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# FOLDABLE FABRIC TROLLEY

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ESM 502



**Team members:**

Amnah Alzeyoudi

Bushra Alnaqbi

Mohamed Alawani

Shaikha Al Alawi

Wala' Abed AlKhader

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**\*Please note that the contribution of each member can be found in a table in the last page**

# 1. Overview

## a. Overview of Product, Project and Company Background

I-Fabric Bag Company is a new company which aims to start establishing its business in UAE by introducing a new project "Foldable Fabric Trolley". This project plans to be taken by four people. The idea of this project is to include a smart fabric bag to a trolley. It can be replaced with the plastic bags that used in supermarkets. This bag will be divided with compartments for different items. It is foldable with wheels and alarm to take it back to the car. The product has different items to be gathered whether it is from inside the company or outside.

## b. Opportunity Analysis

Based on some challenges that faced our markets, there is some chances that identify potential opportunities. A number of European countries have bag taxes in some form and policies are there to reduce the use of plastic bags. Some cities have already banned plastic bags. Our society has become a consumer society in which there is an increase in the number of shoppers. Largest category of these shoppers are shopping from groceries. Most of those shoppers are using plastic bags to carry their goods. However, there is a lack of awareness of the environmental effects of using plastic bags.

- **Opportunity statement**

"Creating an environment friendly fabric bag/trolley replacing plastic bags that meets the needs of customers and helps in saving the environment."

## c. Project Schedule

To achieve our project, a Gantt chart has been created to schedule the project. Based on our plan the project starts on April 17, 2016 and finished on May 5, 2016 but because there was a vacation on some days so we tried to finish the tasks before the assigned days. The project is divide into three different phases. Phase one analyzed customer needs and technical requirements and it is planned to take 5 days. Phase two investigated the concept generation, evaluation, Selection and testing and it is planned to take 7 days. Phase three demonstrated the product design, manufacturing plan and

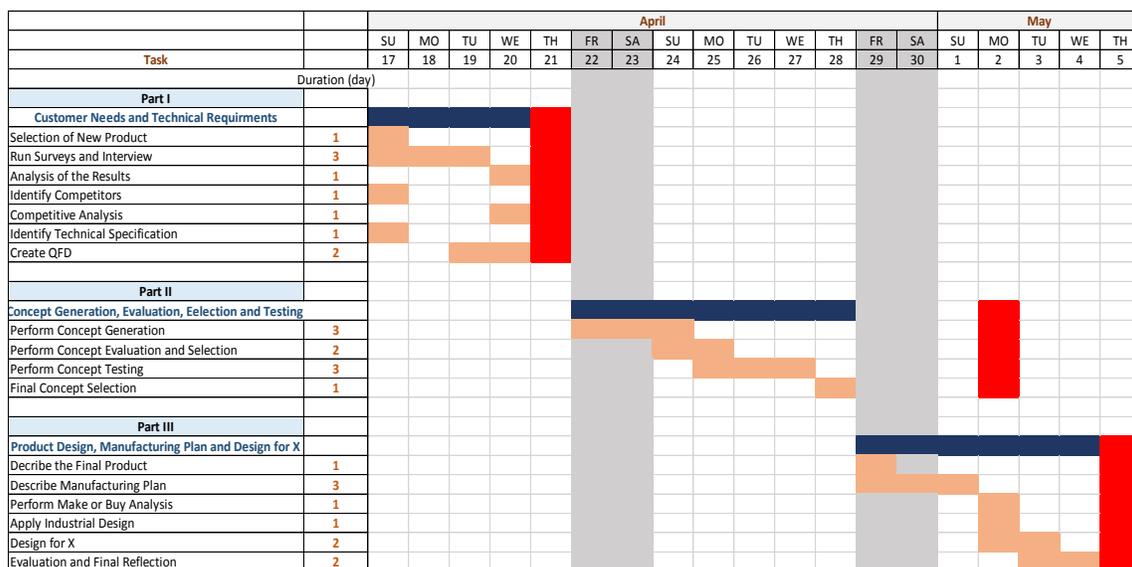


Figure 1: Project Schedule

design for X and started after phase two have been accomplished, as shown in Figure 1 (for clear figure, see [appendix A](#)).

#### d. Project Progress

Our estimated schedule for phase 1 has been changed based on our actual performance. In phase 1, there was a planned durations for each sub task. But we did not follow it because there is some changes led to increase the duration of these tasks. For example, the sub task number 2 “Run Surveys and Interview” was planned to take 3 days, but in reality it takes 2 days, because of a delay in creating survey’s questions.

In phase 2, there are five tasks to be completed. Because of the short time that we had as well as some other external activities, phase 2 started late by one day, and in the middle of the duration we started to work in phase 3. It can be observed that there were changes in the planned schedule.

The tasks duration in Product Design, and Manufacturing Plan Phase have been changed to be started early before the scheduled plan, because of time pressure. All the tasks finish before the estimated time in 2 days because there was a holiday, refer to Figure 2. This phase finalized the last stage of our project, in which demonstrated the final product design, manufacturing plan and decision analysis, refer to Figure 2.

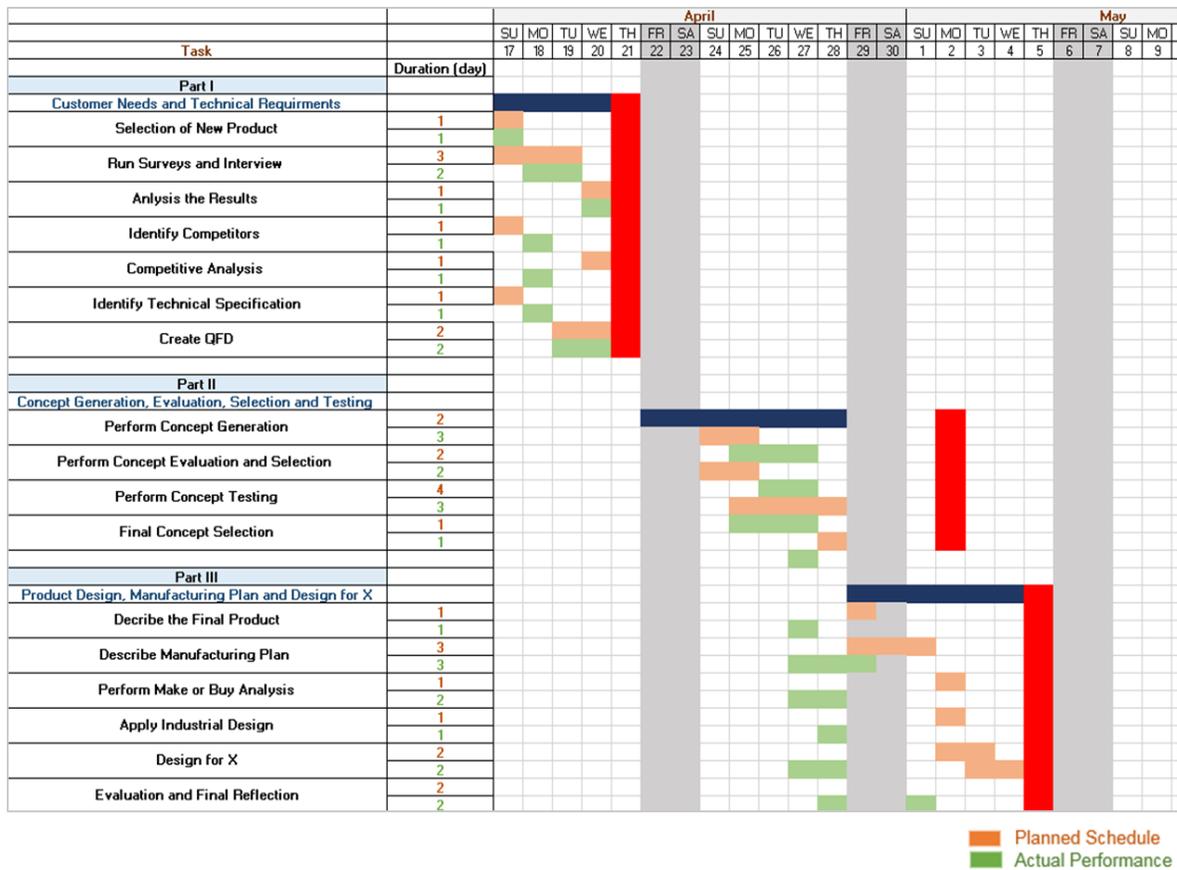


Figure 2: Project Progress

## E. Mission Statement

The product's mission statement summarizes the direction to be followed by the product development team. It provides assumptions and constraints under which the product will be developed.

### **Mission Statement**

Be one of the world's producers and providers of environment friendly fabric bags. Using our expertise, we seek to develop the most creative, innovative and profitable fabric bags to make the shopping experience more comfortable and easy for all the shoppers.

### **Description:**

The idea is a smart fabric bag which can replaced with the plastic bags that are used in the supermarkets. This bag will be divided into compartment for different items. It is fold-able with multi-direction wheels and alarm to warn or notify the shopper if he/she moves a certain distance away from it.

### **Benefit Proposition**

Environment Friendly Fabric Bags for Shoppers. Fast & Simple Shopping.

Shopping? Tired of carrying plastic bags? Our product will make it FUN for you.

Our product makes it easy for the shoppers to distribute, arrange and allocate their purchases in the fabric bag in a safe and convenient way.

- ✓ Affordable
- ✓ Innovative
- ✓ Smart
- ✓ Light
- ✓ Environment friendly
- ✓ Foldable

### **Opportunity Statement:**

Creating an environment friendly fabric bag replacing the plastic bags and fulfilling the needs of customers and assisting in saving the environment.

### **Key Business Goals**

Our first key business goal is the product would be introduced in a well-known innovation exhibition such innovator. Secondly, we would have about 50% of gross margin. Thirdly, we would accomplish 60% of the market share by 2018 hopefully.

### **Target Price**

Our target price is affordable. In other meaning, we would like offer our customers a competitive price taking into consideration the manufacturing cost and ensuring adequate profits out of the given price.

## **Target Market(s)**

### **Primary:**

Our target market shall capture 50% of fabric bag sales in the primary markets such as the Environmentally Friendly markets. Moreover, it shall target the shoppers in the Super and Hyper markets.

### **Secondary:**

The secondary target of the product would be the grocery stores shoppers.

## **Assumptions & Constraints**

Here, we have addressed and highlighted the different assumptions and constraints of our product. The assumption and competitive advantage is that the fabric trolley shall be compatible with IOS/Android operating systems. As most of the shoppers are very concerned about the technology advancement in the smart phone industry. This advantage would certainly be catchy for them.

However, moving on to limitations part, our product would be power assisted. Looking at the technical features introduced to the fabric trolley, this would certainly be a power source. This limitation was into consideration for future development and improvement as we are very concerned and committed in meeting our customer needs and making the shopping experience very comfortable for them.

## **Stakeholders**

Our stakeholders for the sales operations would be consisted of Customers, Distributors and retailers.

## 2. Customer Needs

Identifying the customer needs is one of the significant steps in developing the concept. By knowing who our customers are, we will be able to understand their needs and make them happy. Knowing our potential customers very well helps us to work on how to convince with our product. So, to identify the customer needs, we should follow the three following bold steps:

- **Collect the raw data from the customers**
- **Translate the raw data in terms of the customer needs**
- **Organize the needs into hierarchy**

Collecting the data from the customers can be done by several methods such as: doing some interviews with the potential customers, focus groups, written surveys or observing the product in use. We decided to run a survey because of the short time. The interviews and focus groups will spend more time to gather the data from the customers, however, by running the survey we expected to have a satisfied and rapid result. The following subsection will present the survey, its results and its analysis.

### a. Survey

The survey is one of the methods that helps in gathering the quantitative data about items or products in a population. The Qualtrics Survey Software which is available in Masdar Institute website, was used to run our survey. The survey questions were more about the customers and

what they use to carry their purchased items and how often the customers go to grocery or supermarkets. The survey questions are provided in [Appendix A](#). The target population for our product is anyone who goes to supermarket or any shop to get their needs such as housewives, students, employees, etc. The survey was distributed among 350 person through emails and WhatsApp. The response rate was 14.86 % which means that we got only 52 responses during two days only. We got the results of two days only because of the limited time and to present our works. The following figures show the results of the survey.

<b>1. Please specify your age</b>				
#	Answer		Response	%
1	less than 15 years		0	0%
2	15-25 years		36	69%
3	25-35 years		15	29%
4	35-45 years		1	2%
5	older than 45 years		0	0%
Total			52	100%

Figure 3: Result of Question 1

The result of question 1 shows that most of the respondents about 36 person are in age between 15 and 25 years since we sent the survey for most of the friends. Then, the second highest answer for the first question was people in age between 25 and 35 years because we ensure that the survey will distributed to the families as well.

<b>2. Gender</b>				
#	Answer		Response	%
1	Male		8	15%
2	Female		44	85%
Total			52	100%

Figure 4: Result of Question 2

The result of question 2 which was about the gender shows that 44 respondents are female and the remaining is male because we sent the survey for most of our female friends since most of the families depend on the housewives (the mothers) to bring the missing home items. It is true that the husbands (fathers) is buying the missing home items most of time but the more knowledge of these things is the female.

<b>3. Current occupation</b>				
#	Answer		Response	%
1	Student		47	90%
2	Employee		2	4%
3	Housewife		1	2%
4	Other (please specify)		2	4%
Total			52	100%

Figure 5: Result of Question 3

The result of question 3 shows that 90% of respondents are students because as it mentioned before, the survey was sent to our friends who are most of them students.

#### 4. How often weekly do you go to grocery?

#	Answer	Response	%
1	2-4 times	43	83%
2	4-6 times	6	12%
3	more than 6 times	3	6%
	Total	52	100%

Figure 6: Result of Question 4

The result of question 4 illustrates that around 83% of the respondents go to the grocery from two to four times weekly. However, 12% of the respondents prefer to go to the grocery from 4 to six times weekly.

#### 5. Approximately, what is the weight of your purchased items per week?

#	Answer	Response	%
1	Less than 1 kg	10	19%
2	1-3 kg	26	50%
3	3-5 kg	6	12%
4	more than 5 kg	10	19%
	Total	52	100%

Figure 7: Result of Question 5

The result of question 5 illustrates that 26 of the respondents purchase items that weighted 1-3 kg per week, and the remaining distributed between less than 1, 3-5 and more than 5 kg. So, the buyers go to the grocery 2-4 times and purchase what their home needed weekly.

#### 6. What do you use to carry your purchased items?

#	Answer	Response	%
1	Regular plastic bags	47	90%
2	Traditional trolley	4	8%
3	Your own fabric bag	1	2%
4	Other (please specify)	0	0%
	Total	52	100%

Figure 8: Result of Question 6

The question 6 was about the type of bag or trolley that the buyers prefer to take for carrying their purchased items. So, the result was that 90% of the respondents use the regular plastic bags and the reason of that is the availability of regular plastic bags in most of shops, groceries, and supermarkets as well as the buyers might forget their own bags or trolleys in home.

The question 7 was about if the buyers would like to use a fabric trolley in case if the trolley is available. The result was positive, 54% of the respondents answered with YES and 34% of the respondents answered with MAYBE which means that if the fabric trolley enters the market as a product, there is a probability of its success.

### 7. If your answer in question 6 is regular plastic bag, would you shift to use a fabric trolley if it was available?

#	Answer	Response	%
1	Yes	27	54%
2	Maybe	17	34%
3	No	6	12%
	Total	50	100%

Figure 9: Result of Question 7

However, we asked the buyers about the reason of not using the fabric trolley and their answer was shown in question 8 result. Most of their answer was that they don't have it and others answered that the supermarkets provide only plastic bags. So, we could say that because of the lack of the fabric trolley availability, most people use the plastic bags.

### 8. If your answer in question 6 is regular plastic bag, why don't you use the fabric trolley?

#	Answer	Response	%
1	I don't have	22	45%
2	I don't like to carry	3	6%
3	I have one but forget to carry	5	10%
4	Supermarket provides only plastic bags	15	31%
5	Other (please specify)	4	8%
	Total	49	100%

Figure 10: Result of Question 8

Question 9 was about the requirements of the preferred shopping bags for the buyers. We asked them about the movability of the bags and they liked it. Only 2% of the respondents said NO, however the remaining said YES. The buyers prefer to have moving bags to facilitate the buying process and because they prefer to drag the items and not to carry it to avoid any pain in their hands.

9. Would you prefer the shopping bags to be movable?				
#	Answer		Response	%
1	Yes		36	69%
2	Maybe		15	29%
3	No		1	2%
	Total		52	100%

Figure 11: Result of Question 9

The question 10 was about another requirement which is the size of the bag. We provided three options with some examples to show for the respondent the scale of the bag. The options are small like small purse, medium like laptop bag, and large like trolley. 69% of the respondents prefer to have medium size of the bag.

10. What is your preferable size of the bag?				
#	Answer		Response	%
1	Small (e.g. small purse)		2	4%
2	Medium (e.g. laptop bag)		36	69%
3	Large (e.g. trolley)		14	27%
	Total		52	100%

Figure 12: Result of Question 10

The question 11 was about the flexibility of the shopping fabric bag/ trolley. 54% of the respondents think that the fabric trolley is flexible and 40% said maybe it is flexible.

11. Do you think that using shopping fabric bag/trolley is flexible?				
#	Answer		Response	%
1	Yes		28	54%
2	Maybe		21	40%
3	No		3	6%
	Total		52	100%

Figure 13: Result of Question 11

The result of question 12 shows that most of the buyers prefer to drag one foldable trolley that includes several compartments rather than carrying a pile of separate plastic bags. We think that the buyers prefer the foldable trolley because of ease of storing as well. It will be easy to store one foldable trolley rather than a pile of separate plastic bags.

12. What do you prefer to use in shopping?				
#	Answer		Response	%
1	Carrying a pile of separate plastic bags		16	31%
2	Dragging one foldable trolley including several compartments		36	69%
3	Other (please specify)		0	0%
Total			52	100%

In

Figure 14: Result of Question 12

question 13, we asked the respondents which one of the three options are fashionable and the answer was 79% of the respondents said that fabric bag/trolley is the most fashionable one.

13. Which one do you think is more fashionable?				
#	Answer		Response	%
1	Regular plastic bags		3	6%
2	Traditional trolley		8	15%
3	Fabric bag/trolley		41	79%
Total			52	100%

Figure 15: Result of Question 13

Question 14 was about storing the bag, as we mentioned before, 69% of respondents prefer to store one foldable fabric bag rather than a pile of plastic bags which will keep a space for other usage.

14. What do you prefer for bags/trolleys storage after using?				
#	Answer		Response	%
1	Storing a pile of plastic bags		16	31%
2	Storing one foldable fabric bag		35	69%
Total			51	100%

Figure 16: Result of Question 14

## 15. Would you shift to use a foldable fabric trolley if it would save the environment?

#	Answer	Response	%
1	Yes	38	75%
2	Maybe	12	24%
3	No	1	2%
	Total	51	100%

Figure 17: Result of Question 15

Question 15 was about if the buyers will use the foldable fabric trolley to save the environment. 75% of respondents said YES for saving the environment which means that people start to go for the sustainable product and understand the importance of saving the environment.

So, the last step in identifying the customer needs is to organize the needs into hierarchy and this will be illustrated and explained in Quality Function Deployment (QFD).

### b. Competitive Analysis

A competitive analysis is a critical part of the product making lifecycle. According to this evaluation, we can establish what makes our product unique and therefore what attributes we play up in order to attract the target market.

In our case, the main competitors were identified as follow, first the regular fabric bag which is made from polyester and comes in variety of shapes, sizes and colors, as shown in Figure 18. It can hold stuff up to 5 kg, it is relatively cheap it can be obtained by only 2 AED. In the UAE an example of a famous fabric bag as shown in Figure 19, is the one which is sold in Carrefour and Ikea stores.



Figure 18: Regular Fabric Bags



Figure 19: In left hand side, Carrefour Fabric Bag and in the right hand side, Ikea Fabric Bag

Furthermore, the second competitor is the foldable fabric bag, although it is not popular in the UAE it can be considered as one of our product competitors. The bag has a solid foldable frame as shown in Figure 20. It is made of Flax which can be folded and hold up to 12 kg .It can be obtained from online websites such as Amazon. Its price is ranged according to its size and design, it is usually start from 25 AED.



Figure 20: Foldable Fabric Bag

Next, the third competitor is the fabric bag with clips which consists of single or multiple bags made of flax with plastic clips to be fixed in the trolley cart as shown in Figure 21 and 22.



Figure 21: Fabric Bag with Clips (Multiple bags)



Figure 22: Fabric Bag with Clips (Single bag)

It comes in variety of shapes, sizes and colors and can hold stuff up to 50 kg. Similarly of the foldable fabric bag, the fabric bag with clips is not popular in the UAE but it can be considered as one of our product competitors and can be obtained from online websites such as Amazon. Its price is ranged according to its size and design, it is usually start from 50 AED.

Finally, the last considered competitor is the trolley shopping bag which is a fabric bag attached to metal wheels to facilitate its movability. It can be folded and handle up to 30 kg. It is made of polyester and metal and sold at a price starts from 35 AED.



Figure 23: Trolley Shopping Bag

In addition to identifying all the competitors a further analysis was made in order to compare between them. As shown in the below table, the main three competitors were the plastic bag, the fabric bag (including both the foldable and the one with clips) and the shopping trolley bag. The comparison criteria were based on durability, movability, size, capacity, flexibility of usage, space allocation, aesthetic, ease of storage, environmental impact and availability. The criteria were concluded from the survey result and will be used in the QFD.

Table 1: Competitors' Analysis

Criteria	Plastic bag	Fabric bag	Shopping trolley bag
Durability	Can't be reused	Not durable	Not durable
Movability	None	Low	High
Size	Low variety of sizes (small)	Low variety of sizes (small)	One size medium
Capacity	Low	Low	High
Flexibility of use	High Flexibility	High Flexibility	Low Flexibility

Space allocation	Not organized after usage	Occupy small space	Occupy larger space
Aesthetic	Not attractive at all	Variety of design some of them attractive	Acceptable
Ease of storage	Difficult to store	Easy	Easy
Environmental impact	Huge negative impact	No impact	No impact
Availability	At all supermarket	Some supermarkets	Rarely available

Likewise a detail analysis was made as shown in the below table, in order to identify the drawbacks if each competitor in order to avoid them in our design.

*Table 2: Competitors' drawbacks*

<b>Plastic Bags</b>	<b>Fabric Bags</b>	<b>Trolley shopping bag</b>
Harmful to environment. Cant used more than once. Difficult to handle (one not enough for all goodies). Heavy to carry if it full loaded.	Doesn't come in verity of sizes. Doesn't accommodate all the goodies. Not available at all super markets. Heavy to carry if it full loaded. Material not durable.	Ugly design (not appealing and attractive). Material not durable. Difficult to unload it if it's filled. Rarely available.

### 3. Technical Requirements

#### a. Target Technical Specifications

In order to get the target specifications the results of the survey were implemented along with Human Ergonomics taken into consideration, below is the table that shows each specification along with its targeted value:

Specification	Unit	Target Value
Height of trolley	(cm)	100
Speed of movement	(m/s)	1.5
Number of wheels	wheel	4
Space Volume of the trolley	(m <sup>3</sup> )	0.1
Number of compartments	compartment	7
Attractiveness/ Design and color	Attractive/Normal/Ugly	Attractive
Storage area	(m <sup>3</sup> )	0.02
Net carrying full load weight	(Kg)	7
Life Time	(years)	10
Hazard level	Hazardous/Medium/Not Hazardous	Not Hazardous
Spread of product	(1-5), 1 not spread and 5 is widely spread	5
Material	Fabric, Plastic, Metal	Fabric
Price	Expensive, Affordable, Cheap (Priceless)	Affordable

Height of Trolley, Speed of movement were based on Human factors analysis so that the height of the trolley with the handle extended is equivalent to the height of the elbow bent at 90 degrees (which is the best position for the arm while pushing/pulling the bag), moreover the speed of movement is equivalent to the average speed of human being movement so that the pushing or pulling of the bag will not be an obstacle or will not cause any delay in the movement.

Number of wheels is set to be standard four wheels which makes it easier to move the bag than if it was one or two and more than four might cause imbalance and might make movement even harder.

Space volume of the trolley is based on 1 meter height, 60 cm length and width so the total needed volume is around 0.36 m<sup>3</sup>

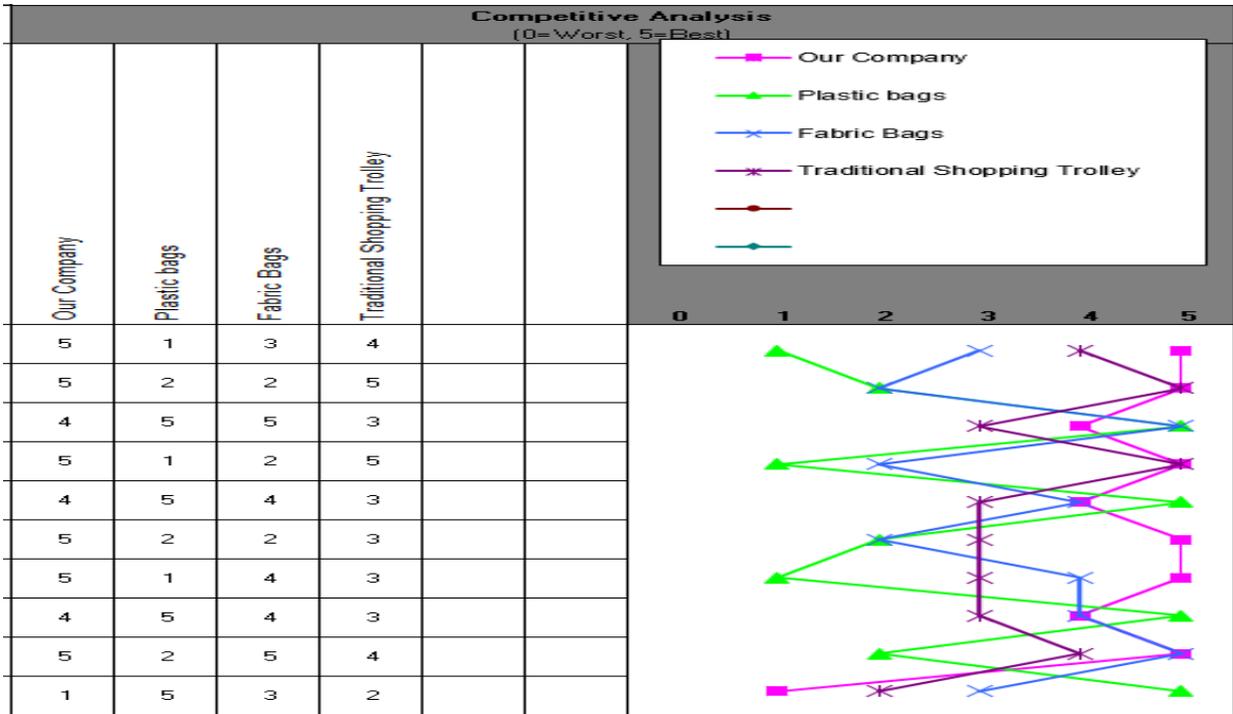
Number of Compartments is 5 so they can fit various types of purchases that the user would prefer to separate from other items.

Storage area of the foldable bag is approximately (60cm x 60cm x 20cm), and the net carrying load is 7 kg or more as we found from the survey results that most responds were that their average shopping weight per time is 3-5kgs.

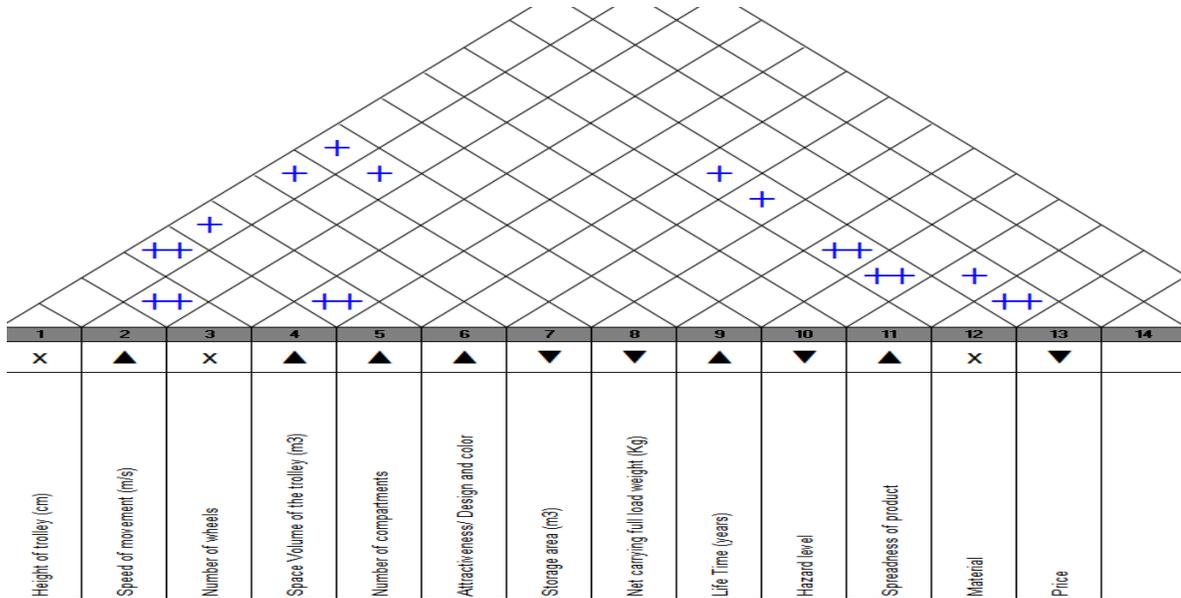
Life time is targeted to be 10 years so the bag is durable and users will not be forced to change them frequently, also it is made of fabric so it's an environmentally friendly material and will not cause bad effects such as the plastic, we are targeting wide spread of the product too make it easier for the customers to get them anywhere and anytime and finally to have it at an affordable price.







#### 4. QFD- Characteristics inter-Relationships



The graph above represents the interrelationships between the different characteristics of the product from the graph we can see that material is related to many other characteristics as well as the height of the trolley and price.

## 5. QFD-Final Results

Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	Height of trolley (cm)	Speed of movement (m/s)	Number of wheels	Space Volume of the trolley (m3)	Number of compartments	Attractiveness/ Design and color	Storage area (m3)	Net carrying full load weight (Kg)	Life Time (years)	Hazard level	Spreadness of product	Material	Price
Demanded Quality (a.k.a. "Customer Requirements" or "Whats")													
Target or Limit Value	100	1.5	4	0.1	7	Attractive	0.02	7	10	Not hazardous	level 5	Fabric	Affordable
Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)													
Max Relationship Value in Column	9	9	9	9	9	9	9	9	9	9	9	9	9
Weight / Importance	132.0	153.0	90.0	99.0	91.0	108.0	114.0	91.0	95.0	45.0	225.0	219.0	321.0
Relative Weight	7.4	8.6	5.0	5.6	5.1	6.1	6.4	5.1	5.3	2.5	12.6	12.3	18.0
Plastic Bag	30	0.5-1	0	0.009	1	ugly	0.009	2	0.25	Hazardous	5	Plastic	cheap
Fabric Bag	30	0.5-1	0	0.009	1	attractive	0.009	2	2	not hazardous	3	Fabric	Affordable
Traditional Trolley	100	1.5-2	4	0.2	1	ugly	0.04	7	5	not hazardous	2	Metal/Fabric	Affordable

From the above table we can see that the ranking of the top most important characteristics is as follow:

- 1- Price
- 2- Spread of product
- 3- Material
- 4- Speed of movement
- 5- Height of Trolley
- 6- Storage area
- 7- Attractiveness (Design and color)

## 6. Concept Generation

Concept generation is the most critical step in the design process. It comes after identifying the customer needs and establishing the target specifications. So, we started to generate the concepts by first decomposing the product into sub-problems using the functional decomposition. The following figure shows the overall function followed by a figure shows the sub-functions.

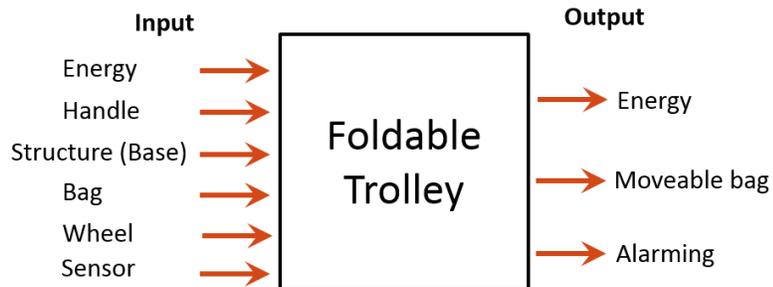


Figure 24: Overall Function

The above diagram illustrates the overall function of the foldable trolley. We put energy, handle, base, bags, wheels and sensor as input and the output is the energy, moveable bags and alarming. We mean here by the energy is pushing/pulling the trolley or other source of energies that can be used to move the trolley such as electrical energy. The handle, base, bags and wheels are the components of the foldable trolley and each of these has its own function. The sensor is for alarming the buyers with the location of their trolleys.

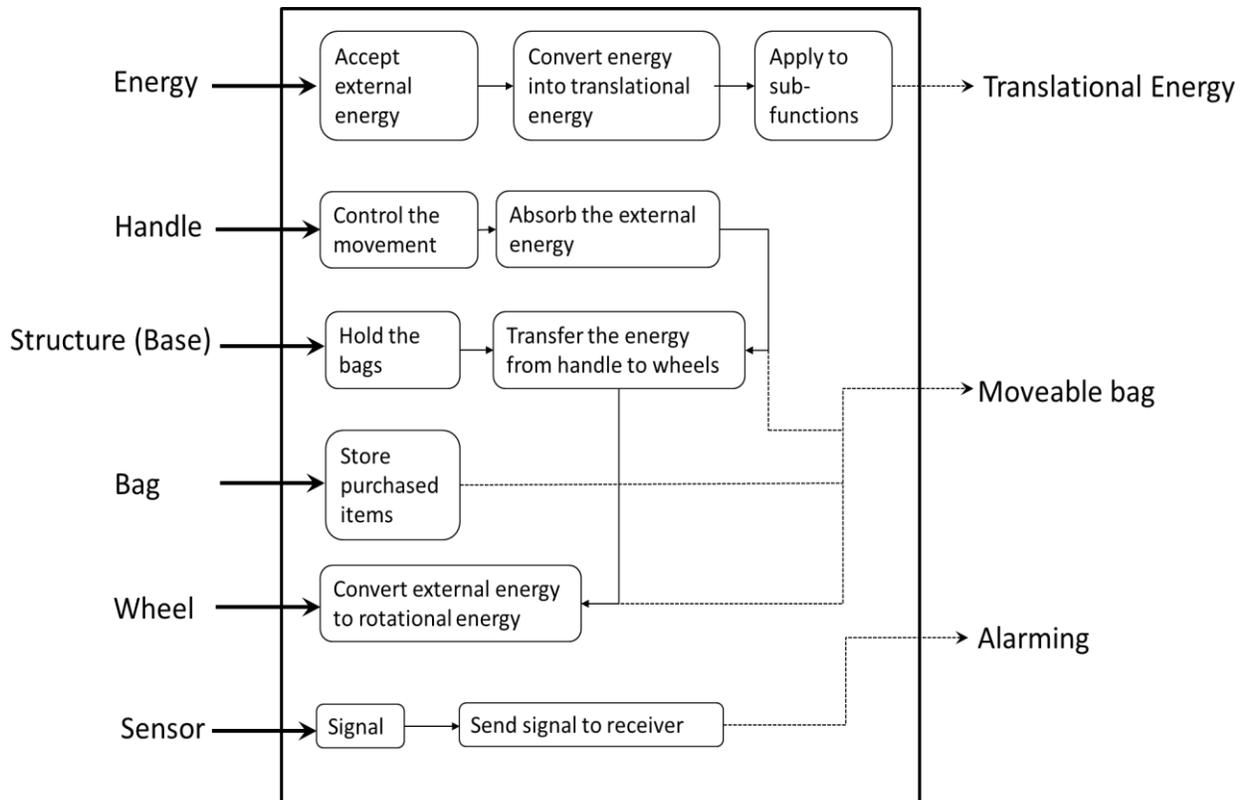


Figure 25: Decomposition of the Overall Function

The function of the energy is to except any external energy such as pushing/pulling or electrical energy and then convert it to the translational energy and apply it to the sub-functions. The handle is for controlling the movement of the trolley. It will absorb the external energy and transfer it to the structure of the trolley. The function of the structure or the base is to hold the bags and combine other components as well. So, the structure will transfer the energy from the handle to the wheels. The bags is used to store the purchased items. However, the wheels will accept the energy from the structure and convert it to rotational energy and not only from the structure, the wheels can accept any external energy. The sensor will be used to alarm the buyers or shoppers of the location of their trolley. So, the output will be a trolley has moveable bags and alarming sensor with applied translational energy. The following table will show some propose solutions for each critical sub-problems. These solutions were proposing based on the existing technology and some of them infeasible, we just added to see if we can do it or not because most of the unusual things leads to creativity.

Table 3: Critical Sub-problems and their Proposing Solutions

Energy source	Movement	Storage of purchased items	Alarming
Chemical	Wheels-one direction	One big compartment	GPS
Pneumatic	Wheels-multi direction	Multiple compartments	Mobile Apps
Electrical	Wheels-fixed	Mix of bags and compartments	Signal receiver
Kinetic	Wheels- moveable	Multiple bags	Watch
Hydraulic	Belt	Mixed configuration (including rubber bands for bottles)	Car base

The proposed solutions for energy are chemical, pneumatic, electrical, kinetic and hydraulic. Chemical, pneumatic and hydraulic are not feasible solutions because our product is so simple and no need for these kind of energy. We just propose all the possibilities that we can select later among them. We proposed for the movement, four solutions related to the type of the wheels and one solution is the belt that are similar to military tank but simple and smaller. However, we focus on the wheels since they are more feasible to the trolley. Third critical problem is the storage of purchased items and this can be solved by using different types of bags and compartments. So, we propose five different solutions such as one big compartment as the usual trolley, multiple compartments for providing more space for storing the items, mix of bags and compartments like one compartment having many attached bags that can be removed or added at any time as needed, multiple bags which attached to each other and mixed configuration which will include a rubber band for bottles. The forth critical problem is alarming. We propose to have a GPS screen, or sensor connected to mobile apps,

signal receiver, smart watch or car base. The following figures show the classification tree for each critical sub-problem with trimming the infeasible solutions.

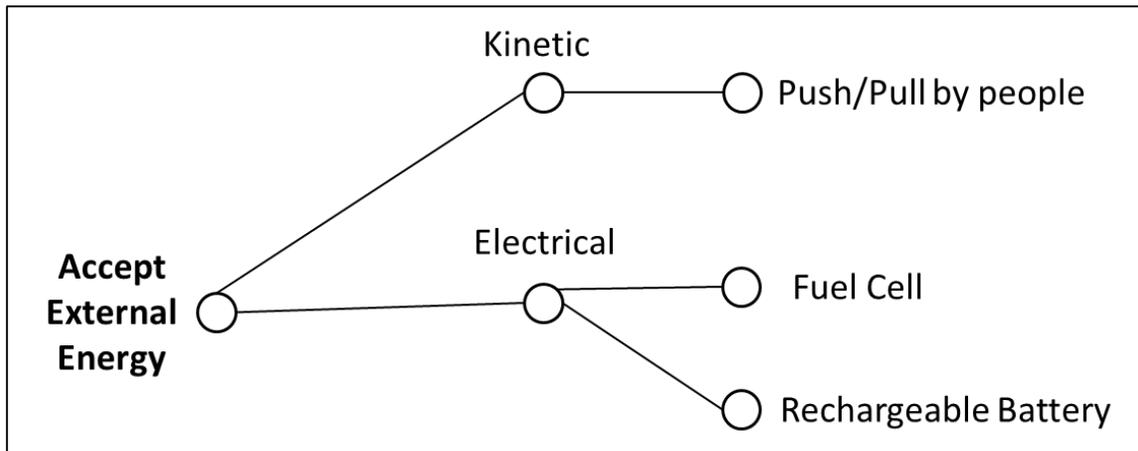


Figure 26: Classification Tree for Energy Source

The classification tree for the energy source shows that we can use kinetic and electrical energies. What we mean by kinetic is the push/pull by people and the electrical such as fuel cells or rechargeable battery.

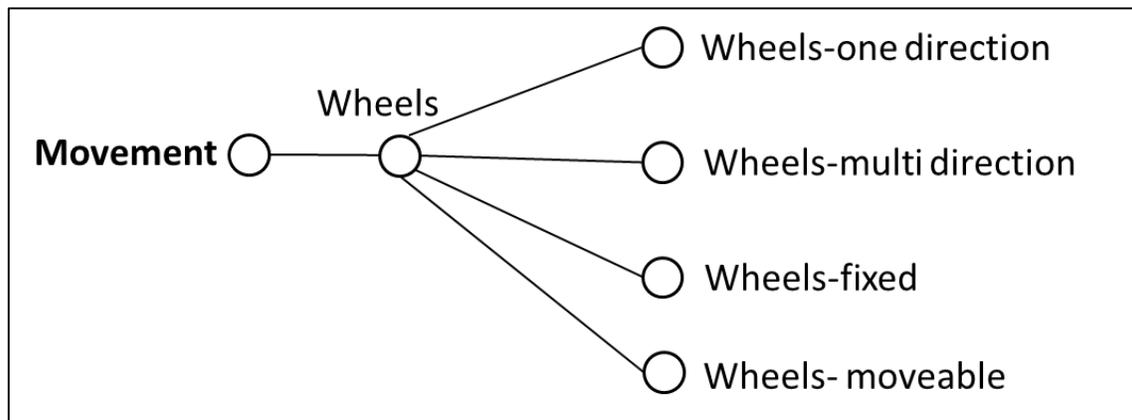


Figure 27: Classification Tree for Movement

As we mentioned before, we trimmed the belt solution from the movement because we want simple and well-known solution, so we keep the wheels but with different type as shown in the above figure.

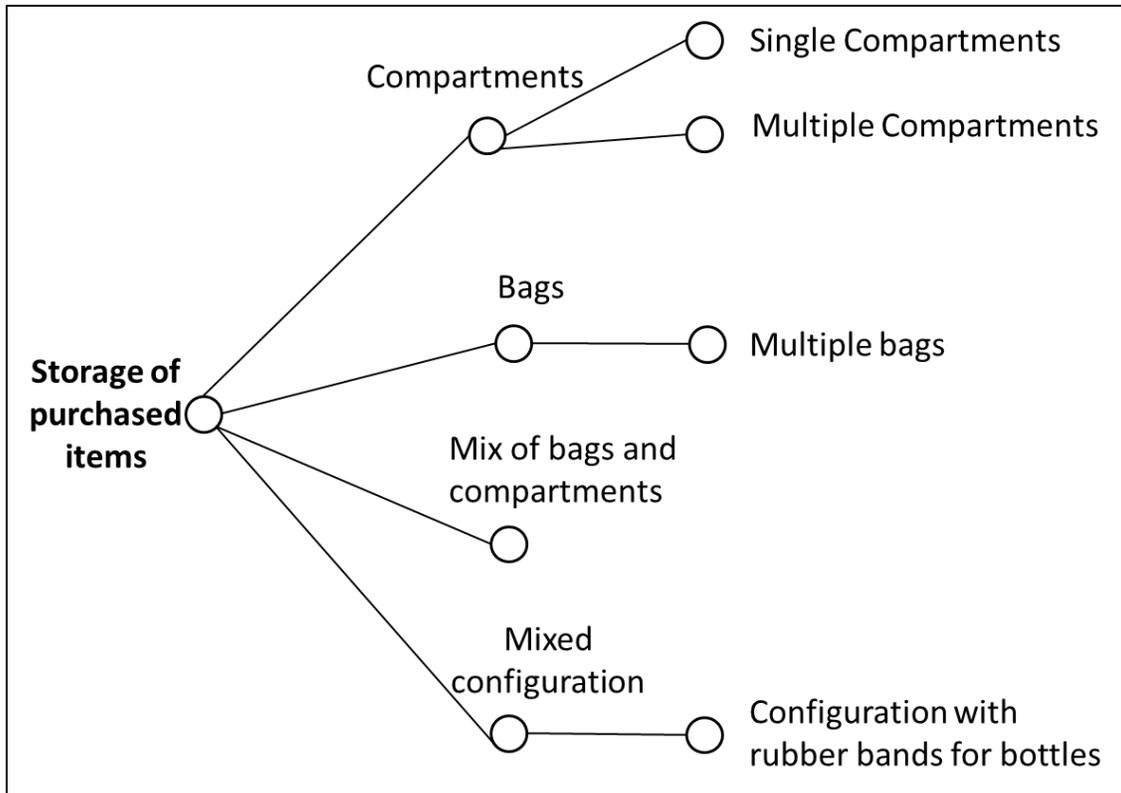


Figure 29: Classification Tree for Storage of Purchased Items

The above classification tree for storage shows the type of bags or compartments that can be used for storage. So, we can use single or multiple compartments or we can use multiple attached bags. Moreover, we can combine the bags and compartments to end up with more satisfied solution or use mixed configuration which is a compartment divided into different sections and there is rubber bands for bottles.

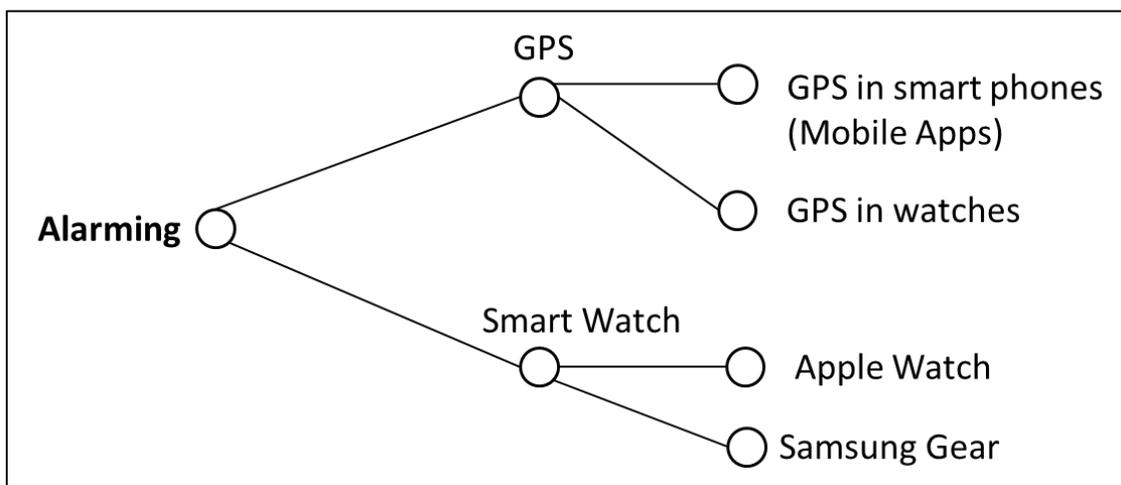


Figure 28: Classification Tree for Alarming

The above figure shows the classification tree for alarming. We keep the GPS and smart watch as the feasible solutions that we can do. The more simple our product and meet the need of the customer, the more the product will be successful.

So, we list the proposed solutions that we take it into account in a table and combine various sub-solutions into several rough product concepts. The following tables show the different concept combinations.

Table 4: Concept Combination 1

Energy source	Movement	Storage of purchased items	Alarming
Electrical	Wheels-one direction	<u>One big compartment</u>	<u>GPS + Mobile Apps</u>
<u>Kinetic</u>	<u>Wheels-multi direction</u>	Multiple compartments	Smart Watch
	Wheels-fixed	Mix of bags and compartments	
	Wheels- moveable	Multiple bags	
		Mixed configuration (including rubber bands for bottles)	

The above table shows the first concept combination which is combining the kinetic energy, multi direction wheels, one big compartment and mobile apps. Pushing the trolley by people is generating a kinetic energy which is delivered to the trolley. The trolley has flexibility of moving with the multi-direction wheels. It has one big compartment for storing the purchased items. It is provided with sensor to alarm the buyers of the location of their trolley. The sensor connects with the buyers' phones by using mobile apps.

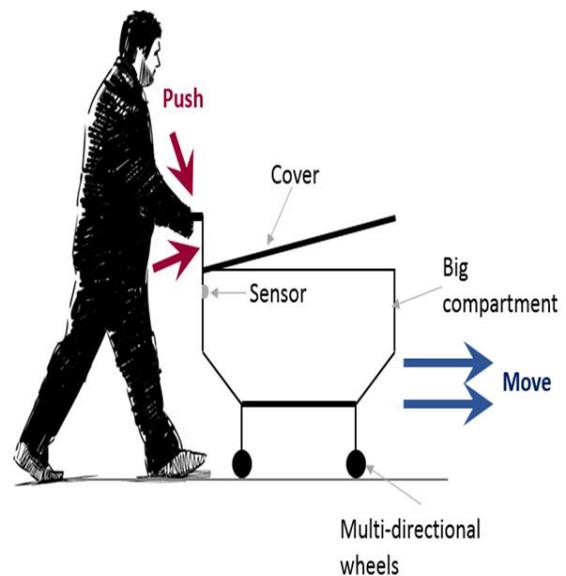


Figure 30: Sketch of First Concept Combination

Table 5: Concept Combination 2

Energy source	Movement	Storage of purchased items	Alarming
Electrical	Wheels-one direction	One big compartment	GPS + Mobile Apps
<b><u>Kinetic</u></b>	Wheels-multi direction	Multiple compartments	<b><u>Smart Watch</u></b>
	Wheels-fixed	Mix of bags and compartments	
	<b><u>Wheels-moveable</u></b>	<b><u>Multiple bags</u></b>	
		Mixed configuration (including rubber bands for bottles)	

The above table shows the second concept combination which is combining the kinetic energy, moveable wheels (foldable), multiple bags and smart watch. Pushing the trolley by people is accumulating a kinetic energy makes the trolley moving. The trolley has multiple attached bags and moveable as well by adding foldable wheels to the bags. The trolley has sensors that connected to the smart watch of the buyers to alarm them of the trolley's location.

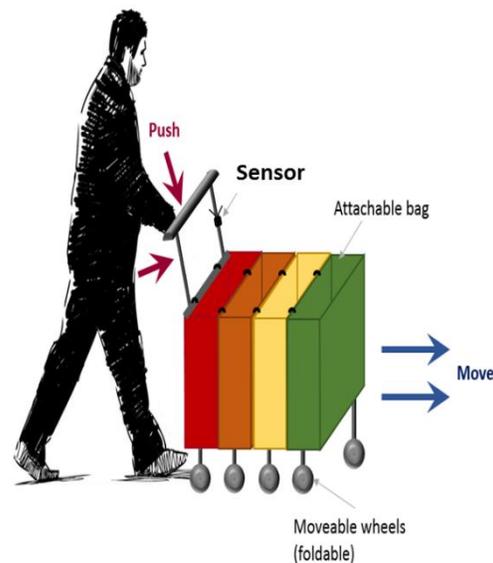


Figure 31: Sketch of Second Concept Combination

Table 6: Concept Combination 3

Energy source	Movement	Storage of purchased items	Alarming
Electrical	Wheels-one direction	One big compartment	<b><u>GPS + Mobile Apps</u></b>

<u>Kinetic</u>	<u>Wheels-multi direction</u>	Multiple compartments	Smart Watch
	Wheels-fixed	<u>Mix of bags and compartments</u>	
	Wheels-moveable	Multiple bags	
		Mixed configuration (including rubber bands for bottles)	

The above table shows third concept combination which is combining the kinetic energy, multi direction wheels, mix of bags and compartments and GPS. Pushing the trolley generates a kinetic energy. The trolley can move easily in multiple directions. Also, it comes with a unique structure by combining bags and compartments. Adding the GPS feature to make it even smarter.

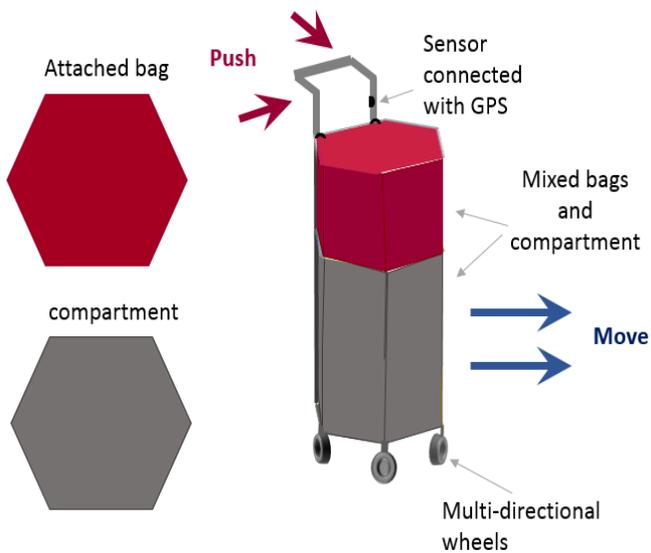


Figure 32: Sketch of Third Concept Combination

Table 7: Concept Combination 4

Energy source	Movement	Storage of purchased items	Alarming
<u>Electrical</u>	<u>Wheels-one direction</u>	One big compartment	<u>GPS + Mobile Apps</u>
Kinetic	Wheels-multi direction	Multiple compartments	Smart Watch
	Wheels-fixed	Mix of bags and compartments	
	Wheels-moveable	Multiple bags	

**Mixed configuration**  
**(including rubber bands for bottles)**

The above table illustrates one of the concept combination which is combining electrical energy, one direction wheels, mixed configuration and GPS. The trolley can move only in one direction which will work by using electrical energy. It has a mixed configuration plus customized bands which is manufactured especially for fragile items. Moreover, sensor that connected to the GPS of the car or phone will alert the shoppers if they leave without taking the trolley with them. It will lead them to the trolley location as well.

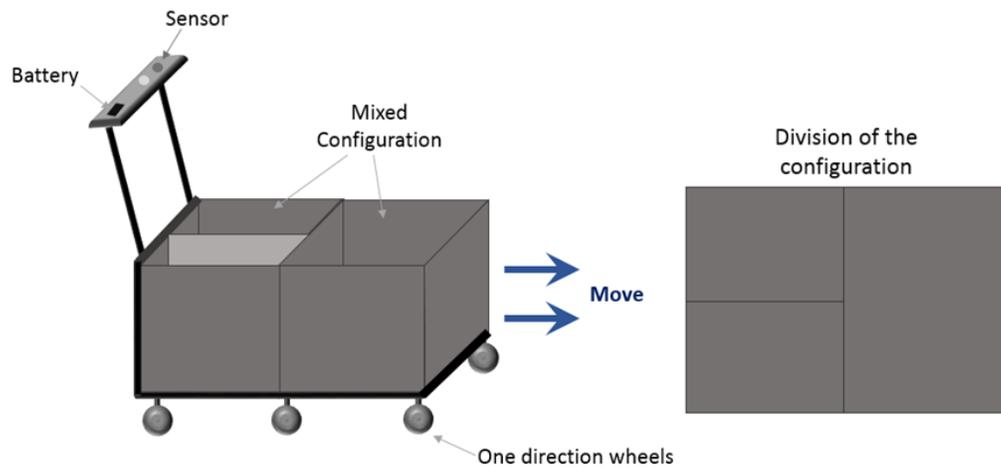


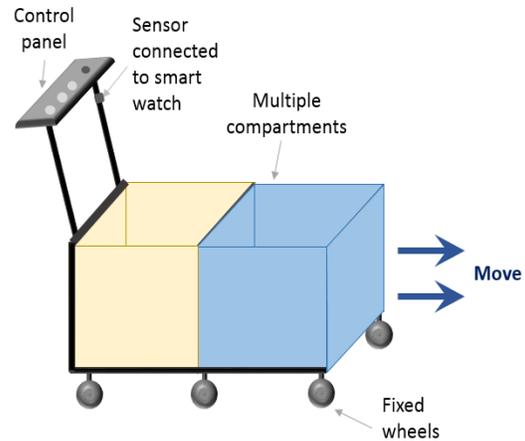
Figure 33: Sketch of Forth Concept Combination

Table 8: Concept Combination 5

Energy source	Movement	Storage of purchased items	Alarming
<b><u>Electrical</u></b>	Wheels-one direction	One big compartment	GPS + Mobile Apps
Kinetic	Wheels-multi direction	<b><u>Multiple compartments</u></b>	<b><u>Smart Watch</u></b>
	<b><u>Wheels-fixed</u></b>	Mix of bags and compartments	
	Wheels-moveable	Multiple bags	

## Mixed configuration (including rubber bands for bottles)

The above table displays the last concept combination that is combining the electrical energy, fixed wheels, multiple compartments and smart watch. The trolley has fixed wheels which will work by using electrical energy. It gives the shopper more space by adding more compartments. Moreover, it will connect the trolley to any smart watch by adding sensor.



## 7. Concept Evaluation and Selection

### a. Concept Screening

After generating the five different concept, a Concept Screening was carried in order to select the promising concepts as well as improve the concepts.

The first step was to identify the criteria that we will use to distinguish the concepts and can itself generate significant debate. The criteria's were concluded from both the first survey and the QFD. They were as follow:

- ✓ Ease of movability
- ✓ Flexibility of use (easy to opening, packing, unpacking)
- ✓ Aesthetic
- ✓ Ease of storage
- ✓ Ease of handling (how to control it in the supermarket)
- ✓ Separation between different items

The second step was choosing a reference concept, against which all other options will be compared, the existed shopping trolley bag was chosen a reference concept. This was a very helpful process, as it is much easier to compare two options than allocate a stand-alone score to a single option. The third step was to examine each concept and compares it against each criterion to give it a relative score this was done by a focused group consist of the team members. The scoring scheme was as follow + if the concept was better than the reference, 0 if it was same as the reference and – if it was worse than the reference. Finally each concept then has its score totaled (net) to show its overall score and according to the net the concepts were ranked as shown in the below table concept 2, 3, 4 were chosen for further improvement and all the other concepts were excluded.

Table 9: Concept Screening

Selection criteria	Concept variants					
	1	2	3	4	5	Ref(existed shopping trolley bag )
Ease of movability	+	+	+	0	+	0
Flexibility of use (easy to opening , packing , unpacking)	0	+	+	0	-	0
Aesthetic	0	-	+	0	-	0
Ease of storage	-	+	0	+	0	0
Ease of handling (how to control it in the supermarket)	0	-	0	+	+	0
Separation between different items	0	+	+	+	+	0
pluses	1	4	4	3	3	-
Same	4	0	2	3	1	-
Minuses	1	2	0	0	2	-
Net	0	2	4	3	1	-
Rank	5	3	1	2	4	-
Continue?		yes	yes	yes	No	-

Next, after selecting the promising concepts, concept 2 and 3 were combined by adding the pluses criteria on each concept the combined concepts has detachable bags (from concept 3) and the shape of concept 2. Concept 4 was improved by adding to its wheels that move in several direction to improve its movability.

### b. Concept Scoring

Then after that a concept scoring was carried in order to select a single promising concept. The steps were somehow close to concept screening but with further detailing and were as follow. The first step was to identify the criteria that we will use to distinguish the concepts .The criteria's were concluded from both the first survey and the QFD and the same as the concept screening criteria's but with more detailing and they were as follow:

- ✓ Ease of rotation
- ✓ Ease of packing and unpacking
- ✓ Attractive look
- ✓ Dose not occupy large space after usage
- ✓ Ease of clean
- ✓ More than one compartment
- ✓ Separation between liquid and solids

The existed shopping trolley bag was chosen a reference concept again. The second step was weighting the selection criteria , the weighting was decided based on a focus group consist from the team members while considering the survey 1 result at the same time. Then the concepts were rated again and the weighting score for each concept were obtained by multiplying the rate of each concept by the weighting of the criteria. The scored were added and the concepts were ranked and the combination of concept 2 and 3 were chosen as seen in the below table.

Table 10: Concept Scoring

Concept							
Selection criteria	Weight	Combination 23		Improved 4		Ref	
		Rating	Weighting score	Rating	Weighting score	Rating	Weighting score
Ease of rotation	20%	5	1	4	1	3	0.6
Ease of packing and unpacking	25%	4	1	3	0.75	3	0.75
Attractive look	7%	4	0.28	1	0.28	3	0.21
Dose not occupy large space after usage	15%	2	0.3	2	0.3	3	0.45
Ease of clean	8%	3	0.24	3	0.24	3	0.24
More than one compartment	20%	5	1	5	1	3	0.6
Separation between liquid and solids	5%	5	0.25	5	0.25	3	0.15
Total score	4.07			3.82		3	

Rank	1	2	3
Continue?	yes	No	No

## 8. Concept Testing

In order to predict the customer acceptance of the selected concept, a survey was conducted.

### a. Survey

First we started by deciding the type of the survey and we determined to conduct an internet type survey since it is the fastest type and has the highest response rate, then we spread it through the social networks. Second, we designed the survey questions the questions were divided into two part the first part was a screening question and the second part consist of questions regarding the shape, features, price, predicted sales rate and area of improvements. Form of the survey is in [appendix A](#).

#### The results of the survey

The total responses were 93 as shown in Figure 34 with having 87% response rate, which is much higher response rate than those in the first survey. We think because of spreading the survey link rapidly through the social networking rather than sending it only through the emails.

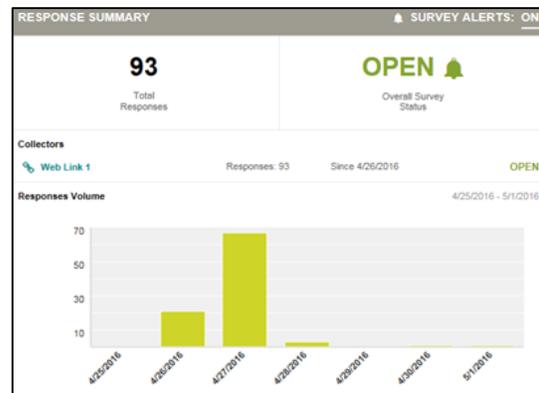


Figure 34: Total Survey Responses

The results of the main questions were as follow, more than 57% answered that maybe they will buy the bag, refer to Figure 35, more than 38% are willing to pay between 50 – 100 AED as price for the bag as shown in Figure 36, finally more than 40% think that the bag need improvement in the shape and form as shown also in Figure 36. So, the improvement was made on the concept, is that instead of the hexagonal shape, the bag was redesigned as rectangle shape.

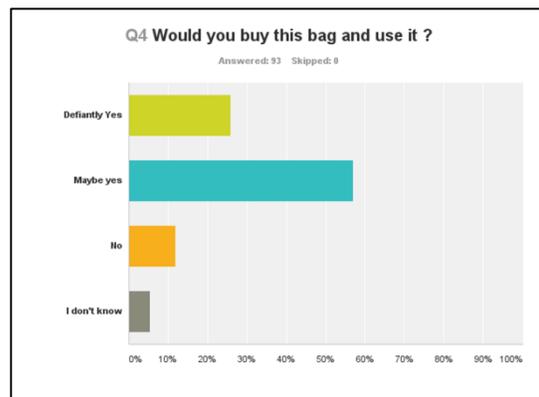


Figure 35: Result of Question 4 in Testing Concept Survey

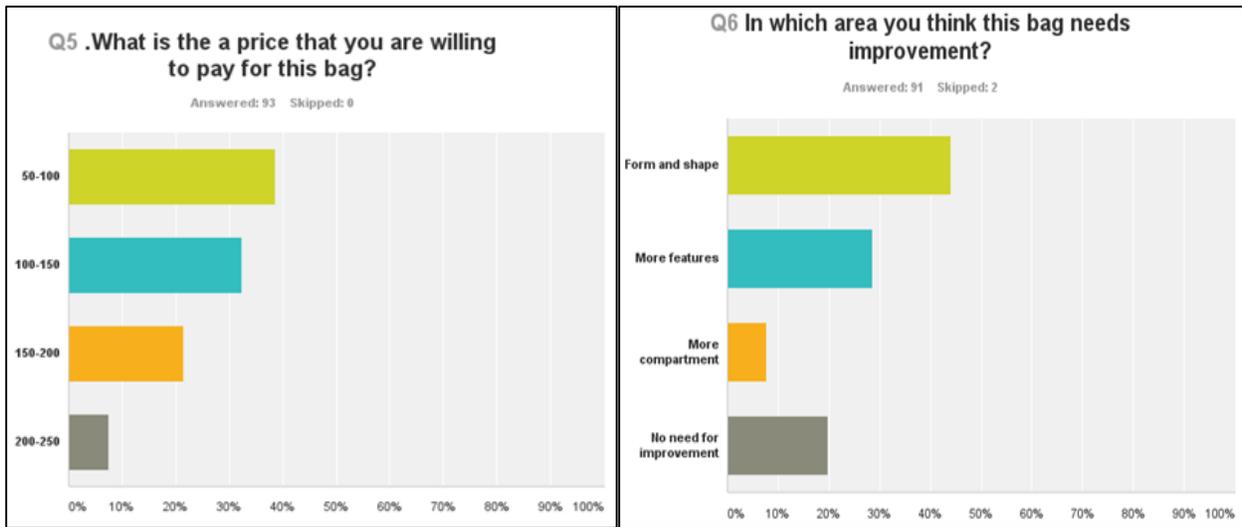
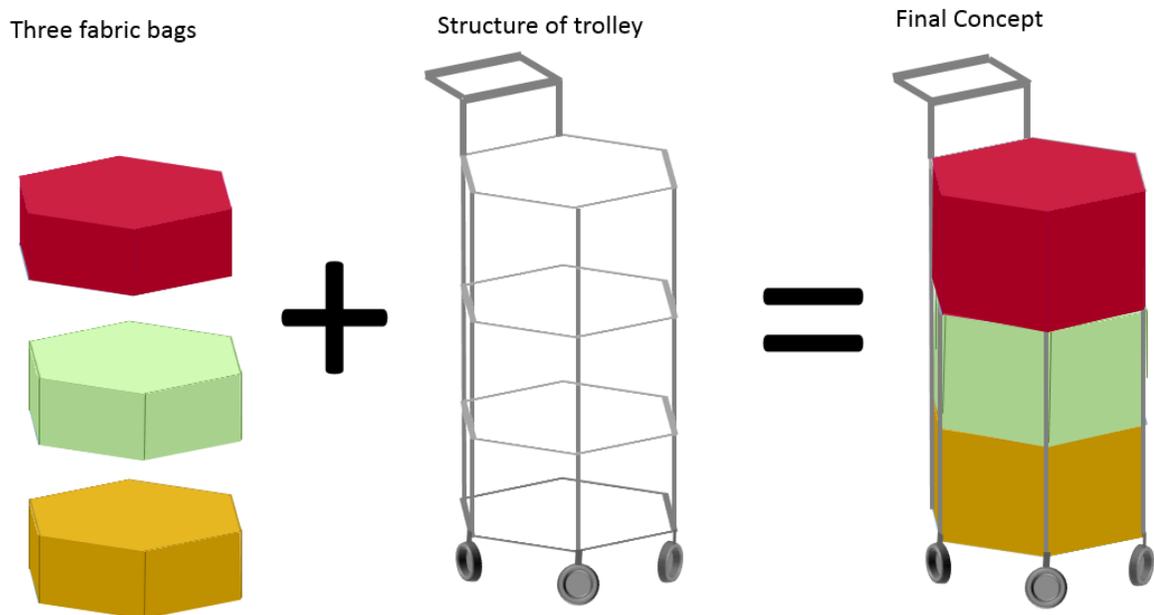
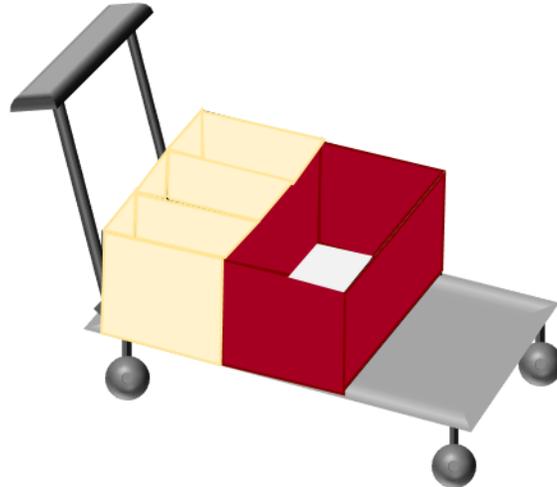


Figure 36: Results of Question 5 and 6 in Testing Concept Survey

## 9. Final Concept Selection



The above figure presents the final selected concept for the survey. We received some comments from respondents demanding enhancement in form and shape and other comments were asking for more horizontal length and less vertical height, so to enhance the shape we decided to change the shape into rectangle bags at wide diameters.



Foldable Fabric trolley

So the final concept would be rectangle, wider on length and smaller in height consisting of foldable frame, separated rectangle bags that can be connected together by clips.

## 10. Product Design

To translate the concept into a manufactural product, several elements should be considered that shown in the below figure.

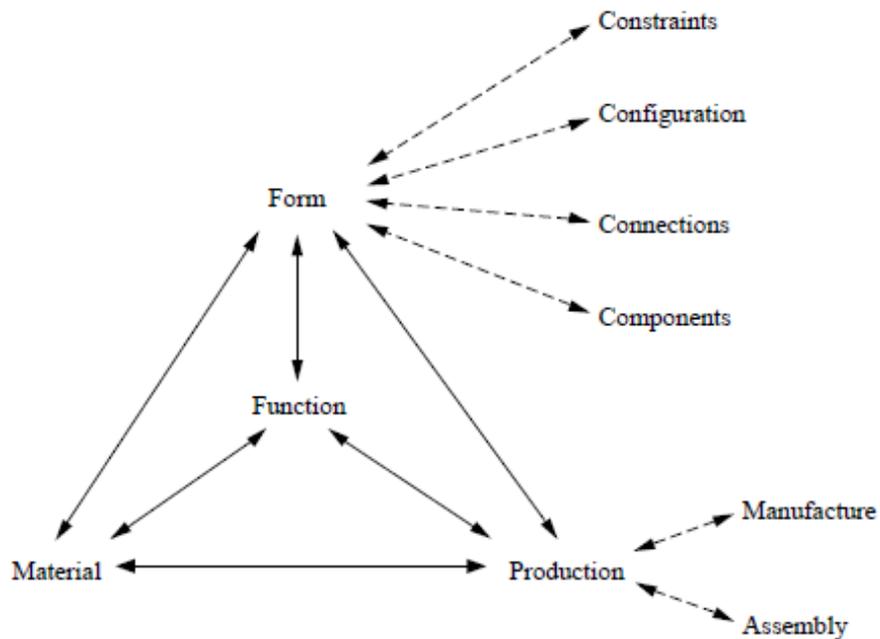


Figure 37: Basic elements of product design

The focus of this figure is the product function and connected with the surroundings which are mutually dependent on each other. The form, material and production have been considered in the conceptual design to develop the function. However, in the product design, these elements should be considered to develop the form that meet the desired function as well as the material that are available. The upcoming sections will describe the form by defining the configuration of connected components, the material and technical specifications of our product as well as the product production with considering the function of the product.

## 11. Manufacturing Plan

There are two core levels created to determine the main components of the Foldable Fabric Trolley. Level 1, represents the two main components; bags and structure assembly. Level 2 characterizes the structure assembly in sub components such as basket base, handle, screws, and wheels. On the other hand, the bags require bag base and clips, as shown in the below two figures.

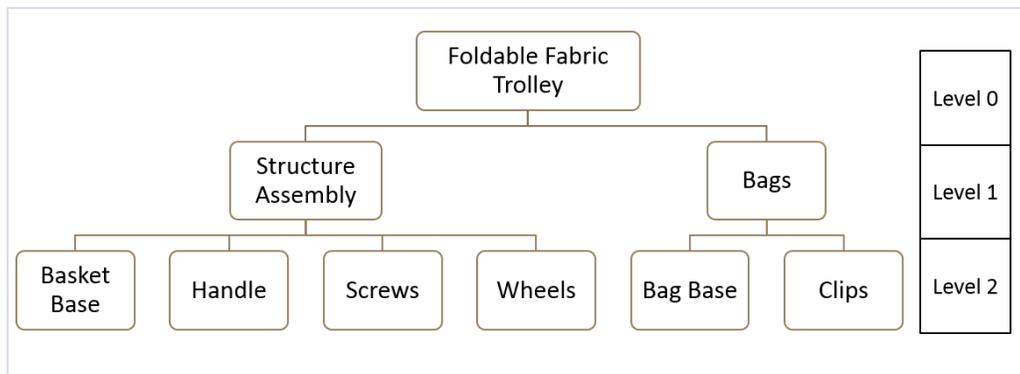


Figure 38: Assembly Hierarchy of Components

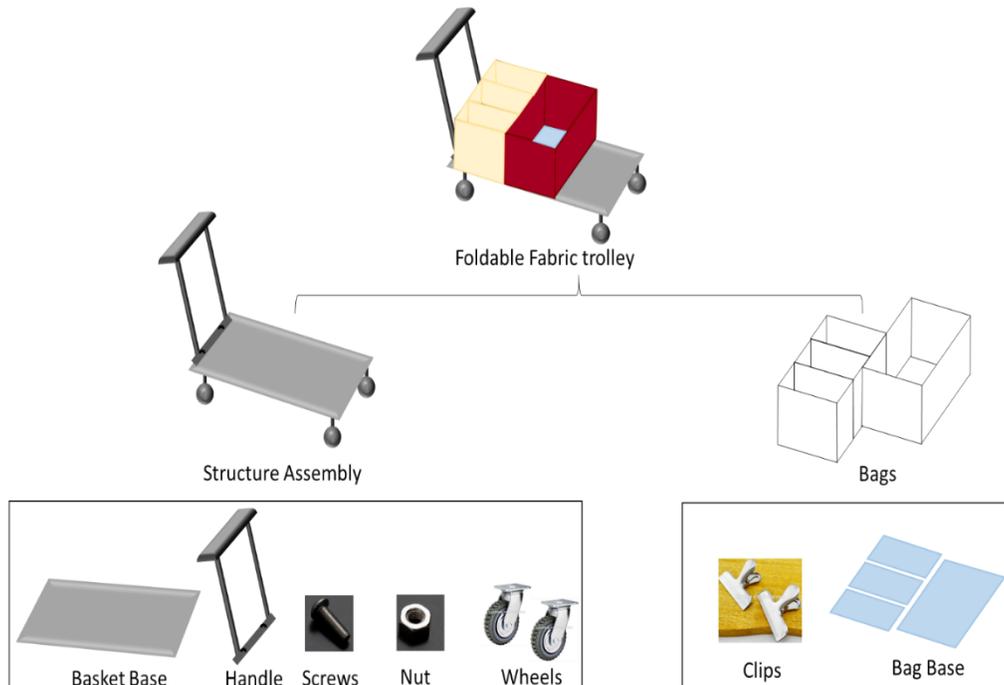


Figure 39: Rough Drawing for each part

### a. Bill of Materials

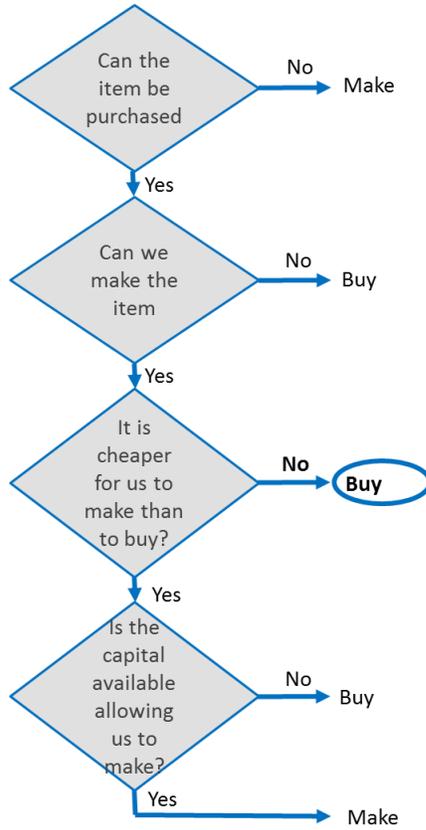
These components need a particular materials in order to produce them. For example, handle and basket base require a steel to build it. And based on the availability of these materials, it can be determine whether to make the component or to buy it form a suppliers, refer to the below table.

Level	Part name	Material	Quantity unit	Diameter	length	Width	Height	Make or Buy
0	Foldable fabric trolley	-	1	-	-	-	-	Make
1	Structure Assembly	-	1	-	-	-	-	Make
2	Handle	Steel	1	5 mm	-	50 mm	100 mm	Buy
2	Screws	Carbon Stainless Steel	12	6.5 mm	-	-	2.5 mm	Buy
2	Nut	Carbon Stainless Steel	12	Inner= 6.55mm Outer= 8mm	-	-	0.7 mm	Buy
2	Basket Base	Steel	1	-	60 cm	45 cm	3 cm	Buy
2	Wheels	PVC	4	150mm	-	50mm	190mm	Buy
1	Bag	Fabric	3	-	40 cm	20 cm	65 cm	Make
			1	-	60 cm	30 cm	65 cm	
2	Bag Base	Hard Plastic	3	-	40 cm	20 cm	1 cm	Buy
			1	-	60 cm	30 cm	1 cm	
2	Clips	Stainless Steel	9	-	7.6 cm	6 cm	3.5 cm	Buy

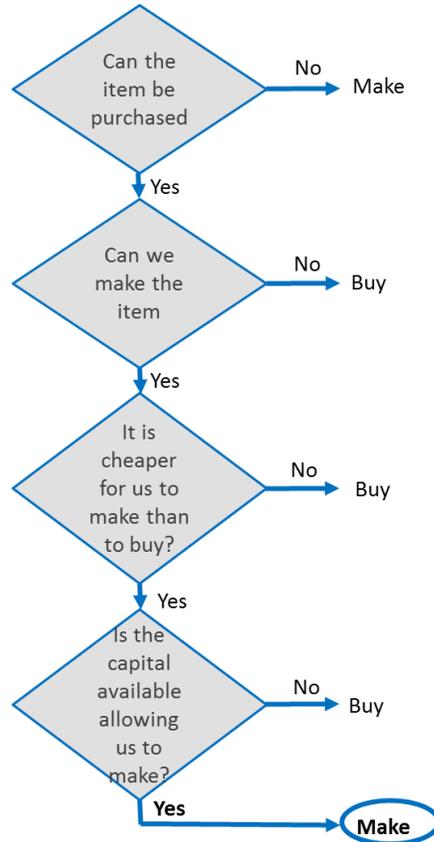
### b. Make or Buy Analysis

This determination can be analyze from our ability to purchase the item or not? If we can make it or not? And is it cheaper or expensive? For example, Handel, Basket base and Bag base, we can purchase the items and we can make them, but it is not cheaper for us, so we decided to buy them form a supplier which is cheaper for us rather than make it. The below figures illustrate the make or buy analysis for our product.

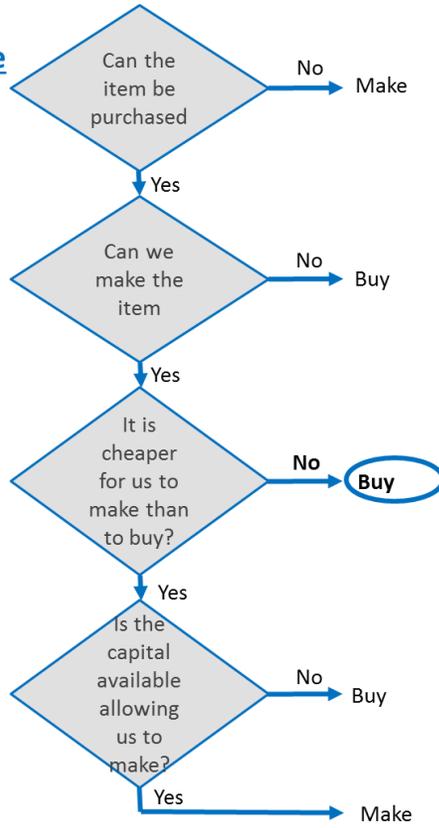
**Handle**



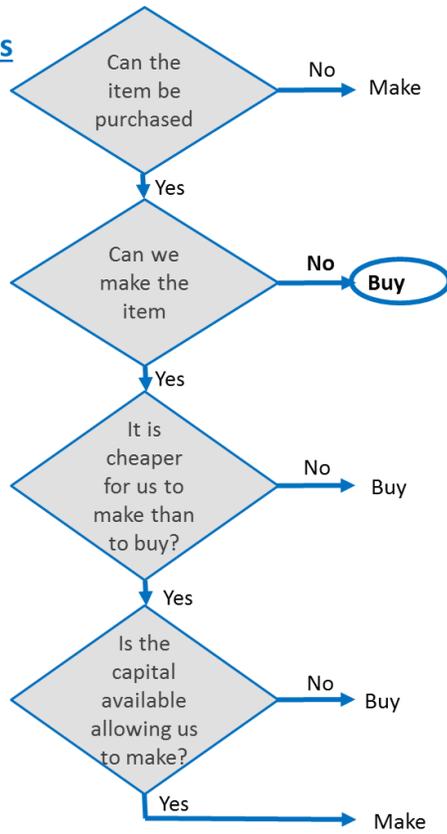
**Fabric Bag**



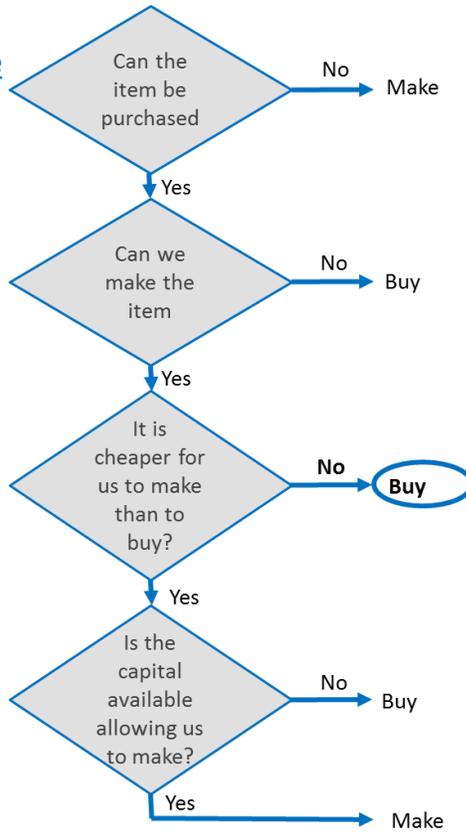
Basket Base



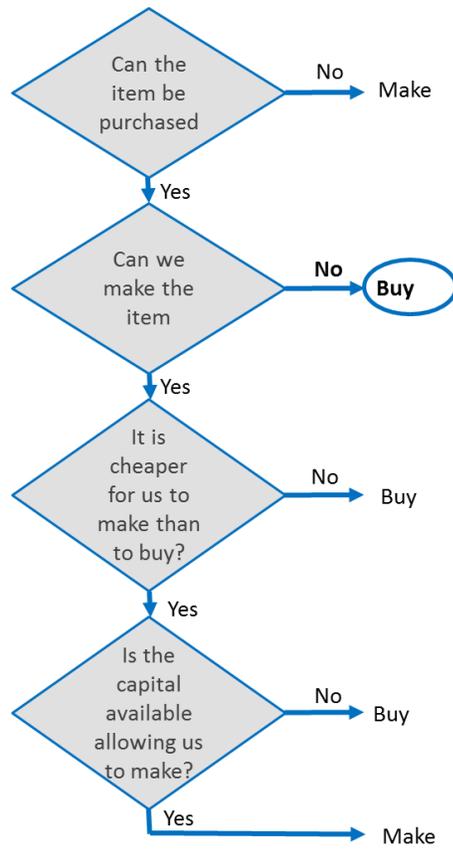
Screws



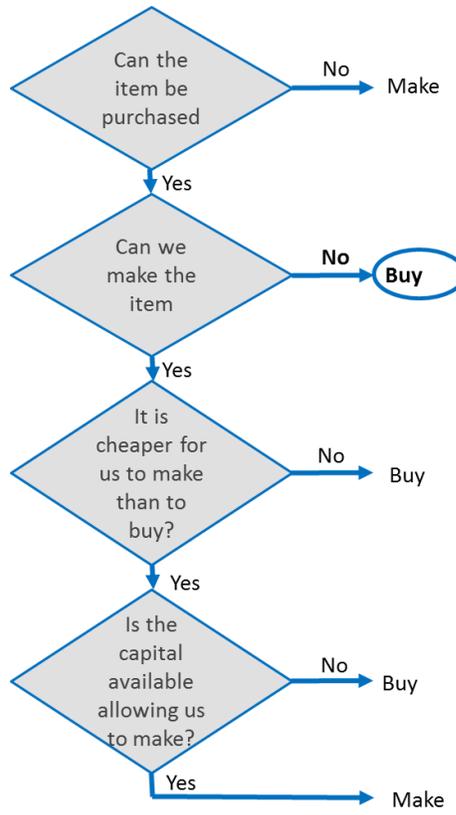
**Bag Base**



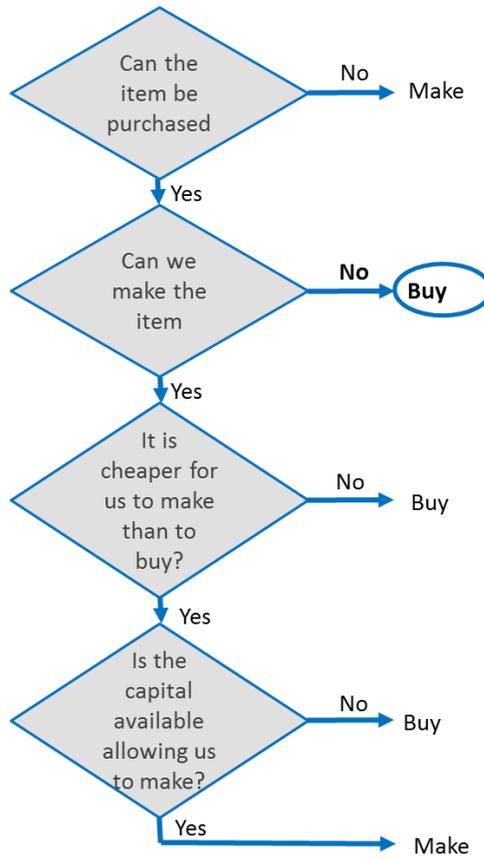
**Wheels**



Clips



Nut



However there are a required criteria's that assist us to decide which supplier we chose such as price and the quality of the items. For example, the below table shows the steel which the handle made of, it cost us 10 AED to buy it from a supplier, but it might cost us a lot if we buy it.

Item	Supplier	Price (AED)
Handle	Tata Iron and Steel Company Limited (TISCO)	10
Basket Base (frame)	Tata Iron and Steel Company Limited (TISCO)	50
Bag Base	Bookshops (plastic files)	3
Fabric	Wadan Textile company	25
Wheels set (4 wheels)	Tianfu Hardware Manufacturer	20
Clips set (12 pcs)	Julphar Metal Construction Industries	8
Screws set (12 pcs)	JINJIA Company	6
Nuts (12 pcs)	JINJIA Company	6

### c. Cost Estimation

Table 11: Suppliers for Purchased Parts

Item	Supplier	Price (AED)
<b>Handle</b>	Tata Iron and Steel Company Limited (TISCO)	10
	Amazon.com	7
	Alibaba.com	4
<b>Basket Base (frame)</b>	Tata Iron and Steel Company Limited (TISCO)	50
	Amazon.com	70
	Alibaba.com	35
<b>Bag Base</b>	Bookshops (plastic files)	3
	Amazon.com	5
	Alibaba.com	4
<b>Fabric</b>	Wadan Textile company	25
	Amazon.com	22
	Alibaba.com	15
<b>Wheels set (4 wheels)</b>	Tianfu Hardware Manufacturer	20
	Amazon.com	35
	Alibaba.com	10

<b>Clips set (12 pcs)</b>	Julphar Metal Construction Industries	8
	Amazon.com	30
	Alibaba.com	6
<b>Screws set + Nut sets (24 pcs)</b>	JINJIA Company	6
	Amazon.com	3
	Alibaba.com	1

Material costs: 15 AED, from Alibaba.com

Purchased parts: 57 AED, the lowest cost was taken for each part.

- **Product Cost Breakdown**

✓ Labor costs :

Estimated time for bag production is 1.5 hours

Table 12: Labor Force

Worker	Number	Hours per bag	Wages AED/hr
<b>Sewing machine operator</b>	1	1/2	<b>17</b>
<b>Assembly worker</b>	2	3/4	14

Total Cost of labor per bag is  $(17 \times 0.5 \times 1) + (14 \times 0.75 \times 2) = 29.5$  AED

✓ Tooling Cost

Tooling	Number	Lifetime	Hours per bag per worker	Bags per year	Price AED/hr	AED per bag
<b>Sewing machine</b>	1	5 years	1	1800	<b>1500</b>	0.167
<b>Assembly kit</b>	2	5 years	2	1800	300	0.033

**8 Working hours per day, 5 days a weeks, 45 weeks per year**

Total hours production per year =  $(8 \times 5 \times 45) = 1800$  hour

Sewing machine cost per bag =  $1500 / (5 \times 1800) = 0.167$  AED per bag

Total Tooling costs per bag =  $0.167 + 0.033 = 0.2$  AED per bag

✓ Overhead : **8 AED per bag**

✓ Selling Expenses : **3 AED per bag**

- ✓ Total Cost = Material costs + Purchased parts + Labor cost + Tooling cost + Overhead + Selling Expenses
- ✓ = 15 AED + 57 AED + 29.5 + 0.2 + 8 + 3 = **112.7 AED**
- ✓ Profit : (Markup 15%) = 112.7 \* 0.15 = **16.905 AED**
- ✓ Discount : (Margin 20%) = (112.7+16.905) \* 0.2 = **25.921 AED**

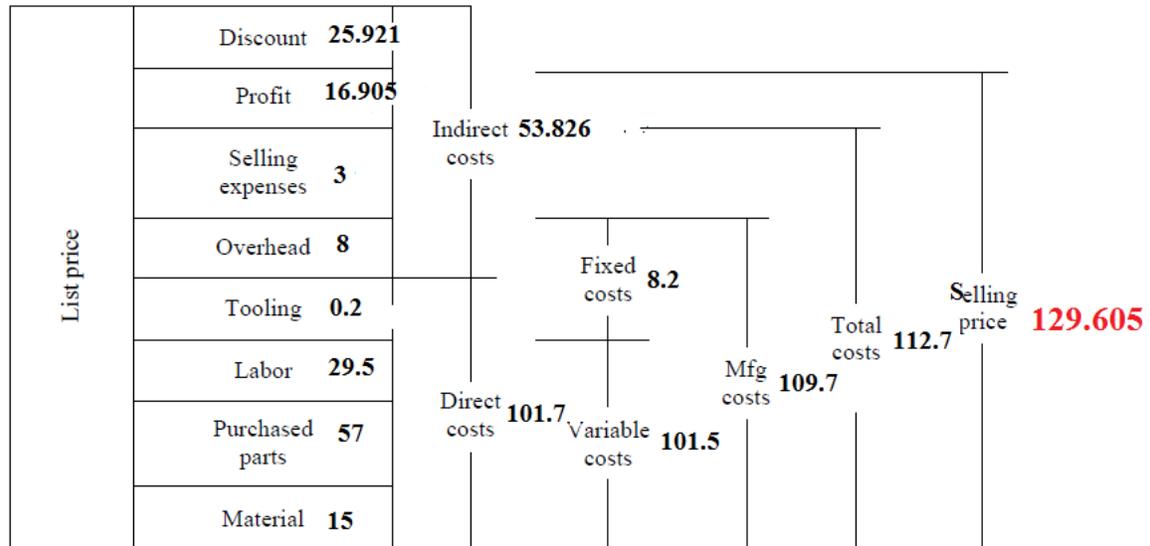


Figure 40: Cost Estimation

## 12. Design for X

### a. Design for Environment

Up to 80%\* of the environmental impacts are determined at the design stage and there are many aspects to be considered. One of them is source reduction where the goal is to use less virgin materials. The second aspect is design for recycling where the objective is to facilitate reuse. In our design both aspects were considered by applying the following features to our product:

#### 1. Maximized use of recycled materials.

- Products is designed with less mass (All the steel sections of the trolley were hollow sections instead of solid sections).

-Product is designed with longer life (more than single service such that the trolley can be used for domestic usage- fabric bags can be detached and used for different proposes like picnic bag)

-Reduce packaging (the product will be packed in a single package after production)

#### 2. Design with less variety of materials

-Only 4 type of materials were used in the design.

## b. Design for Assembly

In our design several guidelines for design for assembly were followed in order to maximize the ease and speed of assembly and they were as follow:

1. Product is designed with a base component for locating other components.

-Trolley has large steel base and all other components like the handle the wheels were attached to it.

-Base is not required to be repositioned during assembly.

-Design components are mate through straight-line assembly.

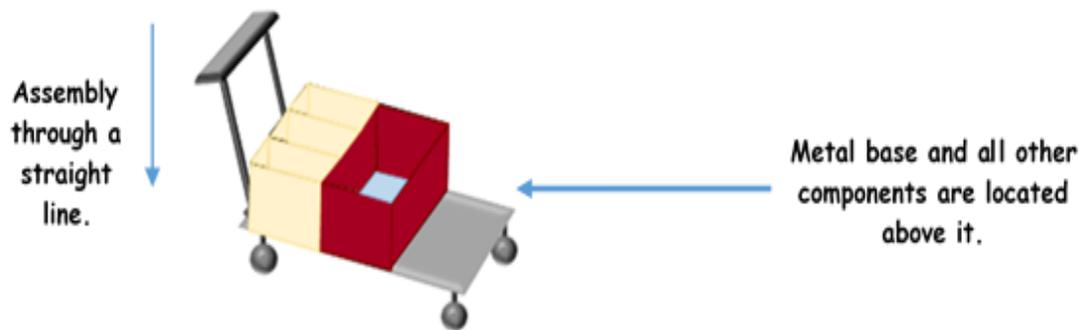


Figure 41: Design for Assembly

## 13. Conclusion

We conclude that our product would hopefully have a great anticipated success in the coming years. The environment friendly feature would have a great impact on the sales operations supporting Abu Dhabi's 2030 vision which aims to have a sustainable city. Furthermore, the technology features introduced to the product would also affect the sales potential positively. This is due to the smart society that we are living in, where everyone loves to have something unique or technology oriented gadgets that is fashionable and stylish in the same time.

### **Lessons Learnt**

At this point of the project, everybody had done their tasks in a very good way. Nevertheless, we had the issue of time management, where we had a very short time for completing the last parts as we were engaged in completing the other obligations. In future projects, we seriously need to tackle such challenge in more appropriate manner.

### **Future Features**

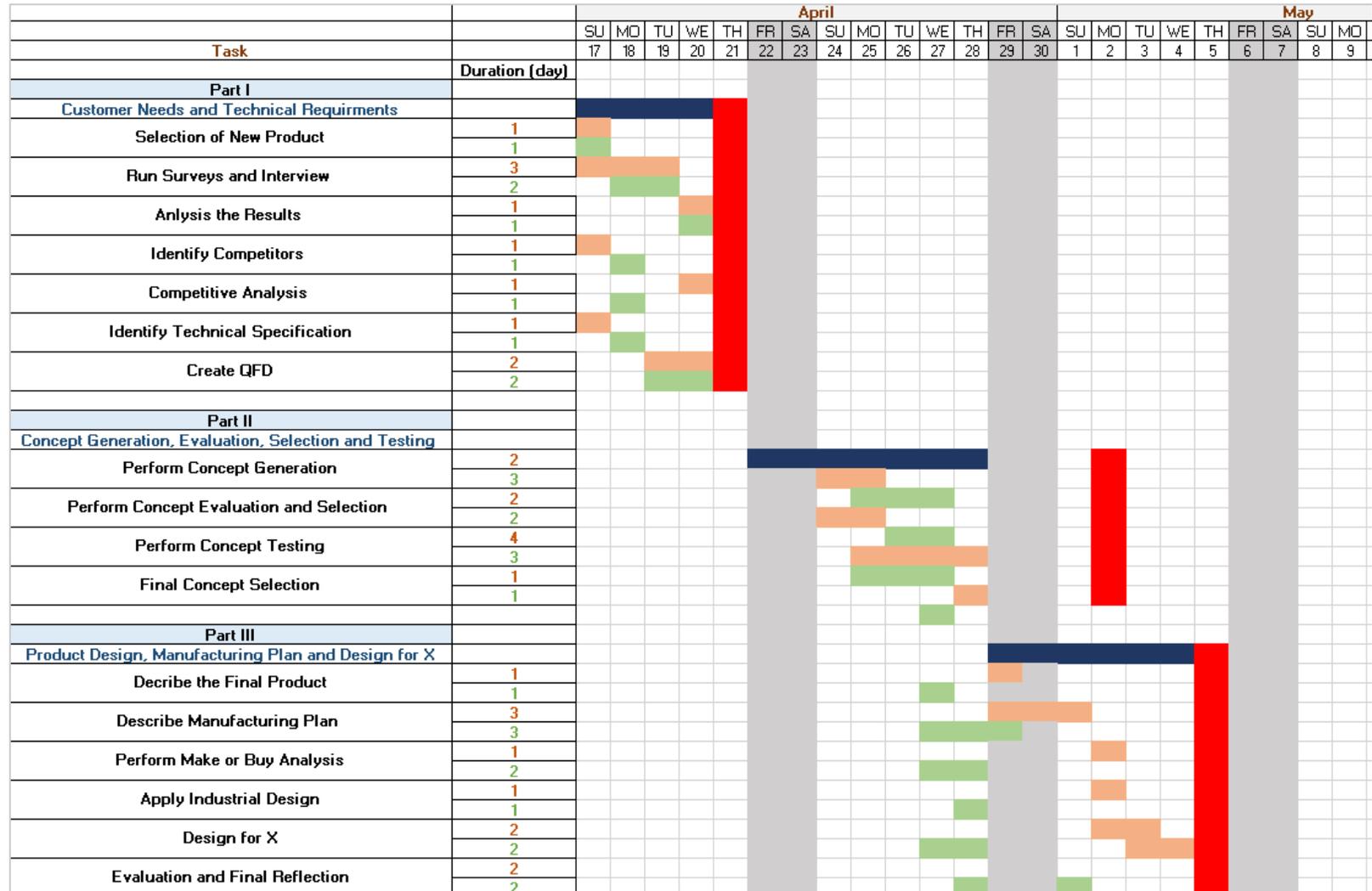
Following Apple's approach in introducing a product and then later on introduce future improvements/enhancements to the existing product. We would like to offer future features to our product, where we will offer an electronic note to write down the grocery list and add a small sensor to detect the written items. Moreover, we are studying the motion sensor which will be installed on the fabric trolley bag which in turn would communicate with an application on a smartphone.

# Appendix A

- Project Schedule

		April														May				
		SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH
Task		17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5
Duration (day)																				
<b>Part I</b>																				
<b>Customer Needs and Technical Requirments</b>																				
Selection of New Product	1																			
Run Surveys and Interview	3																			
Analysis of the Results	1																			
Identify Competitors	1																			
Competitive Analysis	1																			
Identify Technical Specification	1																			
Create QFD	2																			
<b>Part II</b>																				
<b>Concept Generation, Evaluation, Eelection and Testing</b>																				
Perform Concept Generation	3																			
Perform Concept Evaluation and Selection	2																			
Perform Concept Testing	3																			
Final Concept Selection	1																			
<b>Part III</b>																				
<b>Product Design, Manufacturing Plan and Design for X</b>																				
Describe the Final Product	1																			
Describe Manufacturing Plan	3																			
Perform Make or Buy Analysis	1																			
Apply Industrial Design	1																			
Design for X	2																			
Evaluation and Final Reflection	2																			

- Project Progress



■ Planned Schedule  
■ Actual Performance



- **Survey for identifying the customer needs**

**1. Please specify your age**

- less than 15 years
- 15-25 years
- 25-35 years
- 35-45 years
- older than 45 years

**2. Gender**

- Male
- Female

**3. Current occupation**

- Student
- Employee
- Housewife
- Other (please specify)

**4. How often weekly do you go to grocery?**

- 2-4 times
- 4-6 times
- more than 6 times

**5. Approximately, what is the weight of your purchased items per week?**

- Less than 1 kg
- 1-3 kg
- 3-5 kg
- more than 5 kg

**6. What do you use to carry your purchased items?**

- Regular plastic bags
- Traditional trolley
- Your own fabric bag
- Other (please specify)

7. If your answer in question 6 is regular plastic bag, would you shift to use a fabric trolley if it was available?

- Yes
- Maybe
- No

8. If your answer in question 6 is regular plastic bag, why don't you use the fabric trolley?

- I don't have
- I don't like to carry
- I have one but forget to carry
- Supermarket provides only plastic bags
- Other (please specify)

9. Would you prefer the shopping bags to be movable?

- Yes
- Maybe
- No

10. What is your preferable size of the bag?

- Small (e.g. small purse)
- Medium (e.g. laptop bag)
- Large (e.g. trolley)

11. Do you think that using shopping fabric bag/trolley is flexible?

- Yes
- Maybe
- No

12. what do you prefer to use in shopping?

- Carrying a pile of separate plastic bags
- Dragging one foldable trolley including several compartments
- Other (please specify)

13. Which one do you think is more fashionable?

- Regular plastic bags
- Traditional trolley
- Fabric bag/trolley

14. What do you prefer for bags/trolleys storage after using ?

- Storing a pile of plastic bags
- Storing one foldable fabric bag

15. Would you shift to use a foldable fabric trolley if it would save the environment?

- Yes
- Maybe
- No

- Survey for testing the concepts

**1. Please specify your age ?**

- Less than 15 years.
- 15-25
- 25-35
- 35-45
- more than 45

**2. What is your gender?**

- Female
- Male

**3. What do you think about the design of the bag (form ,aesthetic)?**

- Very good
- Acceptable
- Bad

**4. Would you buy this bag and use it ?**

- Definitely Yes
- Maybe yes
- No
- I don't know

**5. .What is the a price that you are willing to pay for this bag?**

- 50-100
- 100-150
- 150-200
- 200-250

**6. In which area you think this bag needs improvement?**

- Form and shape
- More features
- More compartment
- No need for improvement

**7. Mention Any other modification ?**

**8. What is your preferable pattern of the bag?**

- Plain (one color )
- Printed
- Dotted
- Plain (more than one color)

The following table shows the contribution of each team member in each tasks including report and presentation. The scale will be as follow: **main, small, very small and none contribution.**

Tasks	Member Teams				
	Amnah Alzeyoudi	Bushra Alnaqbi	Mohamed Alawani	Shaikha Al Alawi	Wala' Abed AlKhader
Project schedule and project progress (Gantt chart)	Main	Small	None	None	None
Overview of the product, Project and company background	Main	None	None	None	Small
Opportunity statement	Main	None	None	Main	Small
Mission statement	None	None	Main	None	None
Customer needs (survey and analysis)	Very small	Main	Very small	Very small	Small
Competitive analysis	None	None	None	Main	None
Target technical specification and QFD	None	None	None	None	Main
Concept generation (functional decomposition, critical sub-problems and their solutions)	Very small	Main	None	Small	Small
Classification trees	None	Main	None	None	None
Combination tables	None	Main	Small	Small	Small
Concept screening and scoring	None	Very small	None	Main	Very small
Concept testing (survey and analysis)	None	Very small	None	Main	Very small

<b>Final concept selection</b>	None	<b>Main</b>	None	None	<b>Main</b>
<b>Description of final product design</b>	None	<b>Main</b>	None	None	None
<b>Bill of materials</b>	<b>Main</b>	<b>Main</b>	None	None	None
<b>Make or buy analysis</b>	<b>Main</b>	Very small	None	None	Very small
<b>Cost estimation</b>	None	None	None	None	<b>Main</b>
<b>Design for x</b>	None	None	None	<b>Main</b>	None
<b>Conclusion</b>	None	None	<b>Main</b>	None	None