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Knowledge Extracting from Eco-Design Activity

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Abstract. The integration of eco-design in industries is becoming more and more considered as a necessary condition of Sustainable development. It should be noted that the consideration of environmental issues in design can modify the objectives, outputs, resources, processes and performance indicators of a company. Eco-design goals (using of renewable materials, recycling, reducing energy, etc.) coupled with economic and social objectives (implication of stakeholders, sharing knowledge, considering culture aspect, etc.) are more or less considered in proactive or prescriptive way. These approaches lead to develop innovative solutions (circular economy, hybrid energy production, etc.). Even some rules are identified for sustainability but the application of these rules still no common in industries. Each industry try to understand these rules and apply some of them. The relationships between technical, economical and organizational aspects still undetermined. In this paper, extracting knowledge from the applications of sustainability rules in industries is presented as a way to share eco-design indicators. This first studies will help to define concept models of eco-design which help to extract indicators from documents and guide designers to consider environment criteria an evaluate their design.

Keywords: Design projects · Traceability · Classifications

1 Introduction

The integration of eco-design in industries is becoming more and more considered as a necessary condition of Sustainable development. It should be noted that the consideration of environmental issues in design can modify the objectives, outputs, resources, processes and performance indicators of a company. Eco-design goals (using of renewable materials, recycling, reducing energy, etc.) coupled with economic and social objectives (implication of stakeholders, sharing knowledge, considering culture aspect, etc.) are more or less considered in proactive or prescriptive way. These approaches lead to develop innovative solutions (circular economy, hybrid energy production, etc.). We can note that eco-design joins the environmental innovation logic [5, 17] allowing to reduce material and energy impact.

The integration of environmental issues in design was clearly identified by Victor Papanek in his book ‘Design for the Real World: Human Ecology and Social Change’ [19]. The 70’s is a period characterized by a growing interest in environmental studies to support innovative design: Coca-Cola was the first company to realize a multi-

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criteria study to assess the environmental impacts related to the production and the end-of-life of their product [8]. The method is based on the whole life-cycle of the product: from the raw materials extraction to the end-of-life treatment of the product, considering as well the steps of supplying, production, distribution, use and maintenance [10]. This methodology is now part of the ISO14000 environmental management standard since 2006.

Even some rules are identified for sustainability but the application of these rules still no common in industries. Each industry try to understand these rules and apply some of them in companies. The relationships between technical, economical and organizational aspects still undetermined. In this paper, extracting knowledge from the applications of sustainability rules in industries is presented as a way to share eco-design indicators. For this aim, several techniques are used: extracting criteria from documents, extracting decision making concepts from cooperative eco-design projects and identifying domain concepts from expertise. A draft of eco-design domain ontology is built from these studies.

2 Extracting Eco-Design Criteria from Documents

As first steps of this study, design indicators can be identified from analysing experience feedback. Therefore, expertise documents gathered in a young company, containing design data about materials and processes, are analysed. We show in this section how the features defining these materials and processes have been identified.

2.1 Expertise Documents

Altermaker is a young start-up specialized in software development to support design for sustainability. The company led analysis on industrial materials and processes used in mechanical engineering. The results are stocked as MsPowerpoint documents in which several elements are defined for each material or process: advantages, disadvantages, short description and specific comparisons. In these documents (Fig. 1), several features are interesting to consider and other ones need more analysis. Our study aims at analysing these documents in order to define the concepts that show the main features of given materials and processes.

2.2 Analysing Approach

Knowledge engineering techniques [21] are used to analyse Altermaker documents. In this type of approach, expertise documents can be analysed in order to identify the role that elements can play in problem solving related to a specific domain, what is called concepts. Several techniques can be used in documents analysis, we note especially TextMining [7] that is based on repetition of words and on relations between words. In this study, each slide presents a specific material or process. Therefore, using automatic TextMining tools cannot be interesting in our case: documents should be analysed manually.

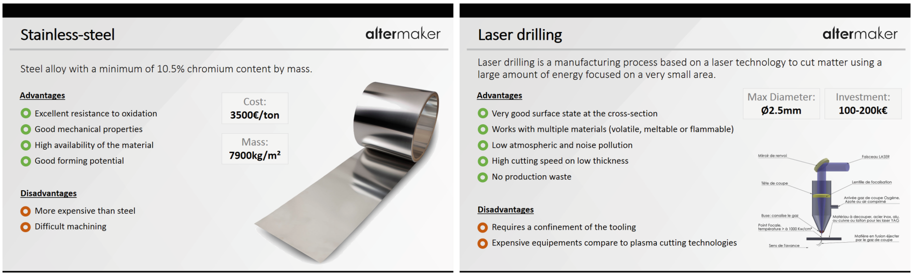

Fig. 1. Example of Altermaker documents (material card and process card)

In total, 80 slides are analysed for materials and 157 for processes. Processes documents are already classified on manufacturing, assembling and cutting. But there is no classification of materials slides. Analysing steps, the procedure can be summarised as:

1. Characteristics are identified from description, advantages and disadvantages (Fig. 2)
2. The number of occurrences of characteristics are counted
3. Results are then presented to two mechanical eco-design experts of Altermaker in order to eliminate noise, conflicts and to validate the relevance of each characteristic
4. Characteristic categories are detailed and split in sub-groups
5. Groups are then validated by the eco-design experts
6. Finally, analysing of omissions in order to possibly complete classifications (Fig. 3).

2.3 Characteristics Classifications

Repetition of characteristics is then used in order to classify them. On one hand, our classification aims at emphasizing the impact of process and materials on the environment and, on another hand, at helping designers to deal with process and materials in eco-design. For instance, the main process characteristics are identified as: cost, consummation, pollution, technicality, etc. (Fig. 4).

For materials, we identify: Resistance, compacity, disassembling, modification, etc. (Fig. 5). Then, for each process type (assembling, drilling, welding, …) values are associated to these classifications.

These identified characteristics and classifications allowed us to build a database of processes and materials with technical, organisational and economic data. These characteristics are then linked to environmental ones and ready to be implemented in the “ECODESIGN STUDIO”[1] software to support decision making of environmental experts.

Besides this analysis, some eco-design projects are analysed. These projects are realized by students in our university. The following section presents this analysis.

[1] http://www.altermaker.com/fr/.

Characteristics	Slides	Repetition	Pourcentag
Acceptance misalignment	373, 374	2	20%
Adjustment of pieces with fine contact	372	1	10%
Automatization	367	1	10%
need other process	370	1	10%
Rapidity	367, 370, 372, 374, 376	5	50%
Innovative concept	372	1	10%
Constraints of temperature (after assembly)	376	1	10%
temperature control	367	1	10%
Quality control	367	1	10%
Cost	376	1	10%
Unusally Distortion	376	1	10%
Disassembling	373, 374	2	20%

Fig. 2. Example of identified first 45 characteristics for Tube assembling.

Process Types	Nb slides	Nb characteristics					
		Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
		Ident. characs	statisitics	Validation 1	Splitting	Validation 2	Missing
Manufacturing	68	113	113	28	33	32	25
Assembling Tubes	6	45	45	20	23	21	20
Assembling Tubes	47	115	115	52	55	51	39
Heatting	7	23	23	19	20	19	17
Micro-drilling	5	22	22	15	15	15	14
Micro-manufacturing	6	20	20	15	16	14	14
drilling	12	26	26	17	19	19	16
Contacted joins	6	22	22	18	18	18	17
	157						

Fig. 3. Results of process documents analysing.

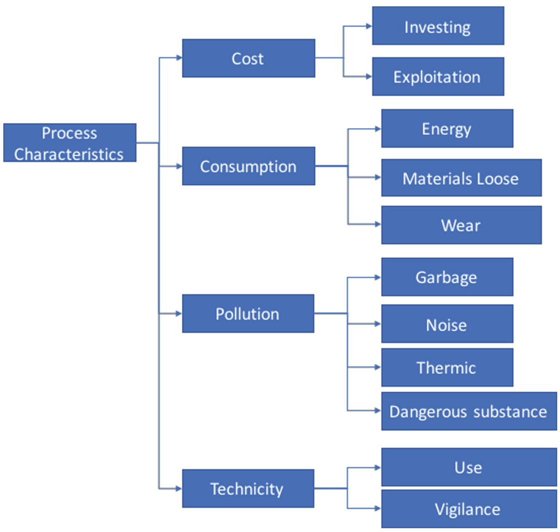

Fig. 4. Example of process characteristics

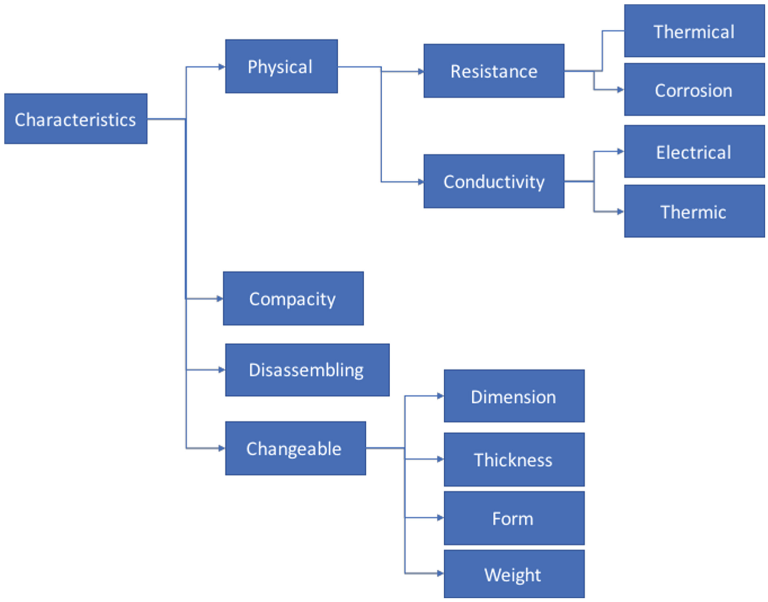

Fig. 5. Example of materials characteristics

3 Extracting Knowledge from Eco-Design Projects

In our university students are asked to design a product respecting environmental constraints. They follow course about eco-design and they have to apply studied theory in simulated projects. The given examples are extracted from real company (as wooden, forge, leather goods, etc.) problems. We study the example on wooden factory "SANTIN" that design windows and doors. This company is located in Aube department in which there are two forest but they use foreign woods. A river cross the department which is not rich in industries. Considering the big competition in this type of factory, SANTIN aim at innovating their production process by opening it to eco-design. Students are then invited to brainstorm about a solution. First, they are invited to look to existing products which can be considered as reference in their analysis. We study their brainstorming meetings in order to identify operational eco-design criteria. Our aim is to study how eco-design theory can be transformed with which type of criteria at operational level.

3.1 Project Execution

Eight brainstorming meetings are done linked to the different phases of the project: existing analysis, problems identification, Identification of related products, Identification of reference product, definition of eco-designed product, comparison of the two products. One additive meeting has been done in order to identify the organization of the project, its finality and a schedule. A report summarizing the project execution and the eco-designed product characteristics has been written. The teacher played the role of environmental expert who guides students to consider environment parameters. Students coming from mechanical design and building design play the role of eco-designers.

3.2 Project Analysis

Meetings are recorded using MMRecord tablet applications [16]. This application help to record discussions related to questions and participants (Fig. 6).

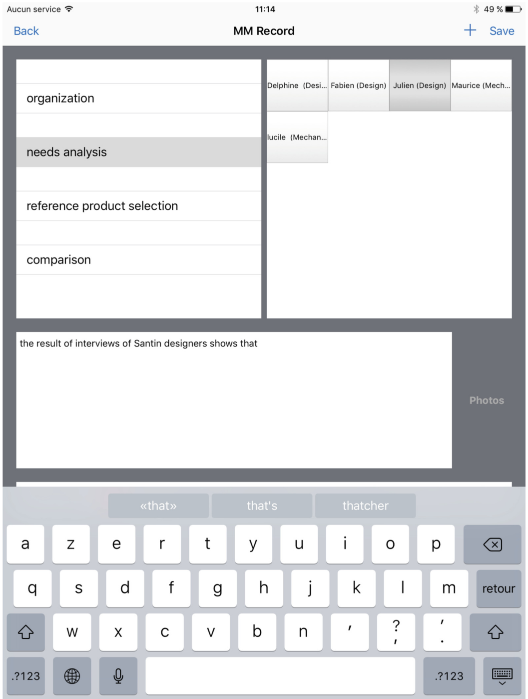

Fig. 6. Example of recording meetings with MMRecord

Meeting 1/2 and 3 Date 28/9/2016- Criteria			Meeting 4/5 and 6 Date 28/9/2016- Criteria			Meeting 7/8 and 9 Date 28/9/2016- Criteria		
Organization	**Design**	**Eco-design**	**Organization**	**Design**	**Eco-design**	**Organization**	**Design**	**Eco-design**
Task	Functions analysis	Finality	Coordination	Product characteristics	Material characteristics	Coordination	Materials Procurement	Environmental evaluation
Role	Flows	Project goal	Plannification	Product Quality	Local resources	Plannification	Manufacturing constraints	Product Reuse
Responsibilities	Needs	Norms/Rules	Infromation Management	cost	Environmental influence		Cost	Environmental Quality
Plannification	Costs	Product Reuse		Documentation	Product Knowing			Manufacturing Energy consuming
Communication	Competition			Performance	Rules			Use Energy Consuming
Coordination	Market			Manufacturing Constraints	Product evaluation			Acidification
Information managemer	Srength/weakness				Social dimension			Aquatic eutrophication
					economic dimension			economic dimension
					Product lifetime			photochemical ozone
								Transport
								Distribution
								Usage
								Product end of life
								Process Reuse
								Product reuse/recycling

Fig. 7. Example of criteria identified from project meetings

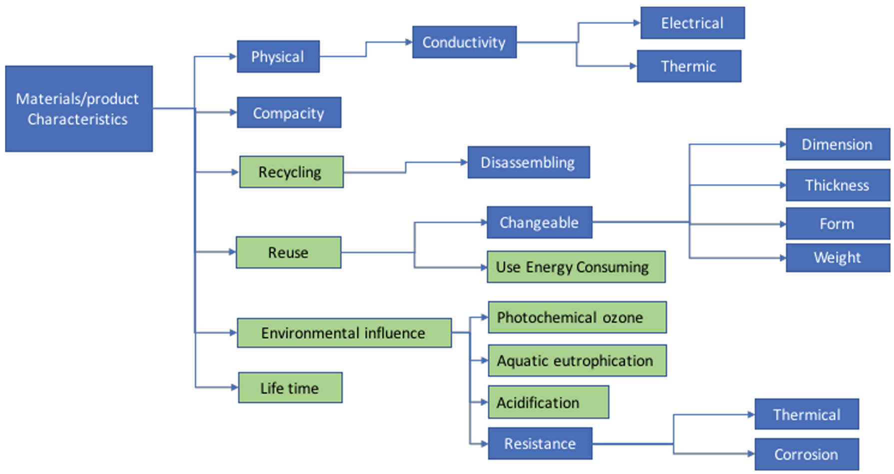

Fig. 8. Linking criteria to material and product characteristics

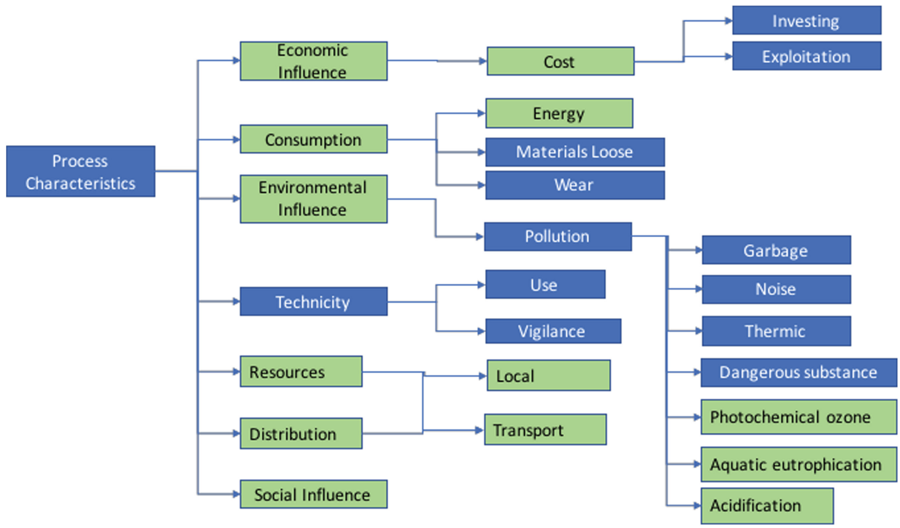

Fig. 9. Linking criteria to process characteristics

We listen then to these records and identify parameters based on from one side theoretical eco-designs parameters, design criteria and organisation indicators. Figure 7 shows an example of identified criteria from meetings. Adding of that, we examine the final report in order to complete our analysis.

These parameters are then attached to the ones identified with documents analysis. The first results show the application of theoretical parameters from one side and the global view of indicators to consider in eco-design from the other side. In fact, besides technical characteristics of the eco-design and manufacturing, organizational and economical ones must be considered (Figs. 8 and 9).

This first studies will help to define concept models of eco-design which help to extract indicators from documents using TextMining, when considering the model as lexicon, from one side and guide designers to consider environment criteria in eco-design projects by using then in evaluation. This work is first step toward a definition of an ontology in eco-design. The following sessions present the collection of concepts from domain experts and scientific papers for this aim.

4 Eco-Design Ontology

There are different works that define ontologies for eco-design. These ontologies are specific to some applications like biorafinery [13] or specific problems as linking raw materials to products [9], or LCA process [12, 14]. Other ones identify emphasize environment main concepts linked to eco-design [11]. In our study, generic ontology is used in order to gather the main concepts in theses ontologies and to identify a domain one as a guide for eco-designers. So, we proceed by an overall approach studying main works in this domain. To define this type of type of ontology, two approaches are used:

- top-down by interviewing experts and defining main concepts structuring the ontology
- bottom-up by extracting concepts from scientific papers, in the domain using Textming technique [2].

4.1 Experts Interviewing

Two eco-design experts have been interviewed. These experts help different industries in the last 3 years. They are also involved in sustainability research. We use Knowledge engineering techniques and we co-build with them the main structures of eco-design ontology. Related to Dolce generic ontology, we identify three types of concepts (Fig. 10):

- Endurant which describes substances, row materials and Energy
- Perdurant related to design activities (Fig. 10) as: raw materials, manufacturing, packaging, distribution, use and recycling.
- Abstract which help to defines influence and changing facts as: Depletion, Transformation, specialization, destroying and consequences (Fig. 10).

The main eco-design activity is to identify how Perdurant (design activity) disturbs Endurant (environment) based on the Abstract influence relations. So, a graph is defined in order to emphasize these influences (Fig. 11). This type of influences is also noted by Ostad [14] when analysing the relation of LCA with the environment.

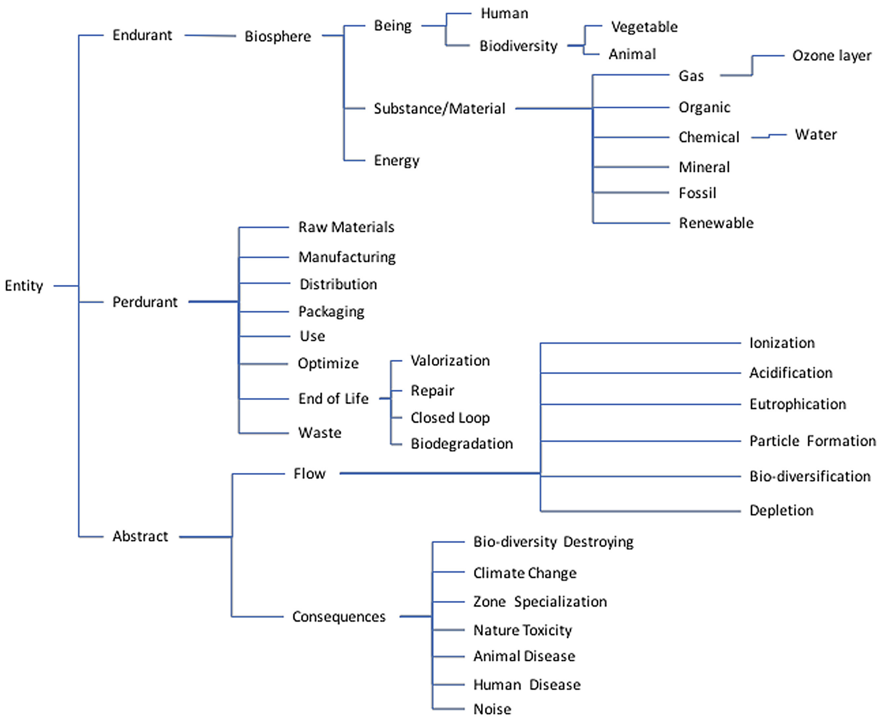

Fig. 10. Eco-design ontology

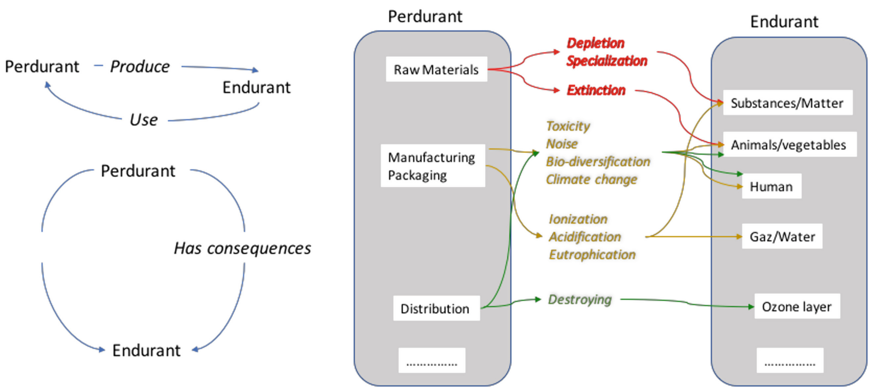

Fig. 11. When Perdurant disturbs Endurant

5 Extracting Concepts from Scientific Papers

38 Eco-design papers, published on ICED 2017, are analysed. The "Voyant Tool" Textmining [2] tool[2]; has been applied on papers related to each topic and a list of terms has been identified.

5.1 Terms Analysis

Firstly, a selection of papers has been done using the term "ecodesign" from ICED2019 proceedings. 38 papers were found. Then the TextMining Tool "Voyant tool" (See footnote 2) has been applied on one time on these documents without any categorization or indication of preferred words 191 occurrences of terms has been identified. After cleaning of usual terms: 69 words are identified related to eco-design. Single and plural terms are then gathered and we obtain 47 terms. Figure 12 shows the number of occurrence of these terms in analysed papers.

Voyant tool shows also relationships between terms in the text based on the existence of terms in the same sentence or paragraph. So, we apply this tool on each paper and we gather links between terms in one graph (Fig. 13).

5.2 Concepts Identification

Concepts are then defined from terms based on the structure if the ontology built with the expert. That help to confirm some concepts and to add other ones. Figures 14 and 15 illustrate this augmented ontology.

These results show that currently several works study process and technologies to enhance eco-design life cycle. Some papers deal with management, economy and social aspects. Behaviour and learning dimensions are also mentioned. The number of these keywords on ICED 2017 proceedings show that the sensibility of research on human, social and economic subjects is not largely developed. The model proposed by Ceschin et al. 2016 shows that the Design For Sustainability (DFS) approaches have progressively extended from technological aspects to human and from unique products to complex systems in a systemic vision [3]. This means that the skills and role of eco-designers have evolved. The work of Millet et al. shows that the eco-designer must have scientific (design, environmental, sustainability and value chain), legal and DFS tools skills [18]. The ontology Fig. 14 shows us that eco-designer nowadays must also have inventive, visionary and troubleshooting capabilities to address sociotechnical issues. The ecodesign must play the role of «cultural intermediary» (in the sense of [20] of the dissemination of DFS knowledge and creator of a stakeholders' network throughout the value chain of a system over one or more life cycles.

We will continue our exploration and study journals papers in sustainability and eco-design in order to enrich this type of ontology and emphasize dimension to consider in DFS.

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[2] https://voyant-tools.org/.

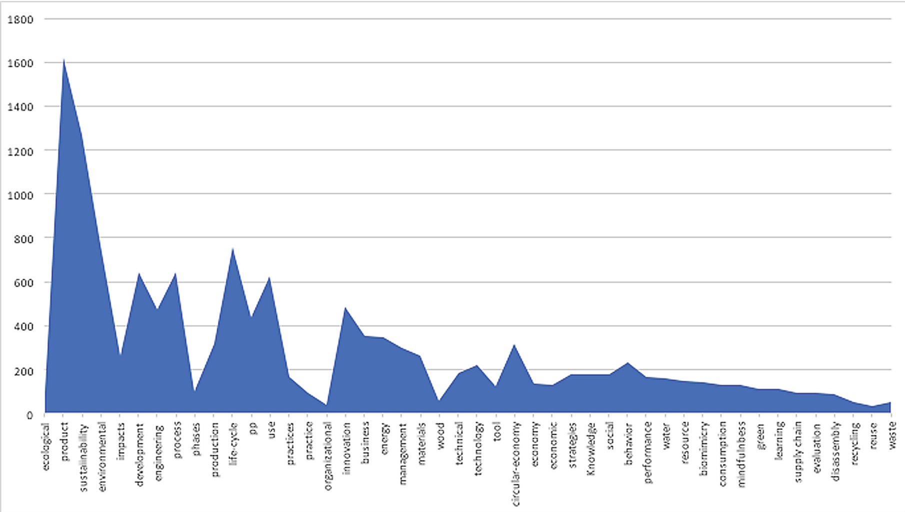

Fig. 12. Occurrence of eco-design terms in selected papers from ICED 2017 proceedings.

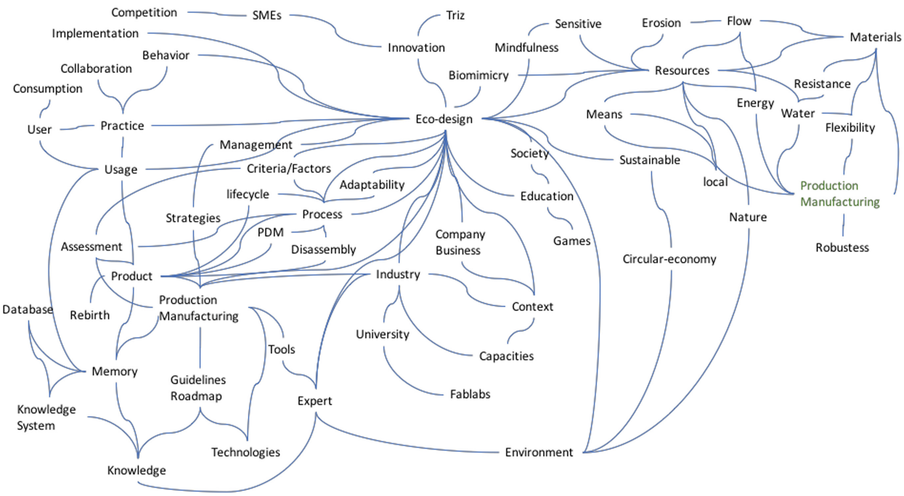

Fig. 13. Links between terms found in selected papers from ICED 2017 proceedings

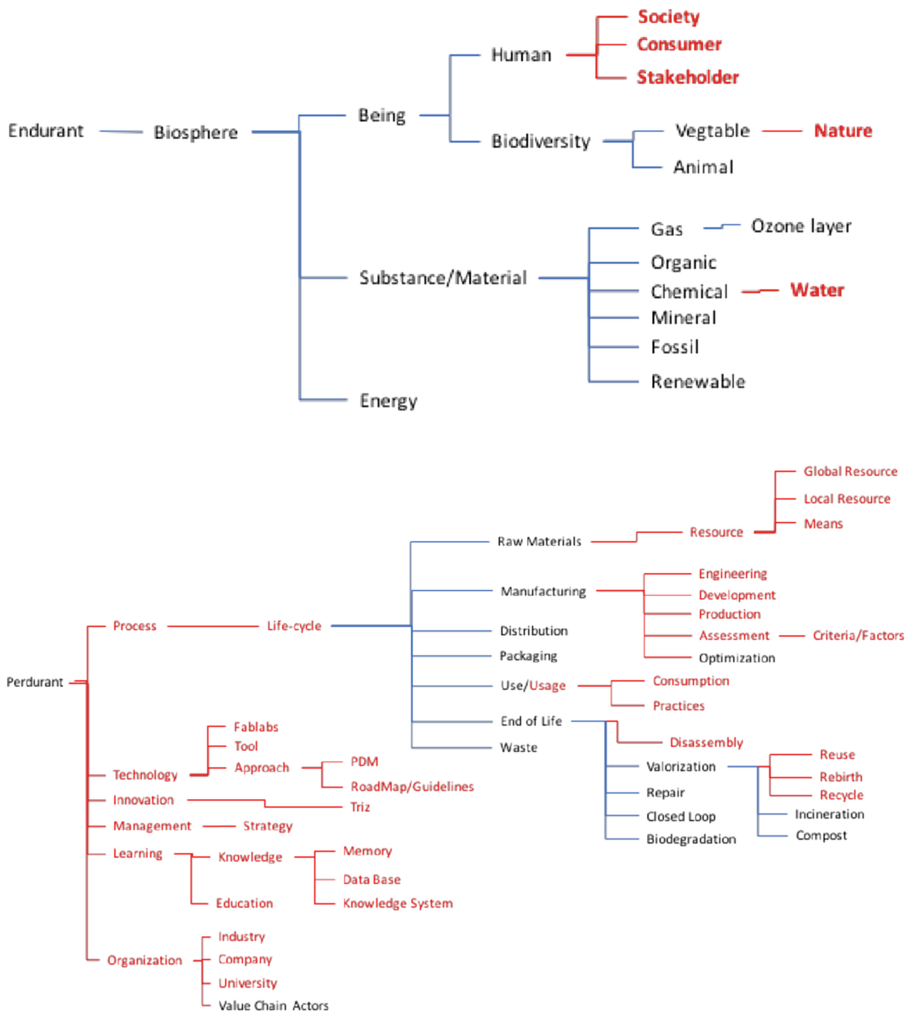

Fig. 14. Augmented eco-design Perdurant and Endurant concepts

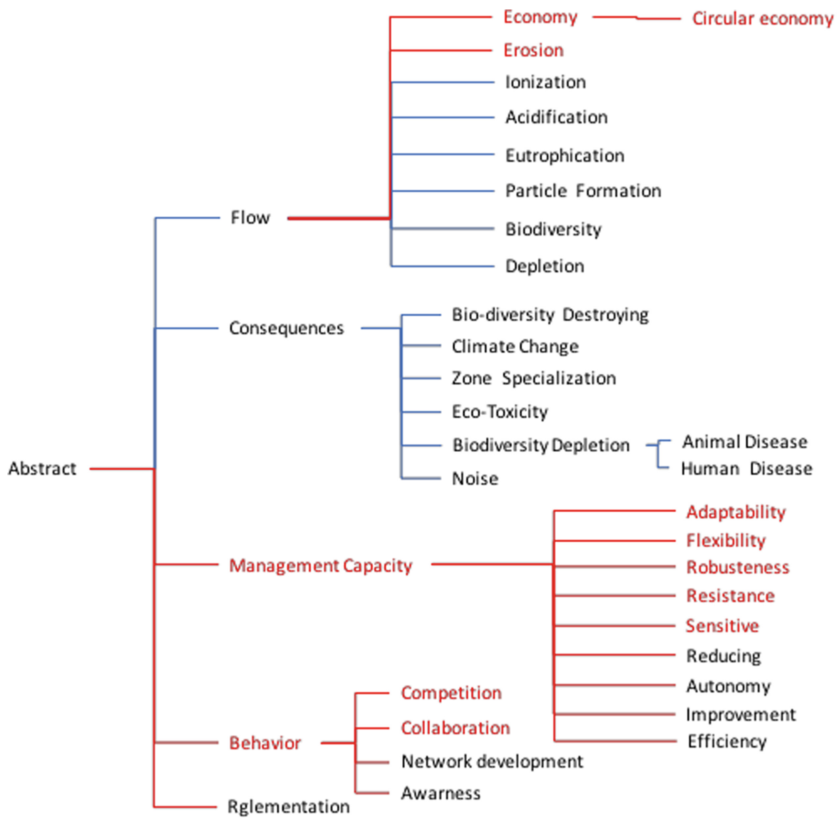

Fig. 15. Augmented eco-design Abstract concept

6 Conclusion

Eco-design experience is still young. Even, technical aspects are studied strongly but there is no consolidation of the relationships between technical and organizational and economical dimensions. We try in this paper to explore this relationships by extracting concepts from using two approaches: related to TextMining from documents and traceability of projects. We obtained criteria in different level of abstraction. As same as, we prove the feasibility of these techniques even there is no big documentation in eco-design (mainly from scientific research) and projects still very innovative. First concepts defined can help us as a lexicon to use TextMining in automatic way and as guides to help in eco-design projects. This work is a first step towards definition of a knowledge Base for eco-design. That can help designers to mainly integrate a green approach in their activity. The eco-design ontology can be considered as a guide in order to define models for specific activities. Main concepts shown in this ontology put on the influence type of production activity on the environment. This work is not exhaustive and eco-design ontology can be completed either from ongoing studies or real applications and studying other scientific papers. We aim at continuing our analysis of eco-design projects using DYPKM [1, 15] traceability approach and KDR [4] classification technique in order to identify more criteria at operational level. Students continue to use MMProject application and keep track of their project execution.

Otherwise, we explore territory literature and design organizational supply chain in order to open eco-design studies to organizational and social dimensions. We hope at the end of this studies to define an ontology of main indicators to help eco-design evaluation process and products. First has been so defined emphasizing from one side materials and natural flows and social and informational organization from another side.

First results will be integrated in eco-design tool the "ECODESIGN STUDIO"[3] that allow to validate our hypothesis in real projects.

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