from a larger range of people. The food diaries would allow a more detailed information about specific types of food waste to be collected and since we asked participants to include the use of photography during this process, valuable information that may otherwise have been missed might be collected. Interviews would provide in depth detail about day-to-day behavior and how this affects food waste in various households. The participants are given time to feel comfortable and talk about various aspects of food and not just waste that may help us design the end product. The consumer journey map (using a character profile), which would be based off our previous findings, could give us an idea of potential intervention points to focus the rest of our design process on. The character used would be based off a mixture of real life people that we personally know (for example siblings and friends) and so their fictional actions will not be far from the actions of actual people.

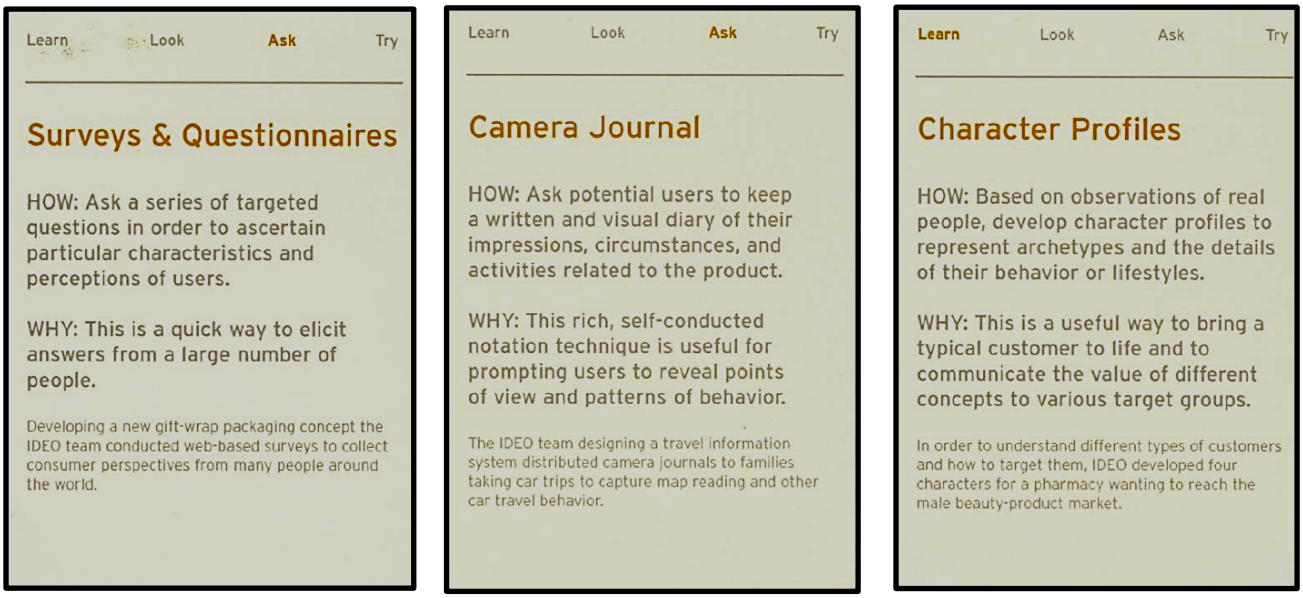


Figure 6 The IDEO methods cards used at this stage of the research (IDEO, 2014)

3.1 Questionnaire

Our four-question questionnaire was disseminated (both electronically and in paper form) to family and friends of different ages using a snowball sampling technique, whereby respondents refer other potential respondents to the questionnaire, this enabled access to a wider range of people. Overall, there were thirty six respondents.

The Questions:

- What is the most common reason for you wasting food within the home? (You may tick more than one answer)
- Which do you believe might be the most effective ways of preventing food waste? (You may tick more than one answer)
- Would you waste less if you were aware of an obvious financial benefit?
- Would you waste less if it were more obvious how much food is wasted?
- How educated do you think you are about food waste?

Once the results were collected, simple bar graphs were created to present the data clearly.

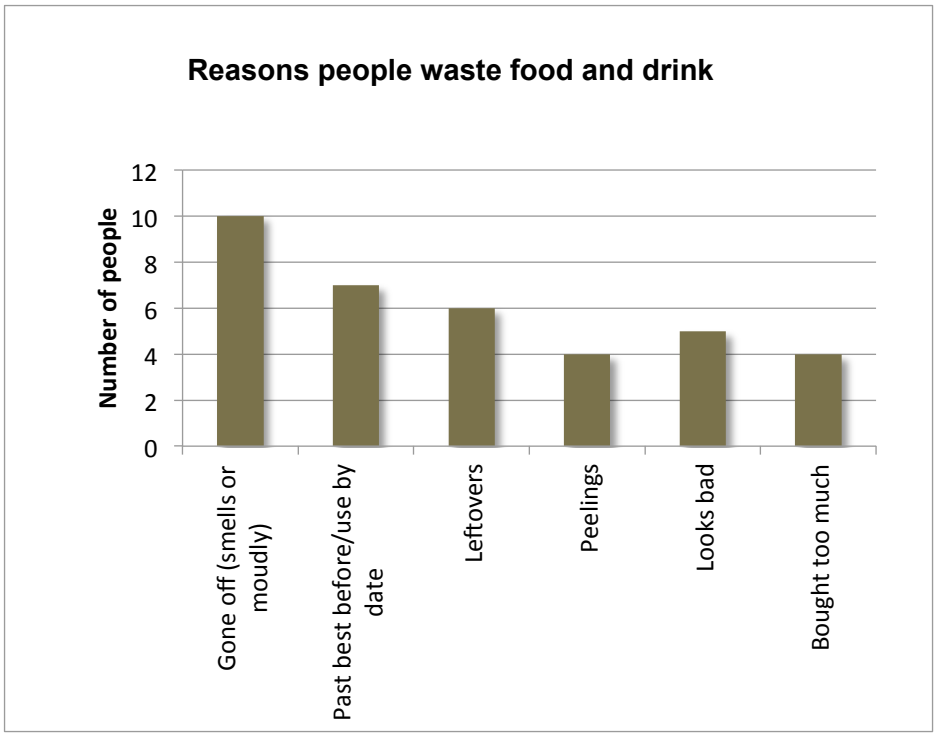


Figure 7 Graph to show the most common reasons why consumers from our questionnaire waste food and drink.

Figure 7 shows that 10 out of 36 respondents think they waste most food because it has been allowed to go off. This response has the highest number of people, with consumers allowing the food to pass best before or use by dates being the second highest response. Maybe then our research and design ideas should be focusing on prolonging the life of foods or highlighting those foods that need to be eaten first. However, as the literature review showed, these actions may also occur because of unclear labeling, poor packaging or unsuitable storage.

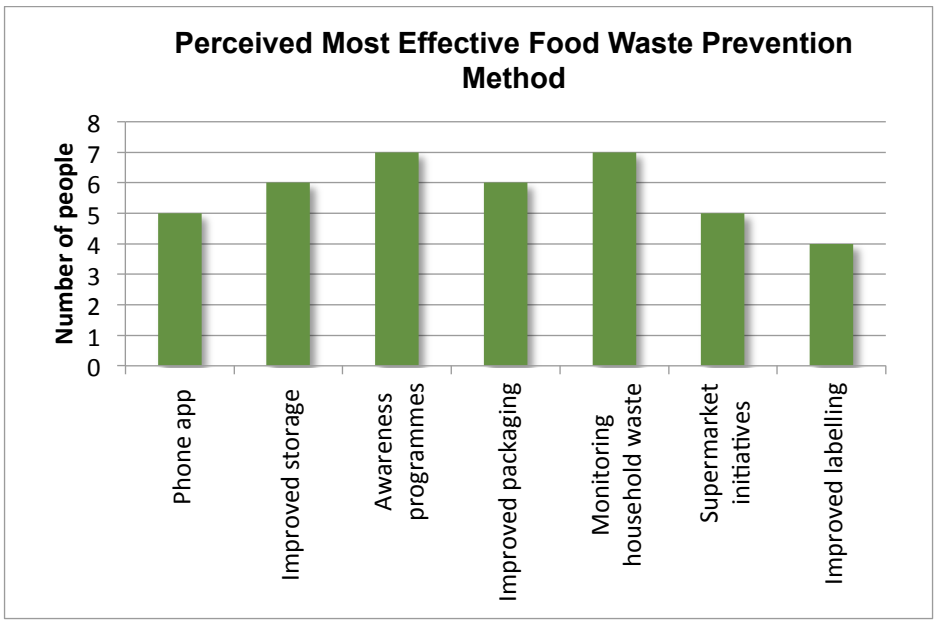


Figure 8 Graph to show how effective consumers from our questionnaire perceive potential waste prevention methods to be.

Figure 8 shows there to be no obvious waste prevention method that consumers believe to be most effective as all options have quite high numbers of responses. However, 'awareness programs' and 'monitoring household waste' do have the highest numbers of people thinking they could be most effective. Therefore, our group could consider designing an awareness initiative to educate consumers about their own food waste or a product/service to monitor household waste. Since these particular results aren't very conclusive though, our final design should be based mostly on other research.

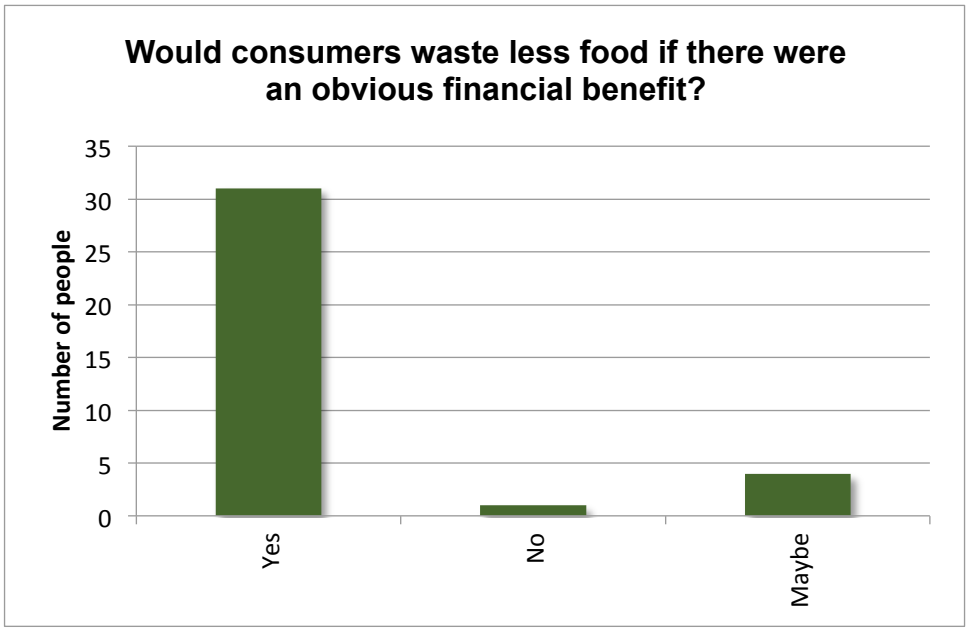


Figure 9 Graph to show whether or not consumers from our questionnaire would waste less food if there were an obvious financial benefit

Figure 9 shows that this particular question has a very conclusive result. Thirty one out of the thirty six respondents said that they would waste less food if there were an obvious financial benefit. Although there is an obvious link between reducing food waste and reducing household expenditure, it is currently difficult for most consumers to see the cumulative cost of their food waste. Our product design could incorporate a system to monitor the cost of food waste over time, making consumers more aware of the total savings of not disposing food.

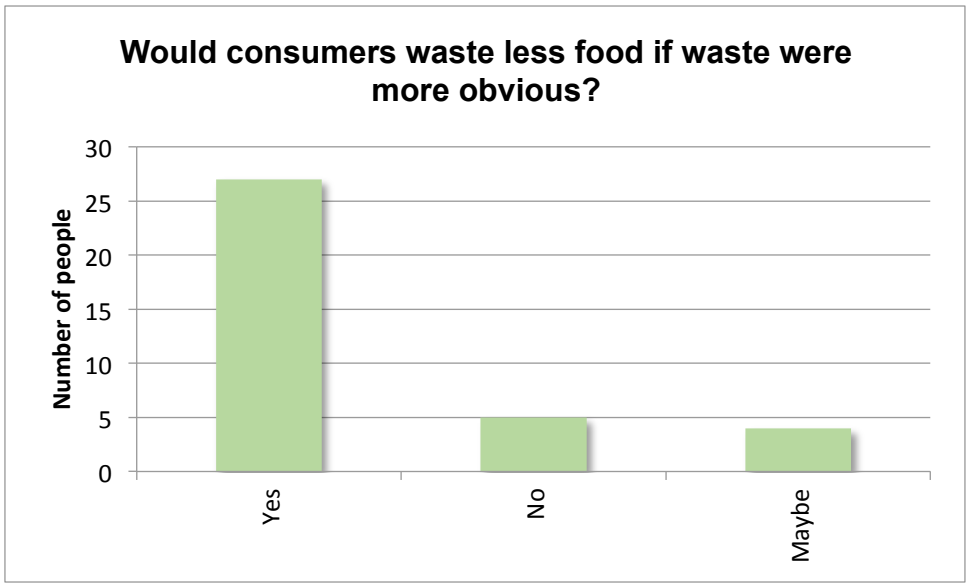


Figure 10 Graph to show whether or not consumers from our questionnaire would waste less food if their waste were more obvious

As in Figure 9, Figure 10 also shows a clear modal response with twenty seven out of thirty six people saying 'yes' they would waste less food if their waste were more obvious to them. This again would suggest that our design should try to incorporate a system of monitoring food waste over time to show cumulative waste. The design could otherwise make the food that is about to be wasted (i.e. is going out of date) more obvious, possibly by using an alarm or alert system to tell consumers which food they need to eat first.

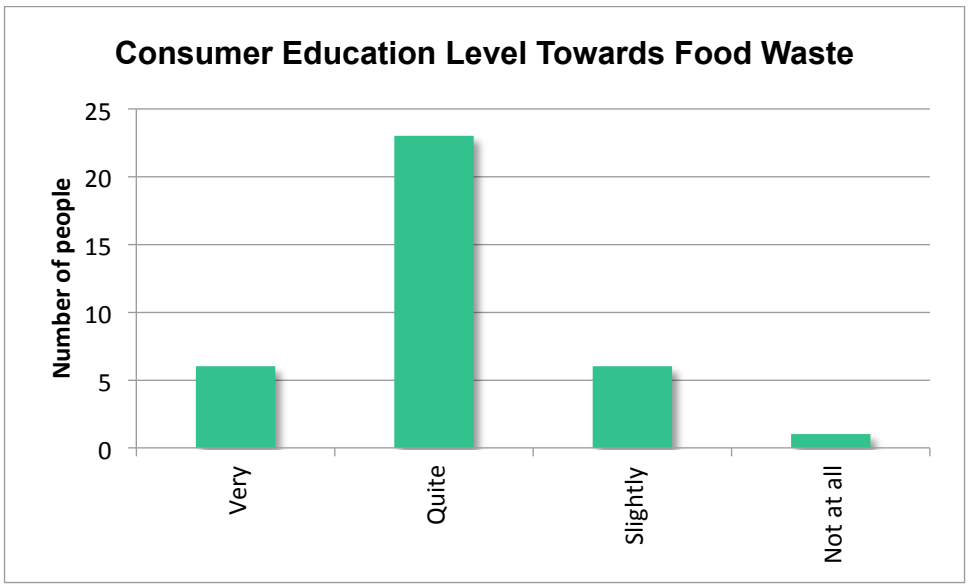


Figure 11 Graph to show the education level of consumers towards food waste

Figure 11 shows that the majority of respondents from our questionnaire (23 out of 36) believe that they are 'quite' educated about food waste and six believe they are 'very' educated. This would then suggest that consumer education is not an issue that needs to be addressed. However, a consumer's idea of how well they are educated about food waste could differ dramatically to government, researcher's and academic's ideas and are extremely subjective. Also, since the majority of our respondents are friends or family of ourselves (university students) it is highly likely that they are relatively well educated compared to a large proportion of the UK's population. It would also be unwise to ignore the seven respondents that replied 'slightly' or 'not at all'. This is almost twenty percent of respondents that do not think they are well educated about food waste. Therefore we should potentially make room for consumer education in our design.

3.2 Food Diaries

We wanted to find out if there were any particular foods or drinks that tend to be wasted more often than others to help us decide whether our design ideas should be focusing on certain types of food waste. Since we are consumers ourselves we decided to record our own food waste for a week, writing down exactly what foods we threw away and why. We also asked two other people (parents) to participate so that we didn't only have student participants. The chart below shows the foods that appeared most in the food waste diaries, with foods only appearing as their own bars if they were wasted more than once.

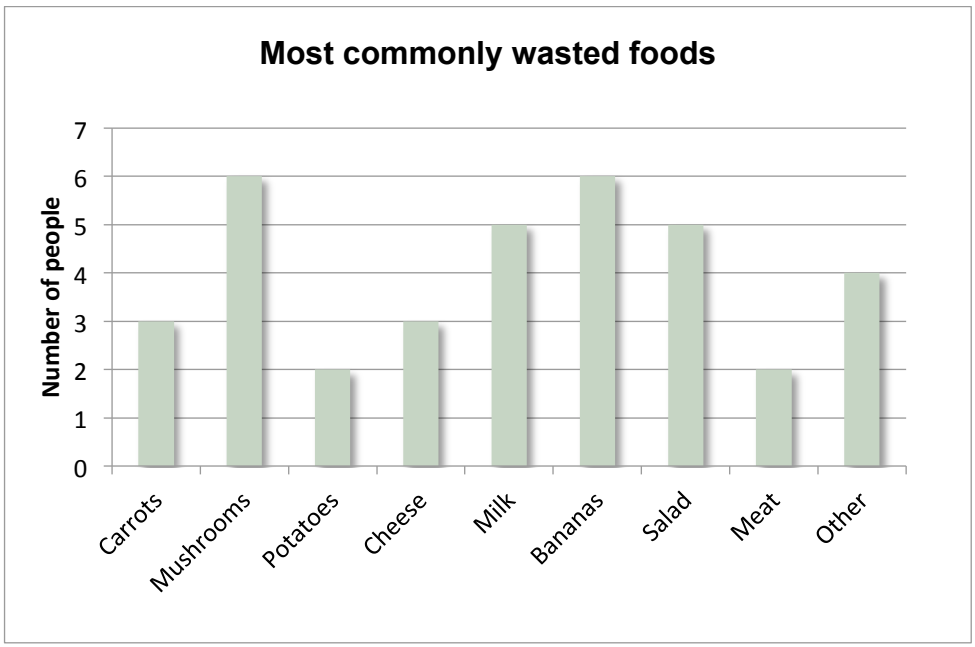


Figure 12 Graph to show the most commonly wasted foods from participant's week long food waste diaries

Not surprisingly, the most commonly wasted foods were fresh produce - with milk, salad, mushrooms and bananas being wasted most often. These foods have particularly short life spans due to reasons mentioned in the previous research such as ethylene production and acceleration of the ripening process due to poor storage or packaging. Therefore, our design should take this into consideration, possibly include storage suggestions, improving packaging or including something to inhibit ethylene production within a product.

The use of photography as part of the food diaries was useful in that it prompted participants to write exactly how they wasted their foods. In fact, it showed that all participants, in all cases threw their food or drink waste either in the bin or down the sink, as shown in Figure 13 (one of the photographs from the food diaries). There is then a huge need for an alternative solution where food waste does not end up in landfill. There is an opportunity for this food waste to be useful, possibly as energy producers, for compost, as animal feed and many more. This could be explored further in the research.

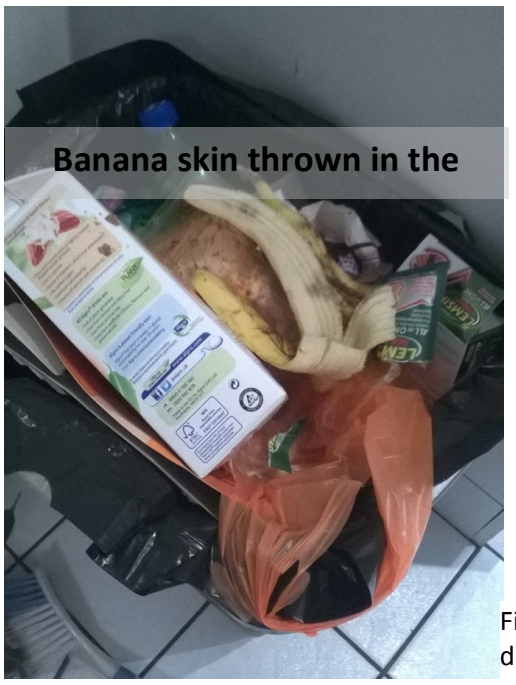


Figure 13 One of the food diary photographs and description

3.3 Interviews

Following the above research methods, we decided it would be beneficial to gain more in depth information about people's interactions with food and the reasons why they waste food. Five people in total were interviewed using a semi-structured interview design so that participants were able to tell us things we hadn't considered previously. People from various demographics were chosen to better represent the overall population; parents, a university student, and a school student.

The following questions were suggested questions for the interviewer to include and to give a slight structure to the interview:

- Do you think you waste a lot of food?
- What are the most common reasons for you wasting food?
- Who is your house wastes the most food? Why do you think that is?
- Who in your house does the shopping? Do you/they plan ahead?
- Do you think preventing food waste is important? Why?/Why not?
- How educated do you think you are about food waste?
- Does cost effect how much food you waste?

The below figure shows the most relevant and interesting comments from all five participants of the interviews.

'It's annoying to come home and find new packets opened and older ones still there.... Communication about food is really lacking or they don't listen anyway.' Alison, 50

'I don't think that much about food waste because at least that will break down in landfill…. Compared to other waste.' Todd, 22

'I'm really conscious about food waste but no-one else in the family is. Yes it annoys me to see food I have spent money on wasted.' Carol, 55

'I don't think I waste a lot, in fact I eat a lot of the food other people in the house are about to waste… but maybe I do over-eat!' Andrew, 56

'I think I know quite a bit about food and wasting it because we learn about growing it at school and sometimes take it home, then I don't want to waste it! My mum also tells me not to waste my food.' Francesca, 10

Figure 14 The most useful quotes about food waste from participants of the interviews.

A particularly interesting finding from the interviews was that within family/shared households, communication often seems to be lacking between the person purchasing the food and other members of the household. It appears common for foods to be wasted simply because some members didn't realize that certain foods needed eating soon and so opted to eat other foods that would have lasted much longer. Our design idea could aim to improve the communication between household members and highlight the foods which need eating first.

The quote from Andrew shows that food waste does not only relate to food that is actually thrown away but also food that is unnecessarily consumed. Previous research has suggested that the obesity problem and diets in the UK and generally in developed countries could be adding to food waste issues. Addressing unhealthy diets and overeating could be an aim of our design project.

Todd, the 22 year old student, perceived food waste to not be that bad since he believed it would breakdown easily in landfill. However, this is not the case as anaerobic digestion of organic matter will cause harmful gases to be emitted, adding to the problem of global warming as well as potentially human health. This could well be the perception of many consumers, so there is possibly a need to educate people about this and other food waste issues. Francesca, a primary school student, highlights how effective school initiatives can be in educating consumers about food waste and more general food production.

3.4 Consumer Journey Maps

Figure 15 Consumer journey map using the character of Fred

From the previous research and literature review, we decided to focus our project on consumer food waste as currently waste within the home is a huge issue. It was decided that our consumer journey map should focus on the scenario discussed above about shared households and lack of communication. An eighteen-year-old man, living at home with his family (Mum, Dad and Sister) was chosen as the character for our journey map and he was named Fred. It focuses on Fred choosing which food to consume within the home, how and why he wastes it and considers various intervention points along the journey.

This journey map shows how a lot of food consumption is done on impulse without consideration of food waste; especially when the consumer is busy which is common of modern lifestyles. The first highlighted intervention point was when he chooses to eat from a new packet of food instead of eating from an already opened and going out of date packet. In this instance we noted he might be feeling overwhelmed by his food options and in a rush to get back to playing his game, therefore just choosing his food quickly without looking for alternatives they may prevent food waste. From this, we thought of various design solutions that could make his decision process easier and quicker whilst also reducing food waste. The food that was going out of date first would need to somehow be made obvious to the consumer. We noted the fridge as an integral factor that influences the consumer's choice and this would potentially be an ideal place to display information about the available food, or elsewhere in the kitchen.

The other intervention point is when Fred throws away his bread crusts (which could also be substituted for any food waste). There could be multiple reasons for this food going in the bin; food preferences, Fred could be full, there may be no alternative to the bin, cultural norms don't accept the re-use of food (e.g. bread crumbs for baking) and so on. Therefore this gives us a few possible ways to intervene; providing an alternative to a bin, such as an indoor composter and food growing space or a digester to produce energy. We could also consider addressing cultural and social norms about foods, for example encouraging consumers to eat edible yet misshaped foods or use their leftovers for a new food dish.

3.5 Methods Conclusion

Overall, our various research methods have highlighted the many areas that our design could intervene at to reduce food waste. It was already decided earlier that we would focus on consumer food waste, since the literature review showed this area of the food system to be particularly wasteful. Our further research then seemed to suggest that waste within the household would be an ideal focus since our questionnaire showed most waste to be from 'gone off' foods, and not from buying too much in the shops. From there, our research suggested that focusing on fresh food going out of date within a shared household setting, where communication about purchased food is often lacking, could be a great way to address food waste. Including information about when the various foods go out of date, how to store them correctly, how much money the consumer might save/waste, how much food the consumer wastes and how to use or re-use different food in dishes would also only enhance our final design idea. Our research also shows it is imperative that the end solution be convenient and easy to use, thereby enabling it fit with modern busy lifestyles.

4. Ideation

4.1 Design Brief

At this point we had fully researched the topic with the intention of gaining an educated understanding of the market. We had determined our objectives, intended intervention point and potential customers using several methodologies, including IDEO's. To realize our objectives we planned to, as a team, come up with as many ideas as possible and develop the best of them with the intention of being able to choose our final concept out of several semi-developed ideas. We would then build on this final concept to the point where we could potentially produce it.

To summarize our research, specify our aims and detail our intended customers we produced a Design Brief. This document would be used to simplify the problem and act as a reference point throughout the remainder of the design process to ensure we kept on track and achieved our objectives. Any concepts we developed would be judged against our Design Brief.

Design Brief
What activity will we be attempting to encourage, or problem space will we engage in? • We are attempting to encourage the consumer to produce less food waste • We will focus on food related to the fridge • We have identified large sources of waste to be households with shared food and fridges
What businesses or organizations do we foresee as potential clients? • Supermarkets • Consumer storage providers • Smartphone app providers • Food package producers • Online cooking channels
Who are our audiences/users/personas that we will focus on as our target audience? • Shared housing, such as families, where the line of communication between the purchaser of food and the consumers of it isn't entirely clear

It was important that, while this Design Brief was a useful tool to represent our market research, we didn't allow it restrict our idea generation, limit the application of our concepts or constrain out potential customer base.

4.2 Concept Generation

Initially, we used divergent thinking to come up with as many ideas as possible. These ideas were randomly generated during a team brainstorming session. We attempted to find solutions to the food waste problem based on our research, personal experience and potential gaps in the market. The ideas we came up with weren't exactly concepts but were directions we could consider taking our designs.

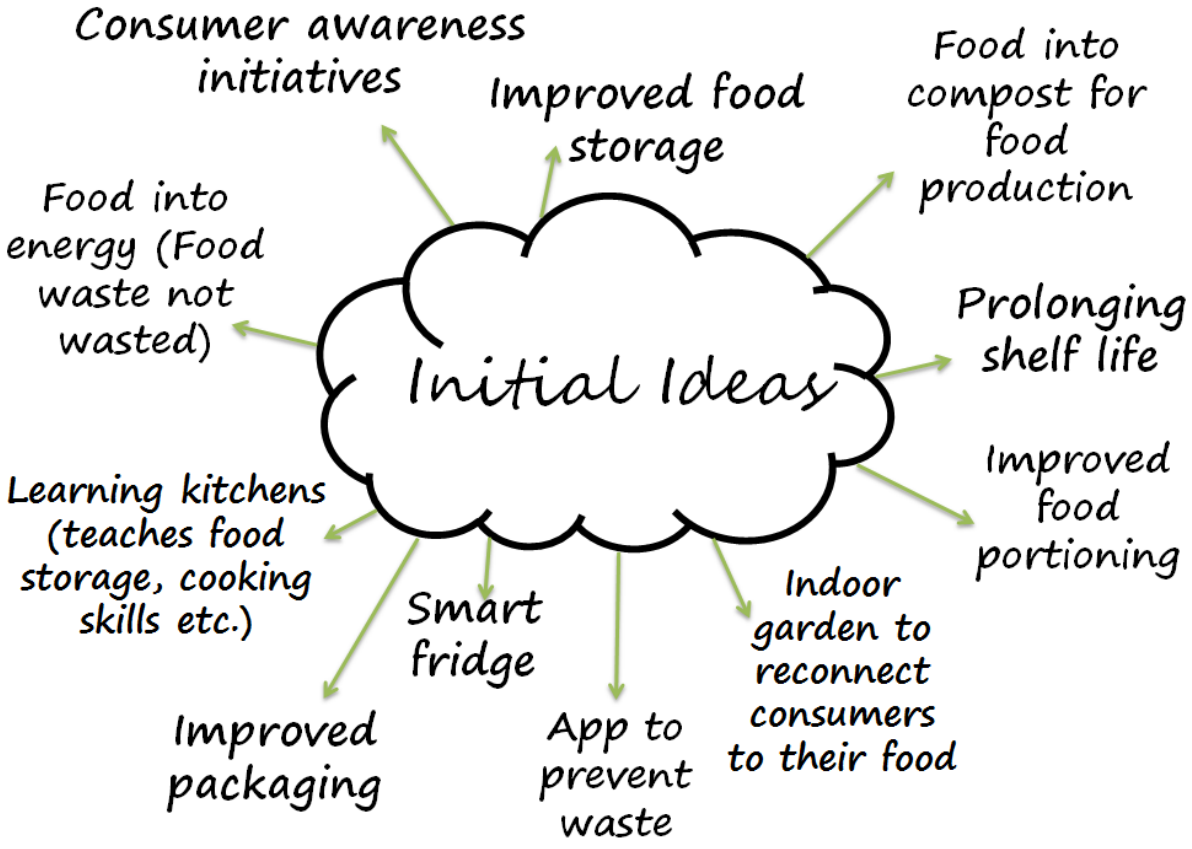


Figure 16 Initial Ideas

We came up with ideas of various forms including stand-alone products, adaptations to existing products, campaigns to change customers' perspectives and infrastructural changes. We decided a product, physical or otherwise, that could become part of a customer's everyday habits and lifestyle in a way that was easily accessible to as many people as possible would be the most effective way of reducing food waste on a large scale.

4.3 Concept Development

We were now at the stage where we had to decide which ideas we would take further and semi-develop into full concepts. If we had at the stage only picked one idea to take forward, we believed that we would have limited our opportunity to come up with creative solutions or advancements. The team decided on three of our best distinct ideas to take further:

Table 4 Concept Development

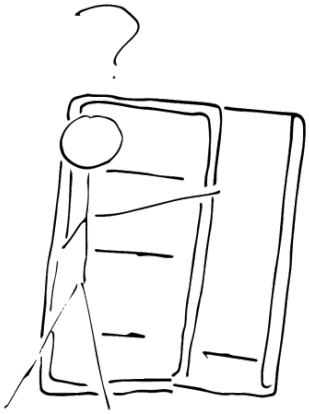
Concept	Origin	Explanation	Problem solved
Food Expiry App	App to prevent waste	An app which would inform users which food was about to go out of date.	Food going off before the customer had a chance to use it.
Shared Buying App	Community sharing initiative	An app which would link people with similar purchasing habits.	Food being bought in quantities that are too large for a single customer/household.
Storage Container	Improved Food Storage	A container that would make food last longer once it had been taken out of its original packaging.	The life of food that is commonly wasted, such as fruit, vegetables and meat, is drastically reduced once it is removed from its original packaging.

The table shows the concepts, how they evolved from our brainstorming session, how they may work in practice and what areas of the problem they could address.

4.3.1 Use Case

We then worked on the use case for each of the chosen concepts where we discussed in further detail how these concepts could work in practice and considered various options. For this process, we put ourselves in the user's shoes and imagined how the concept would fit into their daily routine and any potential opportunities or weaknesses that could arise.

Food Expiry App



The idea behind this concept was to assist the customer in fully utilizing the food they had already purchased. Our research showed that the most common reason people threw food away was due to it going off. The group decided the most likely reasons for this are consumers forgetting about food they had bought, planning their meals incorrectly or being uninformed of alternative ways it could be used. To solve this problem, various design features were considered:

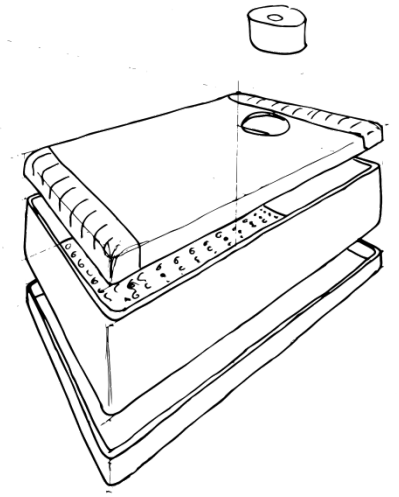
- A traffic light system which showed how close food purchased was to going out of date, so the user wouldn't forgot about items they had purchased
- Incorporation of recipe ideas into the app, which would suggest options for properly using food in the user's fridge or cupboard
- A link to the customer's supermarket loyalty or nectar card to avoid the task of manually inputting the food purchased
- Link together the people in a certain household using the app so that everybody knows what food needs to be eaten.

Shared Buying App

The intention of this concept was to encourage the sharing of food as soon as it is purchased. A big problem that we discovered contributed to food waste was that the size of the portions available to people in supermarkets was often too large for the consumer to use it all before it had to be thrown out. This app would link people together at the stage before the food was purchased with the intention of the consumers then splitting the contents into more suitably sized portions. The group decided this was the best stage to intervene due to the perceived embarrassment and potential hygiene issue of taking people's leftovers. Several features of the app were proposed, including:

- A system which would link together local people using the GPS in their phones, to make the splitting process more convenient
- A feature which records your common purchases and required portion size to autonomously link together people with well suited needs.

Storage Container

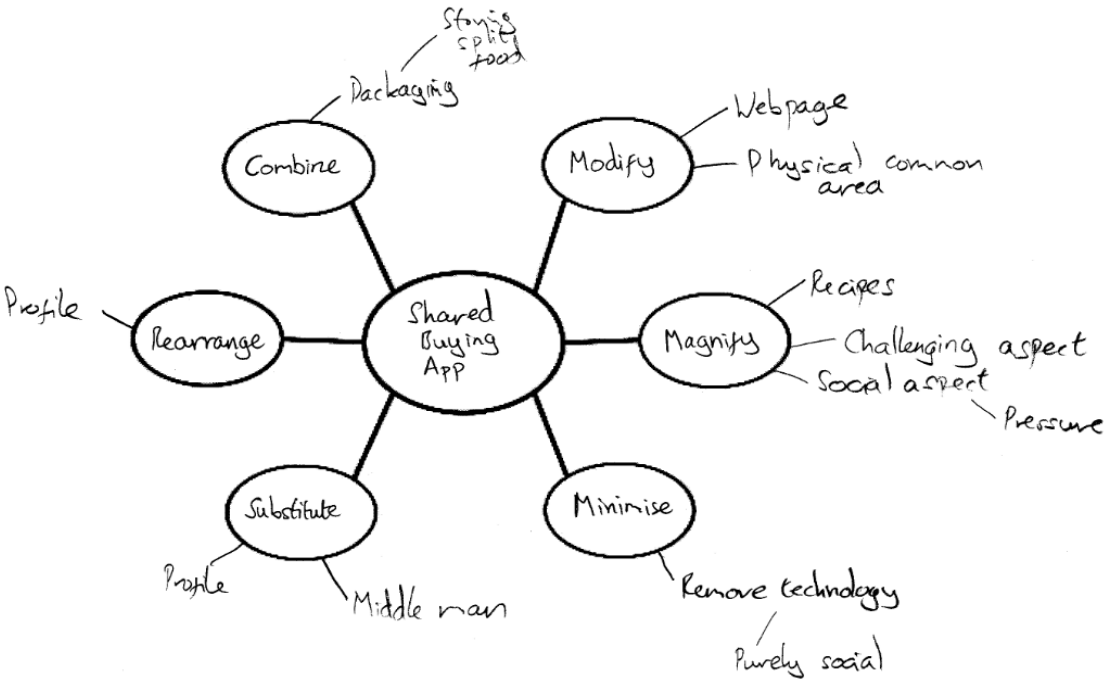


Our research into how various food items go off and become rotten led to us considering this option of a storage container which sought to slow down the deterioration of food that had been taken out of its original packing. The container would do this by removing ethylene, moisture and oxygen from the food's immediate environment to limit the growth of bacteria. To achieve this we considered including several features, such as:

- A material, such as the one used in M&S's 'It's Fresh' packaging, incorporated into the container which would absorb ethylene and slow down the ripening of fruit and vegetables
- A pump system which would remove oxygen from the container after it has been sealed
- A process, such as microwaving or heating, which would reduce the moisture content of the food without affecting its quality.

4.3.2 Osborn Maps

Once we had considered how we perceived each concept might work in practice, we decided to produce Osborn Maps to develop out concepts further. This proved to be a more systematic approach to expanding our concepts by providing direction in terms of altering their form or approach. The following is our Osborn Map for the Shared Buying App:



Along with the equivalent maps for the other concepts being developed, this map proved useful in making us think in different ways about ideas. For example in this case, we began to focus on the function of the core concept, i.e. a method of encouraging people to purchase food as a group.

4.3.3 Limitations Analysis

We then decided to analyze the limitations of each concept with the intention of eliminating or minimizing any weaknesses. This was the last stage of our concept development prior to choosing our final concept, so points raised at this point would be carried over to the selection stage. The following shows some limitations of our Food Expiry App and the options we came up with for minimizing them:

Table 5 Limitations Analysis

Limitation	Explanation	Potential solutions
Method of sourcing the data	The task of manually entering the data would be time-consuming and potentially inaccurate, which would be off-putting to potential customers and limit their commitment to the app	Extracting data from loyalty cards
		Image analysis of receipts using phone camera
		Scan product bar codes as they are stored at home
Partially using a product	The app must have a system that allows the customer to inform it when part of a product has been used and the remainder is still being stored	Split each product into 'portions', for example a packet of tomatoes may be viewed as three portions and the customer may strike one off when it is used
		The customer could have an option of reducing the amount of a product remaining on the app by making an approximation of how much has been used by weight
Variation of expiry date by storage method	Inaccuracies in how much longer the customer may keep a given food product may be created if people store things badly or in different ways	State an advised method of storage which will lead to the expiry date given

4.4 Concept Selection

We now had three workable concepts to choose from. To impartially choose the product that best fit the objectives, we had to use several other tools. If we chose poorly at this point we would either have ended up with an inferior final design or had to backtrack at a later point, which would have wasted time. So it was important to critically investigate our designs from all angles.

4.4.1 SWOT Analysis

The first tool we used was SWOT (i.e. Strengths, Weaknesses, Opportunities and Threats) analysis so that we fully understood the good points and bad points of each concept. This process is useful in that it encourages the designer to examine the concept from both an internal and external viewpoint. In this context a strength of a concept is an internal aspect of the product or organization, such as cost of production, which gives it an advantage over other companies or products that intend to reduce food waste, whereas an opportunity would be an external aspect of the market which could be exploited, such as an increase in the ownership of smartphones if we chose an app. A weakness of a product could include the difficulty of using it, while a threat could be the risk of entering a crowded market. This is our SWOT analysis of the Storage Container:

Table 6 SWOT Analysis

Strengths	It is expected that the product would be very easy to use and incorporate into the user's everyday life and existing habits as it is likely that they already use something to store food, whether it's cling film or standard plastic containers.
	This product is entirely stand-alone, as it doesn't need any other product or platform to function.
	It is possible to use this product with a wide variety of food types, such as fruit, vegetable and meat.
	Research tells us the product is unique in the number of functions it carries out.
Weaknesses	The product will be expensive to produce relative to its competing products, i.e. standard plastic containers, due to its complexity.
	The moisture and ethylene absorbing materials would need occasional replacement so consumers must continually purchase replacement parts.
	The quality of the contents may be negatively affected during the dehydration and evacuating processes.
	The effectiveness of the product would be severely affected by any structural damage, such as holes or a damaged seal, as this will let in moisture and oxygen.
Opportunities	Food waste is quite a popular and well-publicised issue so demand for

	a product that helps will exist.
	The internet provides a cheap, effective and convenient way to advertise a unique product.
Threats	The market for food storage is crowded with a large amount of options available.
	Several large brands exist in the market already and attracting customers and large retailers would be difficult.
	Mass production is much cheaper abroad so logistics could become an issue.

4.5 Decision Matrix

Using the results of the SWOT analysis, we directly compared the characteristics of each design to our original objectives to investigate how each concept matched up to them and ensure we were still on track. This was translated into a quantitative score to allow the creation of a decision matrix. The use of this tool lead to a precise and impartial decision making process where all the important aspects of the concept were taken into account and given an appropriate rating to take into account how important they were relative to each other. This was important as it ensured we picked the most well-rounded concept, for example, a highly effective product that was too expensive to be adopted on a large scale would obviously be impractical. The decision matrix rates each criteria from 1-5 based on perceived importance and each concept from 1-5 based on how well it matches each criteria.

Table 6 Decision Matrix

	Concept Name						
Criteria	**Weight**	**Food expiry app**		**Shared buying app**		**Storage container**	
		Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Convenient to use	**4**	4	16	2	8	4	16
Manufacturing costs	**3**	4	12	4	12	2	6
Ease of manufacture	**2**	4	8	4	8	3	6
Affordable for the customer	**4**	5	20	5	20	3	12
Ability to reduce food waste	**5**	3	15	4	20	3	15
Size of market	**3**	4	12	2	6	3	9
Total			**83**		***74***		***64***

This process lead the team to choose the Food Expiry App as the design that we would take forward and fully develop into a marketable product.

5. Design Discussion

Using the research and results discussed in the preceding chapters there was a clear concept that had taken form. This consisted of an app to inform the user of food going out of date and would help them with their food shopping habits. It was decided to incorporate a separate idea, the fridge device, a magnetic tablet intended for the fridge that would allow a better transition from traditional behaviors and provide a common information point for all members of the family in a shared environment. The service was designed to provide the user with the tools and information that would allow them to improve their shopping and eating habits and reduce food waste. This is a more productive method than a system that forces or nags the user into cooperating.

5.1 User Journey

As the concept is a service based around an app and a product, it was important to first develop the customer journey and develop how all the elements fit into this experience. The user journey is as follows:

1. The user goes shopping and selects products that they require and takes them to the checkout. This can also be done on a shops online service.

2. The products are then scanned at the checkout. This is the method for collecting the information on product bought. However for the service to work it is required to collect best before dates for each individual item. To achieve this, the research recommends adding to the traditional barcode to include this information or switch to a system similar to a QR (Quick Response) code.

3. This information is then collected. There are a few options to how this could be achieved. Firstly the service could use the stores own rewards card to gather the information to an online source. This would limit the user to a single brand so the service could use its own card which would be scanned at the checkout in the same way the customer would a rewards card. The information would then be uploaded to the servers. To take this idea further the system could get rid of a physical card and replace it with a digital card on the app on the users smartphone. Alternatively it could take advantage of new technologies such as near field communication (Cartner, 2014), which could eliminate the need for the store to upload the information and instead it would be loaded directly onto the users phone.

4. The data is then automatically synced with the users app account. This is used to view the use by dates for food in the users possession and gives warnings of food currently getting close to that date. The app has the ability to advise the user on possible recipes that include those foods that are going out of date so they have a better idea of what to do with them. This also provides education to the user and will improve their cooking skills and knowledge of how ingredients can be used. The app also contains a shopping list feature to encourage the user to be more organized by making it easier for them to do so.

5. All this information is also synced to the fridge tablet. This contains the same information as the app but is intended to be used by the entire household and is situated on in the kitchen on the fridge so the information is available where it is required.

6. The user can then use the tablet as a shopping list by scrawling on it using the provided stylus. The device detects the words being used and inserts them into the apps shopping list. The user then uses this shopping list next time they visit the store.

5.2 Fridge Tablet

The fridge tablet is the physical form of this system. It is designed to be two things. Firstly a physical dedicated version of the phone application that allows any member of the household to see the relevant information, secondly a transitional item from paper shopping lists to a digital alternative.

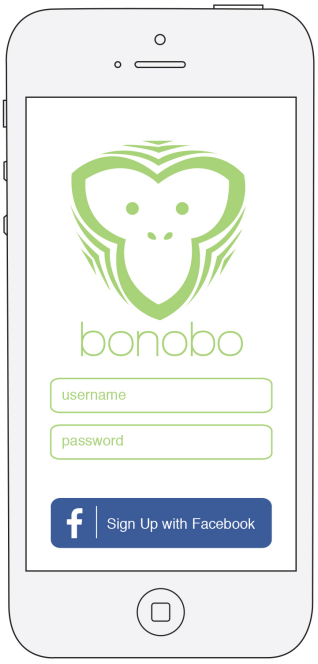
It is designed using inspiration from Jonathan Ives and Dieter Rams style of work and is intended to look minimal therefore providing emphasis on the information rather than the device (Lovell, 2011). The device has been well thought out in terms of innovation, usability, aesthetics and sustainability in thorough detail. Consisting of a main body made from black plastic which houses all the components and stylus. It has a glass screen panel, brushed metal front surface and on/off button and a brushed metal back magnet. The tablet is asymmetrical in order to be easier to hold in one hand while using a stylus and as the stylus can be inserted into both sides it is also usable by left handed users as well. The magnet on the rear of the tablet protrudes further than the casing to enable it to be used with a wider range of fridge surfaces. The design allows it to be fixed to curved surfaces in both directions as well as flat ones, which may have not been possible with a flat rear surface. The shape also helps with gripping the device while using the stylus.

During development of this design one of the major considerations was with the screen. By using current tablets such as the ipad as an example. A screen such as that wouldn't have been possible due to its effect on battery life as an aspect of the design was that it had to be unobtrusive to the user and they would not have to take it of the fridge to recharge. It was decided to use an e-ink display for the design similar to those used on the Amazon Kindle but with the touch screen function as well. Devices with screens have been known to last up to one month as they only use energy when a pixel changes but require no power to keep an image on screen. The screen contains tiny balls suspended in fluid. One side these balls contain positively charged white pigments and the other negatively charged black pigments. When current is supplied to the balls they flip this creating an image (Pervasivedisplays.com, 2014; Bonsor, 2014). While this display allows much longer periods between charging the device it does lose the ability to produce color images.

The content of the fridge tablet mirrors that of the app, which will be explained in the following section besides one feature. The method for manually entering an item in the apps shopping list can be done by

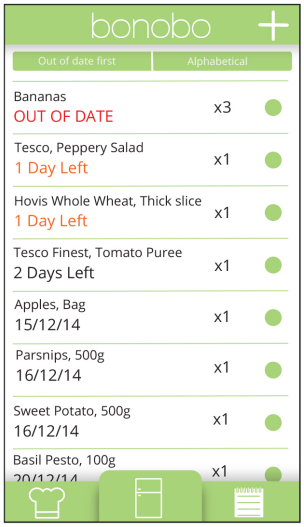
typing as on a phone or by scrawling like you would on a conventional paper notepad. This is to give a feeling of familiarity to the user and help with the transition from physical to digital methods. A consideration for future development with this device that was brought up during presentations was that it could be designed to stand out more and use a color coding system to better show the foods that were going out of date or getting close to that stage. Colors could be used in the physical appearance of the device to attract the users focus or be designed to look appealing to a younger audience, which may encourage them to use the device. Therefore changing behavior and providing education at a younger age which the child would hopefully carry on into later life. A color-coding system on the screen was considered during the development.

5.3 Phone Application



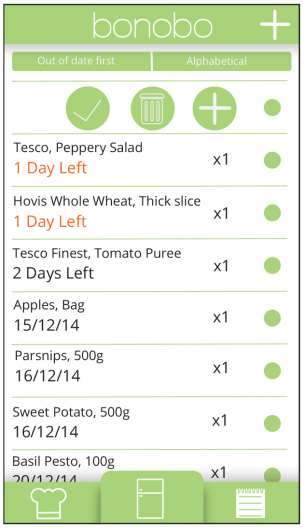
The phone application was designed to be as useful and user friendly as possible whilst having good aesthetic and branding. One of the main focuses was on containing all the relevant information and tools that the user would require while keeping the interface minimal and self-explanatory.

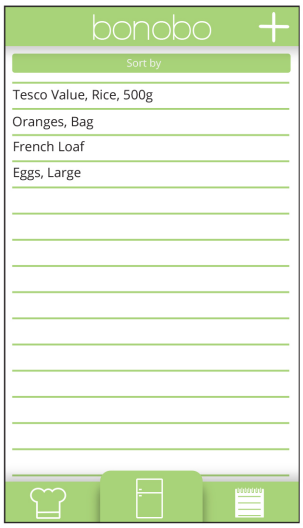
The log-in screen is very simple. The user can either set up an account by entering their email and password or sign in using their Facebook details by selecting the icon. The app is navigated primarily using the icons at the bottom of the screen and the add product icon at the top right. The main aspects of the application operate as follows-



1. The main opening screen is the same as the home screen on the fridge tablet and consists of a list of foods that the user has in stock. This can be viewed in other configurations if the user is searching for a specific type of food or ingredient. This screen includes a color coding system absent on the fridge tablet that more clearly shows foods that are out of date in red and those going out of date in orange. The screen can be reached by selecting the fridge icon at the bottom of the screen. A consideration for future development is to improve this color scale to better portray the message of time decreasing.

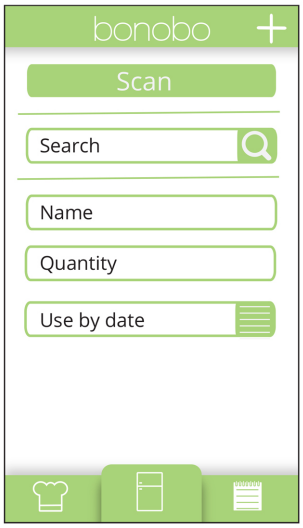
2. On the same screen, once the user has used a product they select the small green dot to the right of that product which reveals more options. These three icons allow the user to either tell the app that the product has been thrown out and wasted by selecting the bin icon or used by selecting the tick icon. They can also use the plus icon to add the product to their shopping list.

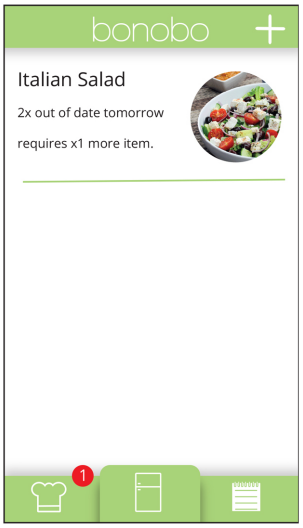




3. The shopping list screen is accessed by selecting the note pad to the bottom right of the screen. This can be added to by the method discussed on the previous screen or by simply selecting an empty line, which will reveal the keyboard and allow the user to input manually. The user has the option to sort this page as required.

4. While the user might just shop at a super market chain that has the ability to gather data on the foods purchased the app allows users to shop elsewhere and add those purchases manually. By selecting the plus icon at the top right of the screen it opens up the menu. The user has three options on how to add a product to the application. Firstly the user can scan the barcode or QR code if the product has one, secondly they can search the applications database for the product and if neither of these options is applicable then they can enter the information manually. The app does help on this third option by allowing the user to search for a suggested use by date on the database.





5. Lastly by selecting the chefs' hat icon at the bottom left of the screen the user opens the recipes screen. A red number representing the number available will appear on the icon if the user hasn't viewed it yet. It is suggested that the app could gather these recipes by collaborating with a third party such as recipe website and app Big Oven.

Another feature for development is the ability for the app to gather information on what foods the user regularly throws away and suggest changes to their shopping habits to further reduce food wastage.

An important consideration of this design is how to influence companies to participate in the system. There are two methods that are considered. Firstly was the opportunity to promote their position on

helping the environment by working with a program aimed at reducing food waste and secondly the ability to advertise their product on the recipe section of the app. The idea is that when the app knows that a product is going out of date and generates a recipe from a source the user may not have all the ingredients for all recipes advised so the app will show the user that it can be purchased from a specific store for and the cost. This would allow the stores to push products and deals but concern is that it may have to be controlled at some level to stop it having a negative impact against the purpose of this service.

5.4 Technology Developments

As this project is theoretical in the sense that the technology was not prototyped, developed or tested in line with the aims of the design. One of the big decisions was where to place the design within the technology timeline. It was decided to only use technology that was currently used within existing products or could be seen as a possibility.

When scanning items at the checkout the current barcode does not hold the use by date required by the service to function. One recommendation is to add to the barcode to include this information, which would require printing a larger barcode without much significant cost. There is a rise in popularity for QR (Quick Response) codes and while at present these are used primarily to provide the reader with a link to a website or server. This could be re-purposed to be used in place of the barcode and would allow for more information to be held and can be scanned from more directions than a barcode. RFID (Radio-Frequency Identification) could also be used in the future. It is argued that the costs of implementing such a system would be to great and would even add to the costs of the packaging. However recent development has allowed researchers to simply print the tag onto the products packaging instead of a barcode. If costs can be reduced to compete with that of printing a barcode then this could be a large consideration in this project. In theory RFID tags could be used in union with a fridge and cupboards containing RFID scanners to detect the food that the user has without the need to take that information at checkout and without the user having to manually remove the item once it has been used (Barcoding.com, 2015; Grossman, 2010).

The other piece of technology that does not currently exist in any product is the screen proposed for the Fridge Tablet. The configuration that could be used in the design is the combination of an E-ink display from an Amazon Kindle with a touch panel found on modern devices. This was for the purpose of energy saving however it is hoped that as technology progresses color displays will use less energy so this would not be required. A color display would also allow for a more eye catching device and the use of a color scale to better show users what items were going out of date as used in the smartphone application.

6. Conclusion

6.1 Issues addressed

During our design process and concept development a number of key issues arose which needed to be addressed. The key issues that arose when developing our concept were convenience, awareness of food waste, food education and cooking skills, consumer budgets, food safety and overall a reduction of food waste. The key issues have been addressed as follows.

6.1.1 Convenience

In the initial stages of our concept development it became apparent that in order to reduce food waste we had to create a product combined with an app, which would be convenient and easy to use. This insight was realised in our focus group, where we discussed our initial concept and envisioned the usability and convenience of our product and app. Our initial idea required users to manually add data to the app. However we realised that the users would not want to process a large quantity of data, especially as we realised that this process would generally take place at peak times of shopping. Given that there is an ever-decreasing shopping time capacity of consumers shown in our research, it was clear that convenience was a key issue, which needed to be addressed. The application and service is designed to be as little time consuming as possible while still providing the user with relevant information.

The convenience of the service increases with continued use of the app as it gathers data on the users habits and helps them to reduce their food waste. All information relevant to the user is displayed to them when they need it and the fridge tablet is placed at the convenient location for the rest of the family. The tasks to be accomplished by the user have been reduced to few as possible. If the user purchases food from the supermarket, the only task the user must complete for the service to work as intended, is to select the food on the app when it is used or binned.

6.1.2 Awareness of food waste

Another key issue that arose when conceptualising our idea, was the lack of awareness of food waste as a cause of the bigger issue. The majority of our design group were unaware of the extent of food waste and that it is a major problem in the UK. In order to confirm our initial observation that there is a national lack of awareness of food waste we undertook a number of research methods. This included questionnaires, focus groups and secondary research. Our research confirmed that the lack of awareness of food waste, was not confined to just our design group, in fact it was apparent in the UK's general public and is a national problem.

Therefore in order to increase awareness of how much food is wasted nationally we conducted extensive research in order to support our argument. After collecting the evidence to support our argument we developed a strategy, which aimed to shock our audience. In our presentation we delivered a number of shocking facts aimed to create emotion in our audience and provoke a reaction.

Based on the feedback that we received in our presentation, we feel that this was achieved. Therefore in order to re-create this reaction we will increase the consumers' awareness of the problem and the

negative effects it has on their environment. However on the flipside we will also give our consumers the ability to help reduce these food waste figures. Our app will give consumers the capacity to help reduce the problem and will also provide consumers with links, information, groups and other products, which all help to reduce food waste.

6.1.3 Food education and cooking skills

During our creative focus groups we identified similarities between successful ideas, apps and products. In order to create a successful app and product we needed to overcome the issue of personalising, educating and engaging with our consumers. It is extremely important to build a relationship with consumers and to personalise the app to meet the needs of each consumer. The app provides this by gathering data and using it to supply a custom service to the user. By adding an educational factor in the form of recipes to our products there will be an increase in usability, interest and reduction in food waste as our users will have an increased education in food preparation.

6.1.4 CONSUMER INTEREST

Another issue that arose when addressing the problem of food waste was how to attract interest from prospective industry retailers and consumers. During times of recession there are substantial declines in resources available for industries; consumer behaviour changes as well as customers becoming more price sensitive. For companies to survive and compete they have to satisfy their customers' needs at a lower price (Pearce and Michael, 2006). Understanding the importance of changing consumer behaviour by using financial incentives gave us an insight into the importance of developing our concept into an app and a product which would help households to save money whilst reducing food waste.

Although we recognise that it would be preferable to change initial customer buying behaviour rather than at the later stages of customer consumption we want to reduce food waste immediately and drastically and feel that our long-term goals will help prevent unnecessary buying behaviour. Therefore our short-term goals will reduce food waste and our long-term goals will educate our consumers and aim to influence their purchasing behaviour.

Therefore our app and fridge tablets ability to alert the user that his food is going out of date and will be inedible will provide a service to encourage the user to eat the food before it goes out of date. Thus, making the user less likely to purchase food from other avenues such as takeaways, food retailers or eating out, which will result in a reduction of the user's spending on food.

6.1.5 Food safety

Another key issue that arose when conceptualising our idea was the safety considerations involved with food waste prevention measures. From our collective research we identified that this could be a serious issue if it was not addressed effectively.

In order for the app and fridge tablet to be effective and reliable, state of the art technology and processes will be used in order to guarantee that the transfer of data from a loyalty cards to the app's databases is reliable and thorough. Extensive research and testing of the software will be undergone in order to certify the reliability, capability and legitimacy of the software.

Fortunately the data that will be processed will be a copy of the data received from supermarkets. Food industries have vigorous food and health safety procedures and measures to meet which will guarantee that our information is correct and they also allow one to three days of leeway (HSE, 2014).

6.2 Other outcomes

There were a number of other outcomes that arose when identifying the key issues involved with reducing food waste. Developing our concept, app and fridge tablet resulted in a number of exciting outcomes that could provide industry interest, generate revenue, gain investment and make our products more accessible.

6.2.1 Commercial and industry interest

Given the economic climate and the increasing competitive nature of businesses it is key for businesses to provide customers with new and innovative products and services. With industry cooperation, our app will provide an exclusive opportunity to capture customer data (ORI, 2014). This data will include customer-spending habits, budgets, choices, time frames and customer interaction in retail outlets. This data can either be sold online to companies such as www.thedataexchange.com or can be used by the retailer in order to meet the needs of the customer in the future (Data Exchange, 2014).

The app contains a function that will encourage the user to add to existing ingredients and food options by completing meal options with a return visit to the supermarket. This will generate more revenue for retailers and increase customer loyalty. Gaining customer loyalty is extremely important given the intense competition in mature and saturated markets. It is proving to be more difficult for retailers to sustain differentiated brands and value propositions (Merlin et al, 2004).

6.2.2 Accessibility

In a constantly evolving and demanding market place, products and services must be accessible to meet the needs of potential customers. This is vital for the success of design products. An early outcome that our group realised was the need for our product to be accessible in terms of price and mass usability. By making the app readily available for smart phone and tablet users at a low cost we will be able to target a large segment of the app users market. Additionally our fridge magnet will be priced competitively and will be aimed at the mass market.

6.2.3 Alternative funding

Another outcome that arose when developing our idea, app and product was alternative means to fund the project or gain investment. One government scheme that has been considered is an Enterprise Investment Scheme (EIS) that essentially encourages high-risk companies to explore opportunities with the incentive of tax relief (HM Revenue and Customs, 2013). After extensive research we discovered a number of schemes that aid environmental friendly or sustainable UK companies. There are government schemes that give incentives to companies who are actively seeking to reduce food waste (HM Revenue and Customs, 2013).

6.3 Limitations

There were a number of limitations that we experienced when working together in a group. Time was the first obvious limitation, we had limited contact time with each other due to group members conflicting timetables, other work commitments, logistical issues and other various issues. Next were the group's collective understanding of the design processes and a collective understanding of the concept and other ideas. This proved difficult, as four out of the five members of the group had not taken a design module before. Although communication is extremely efficient in the twenty first century, there are still communication barriers that exist which can be challenging at times.

Lastly, limitations arose due to the variance of the five separate pathways on MSc International Innovation. In our group we have Design, Environmental, Engineering and Entrepreneurship pathways. Although this gives our group a wealth of knowledge and gives extensive perspectives it meant that there are different backgrounds, which can lead to differing objectives, proving to be challenging and limiting at times.

6.4 Working as a team

However given that there were a number of limitations as previously mentioned we overcame these issues by utilizing a strong work ethic and working well as a team. We helped one another in a number of ways including understanding new design processes taught in lectures and utilizing each other's knowledge and skills. By gaining a clear understanding of extensive design processes we were able to make a collective decision on which design process would be the most suited to meet the needs of our group and to meet our objectives.

Our group was also able to successfully implement creative and efficient brainstorming sessions, which encouraged all members to input ideas and creativity. This helped form the basis for our concept and allowed us to develop the idea of an app and fridge tablet. Utilizing an array of degrees including Doug's MSc International Innovation (Design), Kealan's MSc International Innovation (Engineering), Toby's International Innovation (Entrepreneurship), Samuel's International Innovation (Entrepreneurship) and Bryony's International Innovation (Environmental) background gave a wealth of perspectives on the task of reducing food waste in the UK.

6.5 Objectives

The objectives of our group project were to reduce food waste; change consumer behaviour and improve consumer knowledge; create a marketable app and fridge tablet; create an app and fridge tablet which is easily accessible; and change industry and government behaviour towards food waste.

6.5.1 Reduce food waste

Firstly from the evidence provided it is clear that our app and fridge tablet will reduce food waste as it directly deals with the problem of households not knowing whether their food is past its expiry date and whether it is edible.

6.5.2 Change consumer behaviour and improve consumer knowledge

Secondly our app and fridge tablet will change consumer behaviour and improve consumer knowledge as it will successfully alter consumer behaviour by changing their shopping routines, attitudes towards food waste, awareness of cost savings and improve consumer knowledge of the food they are buying including its origins and other various educational knowledge.

6.5.3 Create a marketable app and fridge tablet

Next we have created a marketable brand, app and fridge tablet, which we feel represents our company ethos, which is to reduce food waste. The Bonobo monkey represents our brand. They are very social animals that share food and knowledge, something that our research highlighted there was a lack of and we are trying to encourage. Our interactive and engaging app can generate revenue in a number of different ways and our fridge tablet can be sold in different retail outlets and/or online.

6.5.4 Create an accessible app and fridge tablet

Another objective was to make the app and fridge tablet easily accessible which we have achieved by making the app readily available at a low cost on smart phones. Also our fridge tablet will be sold to the mass market at a competitive price.

6.5.5 Change industry and government behaviour to food waste

Our last objective was to change industry and government behaviour towards food waste as a serious problem. We understand industry views and behaviour towards food waste to be simply commercial and there is lack of concern for food waste at a consumer level. However by providing industries, especially retailers with the knowledge on how to gain consumer insight, valuable data, as well as increasing brand loyalty and customer satisfaction and generating revenue by reducing food waste gave the clear indication that changing industry behaviour can be achieved. Furthermore our idea to give our users an opportunity to help charities as well as being educated and reducing food waste will gain the interest of the media and government, overall increasing media coverage and developing the brand image.

6.6 Future Development

In order to stay ahead of the competition it is imperative for companies to innovate in order to meet the consumers' needs (Drucker, 2002). In order for our brand, app and fridge tablets initial and continued success it is important to increase usability and gain a competitive advantage. Therefore Bonobo will always aim to offer current and future customers new products, services and features to the app and fridge tablet.

One way in which we hope to achieve increased customer loyalty and gain new customers is to add features to the app and the fridge tablet. One feature that we will immediately install is an alert system for our fridge tablet. Although we have considered a number of different solutions we will initially use a traffic light system. This system will use flashing colors which will correspond to data for the food in the fridge that is going out of date, providing our users with a fun, interactive and engaging way to know

when their food is going out of date. Moreover the information on the fridge tablet will be synced with the app on their smart phone, which will alert the user as well.

We aim to personalize our app and fridge tablet for each one of our users by using near future technology which will help us understand our consumer behavior enabling us to meet each users' unique needs in a more sustainable manner.

Other features added to our app and fridge tablet will be based on customer feedback, technology advances, usability, government regulations and industry changes. Due to our strong brand, company ethos and key message that is to reduce food waste, we will be constantly trying to align our objectives and aims to reducing food waste.

Moreover part of our long-term goal is to raise awareness of food waste as a problem, change consumer, industry and government behavior. Bonobo will seek new innovative ideas and concepts which will encompass design processes, ideas, and our key message and company ethos that will in turn reduce food waste as well as educating the general public, industries, institutions and the government.

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Appendixes

Individual Reflections: Byrony Roberston

What I did:
Within the group I attempted to keep us all on track, sometimes setting weekly deadlines for research or parts of the presentation and report to be written by. Initially I did a lot of the research about food security and consumer behavior, since that was my dissertation topic as a Geography undergraduate, and so I already had some understanding of it. As a team we later allocated sections of the project to one another and I agreed to write up and present the methods and analysis section. Having consulted the IDEO cards together we decided on the main methods being a questionnaire, more in depth interviews, food diaries (using photography as well as descriptions of waste) and the consumer journey map. I was then in charge of designing these methods (i.e. the questionnaire, interview questions and layout of the diaries), having already designed similar at undergraduate level. I conducted the research with some help from the rest of the team who conducted a few of the interviews and they themselves did a food diary each. I have also largely been in charge or formatting and designing the PowerPoint presentation and final report.

The role of design in my discipline:
Within the environmental sciences it is often necessary to have a design thinking approach in order to be able to understand and effectively manipulate/design the environment or create something to protect it. However, solutions are rarely aimed at general public consumers and so it can be difficult to compare this kind of task to ones I have experienced within the environmental sciences. Having studied human geography at undergraduate level though, I have some understanding of consumer behavior and the difficulties and complexities when trying to alter that behavior. This understanding was important for this particular project since altering consumer behavior would be key to a successful product or service on a large scale.

What I enjoyed:

I was really excited about this project as I had not had a chance to engage with a design project since school, where I used to love design technology, art and engineering classes. Since the aim was to solve a social or environmental problem and as we chose to design a product to prevent food waste, the project was even more relevant to my interests. I really enjoyed engaging with team members from different backgrounds and learning from their specific knowledge and ideas. As stated by Brown (2008), collaboration and empathy for colleagues as well as customers, are two of the key characteristics of design thinkers and I think we proved ourselves to be just that. Delivering the presentation was also a great feeling, having known we had accomplished the task very successfully and being able to see the end product.

What I found difficult:

I find that group work is always challenging in that it requires great organization to be able to fit in meetings and deadlines around every member of the team's timetables. It was occasionally impossible for every member to be at meetings, but we worked around this by using social media to communicate

and send documents. I think we also often found it difficult to organize our collective thoughts as ideas quickly progressed, and sometimes were too focused on the task to have remembered to write down our process. Therefore, a few bits of information regarding the process may have been lost. The majority however was recorded. We also found it difficult as a group to create a product or service that would not just address food waste but also question and make changes to the current food system as a whole or the consumer way of thinking, reducing food waste in the long term and on a large scale. With Stephen's and the guest speaker's help we were able to question our own existing design ideas and eventually successfully alter them to better address the problem.

What worked:

As a team I think we worked very well, utilizing each person's strengths to produce a very successful end product. We were also able to learn from each other, sharing each other's knowledge about, for example, CAD, picture editing, formatting, excel, research method design, food waste, etc. The end product also seemed like it would have worked extremely well and been commercially viable if actually produced, and so I think the project as a whole was a great success.

Next time:

If we were to do this project again, I would insist we set smaller and more concrete deadlines throughout the whole term, and improve our recording process. If we had had more time, I would like to have used more IDEO method cards as inspiration for research methods, possibly adapting and improving our final design idea.

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Individual Reflections: Samuel Bafunso

What I did:

Having a background in MSc Environmental Science and Technology, helped me understand the issues surrounding the Global food system. Having completed the module –"Food Security, Agriculture and Climate Change", I have become more enlightened about the food challenges of the 21st Century and the need to ensure the sustainability of the food system. This knowledge which I possess, was integral in the group, because it helped in framing the problem by identifying the gap which existed in the literature. Indeed, this was crucial as it paved the foundation needed to identify areas in the food supply chain where changes needed to be made to curb food waste.

By conducting extensive research in literature, consumer food waste was identified as the point, where innovations had to be made in a bid to reduce food waste. Due to the knowledge which I possess on this topic, I wrote the Introduction and the Literature review of this report. It introduced the topic of food waste globally, relating it to its definition and its characteristics as the introduction progresses. I was more specific in the literature review by narrowing down food waste to the UK. It went on to examine the current UK waste trends, the role of supermarkets in the generation of food waste and the management of consumer waste (Household waste).

The role of design in my discipline:

Presently, I am studying MSc International Innovation (Entrepreneurship) and the role of design in entrepreneurship cannot be over emphasized. I believe that associating design with entrepreneurship is mind blowing, as I am now able to address business issues with a design led thinking approach. It has provided me with the requisite skills, which I can use to improve the likelihood of customer satisfaction and achieving business success. As an entrepreneur, I am always thinking about new opportunities and pulling resources to take advantage of these opportunities. By taking this 'Design-driven innovation' module, I now have the opportunity of thinking like a designer. I can now transform the way I develop products, processes, services and strategy. As an entrepreneur, I am interested in creating customer value, design has taught me to think about how people live their lives, investigate the problems and develop solutions to these problems, before embarking on the project. I have come to understand that the aims of designers and entrepreneurs are the same – from undertaking risks to creating customer value and improving business performance.

What I enjoyed:

It is always exciting to learn something new for the first time - which I enjoyed during the cause of this module. I enjoyed learning about new methods of thinking to solve a problem. The systematic process of problem solving was particularly interesting to me. Furthermore, I enjoyed the concept selection process, which involved taking note of customer needs and also comparing the strengths and weaknesses of each concept before final selection. This whole project has been exciting from start to finish. Lastly, by leveraging on the different backgrounds of my team members, the other teams and the wealth of experience which Stephen possesses in design and guest speakers included, I have learnt a great deal from such a multi-diverse class.

What I found Difficult:

I encountered quite a number of difficulties on this project from the onset. As this was completely new to me coming from a different background, I struggled with understanding the design process, consumer journey mapping and highlighting intervention points. By staying motivated and leveraging on my other team members, who understood the concepts better and by paying a closer attention to Stephen I gradually began to understand the processes. Also, I had a vast knowledge and understanding of the literature on food waste, but coming up with a product to address this seemed to be an arduous challenge for me. Also, as a group, we had a problem of developing a product that would reduce food waste and also be environmentally friendly at the same time. With the advice we got from Stephen and the guest speakers, we were able to come up with a better and more efficient product.

What worked:

I believe the work ethic of all team members made it possible for this project to be a success. Also the carefully constructed detailed lecture notes and lessons further provided us with the knowledge on how to embark on this project. The interdisciplinary background of the team was very crucial to the successful completion of this project.

Next time:

I believe, if allocated more time, there will be an opportunity to think through how to make more effective and convenient the app and fridge magnet. Also, I believe it will be better to have the design

module twice a week, instead of one lecture. I opine that this would foster dedication on the part of team members and also provide an opportunity to receive feedbacks regularly.

Individual Reflections: Toby Venning

What I did:

During the conceptualization part of the project where we came up with our idea I feel that my contribution was significant. In order to come up with an idea which would utilize theory and practice learned during our design driven innovation lectures it was key to be original and creative. My background in marketing and entrepreneurship meant that I was always striving to create marketable apps and products which would generate revenue. In order to promote our idea, it was necessary to use current marketing practices and techniques. I called upon my the knowledge learned from my BSc Marketing and my digital marketing experience. I felt it was extremely important to use digital marketing techniques to promote our app and product due this type of medium being extremely effective and relatively low costing. In terms of the report we decided to continue the theme of our presentation and split the work up respectively. Therefore I wrote the conclusive part of the project which encompassed ideas and research.

The role of my discipline in design:

The role of design for entrepreneurship is extremely important. The combination of both pathways has given me the capability to examine international design and business issues whilst providing me with a platform to develop specialist design driven innovation knowledge and skills. These skills have enabled me to understand numerous design processes which will allow me to apply creative and analytical skills to an extensive range of businesses and social contexts including small businesses, multinational corporations and social enterprises. Design is extremely important for entrepreneurship as it effects all areas of business. This ranges from the design of a company's website, brand, offices, products, services, uniforms. Therefore I am extremely grateful to have a brief insight into a design module which has reignited my interest in design.

What I enjoyed:

There were a number of factors which gave me enjoyment and satisfaction from the project. Firstly I really enjoyed the challenge of trying to tackle a national and global issue which effects most people in the world including myself. To be able to combine this challenge with modern ideas, products and an app was extremely rewarding. Also gaining valuable experience and differing perspectives from my peers was something that I relished. Overall using theories and practice learned in lectures and converting it into a successful concept which addressed the issue at hand was very satisfying.

What I found Difficult:

One difficulty that I experienced when undertaking this project was the varying design processes. Given that I am on the entrepreneurship pathway at times I was frustrated when we could not choose which design process to follow. However with the help of team members who were more qualified and had a more critical understanding of the processes I was able to overcome my frustration. Also it was extremely difficult to come up with an idea that would be practical, reduce food waste and be cost effective. Although the project had minor complications, overall it was a thoroughly enriching and rewarding process.

What worked:

There were a number of factors which contributed to the success of the project. Our teamwork and wealth of knowledge across a number of different disciplines enabled our concept to be original and creative. The design process we chose gave us structure and guidance in order to successfully complete the project. Our app and fridge tablet are both marketable and innovative. The project's success is not dictated by charities or government handouts, instead we felt it was important to create a number of legitimate ways in which Bonobo can generate revenue, help other companies and charities as well as reducing food waste and saving consumers money.

Next time:

Although I think the project was extremely successful, there are a number of changes I would make in order to meet the demands of the task of reducing food waste in the UK. Having received extremely positive feedback we understood our concept to have substance however I feel that there could be potential to add an additional product to our product collection. In terms of group management and time efficiency, I felt that it could have been beneficial to choose a group leader, fortunately Doug took on this role. Also the productivity of the group meetings could be improved. If there was an opportunity to repeat this process it would be extremely beneficial to have a criteria or tasks which should be followed in group meetings.

Individual Reflections: Douglas Pflug

What I did:

As the only student in the group with a background in design I felt like I had the responsibility to provide assistance to over members not as acquainted with the theory and methods as I am. I was able to use skills learned within my Bsc Product Design course such as research techniques, ideation and concept selection and development.

I followed the Design Councils Double Diamond design method with this project as it provided a good structure for the multidisciplinary team to follow. During the project I took part in literature research, ethnography and observatory research methods. I used ideation methods to produce a selection of concepts, which were then put through concept selection methods to produce our final idea. We decided to create an application visualization and a CAD model of the Fridge Tablet for our presentation.

As the designer of the group I took the collective ideas and sketched some ideas and returned to the group for evaluation. The other members of the group provided me with a lot of good insights that I had missed and I used these when creating the final concept visuals. For the application I used Adobe Illustrator to produce screen shots from the application concept and Solidworks to create a model of the Fridge Tablet. The CAD model was inserted into the intended environment using Photoshop.

The role of my discipline in design:

I trained at undergraduate level as a product designer so I was already familiar with most of the theory and methodology. When I consider design in its most basic multidisciplinary form I relate to it as Design Thinking. It has always been a part of my discipline and it helps with every stage of product development. It is an integral part of product, service and experience design and provides them with methods and structure to better complete the tasks associated with these disciplines.

What I enjoyed:

During this project I really enjoyed working in such a multidisciplinary team. During previous projects at undergraduate level I have worked with engineers, textiles students and jewelry students but this project team differed as it was the first time I had worked in one where no other students had been previously trained or exposed to design thinking. It was enjoyable experience helping them discover the benefits of design thinking in projects that they may not have considered to within the design criteria. It benefited me greatly to hear their opinions on the methods used and which they found useful. I believe that good design comes from groups with different backgrounds, as there is a better chance of filling knowledge and perspective gaps therefor producing a more well rounded and throughout design. I also enjoyed learning about design methods in greater detail than I have done in the past. It has provided me with many tools that I can use to better my future projects.

What I found difficult:

While I enjoyed working with a multidisciplinary group and was pleased with what we were able to produce as a combination of our efforts it was definitely hard. Coming from different backgrounds with varying knowledge of design it took a while for everyone to work in sync and as I had previously graduated in a design course I felt some responsibility for managing this. However the group managed to work well together and produced a project that I am pleased with and is a god reflection of our combined effort

5 What worked:

Using design as a tool to solve significant problems worked very well. In my past experience I have used design thinking to help me with projects based on disabilities and other world issues but these have all been with a certain product in mind during development. This was the first time I have used design in a

more open context and found it to work very well when applied to our chosen topic. When used correctly the research, ideation and concept development methodology worked well with a topic that I would have before not considered and I enjoyed that as a group we were able to use these to produce a well-defined and significant outcome.

6 Next time:

Next time I am involved in a project similar to this I would spend time during the initial phases possibly immersing non-designers in basic and fast design briefs which include set methods in order to allow them to quickly see the benefits of the design process thus keeping them enthused for the rest of the project. Another aspect that I would have tackled differently would be the organization of the team. It was agreed with the group at the end of the project that we may have benefited from designated roles early in the design process.

Individual Reflections: Keelan Toal

What I Did:

Our overarching approach to this project was based on the double diamond process from the Design Council. It encouraged us to properly work out what we wanted to get out of our project and choose the tools that would be most helpful in getting us there. Before coming up with any solutions we assessed the problem of food waste. Our intention was to discover where most food waste came from and, through market research, determine its root cause in order to choose an intervention point. To do this we had to choose the Ideo methods that best suited our requirements. The majority of the team had never come across Ideo's methods before so it proved challenging to use them effectively. The simplest methods proved the most effective in gathering the required information and data about our consumer base, mainly the interviews and food diaries. My main contribution to the project came in the next stage once we had constructed our design brief. From my Engineering background, I had some experience of the design process, so coming up with solutions to the given problem came quite naturally. I was familiar with brainstorming ideas, considering how they could work in practice and critically evaluating them to discover and eliminate problems.

The role of design in my discipline:

Original design is integral in creating anything new and innovative within the field of Engineering. In many fields, such as consumer products and building design, it is becoming more and more important to consider the customer as technical systems becomes more complex. Designs must use the most advance technologies available to gain a competitive edge while being intuitive enough to engage the consumer. In most of the projects I've completed during my Engineering education, concept generation came first as the design brief was often given to represent a set of instructions from a hypothetical customer. This lead to a different design process as it limits the potential solutions that would be allowable and constrains their application. Another difference in approach that I came across was the emphasis on the user and other external factors as oppose to the function of the solution itself.

What I enjoyed:

The part of the process I enjoyed most was the concept development stage where we discussed our concepts and came up with creative ideas. It was interesting to see how people from different backgrounds approached a problem, came up with solutions and made decisions. The multiple disciplines of group members suited this project given the absolute creative freedom we had in that we could take the project in whatever direction we wanted and could always judge it from a wide spectrum of points of view. Within the stage of concept development, the moments I most enjoyed came from when the group arrived at a stumbling block and we had to think our way around it. This lead to an feeling of continuous improvement and progress.

What I found difficult:

The aspect of the project I found most difficult was working with a group with very different schedules and external priorities. There were several points where it was tough to get people in the same room with enough time to make real progress. The consequence of this was quite an inconsistent timeline of progress and points of the project where we were unable to take full advantage of our variety of skill sets.

What worked:

The points of the project when we were really effective were when we had a shared and concrete objective in mind. This mainly occurred when we were using the more systematic design tools, such as the Osborn Maps, or striving to reach a particular stage, such as the design brief and the group presentation.

Next time:

If we were to do this or a similar project again, I think we would achieve more if we assigned specific roles to each team member, ideally tied to educational background. For example, if, throughout the project, one team member was responsible for continuously promoting the needs of the end user, while another may focus on keeping the cost of the final product down. Another method that could have benefited our final design could have been to conduct market research at the point where we had chosen and developed our final concept. We could have put time into producing a working model of our solution and allow customers to try it out in real life, this could have revealed existing issues and created opportunities.