université de BORDEAUX

Engineering — Product Design

Proof Of Concept

Liftable and extensible coffee table

Contents

Part I
How to design a coffee table?

This report is about designing a **liftable and extensible coffee table**. Indeed, the project of the **Engineering - Product Design and Innovation** is to think and design that table, according to some initial requirements given by Mr Chen during the beginning of the semester. To do so, we will be helped by some videos we have on the Moodle platform of the course, which are about every step of product designing. But first, we need to understand what is the main word of our course: **design**.

What is design?

Designing a product is a hard task, considering the number of criteria that must be met in order to produce an object that is sufficient, good-looking, and which corresponds to the objectives and needs requested by customers. Designing is not specific to a physical object: one can also design a service, according to musts and needs. For the purpose of this report, I will only talk about designing an object, but definitions can be extended to service designing.
According to me, design is both the process of imagining a product and the methods to create it, that fit the criteria requested by users, by intermediate customers (eg. factories, transporters...) or by law and satisfy them ; and the result of it, ie. the final draw and proof of concept of that product.

Designing is of course difficult, because of these criteria, in relation to the lack of time and of money. Resources are limited, both financial and human — it is therefore needed to quickly find correct answers to problems and requests in order to be competitive.
Moreover, you cannot just design a product according to the requirements of your customers. One have to make a design that is still legal (according to norms and laws), secure, practical... and, especially nowadays, that is good for sustainability, recyclability and environment.

About our product

In this report, we have to design a **liftable and extensible coffee table**, a coffee table, where the user can change both table height and radius. The initial requirements given are the following: the table must be...

- easy to lift,
- easy to extend,
- solide and flat,
- affordable,
- lightweight.

These initial criteria give us a framework to design our table: it should not be a table for rich people, or with a lot of contraptions that add weight or increase the price too much. The designed table should indeed be a portable one, where the table can be moved, or at least extended, quite easily.

Part II
Identifying customers

The first problem of designing a product is to find the customers, the population that will be interested or involved in the participation or the use of that product. The coffee table will indeed be designed accordingly: different customers have different needs, and you can't satisfy everyone. Choices must be made, depending on who will be your customers. Obviously, the final user of the product is a customer, and is the main customer we should care about. But behind that term, we have to include and forecast who will be the people who will have to interact with our product: it includes the factory, the seller, the transporter, etc. These people have their specific needs for your product to be efficient in the way they are using it: a transporter will want your product to be easy to store. Therefore, we will have to make a list of all these intermediate people that will work around our table, and see that are their main needs.

Analysis of the end users

First, we have to figure out who will be the people who could buy this product. There are several methods to try to find this. Here, I choose to ask people and friends several questions to see if they would be interested by this object, and if so what should be their needs. I also asked people who were not interested why, to see if there is a particular reason that could interfere and block potential users to buy this product.
So I polled **32 people**, from 15 to 35, which live in different places, via Internet. I also asked my family, and their answers were included in the survey result.

Globally, the survey shows us that this table would be nice for people who are already installed in their own house, often with childs. Young people told me they would not be interesting at the moment, but maybe later. Indeed, when asked about the potential uses of that table, people said: "To eat *apéro* and then lunch", "To do both homework and parties"... Some mentioned the case of disabled people, for who the table may be interesting, as it could be used as only table to do everything for them.
Most of people told me that would be a table for older men and women. However, I personally do not think that, because this is not only for them.

This survey may have be biaised by the number of young people who voted, and the lack of older person in it. Therefore, a more advanced study should be done about the market and the potential customers. Nevertheless, here are some potential customers for our table:

- Families, with young kids that would like to use the table with their little height;
- People in their 40's, for which that table could be used as a work and lunch table, depending on the configuration;
- Disabled people
- People who invite a lot of friends for parties and lunches. The extensible part of the table is something that is requested!
- Old men and women.

Therefore, we need this table to be as confortable as possible, and to look very familial and not too cold, as these would be a point of no return for this audience who looks for a *cosy* table.

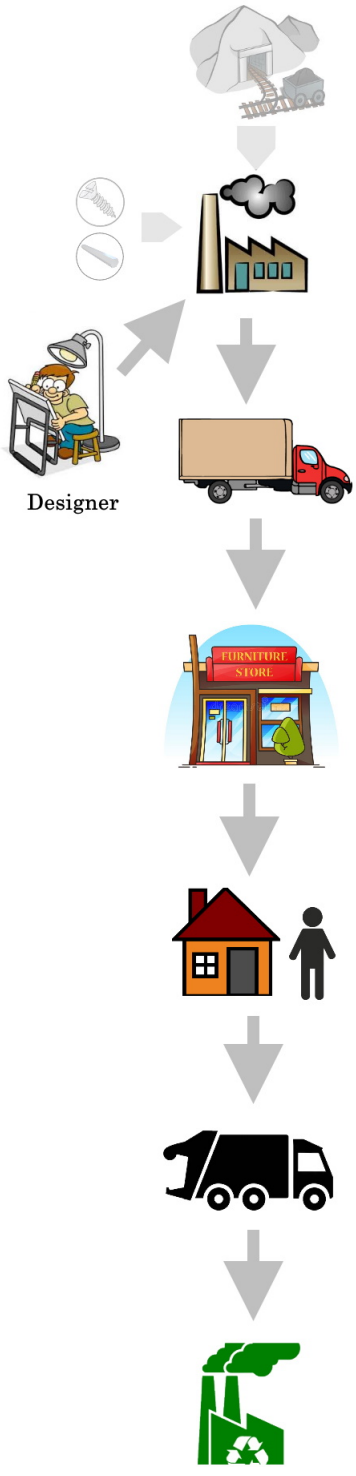
Moreover, I looked at Internet comments to see potential audience that I did not thought about. That sort of *customers benchmarking* confirmed my previous thoughts. On the Internet, we can often see comments of families who love that product, or young couples that just moved to their own house, and are happy of the cozyness of that table. For instance, this comment comes from a similar table, sold by American company Amazon:

Unfortunately, these comments do not give us a lot about the customers themselves. Still they are pretty useful to determine the needs of the customers—something that we will explain a bit later.

Note: due to technical constraints with the survey service, graphs of the survey results were not available for that report.

Product life cycle

However, we must not forget other customers of our product, which are the intermediaries between the designer and the end user... but also the steps after the product has been used: dustmen, dump... that will recycle or burn our table. Therefore, we can imagine the life cycle of our coffee table, and the people who will be implied in the process:



Suppliers

Factory
Need: not too many complex parts
in order to produce quickly

Transporter
Need: can fit in a rectangular box
not too fragile

Furniture store
Need: good-looking, not too heavy

End user
Need: safety, reliability, stability

Dustmen
Need: easy to transport when used

Recycling plant
Need: easy to recycle
ie. easy to disassemble

In this process, suppliers should be mentioned: they are of course an important part of the whole production chain, by obtaining the raw materials needed to produce the table. However, I choose not to include them in my customer research: in fact, the supplying chain is a task specific to the factory, and the designer is really important in the factory, not before. Of course, material choice is the base of that supplying chain, but suppliers don't have specific needs about the product; they just have to supply factories with the needed materials. Furthermore, the base material of our table is one of the most important choices for customers, so we have to consider their needs first.

The life cycle of our table is quite simple: the table is fabricated in a factory that gathers all the screw, iron bars, metal or wood... and is then sent to furniture stores via a transporter. The end user will then pick up the table from the store and transport it to their house.
It is worth mentioning there are two cases to transport the table from the store to the user:

- The customer can use their own car or van to transport the table by themself. In this case, **the customer will want a lightweight, not too big, maybe in kit, table**, so it is easy to transport.
- The customer can also have their table delivered via the store delivery service. There, the table will have to be solid and easy to pick up by the customer from the truck to the house.

But, as mentioned before, the life cycle of our table doesn't stop there. The designer also has to think about the future of his product, after being used. Therefore, we have to take the recycling chain in consideration, from the end user to the plant and after. The main need here is that our table should have not too many parts, especially mixed parts that are composed of both recyclable and non-recyclable materials. Having a table with only a few components is important for the recycling plant, which needs that to recycle the table, maybe in an other table. Thus, we have to consider that need.

Customers are now defined: we obviously have to consider the user, which according to our survey will be a person (either man or woman), in their forties or older, which is often in a family and lives in a house. But we also have to understand the needs of transporters, factories, stores, dustmen and recycling plants, that are part of the production and aftermaths chain.

Part III
Identifying customer's needs

Now we have defined who will be the main target of our liftable and extensible coffee table, we have to see what are their needs, ie. the objectives and uses they want the product to have. These needs are plural: they can be about safety, beauty, practical issues, but also in terms of transportation, removability, shareability...
To consider these needs, we have to figure out by ourselves what could be people concerns, but also ask our main audience what are their cares, by doing a survey or interviews of potentially interested people.
These needs can then be classified, but we won't order them for now, as we will have to consider other sources of potential needs, via benchmarking for instance.

Initial needs

First of all, we must not forget the fundamental needs mentioned in the initial requirements of the coffee table. These requirements can be converted into specific needs that will be saved in our needs list. That conversion is specified in the following table:

Requirement	**Consequent needs**
Easy to lift	Handles to help the rise of the table A system to lock/unlock height change
Easy to extend	Handles Second layer of table that can be cought
Solid and flat	A system to lock/unlock height change, such as a valve Second layer of table must be pushed to first layer height Hookable planks to support the second layer of table
Affordable	Metal tubes that support the height change Use of only a few parts to save money
Lightweight	Metal tubes that support the height change A light raw material

To do so, I tried to describe what can be infirmed from the requirements, and what are their reasons to exist. For instance, I focused on the *Solid and flat* requirement by trying to figure out what could be the expectations of the end user to have a solid and flat coffee table. Thus, I thought they might need a system to lock the height of the table, so the table doesn't fall down when a heavy object is put on it ; I also noticed that, to keep the table completely flat when fully expanded, we should level up (or down) the expension of the table, so we don't have a gap between the base of the table and its other layers.
Some of the needs are pretty easy to find, such as for a lightweight table — we just have to use lightweight materials and reduce the number of parts of our table. But there are already some difficulties to find them, such as to have an easy to extend table: handles? support planks? I mentioned handles because they should be the most requested by users, but this need can then be removed when we will classify our needs.

End user needs

To find all the potential needs of our end users, we can use the empathy method, which consists of thinking as a end user, and trying to list all the needs we have for a coffee table. So, I had to question myself:

What would I want a coffee table to have?

I thought of all the following:

- Stability: I don't want my table to fall when I put an object in the corner;
- Easyness to clean: I don't want taches that are hard to clean due to the grip of the surface;
- Easyness to move: I should be able to move the table without a second person to help me;
- Storage capacity: I would appreciate some cases to put little things behind or below my table;
- Security in corners: I don't want to hurt myself or my children with table edges;
- Protection in edges: if I spill a coffee on the table, the liquid should not land on the floor.

Of course, there are a lot of other needs but they really depend on the preferences of our users: the material, whether if it is transparent or not; if the table should be round or squared... These are choices we will have to do, and we will obviously lose some market people in this. A nice thing to avoid that would be to prepare and design several types of our coffee table (like one transparent, with stained class for instance, and one with an opaque surface), and our public could choose one of the two, so they don't go to our competetors.
To determine what choice should we make about these tricky questions, and to have an other point of view, I've also asked in my previous survey what should I bring in the coffee table. Notably, I asked people to rank their tastes in different materials for that table. I would then design the more selected table consequently.
The survey pointed out several other needs for our coffee table:

- A second layer below the surface of the table, to put stuff (very requested, by more than the half of people who would want a coffee table!);
- Be solid enough to support a kid, because kids love to jump on these.

A third wants a transparent table, while the two other third wanted an opaque table, from wood or metal. The survey doesn't help us a lot...

Other customers' needs

We should not forget that our end users are not the only customers of our table. As we have seen in the previous section, customers come a full range of jobs and entreprises, from factories to dustmen and dumps, including transporters. Here, we only have the choice to use the empathy method to find what could be their needs. Some of them were already said previously, in the *Product life cycle* section. We can explain them, as we have done in the *Initial needs* subpart.
Moreover, we must think of some 'Design for X' requirements, as design for easy storage, or for sustainability. Indeed, these criteria are important for our customers: transport companies need easily movable packages; stores want our package to be as little as possible; recycling plants want our product not to be too hard to recycle, ie. without mix of recyclable and non-recyclable materials, or with components which can be easily separated. Respecting these criteria also helps us by saving us some additional costs or taxes, that our customers can impose to us. The size of our package can influence transportation costs, for instance. Therefore, we need to think about these needs. I found the following:

- Little packaging: transporters and furnitures stores want our package to be as little as possible, in order to be easily movable and storable.
- One rectangular packaging: moreover, it would be hard for transporters and stores to store many packages for a single table. In consequence, our table should fit in one and only one box.
- Not too fragile: transporting a fragile product is hard, so companies would want a solid table, that can support transportation issues.
- Removable parts: recycling plants want our product to be easily recyclable, which means the table's parts should be removable, in order to distinguish recyclable parts and non-recyclable parts. Moreover, it can be useful to reuse parts of our table to other utilisations.
- Not too many parts: in order for our table to be produced quickly, we should avoid having too many components on our table. Therefore, the factory can save cost and time.
- Avoiding rare components: our table should not be made with rare material that are both expensive and not easily recyclable.

Classifying needs

We then have to list and classify all of our needs in several parts, to have a vision of our needs. This step is **not** to rank our needs, as we will find other needs later. That classification will help us later on, in our House of Quality, and we will have a global view of what is needed by our customers.
Needs can be split in four categories: **expectors**, ie. must-have features; **spokens**, ie. features that were requested by customers; **unspokens**, aka. implicit features that were not mentioned but could be nice to add; and **exciters** that are bonuses that would not lack if there weren't in our table. However, as said during the course, needs must be verbs, that will then be fulfilled by the corresponding engineering functions. I then had to replace some *needs* that were previously said, by similar verbs. These changes give us the following classification:

Expectors	Lock or unlock height change Help table extension Be stable Not to hurt people (!)
Spoken	Be not too fragile Fit in a box Be movable Be easy to clean Be elegant
Unspoken	Store things Be solid enough to support a kid Avoid rare components
Exciters	Prevent liquid leaks Have removable parts

Part IV
Benchmarking

Benchmarking is a step that consists in looking what is already done in the current market of our product, and looking for forgotten needs or astonishing features that we could have on our coffee table. As we don't look for the qualities of one product, but of several products, it is not plagiarism, but inspiration — according to the lecture. Indeed, when a feature is mentioned in several products from different companies, we can suppose that this feature is not protected by a patent, because it would have been took down if it was the case. Thus, we can freely inspire by looking at existing products, because risking sues.

Comparision

First, we can look at existing products on the market, here found via several Internet searches.

0.1 Lift coffee table, by Team7

Lift coffee table, by Team7

Here, the table can be lifted thanks to a locking system that prevents the table from falling, by applying a force on the base of the table. To lift the table, that system must be unlocked, and the user just have to pull the table to him. The extensible part is made by the two compartments, that can be used as extensions of the table, as well as storage drawers. Edges are not protected but are not that sharp, so risks of being hurt is reduced.

0.2 Raisable extensible table for little room, by Ulisse

Raisable extensible table for little room, by Ulisse

The legs of this Italian table were replaced by two stands which can be bended in the basic coffee table position, or unfolded to rise the table up to 88 cm, thanks to a gaz cylinder that let change the inclinaison of the stands. Therefore, to rise or pull down the table, a simple button can be pushed in order to free the gaz, letting the user change the height of the table; when the button is released, the height is locked. The two planks of the surface of the table can be pulled to open a middle part, containing the extension planks that can be then installed on top of the table, thus extending it to an additional meter.
We can notice that the table is composed of oak wood, and is thus very heavy: **70 kg**. To counterbalance that weight, bottom bars of the table contains small wheels, so the table can be pushed and moved easily. The weight of the table avoid accidents, but let people move the table alone if they want to.
All of these pros have a big con: its prize: **€1,395**, not including VAT!
Similar design, but in concrete, and way cheaper:

Raisable modulable table for little room — Twinga, sold by Mobiliermoss

0.3 Raisable and extensible coffee table 80x80, by Wink

Raisable and extensible coffee table 80x80, by Wink

This design is more similar to a coffee table: it consists of two planks (here, colored in white) that, in the default configuration, sit one over the over, but can be open and put one next the other, multiplying the surface by two. When extended, the table doesn't fall thanks to springs and sticks that avoid the table from falling at each side; and they can't fall one after the other because they are joigned when extended. To remove these extension, the user just needs to unlock the sticks and rotate both parts, returning in its first configuration. Thus, this table is both liftable and extensible, but not very flexible, with only two possibilities of height and length.
This table is also quite unsecure, because of the edges that can clearly hurt a kid's head. But its prize is very competitive: about **€200**, which seems pretty affordable for a liftable and extensible coffee table.

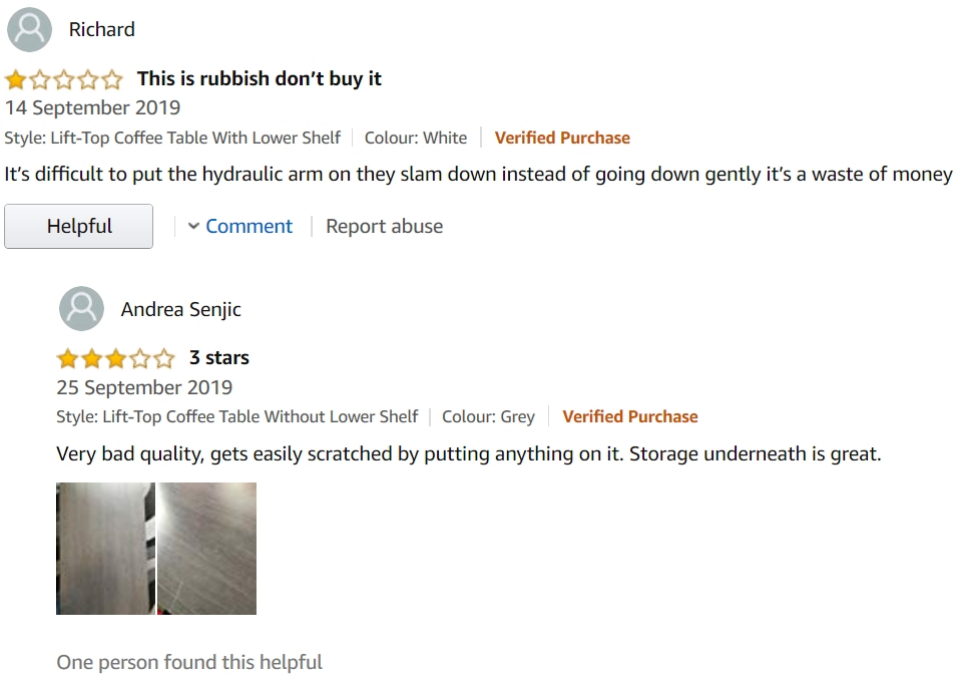
Summary

These designs are three completely different designs, based on three different methods:

	Design 1	**Design 2**	**Design 3**
Lifting system	Liftable leg with a locking system where a force is put on the leg to prevent it from falling	Two legs that form a cross. These can be pulled or retracted via a gaz cylinder to change angle between the legs.	The planks of the table can be risen and stay at their position thanks to springs and sticks that must be installed via the user
Extending system	Drawers in both sides	Pulling the two side planks open an hidden third plank, that can be then levelled up	Lifting the table involves extending it
Moving system	Not a movable table	Small heavy wheels	Lightweight table, easy to move

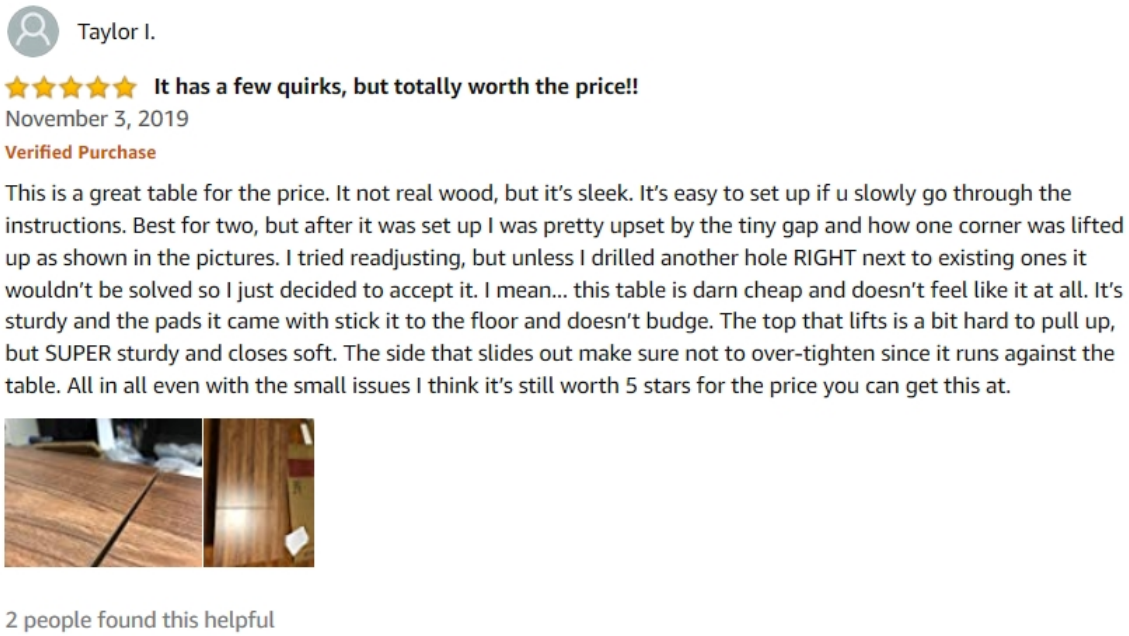
Internet comments

Moreover, in the continuity of the study I made to find customers, I looked at ratings of existing liftable and/or extensible table, to find potential issues that I would not be aware of. That study was really interesting, because I found some things. For instance, these two comments come from the *Amazon Brand - Movian Aggol Lift-Top Coffee Table*, sold by Amazon:



We can clearly see issues of other tables: they get scratched easily, and hydraulic solutions are not the best. This is a key point: we should be cautious about the risk of natural degradation, that would cost us a lot of money because of the mandatory warranty. Therefore, we and our intermediate customers do not want a table that would fail in their very first years.

Here, a person who bought the *WLIVE Wood Coffee Table with Adjustable Lift Top Table* told his disappointment about the gap between the planks of the table, when lifted. That table is indeed like the *Raisable and extensible coffee table 80x80 by Wink* we saw previously.


Taylor I.

It has a few quirks, but totally worth the price!!

November 3, 2019

Verified Purchase

This is a great table for the price. It not real wood, but it's sleek. It's easy to set up if u slowly go through the instructions. Best for two, but after it was set up I was pretty upset by the tiny gap and how one corner was lifted up as shown in the pictures. I tried readjusting, but unless I drilled another hole RIGHT next to existing ones it wouldn't be solved so I just decided to accept it. I mean... this table is darn cheap and doesn't feel like it at all. It's sturdy and the pads it came with stick it to the floor and doesn't budge. The top that lifts is a bit hard to pull up, but SUPER sturdy and closes soft. The side that slides out make sure not to over-tighten since it runs against the table. All in all even with the small issues I think it's still worth 5 stars for the price you can get this at.

2 people found this helpful

These comments, even if they could be fake, should make us aware of potential issues of our table, and needs that come with. Thus, we can make a table which is better than everything in the market.

New needs

This benchmarking made me clear that the lifting system of the table should be locked until the user has pressed a button, in order to prevent the fall of the table by accident. Moreover, these concepts gave me some ideas for the final design of our table: the idea of the crossed legs to easily lift the table is a nice touch that is both affordable and easy to understand. Also, the Internet comments I saw helped me in finding issues and needs we will have to address to our future customers.

Therefore, benchmarking is an useful and important step in our designing process. Now that the needs are known, we need to think of the functions that our table will have, related to these needs.

Part V
Engineering functions

Our needs are now well-defined at this step. Now, we have to figure out the engineering requirements that correspond to our needs. These are multiple: one need can correspond to multiple functions, that will then be classified and ranked in the House of Quality.

It is important to notice that **these functions are not solutions** for our needs. Engineering requirements are in fact the measurable elements of our needs. For instance, an engineering function for the need to be easily liftable could be the force to exert to pull the table or to activate the lifting system.
These functions that correspond to physical problems of our table will then be compared in the House of Quality, to see what are the most important. The solutions for these needs and functions, which are the real design choices that we will do, will be in the *Concept generation* part of this report.

To find these functions, we must consider the measurable facts that correspond to a single need. These are often physical characteristics of the table, ie. stuff what the factory can measure, to see if the need is then sufficiently fulfilled. Why? Because needs are subjective—one can always say that this need is satisfied by the table, while another would say the opposite. Therefore, we should have numerical criteria to compare solutions and to safely say if our product fulfills that need.

Main needs

Here is an array of possible engineering functions related to needs that we previously described as **Expectors** and **Spoken**:

Need to be...	**Engineering functions**
Easily liftable	Force to exert to lift the table Maximum and minimum height Number of intermediate heights
Easily extensible	Force to exert to extend the table Difference between default and extent size
Be stable	Max weight the table can support on one side before collapsing Vibrations of the table depending on the weight of the object Max torsion of the table, between the center and the edges
Safe for people	Maximum weight the table can support
Not too fragile	Maximum weight the table can support Maximum lateral force the table can support
Fit in a box	Size of the packaging
Movable	Force to exert to move the table Inertia of the table when moved*
Lightweight	Weight of the table
Affordable	Production cost of the table
Easily cleanable	Average time to remove a stain

`* Distance covered by the table when moved with a specific force, in order to measure the capacity to move the table and to avoid accidents.`

Other needs

Here are found the functions possibly related to needs that we previously classified as **Unspoken** or **Exciters**, or that we added in our *Benchmarking* step.

Need to...	**Engineering functions**
Store things	Maximum capacity of the table (inside and on it)
Be solid enough to support a kid	Maximum weight the table can support
Avoid rare components	Production cost of the table
Prevent liquid leaks	Maximum liquid the table can have on it before leaking
Have removable parts	Number of parts of the table when dismantled
Be sustainable	Percentage of recyclable components in the final product
Not to take much place	Size of the table when not extended
Prevent accidental falling	Maximum weight the table can support Force to exert to enable the lifting system Max torsion of the table, between the center and the edges

Qualitative needs

Nevertheless, this search for engineering functions is not always something that is beneficial for the purposes of making a cool product. Obviously, quantitative description will be important in concept selection afterwards: the technical characteristics of our table can be compared thanks to numbers, that are factual. Also, these numbers will be the ones in consideration for product comparision in furniture stores or on commercial websites: people will prefer that criteria to that one, and rank available products according to the engineering function related to the criteria.
However, we should not forget that our tastes are also subjective, and that qualitative criteria are as, maybe more, important: the aesthetics of our table, which is something that can not be counted, is really important for end user customers. These criteria will notably be important in the last **Concept generation** part, where we will compare different designs with quantitative and qualitative criteria. However, to do our future House of Quality, we also need to take in consideration these other criteria. According to the lecture, these are not engineering functions—as requirements are characteristics of our product—but I will include them in this part, as *engineering requisites*.
Therefore, we can include:

Need to...	**Engineering requisites**
Be easy to clean	Use of common products to clean the table, not specific ones
Be elegant	Aesthetical table
Be sustainable	Average life cycle of our product

The sum of all these engineering requirements gives us the criteria, the specifications for the final design of our table. Still we need to rank them, because some are more important than others, and some of them are also contradictory...

Part VI
House of Quality

In the first half of this report, we looked for the needs of the potential customers of our table. Some are mandatory to follow, like the needs specified in the initial requirements of our table. Some should really be taken in consideration, as the lack of these would be a problem for the deployment of our table (like having a too fragile table...). The others can also be important, depending on the price and the will of our customers to have them. Nonetheless, we should not forget our factory's capacity, and the cost of these products. Therefore, we have to elaborate some choices, and to *lose* some of our previously said needs. In fact, we even have needs that can be opposed, such as be both stable and movable. We therefore have to rank these needs.

Moreover, as the need of an **affordable** table is one of our fundamental requirements, we must always consider the cost of having additional bonuses that enhance our table! As we have seen in the **Benchmarking** section, we are not looking to be an expensive table, as opposed to the *Raisable extensible table for little room* of Ulisse. We then have to limit ourselves and avoid having too much stuff, in order to cut costs.

To do so, the **quality function deployment** method, aka. the **House of Quality** is a good method to link needs and functions, and relate the consequence of answering a need in other functions. This method consists in a matrix, which is composed of all of our needs as rows, and our functions as columns. There, in every consequent case, we grade the relationship between the need of the row and the function of the related column, according to my own thoughts. The grade scale is from 0 for elements with no relation at all, to 9 for the unique fonction that is the core of our need. These grades will then be multiplied by a weight, which is a number of importance of the need in the product. To define these weights, we can logically define **expectors** as 5, **spoken** as 4, **unspoken** as 3 and **exciters** as 1, as these will not lack in the product.
Moreover, I intentionally added a row for **costs**. Cost is both a need—to be affordable—and a function, but it is more related to the overall matrix. Giving a positive coefficient to a need makes no sense, and has no immediate consequence in the House of Quality. To have a meaning, we must point out the **cost of the development of specific functions**, by giving **negative coefficients** to functions. These costs are obviously related to some needs, and we must not forget that some functions are mandatory in our table, but this addition resolves at least partially the issue of including costs in our House of Quality.
Finally, we sum the coefficients with related weight to obtain a total score for each of our engineering functions. We can then do an other sorting to rank them and prioritize some engineering requirements, and see if some other can be developed, with the potential additional cost in mind.

The House of Quality of our liftable and extensible coffee table can be found on the next page. We then know what we will prioritize the first ten functions, according to the ranking made in the Priority row: a minimum size when not extended, a maximum supported weight while staying lightweight, be able to move the table but not too easily to prevent accidents...

			ENGINEERING FUNCTIONS																		
		WEIGHT	**Force to exert to lift**	**Max and min height**	**Intermediate heights**	**Edges angle**	**Force to exert to extend**	**Min and max size**	**Max weight on one side**	**Vibrations**	**Max torsion**	**Supported weight**	**Supported force**	**Size**	**Weight**	**Force to exert to move**	**Inertia of table when moved**	**Average time to remove a stain**	**Max capacity**	**Maximum supported liquid**	**Number of parts**	**% of recyclable parts**
CUSTOMERS NEEDS	Be easily liftable	5	9	1	3						1			1	3							
	Be easily extensible	5					9	3		1				1	1							
	Be stable	5							3	3	1	9	3		3		1					
	Be safe for people	5				3	1		3			9	3		1	3	1			1		
	Not be too fragile	4								1	3	9	3		1							
	Fit in a box	4												3								
	Can be moved	4												1	3	9	3					
	Can be easily cleaned	4				1												9		3		
	Store things	3										3	3	1					9	1		
	Avoid rare components	3																			1	9
	Prevent liquid leaks	1				1				1	3					1		3		9		
	Have removable parts	1																			9	1
	Be eco-friendly	1																			3	9
	Not to take much place	3		3				3						9					1		1	
	Be elegant	4				1								1	1						1	
	COST	5	-3	-1	-1	-1	-3	-1	-2	-1	-1	-9	-3	-3	-3	-3	-2	-1	-3	-1	-3	-3

Total	30	9	10	19	35	19	20	20	20	90	36	45	45	37	12	34	15	24	7	22
Priority	8	19	18	14	6	14	11	11	11	1	5	2	2	4	17	7	16	9	20	10

Part VII
Concept generation

We have defined plenty functions to elaborate, thanks to the House of Quality. But now we must think of the concepts, of the designs themselves, we will then evaluate with these requirements.
To do so, we need to cut our product's main problems into subproblems and so worth. Then, we will look at potential solutions for each subproblem. Why? Because for a single problem (eg. how to maintain the height of the table when lifted), we can think about combinaisons of several solutions to create one big solution for our problem. Furthermore this decomposition will help us to find solutions, as stuff can be a solution to a specific subproblem, and not the entire one. After this step of finding second (maybe third?) order problems, we will then try to think of potential solutions for each of these. The products we have seen in the **Benchmarking** part can also help us to be creative, by taking the best of what is already done in the market. Finally, we will mix them to create a few concepts that would solve our big problem—these concepts will be evaluated in the **Concept selection** final part of our report, according to the criteria and requirements we've selected in our **House of Quality**.

However, these parts would be too long if we talked about every element of our table. Therefore, and as mentioned in the class, we will restrain ourselves to only two problems of our table, one which is fundamental, **how to lift the table**, the other which is not that important but still needs attention according to our previous House of Quality, **How to avoid liquid leaks**.

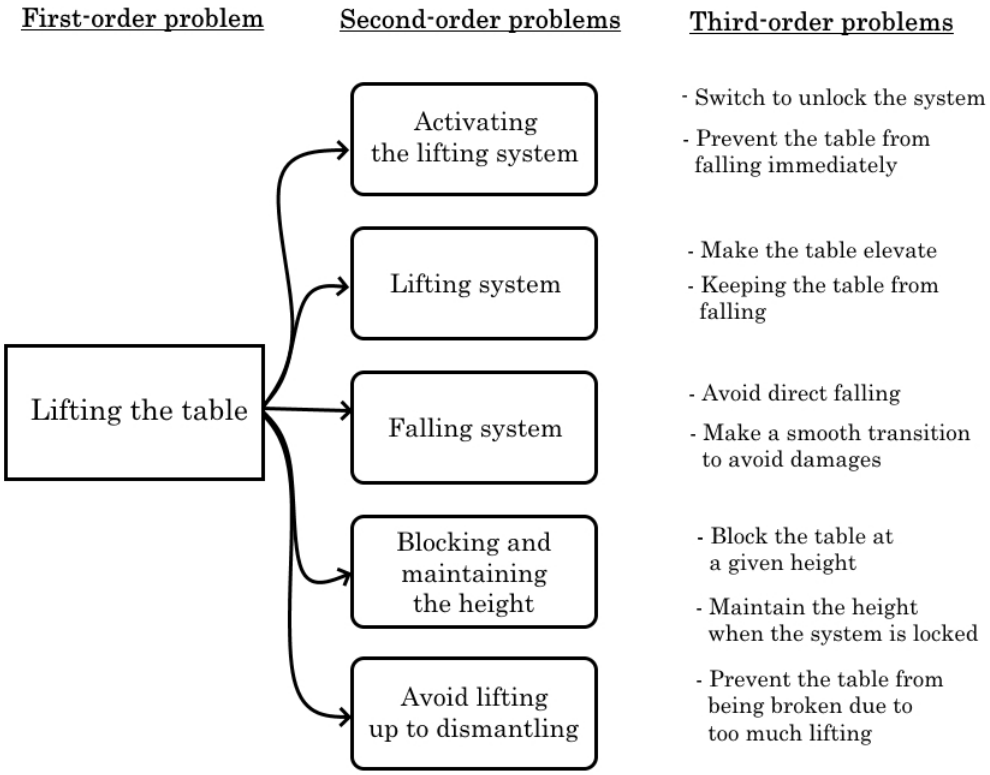
Lifting the table

As our initial requirements said, our table should be both **liftable and extensible**, and potentially at the same time. Therefore, one of the main issue of our table is... how to lift the table. That big problem can be split into smaller ones:

- activating the lifting system ;
- lifting system ;
- falling system ;
- blocking the lift to a position ;
- avoid lifting up to dismantling.

These second-order problems can then be split again into smaller ones: how to prevent the table from falling immediately after activating the lifting system, make to a smooth transition when the table is falling in order to avoid damages to the jawlery...
These tertiary problems can often be grouped into packs, or are often directly related to the resolution of the main problem ; therefore, and as said in the lecture, we can simplify our quest to solve the second-order problems.

The flowchart of this problem finding is the following:



We can then think of solutions for each of these second-order problems, keeping in mind third-order problems. Here are some possibilities for our problems.

Activation	**Lifting...**	**& falling system**	**Height blocking**	**Limiting height**
Button	Hydraulic system		Screws	Screws
Switch/lever	Electric elevation		Magnets	Bar
Screws to rotate	Angle variation between legs		Bar(s) that blocks	Springs
Bar to remove	Human action		the height	
		Springs		

That process is probably one of the hardest in designing a product. This requires creativity, in order to think about the different possibilities to solve a problem, and mix them into nice combinaisons that will fit our final product. Obviously here team working would be recommanded, to compare our thoughts and choose the best solutions given by the team; but here as this is an individual work, we are supposed to do it by ourselves. However, an other source of creativity for the resolution of these problems in our **Benchmarking**. We can inspire ourselves with the solutions that are already in the current market to counter these problems. That is for instance the case of screws and angle variation solutions, that I did not thought about, until when I saw the *raisable extensible table for little room, by Ulisse*, or the one with springs and sticks, that we saw in the *Raisable and extensible coffee table 80x80, by Wink.*t In that case, I could have figured out more items maybe, but this first shot gives us an idea of the whole process to do, for every problem, to design our table.

Now, we have to generate concepts, made with one solution in every subproblem, like an interweaving of solutions. This choice still has to follow a logic: we should not mix

button to activate a screw... In the purpose of this report, I deliberately have chosen four opposed designs:

1. A **button** activates an **electric elevation** with **magnets** to lock the height, and **springs** to prevent dismantlement;
2. A **lever/switch** to press and force in order to activate an **hydraulic system** that will change the table height. The height will then be blocked with that **hydraulic system**, and **springs** to avoid damages.
3. Some **screws** to rotate to unlock the height blocking system. The user will have to **carry the table by itself**, with **springs** to avoid accidental fall. The height will be limited with **other screws**, that could be removed if we wanted to dismantle the table into several parts, as our *Design for sustainability* required.
4. A **bar to remove**, to allow the **variation of the angle** between the legs of our table. The legs will block at some point. Here, **we do not have the issue** of limiting height, as legs can not be turned so much. To lock the height, we can then just **reuse the bar** to block the legs.
5. The **same design**, but instead of using a bar to lock and unlock the legs, we could use **buttons** that must be pressed during the operation, which **pull or push a bar** that would lock the legs. Therefore, instead of having a second person to lock the height, one person would only be necessary.

Avoiding liquid leaks

Sometimes on a table, a glass can be broken or turned over, spilling the liquid that was contained in it. The liquid can then flow on the table, ultimately dripping on the floor if there is not sufficient protection on the table. In our search for **Customer's needs**, some people I met in the survey wanted then a consequent solution to the people of liquid dripping over the table, to protect their surroundings. Solutions for this problem will not cost very much, therefore we can add this as an exciter in our table—something that will make our table different from others in the market. Here, this problem can be split into two minor ones:

- Avoid liquid spreading on the table
- Prevent liquid from falling on edges
  - Avoid vibrations of the table
  - Keep liquid in edges, not spilling to the floor

To avoid liquid from being spread all over the table, we can think of two similar solutions: having a grippy surface on our table, such that the liquid will be sticked to the surface, or covering our table with very little holes, that can not be discovered by human eye, and which will be filled with the liquid when necessary. The downside of this is that the table may then be hard to clean, due to static liquid in the table...

The quest to avoid vibrations is not specific to avoid liquid leaks. As we have seen in the **House of Quality**, vibrations are more important in the expected need to be stable. We can still think of some solutions, as these were not specified before: we could reenforce

the surface of the table by consolidating it with raw, metal materials; we could simply put four legs on our table—but this would definitely harden the way more important function of having a liftable table with small costs.

Last but not least, we can try to keep liquid in edges, thus avoiding it spilling on the floor of the house or a store, by creating a gutter-like edge on our table. With a small pit around our table, the liquid would then be kept inside that *river*, avoiding leaks. When empty, the liquid would also be a nice decorative touch for our table, especially if it is made of wood—the pit would then make like an engraving. An other way would be to benefit from a border that we could add to protect the edges of our table and avoid accidents, in particular with kids that could be hurt when running to the table. If that is installed, it would also be a nice way to avoid liquid from leaking outside the table. . . at the cost of aesthetics of our table, as a border may be reluctant to some purchasers of our table.

As a result, we can see that there is not an unique solution to a problem. In this case however, we should more choose only one solution amongst all what we have just said. Indeed, putting one solution in our table would already solve the problem, at least partially, and having two or more solutions (like, little holes of the surface and a border all around it) would be redondant, cost-losing and not really more efficient.
Thus, we will note these concepts as:

(i) Spores on the surface of the table;

(ii) Reenforcing the table;

(iii) Using four legs to have a stable table;

(iv) Cutting gutter-like edges;

(v) Putting an elegant border on the edges of the table.

But then, how do we choose which solution we will implement in our table? That is part of the final section of this report, **Concept selection**.

Part VIII
Concept selection

After we have determined who are our customers, what are their needs, how the current market solved these problems, how can we solve these problems, what is the relationship between the needs and the specifications of our product, and decided of several concepts for our table, we can finally select the design for our liftable and extensible coffee table. In the previous part, we have seen several solutions for each of our problem. Thanks to these, we can now compare different concepts, made with these solutions.

As mentioned in the lecture, this selection should not be biaised to gut-feelings. Therefore, in order to try to make a common choice, we practice datum comparisions between our concepts. To do so, we will choose one concept in the market as our datum, and we will see what are our concepts that suits more the datum... This process will continue until we have found the design which is the best among the others, if it was used as a datum.

Nonetheless, as we have not treated all the problems of a liftable and extensible coffee table, we will not be able to look at global designs, but only at concepts related to specific problems. This is not a big issue with the problems we have address as examples, but it could be one if we treated similar problems, as one good concept for a problem can make an other problem worse—as we have seen before, with the will of stability, which can lead to complicated and costly liftable systems to compensate that stability.

To rank our concepts, we will classify them according to the related needs in our **House of Quality**. We will also keep the weight we put on our needs, to have a weighted comparision matrix, because some points are more relevant than others. Obviously, the cost will be part of the criteria, as this is a fundamental need. Then, we will add an additional row for **consequences** of choosing this concept, in other problems. As a result, concepts which are good for this problem but create too much disturbtion for other key issues will be forgotten, as we do not want expensive R&D and huge production costs. We can also add other specific criteria, that will differentiate each of our product. Indeed, using the main need of our concept as a criterion is a bit useless, as the designs we have proposed are solutions to that need! We then have to separate them according to other criteria that we will find during the test.
Finally, we will count the plus and the minus we have address on concepts, in comparision to the datum one, and the best of it will be chosen as a datum for an other comparision.

The design I choose as the initial datum is the *lift coffee table, by Team7*, as this is a design I did not used previously, even if it is the design that appears the first on search engines.

Lifting the table

As a reminder, here are the five designs I considered:

1. A **button** activates an **electric elevation** with **magnets** to lock the height, and **springs** to prevent dismantlement;

2. A **lever/switch** to press and force in order to activate an **hydraulic system** that will change the table height. The height will then be blocked with that **hydraulic system**, and **springs** to avoid damages.

3. Some **screws** to rotate to unlock the height blocking system. The user will have to **carry the table by itself**, with **springs** to avoid accidental fall. The height will be limited with **other screws**, that could be removed if we wanted to dismantle the table into several parts, as our *Design for sustainability* required.

4. A **bar to remove**, to allow the **variation of the angle** between the legs of our table. The legs will block at some point. Here, **we do not have the issue** of limiting height, as legs can not be turned so much. To lock the height, we can then just **reuse the bar** to block the legs.

5. The **same design**, but instead of using a bar to lock and unlock the legs, we could use **buttons** that must be pressed during the operation, which **pull or push a bar** that would lock the legs. Therefore, instead of having a second person to lock the height, one person would only be necessary.

Also, the concept of our datum is the following:

- The user has to pull a little lever under the table to unlock the height. There, the customer has to pull or push the surface of the table in order to change the height, without any intermediate step: he can decide of the height he wants the table to have. The maximum height is assured by the metal bar that is the leg of the table: when at its maximum, the bar is fully extended, but can not be separated of the table thanks to screw in its basis.

- An electric system is sold as an option. The power is given by a battery, with an battery life of approximately a hundred lifts.

Concepts / Needs		DATUM 0	1	2	3	4	5	DATUM 1	2	3	5	DATUM 2	1	5
Be easily liftable	5		+	+	-	=	=		=	-	-		=	-
Be safe for people	4		=	-	=	+	+		-	-	=		-	+
Be stable	4		=	=	-	-	=		=	-	=		=	-
Not too big	3		=	=	+	-	=		=	+	+		-	=
Be elegant	1		+	=	=	-	=		=	-	-		-	+
Cost	2		-	-	+	+	+		=	+	+		=	+
Sum of +'s			6	5	5	6	6		0	5	5		0	7
Sum of -'s			2	2	9	9	0		4	14	6		8	9

Some explanations about this table:

- You can notice that I did not used **Other consequences** as a criterion here. Indeed, lifting the table is one of the most important problems of our table; therefore it would be to other minor issues to adapt to the solution we would have taken. Moreover, this would not have changed our sorting.

- I first removed the forth design, even it had less minuses than the third, because design (4) and (5) are similar, and the design (5) has clearly less disadvantages than the other.

- I then took the first design as my datum, because it was the one who clearly led the array (behind design (5), though, but I would consider it later).
- Then, I have done another comparision between the remaining designs and my datum. Here, I wrote that the hydraulic and the electric systems were not safe for people, as with hydraulic system, a critical issue would make the table fall and break all the jawlery on it, and as with electric system, liquid could enter in the system and make the table not liftable, even dangerous for kids!
- I then removed the design (3) which was not really something great, according to our first two comparisions.
- I also used the second design as my datum, in the last comparision, to see if the use of the design (1) did not biaised my judgement. As we can see in the table, we had even poor results. Nevertheless, we can clearly see that the design (5) was decent in every scenario. Therefore, **the design we will choose for the lifting system of our table is the design (5).**

Avoiding liquid leaks

Last but not least, we can apply the same algorithm to our minor quest to avoid liquid leaks. We first choose five potential ideas:

(i) Spores on the surface of the table;

(ii) Reenforcing the table;

(iii) Using four legs to have a stable table;

(iv) Cutting gutter-like edges;

(v) Putting an elegant border on the edges of the table.

We can apply the same algorithm, with different criteria we saw in the **House of Quality**, such as *be safe for people*, *can be easily cleaned*, *store things*, *prevent liquid leaks*, but also the *cost* of the solution, and the **other consequences** this minor solution can have on bigger ones. Here, as the quest of avoiding liquid leaks is only attributed to the main function of the maximum liquid the table can support, we will use **the coefficients** we put in the **House of Quality** as our weights. For instance, the need to *prevent liquid leaks* will be weighted as 5, because it was the most relevant need for that function. In the other hand, *store things* will only be weighted as 1, because the product of the weight of the need (3) and the coefficient in the matrix (1) is the lowest in our **House of Quality** for that function. We can then deduce the weights of the other needs: *can be easily cleaned* will be 4, as this is the second most important need for that function, *be safe for people* will be 3. Cost and the need to be elegant would be 2, as global issues. This can be resumed in the following chart:

Need	House of Quality			Comparision
	Weight	Coefficient	Product	Weight
Prevent liquid leaks	1	9 (major!)	9	**5**
Can be easily cleaned	4	3	12	**4**
Be safe for people	5	1	5	**3**
Store things	3	1	3	**1**
Be elegant	4	0	0	**2**
Cost	5	-1	-5	**2**
Other consequences				**2**

As a reminder, our initial datum table does not have any system to prevent liquid spreading. This is also the case for the other tables we have seen in our **Benchmarking** section, and it is commonly the case for other tables in the market. Therefore, this minor issue can be something that will differenciate our table from others in the market. A downside to this is that our main criterion won't be useful in that table, as every solution will be better than our initial datum. However, this comparision is still interesing, due to the other criteria we can use. Which gives us the following table:

Concepts / Needs		DATUM 0	i	ii	iii	iv	v	DATUM v	ii	iii	iv	DATUM iv	v
Prevent liquid leaks	5		+	=	=	+	+		-	-	=		=
Can be easily cleaned	4		-	=	=	+	-		=	=	+		-
Be safe for people	3		=	+	+	=	+		=	=	-		+
Store things	1		=	-	+	+	-		-	+	=		=
Be elegant	2		-	=	=	±	∓		-	-	=		=
Cost	2		-	-	-	+	+		-	-	-		+
Other consequences	2		=	+	-	=	+		+	-	=		+
Sum of +'s			5	5	4	12	14		2	1	4		7
Sum of -'s			8	3	4	2	7		10	11	5		4

Here again, to explain a bit this table:

- I consider reenforcement solutions as not-really good solutions to prevent liquid leaks, as this does not stop the liquid on the table when it is spilt.
- I put ± and ∓ for the elegance of the design iv and v, as this really depends on the tastes of everyone. Therefore, I counted it as 2 for each + and -.
- In the end, we can clearly that the solution of spores in the table is not something great. Therefore, I took design v as my next datum, because it was the design with the most +.
- In the end, I removed both design ii and iii. Only designs iv and v remained, but I could not choose between them. That is why I used my design iv as a datum to compare with design v. However, we can clearly see that the design v has more advantages than the design iv, with opposed datums. Thus, **I choose design v, ie. putting a border all over the table, to avoid liquid leaks**.

Part IX
Final design & Conclusion

All over the semester, we have tried to design our own liftable and extensible coffee table. We first identified potential customers of that product, thanks to survey and a study of the intermediate people who will work with that table. We then discovered their needs, again with surveys, but also with personal thoughts, and Internet comments. We looked at what is already on the market, which gave us ideas for new needs we have not thought about before, but also for solutions to problems that we tried to figure out in **Engineering functions**. We then looked for solutions, and choose the best among the others, thanks to the **House of Quality** that guided us all among the report, and via other methods that we saw during the lecture.

The result of this is my own table, which is presented below. Obviously, it is and it will remain only a design, a drawing on a paper, but it is the proof that everyone can design the product they want to have, and that designing is not that complicated, **it is just a matter of time and collaboration**.

Of course, we could have done things differently. It would have been better to cooperate between students in the class, to exchange ideas, surveys, to discover and mix our solutions to do ***the best table of our world***. We could have done all the process for every need of our table, but this would have taken us plenty of time. Still, I am proud of presenting that table. That, maybe one day, will be in your house.