

“Sustainability in design education: Introduction of life cycle assessment (LCA)”

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1. INTRODUCTION

The production of products which end up generating waste and greatly increasing the volume of garbage dumps and landfills. Many researchers [1-9] study alternatives to the disposal of products that do not harm the environment.

The activity of industrial design is adding tools focused on sustainability to contribute to traditional design methodology. One such tool is the analysis of Life Cycle Assessment (LCA).

In this paper the purpose is to reflect about material selection in Life Cycle Assessment, presenting LCA studies developed in the discipline of design and sustainability at the University UNISINOS. These studies were designed to examine one type of product, squeeze, performing a comparative analysis of six models of this product. Explores thus the tool Life Cycle Assessment, reflecting about the selecting materials and processes

These studies also seek to educate students about the role that the designer has the future in relation to sustainability. The results show the complexity and importance of the selection of materials and processes for sustainability.

1.1. Design and sustainability: Life Cycle Assessment

Good projects depend, among other factors, accurate information about materials, manufacturing processes and measurement of environmental impact. The selection of the suitable material is fundamental in developing the project.

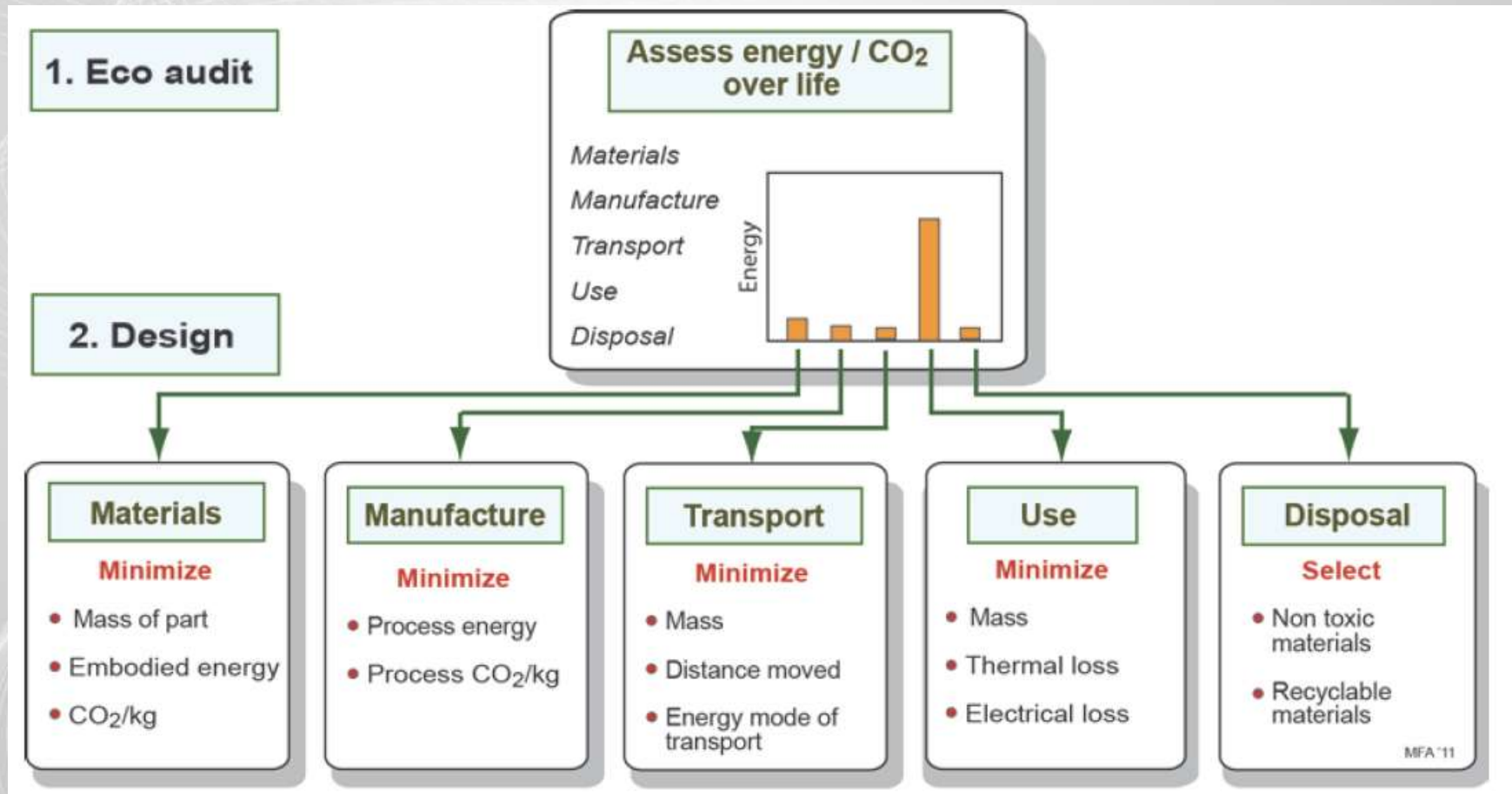
As Andrae [10], there are a number of methods and tools related to environmental assessment, such as Life Cycle Assessment (LCA) and carbon footprint, all with the intent to indicate which alternative is better compared to other.

In search of progress in the techniques of selecting materials and their interpretations or comparisons with other existing, Ashby [1] created the “maps of properties” , which gave rise to software Materials Selection, named Cambridge Engineering Selector® - CES with the support of the developers of Granta Design® [11].

This software allows you to separate the materials best suited to the proposed project, limiting them to a few units for application, after several steps of restrictions. In the 2011 version of the software, other applications have been introduced, one these is Eco Audit allowing comparison of materials counting all stages of the life cycle of the materials, figure 1. This software was chosen to be used for the Life Cycle Assessment.

1.1. Design and sustainability: Life Cycle Assessment

Figure 1: Software ESC Edupack 2011 integrating the Life Cycle Assessment tool [12].



2. Methods

The methodology used in this study was divided into three phases:

Phase 1: Disassembly and data collection:

- Disassembly and separation of product components.
- Identification of different components, their materials and processes used.
- Weighing with a digital scale of the different components.
- Search of information materials on the manufacturer's website if haven't an identification on the products.
- Research on the recycling of different materials to placing the data in the software.

Phase 2: Placing data in the software:

- Entering the quantity and material of each components, the percentage of recycling (0-100 %), the weight, the primary process and the final destination of the component (landfill, incineration, downcycle, reuse, remanufacturing, recycling). It was first used for the perception of the student and then research on the potential final component to our context.
- Placement of the various types of transport and their distance to each phase of the life cycle that uses transport.
- Placing of energy costs involved in the use phase of the product. In the case of squeeze the spent cooling predicting use.
- The products analyzed were: 6 Squeezes different existing models, table 1. These were chosen by the students by placing the product used this time (lifetime).
- In this phase was used the software CES EduPack 2011 with the tool Eco Audit to the Life Cycle Assessment, Figure 2.

Table 1: Squeezes analyzed and summary information placed on the software. Source: Author.


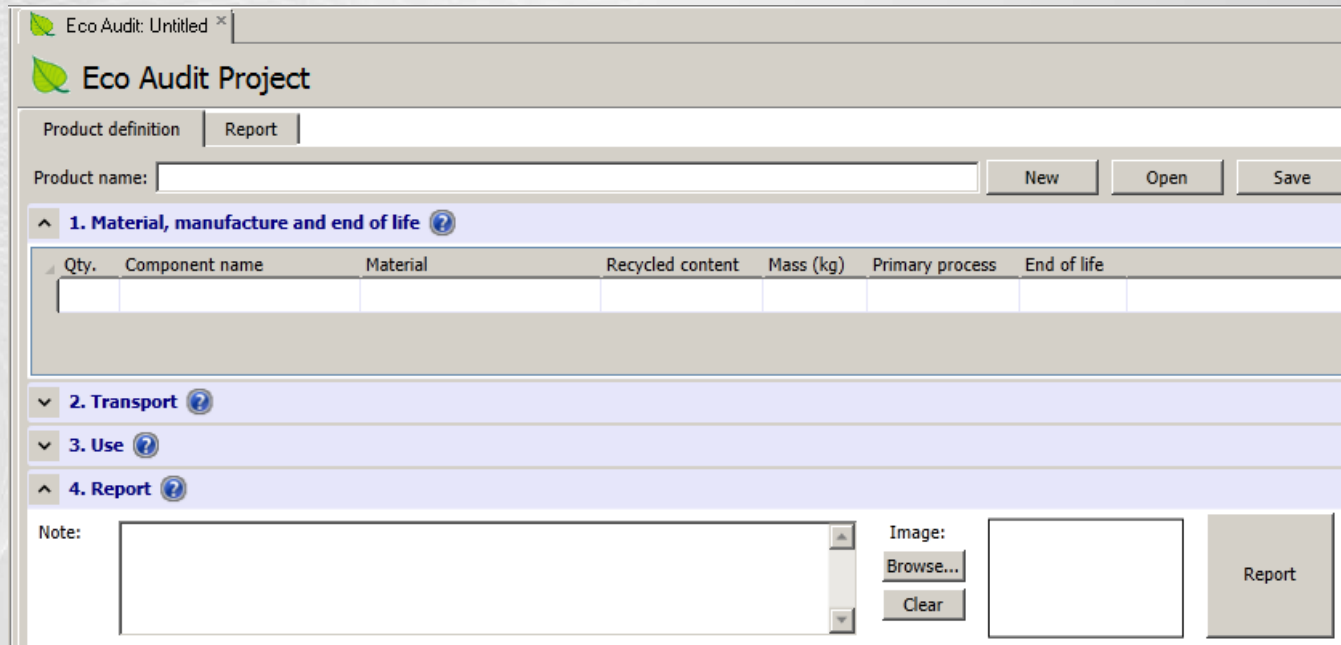
Phases of the life cycle	Squeeze "A"	Squeeze "B"	Squeeze "C"	Squeeze "D"	Squeeze "E"	Squeeze "F"
Product						
Materials	- Aluminum Alloy - PP - EVA	- PP - Neoprene - Aluminum Alloy	- PP - PET - PE	- PEAD - PS - PELBD - PP	- PET - PP - Paper	- PET - PS - PEAD
Lifetime	8 years	5 years	2 years	0,5 years (6 months)	0,25 years (3 months)	0,08 years (1 months)
Mass (kg)	0,250	0,260	0,062	0,045	0,034	0,031
Transport	Truck: 217km	Air freight: 10.140km Truck: 1200km.	Truck: 3474km	Truck: 1520km	Truck: 85km. Air freight: 10.600km. Rail freight: 185km	Truck: 419km. Air freight: 9.650km
Electricity (cooling)	192 days per year, 2 hours per day.	324 days per year, 2 hours per day.	216 days per year, 2 hours per day.	200 days per year, 1 hour per day.	90 days per year, 2 hours per day.	30 days per year, 2 hours per day.

Figure 2: Home Eco Audit in this software CES EduPack 2011 [11].



Eco Audit: Untitled ×

Eco Audit Project

Product definition | Report

Product name:

^ 1. Material, manufacture and end of life ?

Qty.	Component name	Material	Recycled content	Mass (kg)	Primary process	End of life

∨ 2. Transport ?

∨ 3. Use ?

^ 4. Report ?

Note:

Image:

Phase 3: Analysis of the data:

- Analysis regard to energy costs in each of the phases.
- Analysis about the generation of CO₂ in each stage.
- Comparison of the different samples of each product.
- Comparative analysis of life cycle in relation to squeeze more life estimates.
- Analysis among students regarding the products analyzed and their life estimates reflecting on their consumption.

3. Results and Discussion

The software used (CES EduPack 2011, tool Eco Audit) works by measuring the energy consumption and CO₂ emissions caused by the choice of material and its manufacture, the means of transport and distance, as well as the consumption of energy in the use phase.

We presented works done at the University UNISINOS, presenting a comparative study of six types of squeezes in the market, showing in Table 2 phases of the life cycle of data with energy costs and CO₂ generation.

Table 2: Comparison of energy consumption (MJ) and CO₂ generated (kg) of 6 squeezes analyzed.
Source: Author.

Energy consumption (MJ) for 1 product							
Squeezes	Material	Manufacture	Transport	Use	Disposal	Total (for first life)	End of life potential
Squeeze "A"	20,6	2,17	0,0461	0,0578	0,175	23	-14,7
Squeeze "B"	25	5,3	21,7	0,0609	0,154	52,3	-17
Squeeze "C"	5,51	1,23	0,183	0,0163	0,0434	6,98	-3,19
Squeeze "D"	4,16	0,912	0,0319	1,67	0,028	6,8	-1,56
Squeeze "E"	2,75	0,555	3	0,846	0,0238	7,17	-1,05
Squeeze "F"	2,62	0,602	2,47	0,0591	0,00616	5,76	0
CO ₂ generated (kg) for 1 product							
Squeezes	Material	Manufacture	Transport	Use	Disposal	Total (for first life)	End of life potential
Squeeze "A"	1,02	0,163	0,00328	0,00216	0,0123	1,2	-0,739
Squeeze "B"	0,784	0,402	1,46	0,00228	0,0107	2,66	-0,552
Squeeze "C"	0,155	0,0922	0,013	0,000608	0,00304	0,264	-0,0898
Squeeze "D"	0,14	0,0684	0,00227	0,0626	0,00196	0,275	-0,0618
Squeeze "E"	0,0867	0,0416	0,201	0,0317	0,00167	0,363	-0,0357
Squeeze "F"	0,0755	0,0451	0,166	0,000881	0,000431	0,288	0

It is noted in Table 2, the large energy consumption and consequently CO₂ squeezes of “A” and “B”. The squeeze “A” having an estimated life of 8 years absorbs this environmental impact better than the squeeze “B”, of 5 years. The consumption of energy in the use phase to be great for these two squeezes, “A” and “B”, is due to the materials used and the weight of them. As for the potential at the end of life return these energy costs and CO₂ generation, the squeeze “A” presents good results by having his body held in metal (aluminum alloy), which is recycled and thus “recover” the energy expended in production. The squeeze “B” also has a potential higher in late life, because it recycles most of the existing materials in the squeeze.

Also about the squeeze “B” production in another country to be reflected in energy consumption and CO₂ generation during transport of this product. About squeeze “C”, with an estimated short life of 2 years, has a lower energy and CO₂ generation, but has the potential at the end of life small. The squeezes “D”, “E” and “F” have a small mass in kg, which reflects the energy consumption during in materials and workmanship to be small, reflecting also the transport phase. But the squeeze “E” that has produced in another country had a high value on shipping even being lightweight. The squeeze “D” is not recycles all elements body only. The squeeze “E” it recycles all components and squeeze “F” neither component is recycled, all the components being put in landfill, which reflects the potential at the end of life being reset.

These choices of components that were placed in the software are to be recycled or landfilled were student choices, common sense these students and what they would do with these products when their useful life would end.

3.1 Comparative analysis in relation to squeeze with highest life estimate

The second part of the study was to use the squeeze more life estimation, squeeze the eight years to make new analysis by placing the amount of product that would be required to use in eight years to match this first squeeze. Shown in Tables 3 and 4, the number of squeezes required at the same time spent lifetime and energy (MJ) and the generation of CO₂ for 8 years of useful life squeezes.

Table 3: Reference squeeze A and comparing the amount of product for the same lifetime. Source: Author.

	Squeeze "A"	Squeeze "B"	Squeeze "C"	Squeeze "D"	Squeeze "E"	Squeeze "F"
Useful lifetime	8 years	5 years	2 years	0,5 years (6 months)	0,25 years (3 months)	0,08 years (1 month)
Number of products	1	1,6	4	16	32	100

3.1 Comparative analysis in relation to squeeze with highest life estimate

Table 4: Comparison of energy consumption (MJ) and CO₂ generated (kg) of 6 squeezes analyzed in relation to the product with the highest estimated life. Source: Author.

Energy consumption (MJ) for 1 product and the comparison with more products								
Quant.	Squeezes	Material	Manufacture	Transport	Use	Disposal	Total	End of life potential
1	Squeeze A*	20,6	2,17	0,0461	0,0578	0,175	23	-14,7
1,6	Squeeze B	40	8,48	0,07376	0,09248	0,28	36,8	-23,52
4	Squeeze C	22,04	4,92	86,8	0,2436	0,616	209,2	-68
16	Squeeze D	66,56	14,592	0,5104	26,72	0,448	108,8	-24,96
32	Squeeze E	88	17,76	96	27,072	0,7616	229,44	-33,6
100	Squeeze F	262	60,2	247	5,91	0,616	576	0
CO2 generated (kg) for 1 product and the comparison with more products								
	Squeezes	Material	Manufacture	Transport	Use	Disposal	Total	End of life potential
1	Squeeze A	1,02	0,163	0,00328	0,00216	0,0123	1,2	-0,739
1,6	Squeeze B	1,2544	0,6432	2,336	0,003648	0,01712	4,256	-0,8832
4	Squeeze C	0,62	0,3688	0,052	0,002432	0,01216	1,056	-0,3592
16	Squeeze D	2,24	1,0944	0,03632	1,0016	0,03136	4,4	-0,9888
32	Squeeze E	2,7744	1,3312	6,432	1,0144	0,05344	11,616	-1,1424
100	Squeeze F	7,55	4,51	16,6	0,0881	0,0431	28,8	0

* Squeeze reference for comparison.

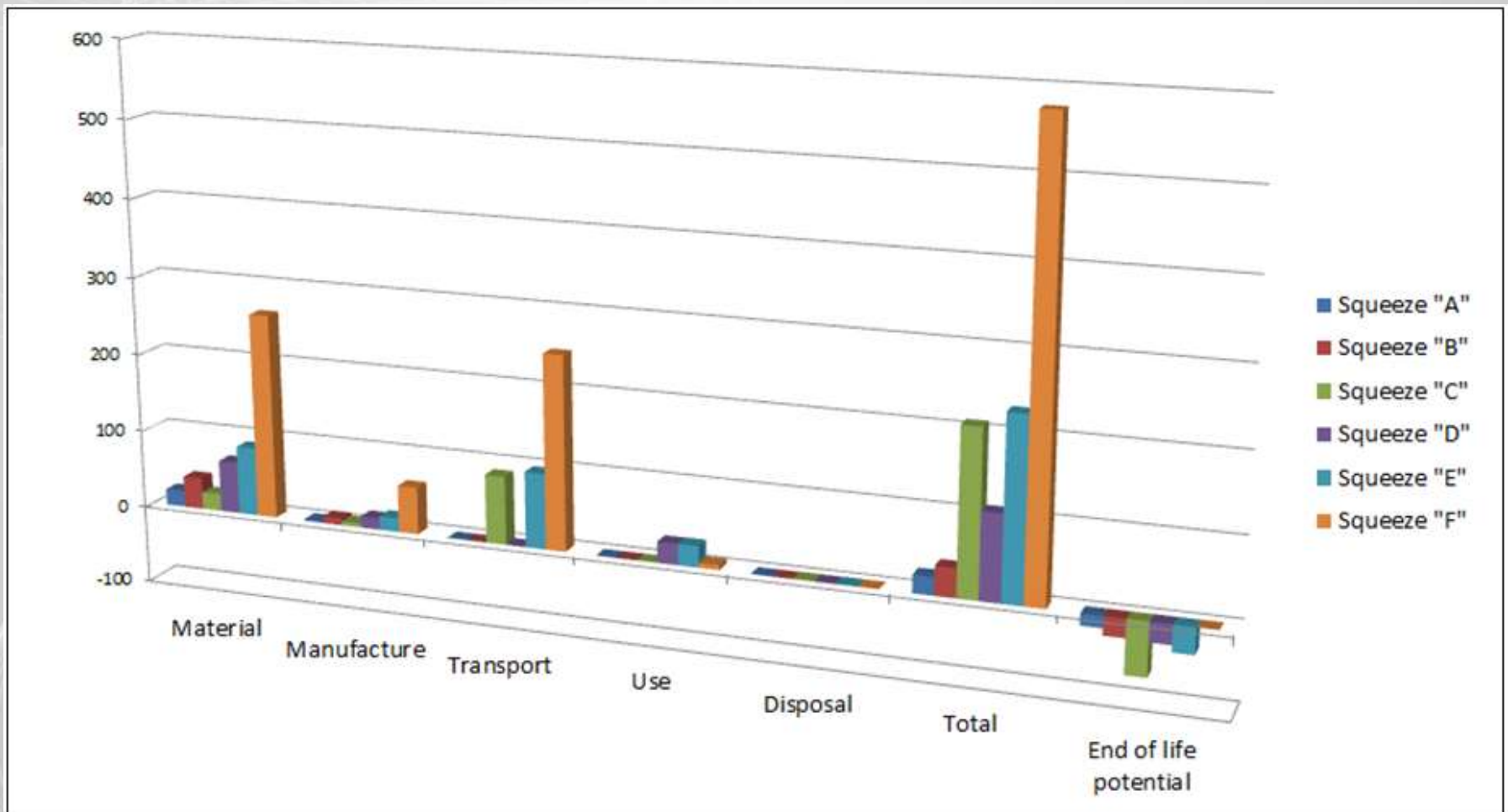
3.1 Comparative analysis in relation to squeeze with highest life estimate

According to data obtained from the Life Cycle Assessment realizes that the first review for this change much the results, passing the squeeze that the first analysis had the lowest environmental impact, squeeze “F”, which has to be the greatest environmental impact. This is because the amount of 100 squeezes to be used in the 8 years to treat the squeeze reference. This becomes clearer in Figure 3, showing a big difference between the squeeze “F” and the others, showing the short life span of each squeeze of type “F”.

This shows the importance of the design of this product rethinking the materials selection, selecting materials with less energy consumption and CO₂ generation, higher opportunities of being recycled, lighter and easier to dismantle and other aspects.

3.1 Comparative analysis in relation to squeeze with highest life estimate

Figure 3: Comparison chart of the 3 products analyzed in relation to energy consumption (MJ).
Source: Author.



3.2 Analysis among students regarding the products analyzed

From this type of study with students, is possible to think about the role that these future designers have in relation to sustainability.

The salient points by the students during and after this activity Life Cycle Assessment were:

- In relation to materials, studying the amount of these, various compositions, which are aggregated to produce simple objects of day-to-day, helped them to rethink and reassess the concepts at the time of purchase.
- Underlined the large consumption of the same product, namely the rapid exchange of products, even still being useful to the desired function, generating more unnecessary disposal of materials.
- The students said the importance of the durability of a product, so, the useful life of product to sustainability, which was reflected in the second comparative analysis between squeezes with an estimated 8 years.
- All of these factors helped to rethink and reevaluate their concepts when buying a simple product.
- Through this the students were able to understand some aspects regarding the analysis of the life cycle of a product, suggesting that LCA was implemented in the design phase to reduce the environmental impact.

4. Conclusions

The concern and responsibility for the environmental impact made emerging new challenges for designers. Agreeing with this, it is proposed that a designer should be aware of changes and continuously look for new solutions, particularly in relation to aspects related to environmental issues.

Faced with these challenges in relation to sustainability, product design activity has been adding tools and one of them is the Life Cycle Assessment (LCA). The techniques applied to sustainability enable designers and drafters can design taking into account environmental issues. Apply new methods applied to the project, studying and analyzing the life cycle of a product, benefit the environment and future generations.

Through exercises in disciplines of sustainability in design courses show up different analyzes for the same type of product, reflecting on the choice of materials and processes these. In the presented paper was reflected on sustainable consumption, exploring a tool of Life Cycle Assessment in a product of low technological complexity that was the squeeze.

The results show the complexity and importance of the selection of materials and processes for sustainability. It was important for students to analyze the different products they realize the importance of the selection of materials and the influence this has on the environmental impact. Students were able to understand the issue of sustainability, analyzing the entire life cycle of product, it is important to highlight the different perceptions of students in relation to sustainability and the selection of materials and activities at the beginning of the end.

Students become stimulated to study more stiffness the correct selection of materials in the design phase, covering all stages of the life cycle of these products, which allowed students to visualize more clearly how you need a systemic view of the entire cycle this product life.

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