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A Guidance System for Selecting an Appropriate Eco-Design Checklist in the Early Stages of Product Development

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Abstract

The early stages of product development play a crucial role over the entire life cycle of a product from raw material extraction to its end-of-life since environmental impacts of the product are mainly determined by product design. However, incorporating environmental aspects as early as possible will result in making an environmentally conscious product. Various quantitative and qualitative eco-design tools have been developed so far. Currently, eco-design practitioners are unwilling to apply the quantitative tools due to their time- and energy-demanding nature. In contrast, among the qualitative tools, checklist tools are preferred for quick evaluation and consideration of environmental impacts over the whole life cycle of a product. A comprehensive understanding and a selection guide are needed for eco-design checklist tools so that practitioners can utilize them appropriately for specific product development contexts. This research aims to analyze various eco-design checklists with regard to their features, and attributes. Then, a guidance system is proposed to help product designers choose a proper eco-design checklist for application into a specific context of product development.

Keywords*:* Early stages of product development, enviornmental impacts, eco-design checklists, guidance system.

1. Introduction

During last decades, due to increasing awareness of society about various environmental impacts of products such as pollution, global warming, clean water, and etc., companies have come to the conclusion that environmental performance of products, eventually, will become a significant competitive advantage in the global market. In recent years, a substantial shift in the manufacturing companies has been taken place from “end-of-pipe” solutions, i.e., solutions aimed at reducing the amount of harmful emissions, to “the environmental performance of products [1].” Here is where the product development practices can be strongly highlighted since products do affect the environment at many points over their entire life cycle from raw material acquisition to their end of life stage. Environmental requirements in the design stages of product development are defined as minimizing raw

materials, energy consumption, waste generation and etc. When it comes to the context of new product design, environmental sustainability of products performs an essential role. However, the challenge of sustainability is to protect our environment which needs to find ways not merely to diminish the negative impacts of products but rather to eliminate the environmental impacts [2]. Consequently, it is of a major importance for addressing the environmental impacts of products' at the early stages of product development where none of the decisions about products have been finalized and design concepts are still flexible in order to eliminate the environmental impacts. London Design council [3] indicates that since between 80 - 90% of products' economic and environmental costs are determined at early stages, the environmental impacts of products are largely decided at the early stages of design. Although, a more recent survey found out that environmental aspects of products are mainly coped with at the later design stages, vast majority of companies recognize the need for early integration of environmental aspects [4, 5, 6]. To fulfill of this purpose, the concept and practice of "Eco-Design" has been developed which is the systematic consideration of design performance with respect to environmental, health and safety objectives over the entire product life cycle. It is worth noting that Eco-Design and Design for Environment (DFE) pursue the same objectives and are used interchangeably in accordance with specific contexts. A plethora of different eco-design tools for analyzing environmental aspects of products have been developed thus far [7, 8]. The authors of this paper have found more than ninety multifarious eco-design tools in the literature. According to the literature, the main objectives of eco-design tools are (1) environmental performance analysis and evaluation, (2) selection and definition of priorities for further development and improvement, and (3) coming up with design guidelines and solutions. These tools generally can be classified in three categories including: quantitative, semi-quantitative and qualitative tools. As a brief description, quantitative tools are analytical and require large amounts of information, time and efforts such as Life Cycle Assessment (LCA), Material Glow Analysis (MFA), Cost-Benefit Analysis (CBA), and etc. Semi-quantitative tools need somehow large amounts of data, and are partially qualitative such as MET Matrix, Boeing Process Environmental Matrix, etc. Finally, qualitative tools are simpler, and require less information and time such as checklists, guideline and strategies, network diagrams, etc.

Currently, eco-design practitioners are disinclined to utilize the quantitative tools in light of their time- and energy-demanding natures and complexity. As a matter of fact, a common LCA quite often needs quantified data which is not available at the earlier stages of product design process. The same holds true for semi-quantitative tools. In contrast, there are very few exploitable eco-design tools which can be applied at the early stages of product design. Among the qualitative tools, checklist tools are preferred for quick evaluation and consideration of environmental impacts over the entire life cycle of a product. Eco-design checklists are generally a set of items used for assessing a product from environmental viewpoints. Despite the fact that

several eco-design checklists have been developed so far [9, 10, 11], Lindhal [12, 13] articulate that today's eco-design tools selection is unstructured and sometimes dependent on the specific tool's popularity rather than a real analysis of the need. As a result, a profound understanding and a selection guide are needed for eco-design checklist tools so that practitioners can apply them congruously to their product development context. This paper aims to investigate and analyze variegated eco-design checklists, and proposes a guidance system to assist product designers in order to select a fitted eco-design checklist for application into specific contexts of product development.

This paper is organized as follows. The approach is defined in the next section; then the results of the approach, i.e., applying guidance system, is revealed; and finally the paper closes with a discussion of conclusion, limitations, and suggestions for further research.

2. Approach

Nowadays, manufacturing companies employ varied eco-design tools and methods. Masui [14] reports that Japanese manufacturers often use checklists and life cycle assessment (LCA) for assessing environmental aspects of their products. Checklist tools, however, are widely-used tools in order for decision-making process in integrating environmental aspects into product development. These checklists commonly consist of attributes that ought to be considered while designing green products. According to the literature, there are approximately twenty-one existing eco-design checklists which have been developed by both academicians and practitioners. One of the most prevailing checklists called "The EcoDesign Checklist" has been developed by [10]. It covers the entire life cycle of a product from needs analysis to the recovery and disposal stage. This checklist provides essential questions which must be addressed to assess environmental aspects of a product. Furthermore, it comes up with a couple of design solutions for every single stage of whole life cycle. Some of current checklists are mainly used to assess products in terms of their environmental performance such as Eco-Design Health Check [15], ECODESIGN PILOT [9], Eco Mark Checklist [16], and so on. Some other checklists are intended for strategy developing or policy making such as Environmental Policy Checklist [17], Environmental Weather Map [18], and so on.

Since product-based firms have their own and specific product development processes with various objectives in accordance with environmental performance and eco-design practices, it seems that there is a need for a structured guidance system for these companies in order to help them choose an appropriate eco-design checklist in their specified product development contexts. Notwithstanding the fact that there is a limited number of current eco-design checklist tools in the literature, no systematic way for selection of which checklist to integrate into product development process is available. Consequently, in order to fill this gap, firstly, the authors of the paper analyze exiting checklist tools form fundamental perspectives such as features, capabilities, and benefits; secondly, according to the classification of existing checklists, they come up with a guidance system to select a proper one. For this intention, the checklists have been categorized by four

main characteristic including Assessing Target, Coverage of Life Cycle, Screening, and Guidance & Strategy. This category is drawn in Table 1. As it can be seen in this table, screening feature itself includes qualitative and quantitative parts since a couple of checklists provide quantitative screening, besides to qualitative screening. It is noted that in screening section, checklists with less than twenty items are recognized as “rough” and those ones with more than twenty items are listed as “detailed” checklists. The same holds true for “Guidance and Strategy” part. The number mentioned in parenthesis indicates the number of items for each checklist.

Based on the category of existing checklist tools from various features, a guidance system to select an applicable one is proposed. This system is based on key questions that must be addressed precisely. As shown in Fig. 1, the questions are as follows:

1) What is the target of assessment?
2) What is the coverage of Life Cycle span?
3) What type of input is needed?
4) What level of analysis is required?
5) What type of output is demanded?

Table 1. Eco-Design Checklist Category

	Eco-Design Checklist	Assessing Target	Coverage of Life Cycle	Screening			Guidance & Strategy
				Qualitative	Quantitative		
					Subjective Opinion	Objective Measurment	
1	The EcoDesign Checklist	Product	Whole Life Cycle	Detailed (39)	-	-	Yes (35)
2	Eco-Design Health Check	Product	Whole Life Cycle	Rough (10)	Rating (0 to 4)	-	-
3	ECODESIGN PILOT	Product	Whole Life Cycle	Detailed (216)	Rating (Relevance and Fulfillment)	-	Yes (216)
4	Eco Mark Checklist	Product	Whole Life Cycle	Rough (9)	-	-	-
5	ECMA 341-Environmental Design Consideration for ICT & CE products	Product	Whole Life Cycle	Detailed (81)	-	-	-
6	Smart ecoDesign™ Checklist for Electronic Manufacturers	Product	Whole Life Cycle	Detailed (55)	-	-	Yes (25)
7	Smart ecoDesign™ Energy Using Devices (EuP) Eco-design Checklist	Product	Whole Life Cycle	Detailed (62)	-	-	-
8	EuP Active Electronic Components Checklists	Product	Whole Life Cycle	Rough (11)	-	-	-
9	EuP Passive Electronic Components Checklists	Product	Whole Life Cycle	Rough (11)	-	-	-
10	EuP Printed Wiring Boards Checklists	Product	Whole Life Cycle	Rough (11)	-	-	-
11	EuP Mechanical Component Checklists	Product	Whole Life Cycle	Rough (11)	-	-	Yes (32)
12	Philips Fast Five Awareness	Product	Whole Life Cycle	Rough (7)	No. of times answering "Yes"	-	-
13	Volvo's Corporate Standard STD 1009,1- Black List	Product	Material Selection	Detailed (32)	-	-	-
14	Volvo's Corporate Standard STD 1009,11- Grey List	Product	Material Selection	Detailed (42)	-	-	-
15	Volvo's Corporate Standard STD 1009,2- White List	Product	Material Selection	Detailed (78)	-	-	-
16	Sony's Green Product Check Sheet and Product Profile	Product	Whole Life Cycle	Detailed (23)	10-Points Rating	Detailed (16)	-
17	Recycling Checklist for EC Directive on WEEE	Product	End-of-Life	Rough (6)	-	-	-
18	Product Assessment Checklist/Guideline	Product	Whole Life Cycle	Detailed (89)	-	Detailed (89)	-
19	Environmental Policy Checklist	Policy	-	Rough (20)	Rating (1 to 5)	-	-
20	Environmental Statement and/or Environmental Report Checklist	Policy	-	Detailed (39)	Rating (0,1,3,5)	-	-
21	Environmental Weather Map	Strategy	-	Rough (18)	Rating (Sunny to Rainy)	-	-

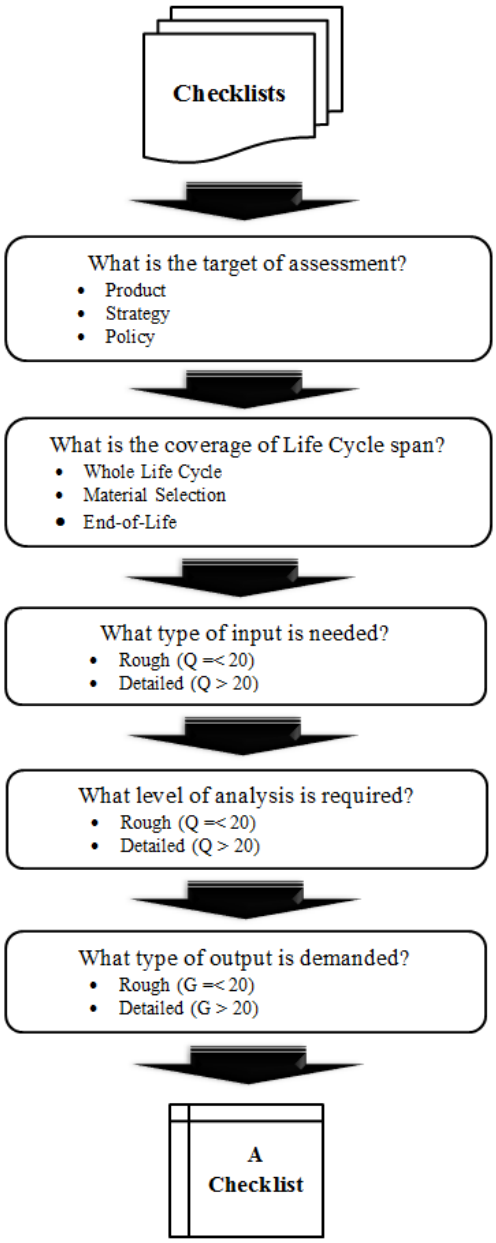

Fig.1 Selection Guidance System for Selecting Eco-Design Checklist

3. Results

As an illustration to demonstrate how to apply this guidance system, a company that intends to assess environmental aspects of its products must choose those checklists which have been developed for this target. In the next step, from the life cycle perspective, proper checklists can be selected, i.e., covering the whole life cycle of products or just covering one single phase such as materials selection or end-of-life. The next step determines the type of data which is needed to use the checklist. The company must decide whether or not it prefers to use a quick and rough checklist; otherwise, it must use a more detailed checklist. One step further is related to level of analysis by the tool that can be a quick and rough or a detailed analysis. Finally, this guidance system requires the type of output data that the company desires to get. A very few number of existing checklists provide this final step which includes eco-design guidance and strategies.

As depicted by the category and the guidance system, there is an array of practical eco-design checklists available to be utilized by designers, and selection of which tool to apply in eco-design practices and integrating them into product development process depends on various needs of companies as well as determining which one is most compatible with the culture and current system at the company. However, this might need to customize the existing tool.

4. Discussion

Eco-design can be described as the systematic integration of environmental aspects into the product development process with the aiming of eliminating the impacts. To do so, however, the best and effective way is early integration of eco-design tools in the product development since the vast majority of product attributes are determined and decided at the early stages. Variety of eco-design tools have been developed which are mainly impracticable because enough information of product design concepts is not available at the early stages. Consequently, eco-design checklists,

among qualitative tools, are the most useful and practical tools to address environmental issues at the early stage of product development. This paper investigated and analyzed the literature of eco-design tools deeply, and broke down the existing checklists with regard to their features and functions. Based on the analysis of these tools, the paper came up with a guidance system in order to help product designers and eco-design practitioners choose an appropriate checklist which meets the needs of their own product development context.

In spite of the fact that a myriad of eco-design tools have been invented thus far, almost there is no one single paper which classifies all the existing tools. The authors of the paper did an in-depth research and analysis of developed tools and found more than ninety applicable tools. It seems that there is a need to develop taxonomy of eco-design tools in a systematic and structured way. What is more, most of eco-design checklists do suffer from quantitative or objective measurements since their requirements are mostly evaluated as “Yes” or “No.” Consequently, in order to address this shortcoming, it appears that a new and comprehensive and at the same time simple and quick eco-design checklist should be developed in order to be applied at the early stage of product development. Needless to say, it will be very helpful to enhance the accuracy of assessing environmental impacts during the design process.

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