Definition of Experience Feedback Sheet for Eco-design

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Abstract: In this paper, we propose a Knowledge to use experience feedback techniques in order to keep track of eco-design decisions. The integration of eco-design in industries is becoming more and more considered as a necessary condition of Sustainable development. Even sustainable rules become to be defined as norms, but the application of these rules in design still difficult. Firstly, eco-design criteria are extracted from documents in order to help the definition of experience feedback sheets main points. CommonKADS generic models are also used in order to define adequate sheets to reasoning and task types linked to eco-design phases.

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 (Depret and Hamdouch, 2009; Michelin et al, 2014) allowing to reduce material and energy impact. 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.

In order to answer this problem, we use two types of approaches: extracting criteria from documents related to sustainability studies and keeping track of eco-design activity using experience feedback sheets. This paper presents this work and especially how extracted criteria can be used as an index of experience feedback sheets in order to facilitate their reuse.

2 EXTRACTING 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 Eco-design 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 (0), 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.

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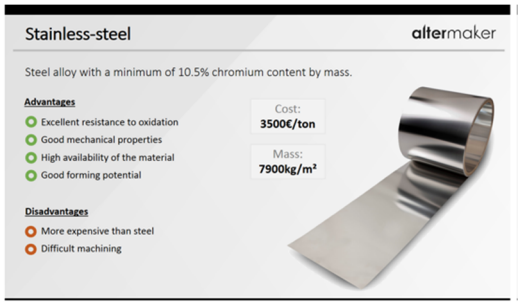

Figure 1: Example of Altermaker documents (material card).

2.2 Analysing Approach

Knowledge engineering techniques (Studer and al, 1998) 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 (Feldman and al, 2007) 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.

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.
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 (0).

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%

Figure 2: Results of process documents analysing.

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. (0).

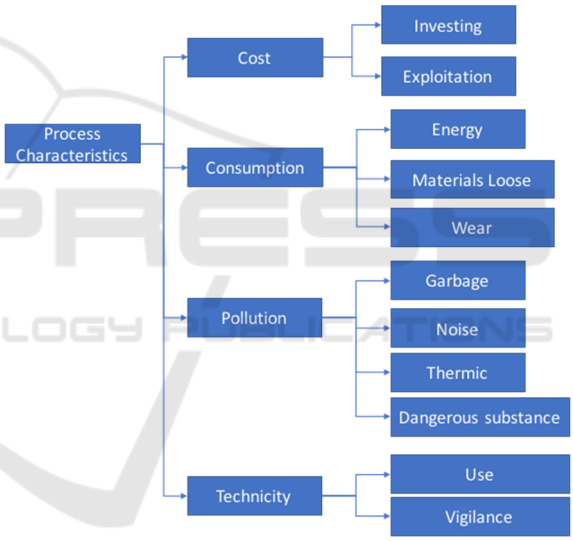

Figure 3: Example of Process characteristics.

For materials, we identify: Resistance, compacity, disassembling, modification, etc. (0). Then, for each process type (assembling, drilling, welding,…) values are associated to these classifications.

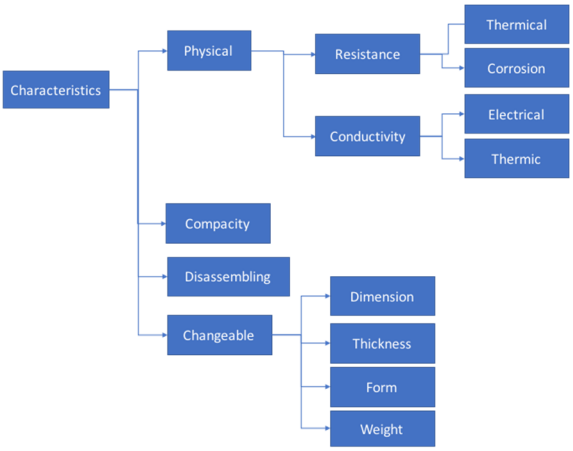

Figure 4: Example of Materials characteristics.

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.

To complete this study, we use REX method (Malvache and Prieur, 1993) in order to extract knowledge from eco-design activity.

3 KEEPRING TRACK OF ECO-DESIGN ACTIVITY

3.1 REX Method

The REX method enhances capturing and structuring of daily knowledge (Malvache and Prieur, 1993). In this method, an actor has to fulfil an experience feedback sheet as a report of his daily activity. Each form is structured in order to show the definition of a problem and how the actor solves it (0).

A lexicon that offers an easy access to these forms indexes experience feedback forms. Forms can be also organized and indexed using different viewpoints in order to reflect the domain diversity in an organization.

The definition of these sheets must correspond to the type of the activity. That helps actors to answer expertise key elements integrated in these sheets. REX sheets are used especially in diagnosis

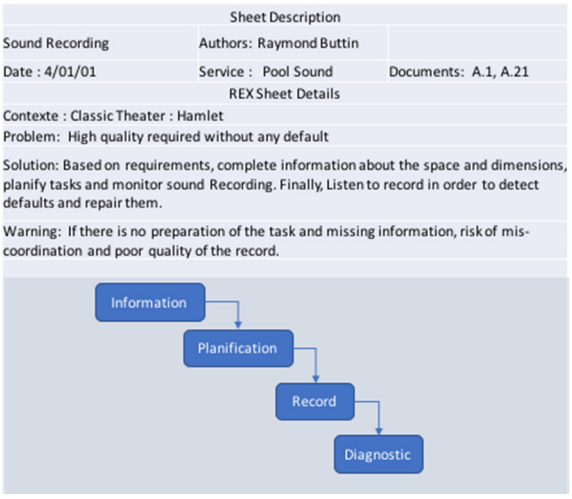

Figure 5: Example of a REX Sheet.

applications for radio and sound company (Renaud et al, 2008), for design applications in Prowhy tool[2] (Kuntz et al, 2016). In our work, we try to use these sheets for other types of task. So before defining REX sheets for eco-design, lets us study the different types of tasks of this activity.

3.2 Eco-design Task Types

Several studies in eco-design tends to integrate environmental consideration in the whole design process. We note especially studies of Victor Papanek in his book 'Design for the Real World: Human Ecology and Social Change' (Jackson, 1993). 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 (Knight and Jenkins, 2009). This methodology is now part of the ISO14000 environmental management standard since 2006. In our work, we consider the main phases of this process as first step of our analysis:

1. Need analysis and requirement definition
2. Specification and design of artefact
3. Test and Manufacturing
4. Product using and recycling

The reasoning type used in each phase is then identified based o cognitive studies; Clancey tree (Clancey, 1985) and the application of this tree (0) in knowledge engineering approach especially CommonKADS (Schreiber, 2000). In fact, Clancey

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

[2] http://www.prowhy.org/

tree help to distinguish analysis from synthesis reasoning.

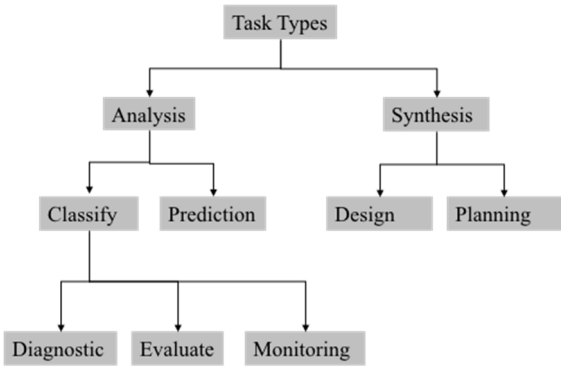

Figure 6: Task Types Tree.

CommonKADS approach presents primitives in order to help to distinguish the type of knowledge used related of each reasoning types. For instance, in diagnosis task, actor try to identify symptom from observations, generates hypothesis based on his experience and discriminate these hypotheses by testing them in order to find the default. 0 presents main CommonKADs, we used in order to define REX sheets.

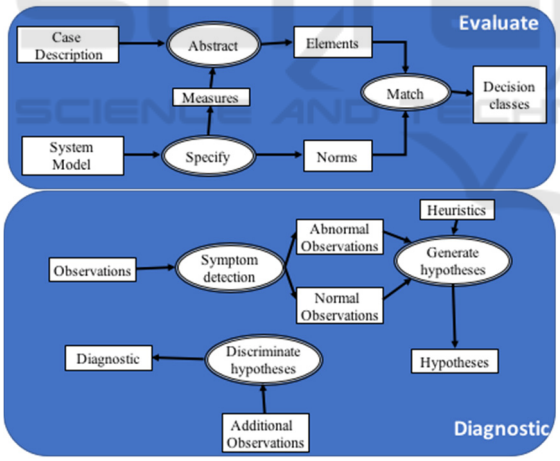

Figure 7: CommonKADS evaluation and diagnostic generic models.

3.3 Eco-design REX Sheet Definition

To define REX sheet types, we need from one hand to identify expertise activity types and from the other hand, to adapt sheets elements with the expert. For each main phase in eco-design, the type of reasoning is identified as follows:

Need, usage and recycling analysis can be considered as evaluation reasoning type, when actor try to identify the main parameters of a situation and identify needs by comparing these parameters to situation models he knows. So, main elements characterizing knowledge used and produced in this step can be:

- Reference models: Systems, behaviours, Components, techniques, market, usage, etc.
- Observations: systems, components, behaviours, market, usage, etc.
- Decision: Needs, requirements, constraints, recommendations, etc.

Actors use diagnosis sometimes in order to detect problems and discrepancies in existing systems, market and especially recycling products. So, some points can, be added to the sheet like: symptoms, problems hypothesis, discrimination tests and measures (0).

Figure 8: Analysis sheet type.

For design and Manufacturing, requirements, components, and evaluation results with argumentation must be described (0). Tests is the prediction of future behaviour of the system.

Based on eco-design parameters, environmental parameters must be added to these sheets like: Energy, water, CO2, pollution, resources and economic Impacts. These elements can so be added to

description of each systems, components and behaviours (0).

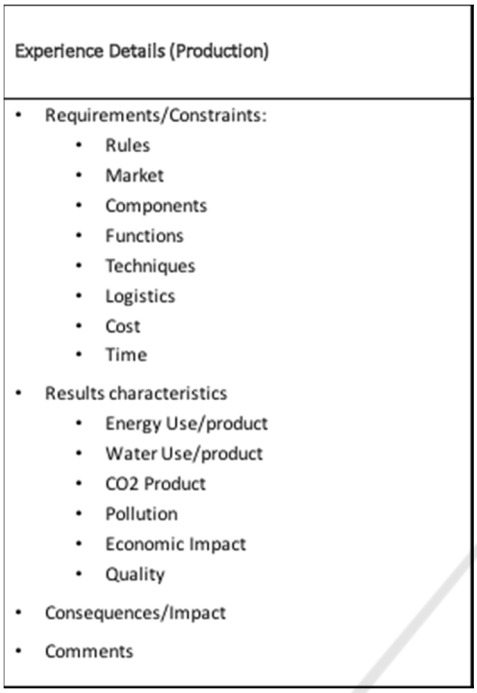

Figure 9: Design and Manufacturing sheet type.

These REX sheets will be integrated in the eco-design actors' environment, for instance in PLM and environmental tools like the "ECODESIGN STUDIO"[3], as first page or summary of documents produced at each phase in eco-design.

Characteristics we try to define (section 1) can be used to give a cognitive index of these sheets adding to main keywords extracted from them. So, the access to knowledge embedded in this type of sheets can be through a tree summarizing main characteristics (Section 1.) or with simple keyword research. Inference engine like Protege (Noy et al, 2001) or CORESE (Corby et la, 2004) can be used for that. These techniques can be directly integrated as a Knowledge Based Engineering system (Chapman et al, 1999) already used in design. These techniques can use REX sheet instead of rules bases.

We illustrate in the following an example of the application of REX sheet in eco-design.

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

4 EXAMPLE OF REX SHEETS IN BREAD TOASTER ECO-DESIGN

A group of students in our university had to redesign a bread toaster with eco-design needs. They plan their work in: strategic, functions, component analysis and eco-design recommendations. They use "ECODESIGN STUDIO"[4] in this analysis. In the strategic analysis, they study the impact of the current product in the environment under several criteria: raw material, Procurement logistics, manufacturing process, distribution, usage and end-of-life (0).

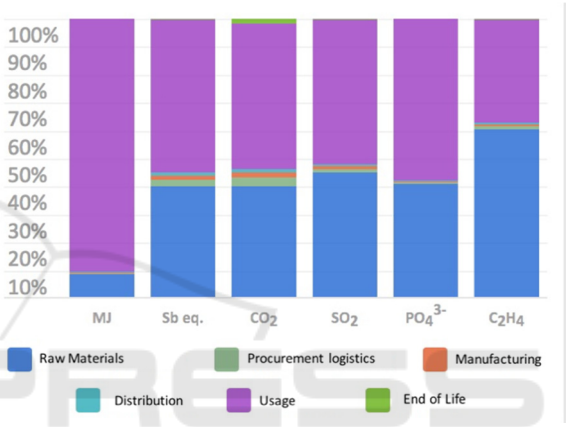

Figure 10: Bread Toaster Strategic analysis for the current product.

Even, there is a number of criteria showed in this analysis, but how and why these analysis is driven are not described. Main comments they note about that was only about the choice of the product range to analyse. There was nothing about how they analyse these criteria (0).

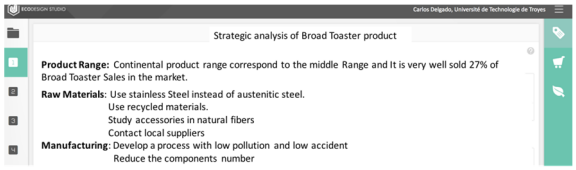

Figure 11: Comments about Bread Toaster Strategic Analysis.

To push actors to make explicit their choices and their analysis, Analysis REX sheet can be used. As we note above, in this type of sheet, actors have to identify the reference models that they compared the

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

Figure 12: Bread Toaster need analysis REX Sheet.

observations with. Different criteria categories like Market, Manufacturing Techniques, Components, Recycling, and Usage help actors to structure their answers and write clear sentence usable for learning. For instance, in needs and market analysis (0) choosing steel is important to reduce energy in product usage. Reducing Raw materials numbers is important to have a light product and for minimize manufacturing pollution impact and product recycling. Light Product is important to reduce energy in product usage. The cycle of materials procurement is important to study in order to reduce CO2 impact. Putting reference models and decision in the same sheet, is very important to push actors to answer main elements to consider in eco-design and help learners to understand choices by comparing reference model's characteristics to observed symptoms and decisions. For product design, how choices answers eco-design requirements is emphasized by inviting learners to compare requirements with results characteristics and impact (0). We can note that inviting actors to comment their decisions using dedicated REX sheets put on from one side, main elements used in their reasoning to obtain these decisions and from the other side help to structure their comments (instead of sentences in which different elements are mixed) in a clear way avoiding the confusion of natural language sentence and the omissions of criteria.

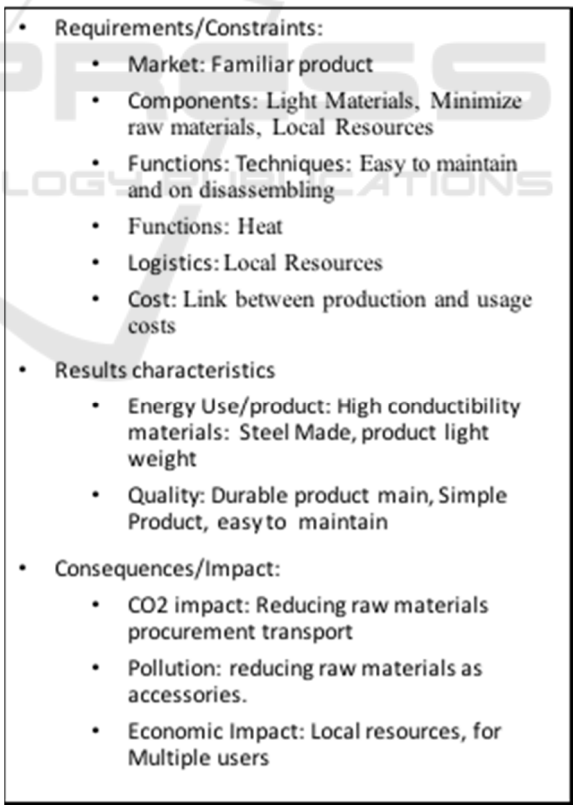

Figure 13: Beard Toaster design REX sheet.

5 CONCLUSION

There is still no experience feedback techniques used in eco-design. Each company try to answer norms and rules by using own techniques. The aim of our work is to enhance learning between these company using their experience feedback. Keeping track of experience using REX sheet and memory is proposed in this paper. REX sheet types are defined related to different phases of eco-design: analysis, design, manufacturing, test, usage and recycling. Eco-design criteria are also extracted from documents analysis that help to index REX sheets and give a cognitive access to these experience traces. REX Sheets can be integrated in eco-design tools as argumentation and notes of each decision making and propositions.

We tend to apply these sheet in other eco-design application in order to validate and complete their descriptions. These sheets and criteria will be integrated in eco-design environments like "ECODESIGN STUDIO". First tests can be done by our students in their eco-design projects. Finally, tests with students will be done, in order to analysis REX sheet writing and use possibilities. Finally, REX sheets can then be compared and classified in order to identify lessons from experiences as it is used for project memory (Dai et al,2014).

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