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DESIGN AND DEVELOPMENT OF A SUSTAINABLE LUNCH BOX, WHICH AIMS TO CONTRIBUTE TO A BETTER QUALITY OF LIFE

Abstract: *Meals prepared at home are healthier than those that are purchased. So, we have been considering the possibility of offering an aesthetically appealing product whose purpose is to store, protect and carry meals, particularly meals prepared with healthy food in balanced quantities. The SIPOC diagrams were considered in the present work. The results obtained demonstrated that the SIPOC diagram plays an important role in the process definition and improvement and should be reflected firstly before the mapping process. The prototype under study triggered more positive than negative emotions in the respondents. We hope the product can contribute to future researches, both in the promotion of a strategic planning in the design of sustainable products, and also contribute to future research on the SIPOC diagram.*

Keywords: *Product design, SIPOC diagram, Emotional design, Quality of life, Healthy eating, Case study.*

1. Introduction

Quality of life is defined as the result of combining living conditions and control of the environment. Balanced nutrition is an important condition for quality of life (Walters, 2009). It is of the prime importance to make healthy and sustainable lunchbox in order to boost energy needed to have quality of life. Lunch box is an useful interface between food and consumers; its primary functions are to protect and store food, and its secondary functions are mainly related to the importance of getting the packaging to communicate with the users. Considering this relevance, we should note that the packaging should express the identity of the food products it contains (Meroni, 2000; Piqueras-Fiszman & Spence, 2011; Venter et al., 2011) and, therefore, a product that is used to store and carry food should have appealing colours, shapes and materials.

In this regard, the increased competition in the lunch box and food packaging market is forcing companies and researchers to invest in a functional design that generates a positive emotional experience in the interaction between user and object, exploring, for example, the fact that materials with pleasant textures provide comfort through touch, the fact that balanced colours allow the product to convey pleasant sensations through sight, or of the fact that the shape of the product can trigger memories associated with other products or references to nature (Dransfield, Zamora & Bayle, 1998; Vink & De Looze, 2008). All the factors that allow a product to trigger an experience are intended to add value to it, so that it can stand out and meet the consumers' preferences (Honea & Horsky, 2012; Wang, 2013).

That said, we wanted to create an aesthetically appealing product to store, protect and carry meals, particularly healthy

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meals, to the workplace and while travelling, to be used either on a daily basis or occasionally. The term healthy means that there is an emphasis on the preservation of health, thus fostering healthy eating habits and raising people's awareness to the type and amount of food they eat (Ashby et al., 2004; Chen et al., 2009; Ljungberg & Edwards, 2003). Therefore, this product aims at demonstrating that there is an alternative to fast-food meals.

Currently, the market of food packaging and lunch boxes is missing a product that is simultaneously focused on the importance of choosing natural materials, on separating each food group by size in different modular containers, and on placing a hole in each container with the purpose of storing hot or frozen water to preserve the food at the desired temperature.

The SIPOC (**S**uppliers, **I**nputs, **P**rocess, **O**utputs, **C**ustomers) diagram is used in the methodology for a better definition of the project. It provides a clear and simple information of the process. A SIPOC diagram maps a process and identifies potential gaps between suppliers and inputs specifications, as well as, between outputs specifications and customer expectations, thus defining the scope for process improvement activities. The SIPOC diagram provide a broad perspective of the process it's investigating. It helps teams stay on course and ensures that all team members are viewing the process in the same way.

The main objective of this work is the conception of a sustainable lunchbox prototype, considering the emotional aspects of a product, which aims to improve the quality of meals.

2. Brief review of the literature

2.1. The SIPOC diagram

SIPOC diagram is an excellent tool to use at the very beginning of change strategy. It acts from the start to the desired end point of the change initiative. The 5 categories are suppliers, inputs, processes, outputs and customers. SIPOC is a visual tool to define a complex project, and is typically employed at the Measure phase of the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) methodology (Enoch, Shuaib & Hasbullah, 2015; Yeung, 2009).

What follows is a very brief summary of the most common process (Yeung, 2009):

- Supplier: are the suppliers of the process, who are responsible to make the process inputs available;
- Input: everything that goes into the process in one way and undergoes a modification to be transformed into output;
- Process: main activities of a specific process
- Output: everything that leaves the process after the modification;
- Customer: is the client of the process, the beneficiary of the accomplishment of that process.

Firstly, the major elements of the process should be noted down. Based on these elements everything that is affected during the process should be accounted for. Then, the outputs need to be identified, followed by defining the customers or possible users. The inputs followed by the suppliers are the final elements to be noted down (Yeung, 2009).

2.2. The importance of good meals to have quality of life

Basic needs for people are normally defined as adequate shelter, protection, food, health care, and nurturance; The quality of life is related with the living standard of all the members of the family. Human life cannot be successful without the quality of living standard (Walters, 2009).

The consumption of healthy meals is essential to the quality of life and the area of healthy eating is growing surprisingly. The nutrition has influence on the health and welfare of all individuals. However, daily activities and the

lack of alternatives often interfere in the preparation of healthy, balanced, varied, and delicious food, putting determinant factors to human condition in question. (Walters, 2009).

Meals prepared at home can be healthier than those that are purchased. However, what often happens is that people place their meals in random lunch boxes, without taking the variety and amount of food they should be eating into consideration. Consequently, when it's time to eat and the boxed meal is cold, almost everyone feels the need to heat it up, often using a microwave oven and losing the main health-friendly properties of the food through heating (Marino & Galloni, 2011; Sarata et al., 2015). However, it is fundamental to a physical and psychological well being of people to be concerned with a proper and balanced choice of food, such as the preparation, storage, hygiene and consumption (Nishimoto et al., 2015).

According to Paine & Paine (1992), the product containing food functions requires a number of basic requirements, namely:

- Containment: the product containing food must keep its contents secure between the end of the packaging line and the time when all the food has been eaten;
- Protection and preservation: the product containing food must protect the food from both mechanical damage during handling and deterioration by the climate(s);
- Communication: the product containing food must communicate. Not only must the contents be identified and the legal requirements of labeling be met, but often the packaging is an important factor in promoting sales;
- Machinability: in addition to being useful, it should be a good performance and be comfortable. It should also be the result of a material removal process, provide tolerant and suitable finishes and affordable costs (Marques et al., 2018);
- Convenience at proper shape, size and weight for the handling and storage: it should provide the user with a fluid and pleasant interaction, for example, be easy to open, as well as, having appropriate measures and weight for most individuals;
- Adapted to the use of the product it contains: it must be accommodated according to its intended purpose, for example, storage and transport of food;
- Respect the environment, from its manufacture: it should save costs, contain sustainable, recyclable and/or reusable materials.

Therefore, it is important to point out quality of life plays a vital role to bring the change in human, social and cultural development.
The development of sustainable products (Santos, 2016; Santos et al., 2018c) aimed at the containment of food has made an incomparable contribution to the quality of human life (Walters, 2009).

2.3. Importance of Emotional Design

The concept of product emotion is broad, because products can trigger different emotions. On the other hand, emotions are subjective, as different individuals have different emotional responses to a given object, and it is even possible for the same person to experience different emotions when faced with the same product at different times (Desmet & Schifferstein, 2008; Bagozzi, Gopinath & Nyer, 1999). Furthermore, products often trigger various emotions at the same time, as every object has many different aspects liable to trigger an emotional impact, such as, its overall look, specific details, implicit and explicit expectations and associated, remembered and fantasized meanings (Desmet & Schifferstein, 2008; Ortony & Turner, 1990).

Emotional design is developed with the purpose of triggering positive emotions (Walter, 2011). It is related to three different

cerebral processing levels: visceral, behavioural and reflective. The visceral level enables quick judgements of what is good and bad, safe and dangerous, being related to the initial impact of the product, associated with its appearance, and, next, with human touch and feeling. The behavioural level is associated with usage, with the experience we have via the function, performance and usability of a given object. On the other hand, the reflective level is related to the meaning and memories triggered by a product, as well as, to the personal satisfaction it provides (Norman, 2004; Wrigley, 2013; Wrigley & Ramsey, 2016).

Desmet (2002) argues that there are fourteen emotions divided into two groups - seven pleasant emotions and seven unpleasant emotions; the positive emotions are: desire, satisfaction, inspiration, fascination, amusement, pleasant surprise and admiration. The negative emotions are: disgust, boredom, indignation, unpleasant surprise, contempt, disappointment and dissatisfaction (Desmet, 2002; Desmet & Schifferstein, 2008).

The product should seduce the users (Dagman et al., 2010; Pentus et al., 2014). Product design requires the ability to materialize intentions into new solutions (Goodale & Humphrey, 1998).

Designers can manipulate many variables, such as product shape, weight, smell, and finish, to fulfill these intentions. In the end it is the interplay between all of these design variables that will determine the experiential value of the design (Scherer, 1984; Schifferstein & Spence, 2008).

An interaction with a product typically involves perceiving, thinking and acting. Perceiving is the ability to comprehend information, which can be in many forms such as speech, text, sounds, shapes or images. Consumers are strongly influenced by the product's general character. The form, color, and style of the product all influence the user's assessment of its aesthetic, symbolic and practical value (Clarkson, 2008; Fenko, Schifferstein & Hekkert, 2009; Hassenzahl, 2008; Schifferstein et al., 2013; Shin & Thomas, 2015; Sonneveld & Schifferstein, 2008).

Order, balance or harmony, symmetry and 'good' proportion are used to make a design coherent and orderly and, therefore, pleasant to look at (Hekkert & Leder, 2008). Design often gains value according to certain desired and necessary attributes, to a certain shape or function that gives meaning to individuals (Chung, 2015; Mugge, Schoormans & Schifferstein, 2008; Nefs, 2008; Piqueras-Fiszman & Spence, 2011; Scherer, 2005).

3. Methodology

A questionnaire was made and distributed online during the month of May 2016, via the Googledocs platform, allowing us to identify the possible needs of people who take their meals to work and care about their diets, as well as of individuals who do not take their meals to work and of individuals who have unhealthy eating habits, to try to understand their needs and wishes. The sample consisted of 98 responses.

The questionnaire allowed to establish a number of requirements of the product, namely to be:

- Functional;
- Hygienic;
- Ergonomic;
- Aesthetically appealing;
- Weather resistant;
- Suitable for people with back and hand problems;
- Focused on healthy food;
- Innovator;
- Affordable price;
- Rectangular shape;
- Based on a natural food heating method.

In this regard, the respondents highlighted functionality as the most important factor and the product's symbolism as the least relevant aspect. In terms of compartments, the respondents mentioned that it would be

important for the product to have several partitions to separate different food groups, for example, vegetables and greens. They also highlighted the importance to keep the food's temperature for some time, and that the product should have an elegant shape so as to avoid constraints related to carrying home-made food.

In order to keep the food at the appropriate temperature, there is a hole that allows the use of hot water or water at room temperature for freezing (the container should be placed in the freezer for the water to freeze), according to the type of food that is placed in each container. The final product should have various containers, each of which is adjusted to a specific food group. The chosen food groups were suggested by the respondents, and are the following: whole grains, vegetables, fish, salad, soup, seeds, fruit and natural beverage. The sizes of the various containers were defined based on the opinions provided by nutritionists.

The container presented in this study is the one designed for the vegetable group; a prototype is made from ABS (Acrylonitrile butadiene styrene), but we should note that the final product should be ceramic.

The backpack is made from "burel" fabric, a material with a high level of impermeability; the structure is made from cork sheets, an impact-resistant material that allows to protect the containers and, like "burel" fabric, is 100% natural. The container straps, which allows to hold the containers and keep them balanced, are also made of cork, sealing them in order to avoid liquid or food spillage or the undesirable entrance of air or dust. This product must follow the rules of quality management during its production process (Ribeiro et al., 2017; Rebelo et al., 2016; Santos & Millán, 2013; Rebelo et al., 2017; Carvalho et al., 2018)

4. Experimental

This work utilizes SIPOC diagram to identify all relevant elements in the project. It provides map process, used by leadership to quickly explain a project and provide common reference points to all team members (Table 1).

Table 1. SIPOC diagram

Suppliers	Inputs	Process	Outputs	Customers
Designers	- Client - Paper - Markers - ABS (Acrylonitrile butadiene styrene) - SPSS statistics software - Excel spreadsheet - CAD software - 3D prints - Sewing machine - Scissors - Lines -Bag accessories - 3D prototyping - "Burel" fabric - Cork	Design and development of a sustainable lunch box	- Bag - Containers Final product: - Lunch box	- People who enjoy healthy lifestyles Validate the prototype: - 98 individuals - Of both genders - Ages ranging from 18 to 65
Design process Questionnaires → Sketches → Choice of the final concept → Physically produce ↓ 3D prints → 3D prototyping (Bag) → Validate the prototype ↓ Perceive the emotions of the user				

The development of the project aims to take the following aspects into consideration:

- Empathize: it is necessary to understand the consumer;
- Define and synthesize: it is important to interpret the consumer's needs and wishes;
- Ideate: brainstorming ideas, following a creative process which allows to explore possible solutions and alternatives;
- Prototype, assess and enhance: this stage involves producing something tangible based on what was designed and selected, to test the idea and the product (Santos et al., 2018a);
- Implement and test: once there is a more consistent product, it is important to test it on the users.

Possible solutions through sketches and according to the requirements outlined by the respondents were developed. Next, from the ten final concepts, we chose the most relevant one. The choice of the final concept was made by 36 individuals, and concept 10 was the one that received more votes (figure 1).

Once the final concept was chosen, a series of detailed drawings to define every aspect of the product was prepared. The chosen colours for the bag were light blue and black, as most of the possible users of the product mentioned them in the questionnaires when they were asked about their favourite colours (figure 2). In order to define every technical aspect in detail, it was necessary to develop virtual models (figure 3) and 3D prints (Bravi et al., 2017; Doiro et al., 2017; Santos et al, 2018b).

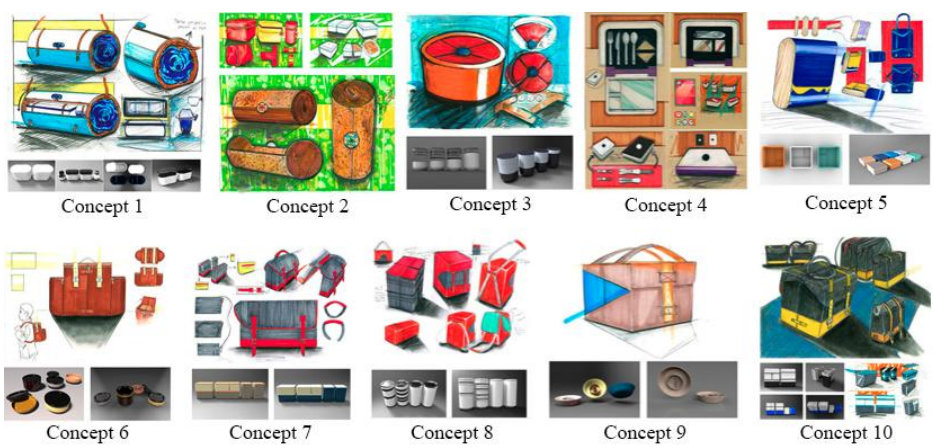

Figure 1. Selected concepts.

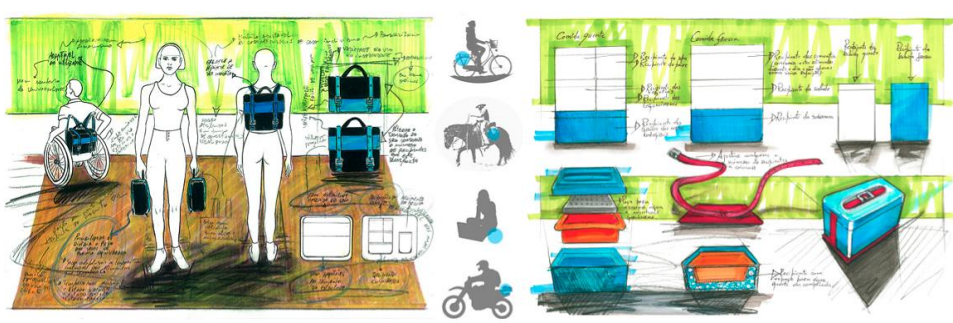

Figure 2. From left to right: Representations of the possibilities of using the backpack. Detailed drawings of containers.

Figure 3. From left to right: Exterior views of stacked containers. Outside views of one of the containers and drink cups. Possibility of placing containers on the table.

The 3D prints, as volumetric studies, were mainly used as first attempts to turn the idea into early physical representations, in order to test them. The various parts were initially designed in Solidworks and then saved as an STL file format, allowing to transfer the designs from the CAD software to the rapid 3D prototyping machine in order to produce the parts physically (figure 4, 5 and 6). The container strap and stopper are made of cork (figure 6 and 7). Once the parts were manufactured, a physical model of the backpack (fig. 8 and 9) was prepared. The volume of the backpack was tested using a cork-sheet structure.

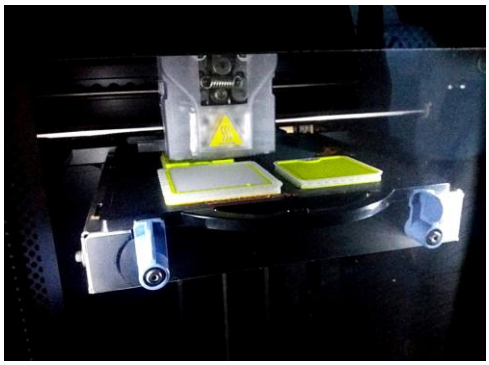

Figure 4. 3D printing of parts.

Figure 5. 3D printing of parts.

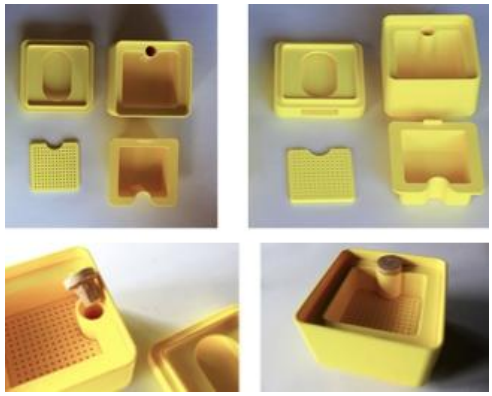

Figure 6. Vegetable container prototype.

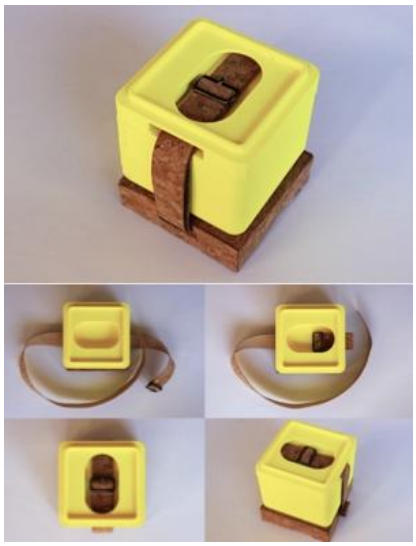

Figure 7. Straps inserted into the container.

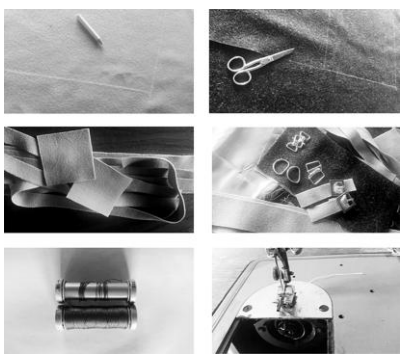

Figure 8. Production of the backpack.

Figure 9. Result of the backpack model.

To validate the prototype, intended to offer an aesthetically appealing packaging for possible users to carry their meals from home to work or while travelling, we carried out usability tests in mid-October 2016 (figure 10 and 11), which involved 98 individuals from the district of Aveiro, Portugal, of both genders, ages ranging from 18 to 65. The age group was chosen considering the active population in the labour market.

We were able to divide the participants into two groups: those who care about having healthy eating habits, particularly with regard to the type and amount of food they eat on a daily basis, comprising 39 individuals, and the group of those who prefer to eat fast food and do not care about eating balanced meals, comprising 59 individuals. In order to consider the requirements determined by the respondents, the tests involved people both with and without hand and back problems.

The usability tests were based on the collection and analysis of information for a qualitative and quantitative assessment of the use of the prototype, on subjective information regarding each participant's difficulties and satisfactions and on an analysis of the emotions experienced according to Desmet's PrEmo measuring tool. (Desmet, 2002). The emotions adapted from Desmet's PrEmo were used to determine the emotions experienced by the respondents while interacting with the prototype under study.

The surveys regarding the usability tests were made on printed paper. In order to handle the obtained data as a statistical analysis, we used the Statical Package for the Social Sciences software and the Excel spreadsheet.

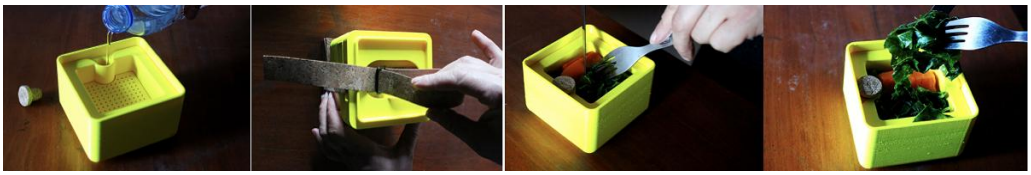

Figure 10. From left to right: Placing water into the container. Placing the strap in the container. Use the cutlery inside the container. Pick up the vegetables with the cutlery.

Figure 11. From left to right: Pick up the backpack. Use the backpack in hand. Position of the backpack on the back. Use of the backpack.

5. Results

It was possible to observe that 51.0% of the participants in the usability tests were female, while 49% were male. With regard to the first question, in which we asked the respondents whether they took their meals to work, we found that most of the respondents who take their meals to work are women.

In terms of the prototype trial, we should highlight that all the participants were able to put water successfully inside the container.

With regard to the use of cutlery inside the container, we noted that 62.2% said that using cutlery to move and pick up vegetables was convenient, 7.2% disagreed and 30.6% were indifferent. On the other hand, once the vegetables and the water were inside the container and it was closed with the strap, there was no spillage of food or liquids.

In terms of the size of the container, most participants were satisfied with the proposed proportions. However, 21.4% of the participants found the container too bulky.

As for the assembly of the container, 56.1% of the participants mentioned that the food container was not necessary, because the container used to store water could also be used to store food.

In terms of the number of containers that the participants found appropriate, considering the food groups necessary for a meal, 68 individuals referred a total of 10 as the most appropriate number, highlighting that there should be different containers for whole cereals, vegetables, legumes, soup, fish/meat, salad, dessert, water, tea/coffee and also one for cutlery. The respondents showed interest in the possibility of preserving food temperature by means of the state of the water kept in the container; however, several individuals mentioned that they would like to test this feature using a ceramic container instead of a plastic one.

When it came to lift up the bag, we noted that 81.8% of the participants had no difficulties in completing the task, while 5.0% had some constraints; 5 of these participants shared a problem with swollen hands. However, when it came to carry the bag on their backs, 48.0% of the respondents were able to easily carry the prototype, 16.4% felt constraints due to back pain and 35.7% were indifferent.

In terms of the type of materials that were used, 78.6% of the participants agreed that "burel" wood would be an appropriate, appealing and resistant material for the bag, and 69.4% of the participants found cork a suitable material for the straps. Regarding the colours of the bag, a vast majority of the participants (78.6%), mostly men, were not pleased with the combination of light blue and grey, as they considered that these

colours would not be appropriate for all the seasons of the year.

Alternatively, several respondents mentioned that light blue should be replaced with a neutral colour or have darker shades, and they also mentioned that they preferred to use dark colours throughout the year; however, all the respondents found the product innovative.

"Pleasant surprise" was the most commonly experienced emotion while using the prototype, followed by desire and satisfaction. Negative emotions were less experienced than positive ones, and disgust, indignation and unpleasant surprise were not felt by any of the participants (Table 2).

Table 2. Emotions experienced during the usability tests.

Emotions experienced during the use of the pre-prototype		
Emotions	Number of participants who felt the emotion	Number of participants who did not feel the emotion
Desire	53	45
Disgust	0	98
Satisfaction	45	53
Boredom	8	90
Inspiration	21	77
Indignation	0	98
Fascination	5	93
Unpleasant surprise	0	98
Fun	19	79
Contempt	1	97
Pleasant Surprise	64	34
Disappointment	7	91
Admiration	32	66
Dissatisfaction	14	84

At this point, we should mention that there is a significant difference between the positive emotions group and the negative emotions group, as the number of participants who experienced positive emotions was much higher than the number of participants who felt negative emotions. On the other hand, there were very similar emotions among the individuals from the group of people that care about the food they eat while, by contrast, there were very different emotions among the individuals from the group that underestimates good eating habits.

As for the price that the respondents would be willing to pay for the final product, the majority of the respondents said that they would purchase it if it costed between 20 and 39 euros**.**

Finally, we should mention that, when asked if they would use the product, 56.1% of the participants said yes and 43.9% said no. Most of the individuals who would use it were from the group of people who care about good eating habits, and mentioned that the product under study could contribute towards encouraging people to adopt healthy eating habits because, according to most of them, by using an innovative product that is convenient, safe and pleasant to use, users feel more attracted to use it and to experience the lifestyle advocated by the project as they find it different and motivating; given that the product will have various containers whose sizes are adjusted to different healthy food groups, it will be easier for users to prepare balanced and healthy meals.

6. Discussion

The results obtained through an analysis of the usability tests showed that there is the need to make several changes to the design.

First of all, we noted that there should be ten containers, given that there is no need to have a seed container as initially intended, and it would also be appropriate to design a cutlery-specific container. On the other hand, each container had an item used to store food that would be unnecessary, as the item used to store water could easily be used to store food also.

Thinking of the colours of the bag - light blue and black - the usability tests allowed to realize that they did not correspond to the satisfaction experienced by most of the male respondents, meaning that the selection of the colours for a given product should be assessed once its prototype is completed, as it is not enough to find out what the users' favourite colours are through questionnaires. So, we should change the colours of the bag to darker tones, to make it more convenient to use all year round. It should also have two pockets for the beverage containers, one on each side of the bag in order to balance the weight, and be longer, to allow piling up all the food containers (figure 12).

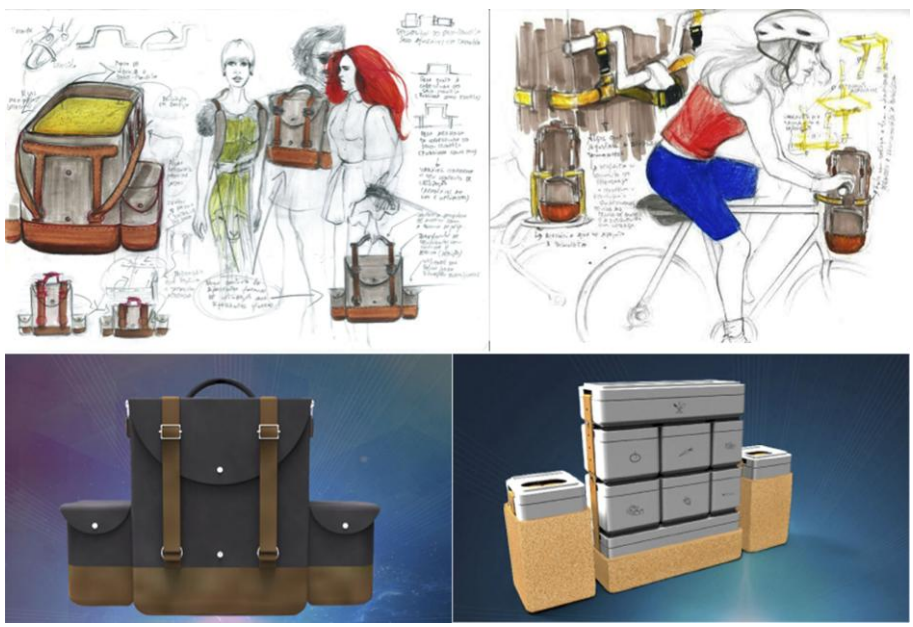

Figure 12. From top to bottom, from left to right: Drawing of the possibilities of carrying the backpack. Design of possibilities of the product being transported on bicycles. Front view of the backpack result. Result of the containers.

We were able to identify several weaknesses and strengths in this study. The strengths are the following: there are many studies that support the relevance of the role played by emotional design in product creation; there are many studies that support the adoption of healthy eating habits as a benefit for human health; this study can contribute to future research on the way design can act in connection with human nutrition; this study aims at promoting healthy eating habits; this study aims at developing a product that is associated with globalization and with the needs it generates. On the other hand, we can identify the following weaknesses: the lack of studies that support the relevance of a specific association between emotional design and the creation of products aimed at storing, protecting and carrying meals; the possibility of the product being copied; the need for more prototypes and usability tests to strengthen this study.

Finally, we should note that as the users' wishes and needs are met, more positive emotions will be shown and less negative emotions will be experienced, resulting in better interactions with the product.

7. Conclusion and future work

The SIPOC diagram helped break down our process into external inputs and their suppliers, process steps, and outputs, and their customers. It was one of the most important tools in this work. This tool helped the team identify whether they have focused on the right process. The SIPOC also helped the team to understand who their customers are and what their requirements and needs before the product development process are.

Considering the references that were studied, it is important to highlight the fact that emotional design can change the way people interact with products on a daily basis, as the products that generate positive emotions are more easily integrated into the consumers' preferences and arouse the individuals' interest in using them. However, the emotional design approach can also be improved through a better understanding of the users' emotions.

This paper contributes to future research on the way design can act in connection with healthy eating habits, as it is focuses on the development of an innovative product aimed at encouraging people to eat appropriate meals in the appropriate quantities. As the product design development process and, particularly, the emotional design process meets the individuals' needs and wishes, their emotional responses will be increasingly positive. The study results revealed that the attitudes towards the lunchbox influenced the consumers' perception of the value of the food product. Lunchbox design, therefore, is an important factor of the consumer evaluation of food products. This study shows that the consumers possessing a positive attitude toward lunchbox tend to evaluate the food product positively.

However, given the constraints shown by the respondents in the first usability tests, the product under study should be improved in its redesign, followed by the development of a final prototype to be subjected to further usability tests.

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