THE IDEALITY "WHAT" MODEL FOR PRODUCT DESIGN

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ABSTRACT
This article presents an innovative design model for both designers and engineers that can serve as a crucial compass during the formulation of a Product Design brief. The model was developed in order to bridge the gap that exists between the quest for sustainable design and the limitations of traditional briefs by focusing on the analysis level of the "WHAT" in order to enhance the "HOW" hands-on output. The model is based on the TRIZ ideality concept and the Bio-mimicry approach, incorporating sustainability principles inspired by nature. This design model directs designers and engineers through complex planning challenges, including the demand for sustainable processes and materials, novel attributes, efficiency, functionality and lower costs. Mechanical engineers and product designers that utilize this model achieve interactive strategic thinking that can balance the main planning stages of product functionality, such as manufacturing, advanced materials, logistics processes, marketing demands and related costs. This article presents and expands upon the theoretical basis of the model and also discusses its practical contribution through a case study conducted in an academic classroom experiment with students in a program for Mechanical Engineering and Product Design.

Keywords: Increasing benefits, efficiency, sustainability, TRIZ, Bio-mimicry, Bio-inspiration, ideality, product design.

1 INTRODUCTION

In light of global change it has become increasingly important that designers and engineers consider any influence a project may have on the environment, even in the earliest design stages [1]. At the same time, we are witness to fast-paced changes in the complexity of our modern way of life, both environmentally and socio-economically. The result is a pressing need for new models that will address the sustainability perspective in a complex environment, while improving the risk-management policies and design efficiency. While it is imperative that designers keep track of the current path of changing demands as well as international standards and technology costs, design methods have remained relatively conservative. As a result, some designs are too complex for the solutions that can be provided using traditional methods, which do not fulfill their needs [2]. Therefore, the idea that the designer must continue to provide solutions to new demands using these traditional methods is no longer relevant [3]. In light of this gap, designers must have the ability to glean skills from different fields and decide upon the best method for advancing the design process [4].

Nature is a promising source of knowledge that should be investigated for inspiration for innovation and sustainability in design. Biological systems operate within restricted conditions while minimizing waste and irreversible damage to the ecosystem. On the contrary, they often enrich and sustain ecosystems. Nature's forms and structures provide a wide range of properties while minimizing the usage of materials and energy. Nature-based manufacturing processes are conducted within the conditions that allow for life and therefore exist without high temperatures, strong pressures or toxic materials [5]. Natural systems demonstrate efficient energy and material flows. Therefore, design models that rely on nature-based solutions suggest promising potential for innovation and sustainability and allow designers to address sustainability during the early design phase [6]. These models are associated with the field of Bio-mimicry and Bio-inspiration—the imitation of nature

design solutions on the levels of structures, processes, systems, planning principles, strategies and patterns.

Bio-inspired sustainability design tools are based on patterns that are essentially simplifications of nature's sustainability design solutions. Life Principles [5] are strategies that nature maintains in order to survive under the conditions on planet Earth. The Ideality Tool for sustainable design [7] is another example of nature's sustainability patterns formulated by the TRIZ ideality framework. Ideality is a basic concept in TRIZ (the theory of inventive problem solving)[8], which describes the qualitative ratio of all system useful to harmful functions, or simply the ratio of system's benefits to costs, the two main ideality categories. The ideality tool for sustainable design utilizes nature's strategies to increase system benefits (e.g. multifunctional design) and reduce system costs (e.g. defensive strategy to prevent damage to the system). The relationship between sustainability and ideality was the basis for the development of practical eco-guidelines for product innovation and sustainability, while nature ideality strategies can serve as sustainability tools [7]. However, these bio-inspired sustainability tools do not incorporate product design methodologies in general or design brief methodologies and their specific requirements in particular. Adaptation of such tools for product design is therefore essential.

Product designers work mostly on multidisciplinary teams characterized by an amalgam of different approaches. While scientists tend to focus on how to solve problems through analysis, designers focus on user scenario and problem solving through creation [9]. Moreover, the challenges that arise when working on multidisciplinary teams are also related to environment complexity. The problems the designer must solve in a complex environment are considered to be "ill-defined" or "ill-structured"—that is, they are not clearly defined and cannot be solved using standard calculations [2]. As a result, there is a tendency to "skip" the "WHAT" stage and moved to the "HOW". The "WHAT" stage is crucial; if we formulate the details of the "WHAT" it will help us plan the "HOW" and select the type of solution we should implement. Thus, defining the "HOW" at the start of the brief will likely narrow down the designer's possibilities for finding additional solutions while adaptation of the bio-inspired sustainability tools for the needs of product design should address these multidisciplinary and complex aspects. The ideality model for product brief composition is suggested as a Bio- inspired sustainability tool, adjusted for a product design brief. The model aims to achieve a broader effect within existing constraints, launching the designer's capabilities in creating an ideal brief that focuses mainly on the question of the intention of the "WHAT" while avoiding the tendency to "flee" towards the question of "HOW".

2 THE IDEALITY "WHAT" MODEL FOR PRODUCT BRIEF

The ideality "WHAT" model for a product brief is based on the ideality tool for sustainable design [7] and serves as a design tool for the formulation of a design brief. The objective of the model is to achieve a broader effect within existing constraints, serving as a design platform for the schematic thought process of engineers in combination with the creative thought process of product designers. The structure of the model provides a useful starting point after receiving the client's brief. This contains instructions that must be followed while considering the existing constraints. The model promotes management, identification, definition and expansion of the opportunities that are embodied in the product and has an amorphic structure that changes and adapts to the product's needs. The model can be used by individuals or by teams. The model integrates creative and rational methods: first, it is based on the **creative method,** which focuses on Synectics as a technique for problem solving through creative thinking and varied analogies. The ideality "WHAT" model promotes the thinking process and steers it towards finding defined attributes using structured questions. Second, it is based on the **rational method**, which examines the various questions and adapts them to the list of actions required for ideal performance, all within the framework of the constraints and criteria. This allows for more targeted data flow and improved process efficiency and quality in the design decision-making process.

The use of a question format in the screening process helps to define the features of the functions crucial to the design and optimize the brief composition. The model is used as a checklist divided into topics and sub-topics that direct the designer inwards, emphasizing the various user scenarios and product usability. The complexity of modern products requires that the design focus on the user and his or her needs [2], an approach that allows for in-depth and intensive examination of the user's environment and schematic management of the design measures. Thus, the method requires both flexibility to account for crucial objectives listed in the brief and consideration of important

environmental and social issues. The design planning process must account for all of the environmental and ecological variables during all stages of product development [4]. It is the designer's responsibility to understand any problems and find solutions according to the defined product brief, while still accounting for the life cycle, profitability, and social and environmental aspects while minimizing resource consumption and waste production [10].

2.1 Model usage and its advantages

The ideality "WHAT" model is described in Fig.1 and contains two main realms of knowledge. The first aims to reduce costs and the second aims to increase benefits. Both categories have two layers (marked 2-3): The General Strategy and the Design Principle that form the basis the design brief. These two categories act as the foundations for the development of a "WHAT" oriented product design brief, and its two main sub-categories: Product Brief Checklist and Scenario-focused Questions (4-6). The product brief checklist deals with elements such as project management, regulation, production, marketing, user experience, prototyping, product features and their sub-categories. For example, the sub-categories of product's features and hard attributes, as presented in Fig.2, are engineering development, mechanical and geometrical properties, restrictions, features and performance. The intersection of these two realms of knowledge encourages designers to examine how each ideality principle can be realized in every product design brief and refers to the "WHAT" which leads to the "HOW" [8].

The following algorithm explains implementation of the "WHAT" model in the product design brief. First a central ideality category is selected with the objective of either increasing benefits or reducing costs, and then one of the ideality strategies and its related design principle is selected. Next, we address the product design space and choose a category from the product brief checklist and its related sub-categories. At this stage, as described in Fig 2, we examine how each one of the product brief sub-categories can be infused using the chosen ideality principle. For example, one could ask how to increase the number of functions associated with the product's mechanical and geometrical properties in order to increase the product ideality. We repeat this process for various ideality principles and design brief categories and associated sub-categories, though only in some combinations the ideality principles are applicable and shift the product design towards ideality, while in other combinations they do not. During the final stage, we examine the product brief categories and sub-categories in the framework of scenario-oriented questions such as "what", "which", "why", "where" and "when" (5), where the objective is to reach the most extensive range of possibilities in the search results. The product of this algorithm is a draft of the "WHAT" (6) qualities that will later dictate the "HOW" (8). At this point, through the integration of the Bio-mimicry approach, we can define design concepts for achieving the "HOW" through the use of inspiration, imitation and abstraction of solutions that are analogous to biological systems (7).

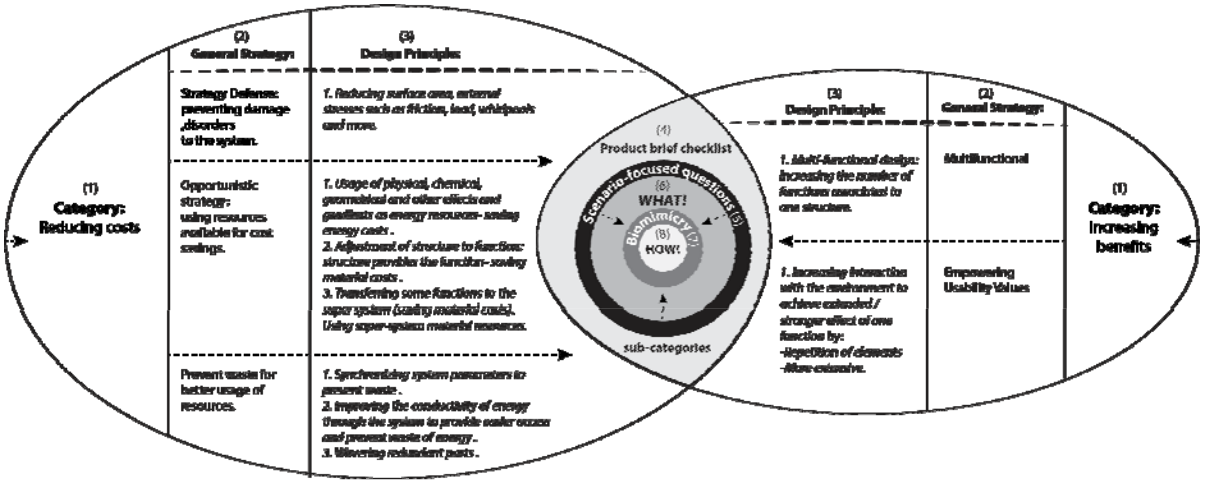

Figure 1. A schematic diagram of the model - the table provides a glimpse into the model

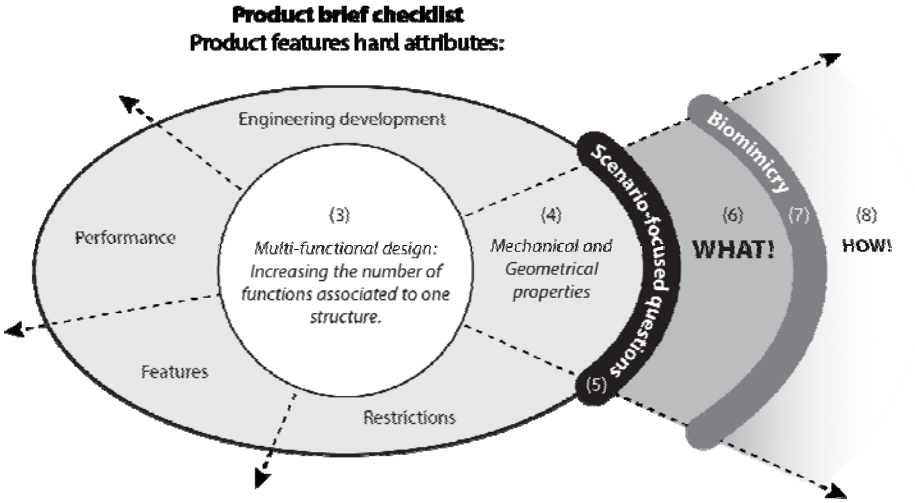

Figure 2. A schematic diagram of the model - the table demonstrates the view from inside the model out

2.2 How was the model developed?

The model was developed as a derivative of the sustainability ideality tool [7] in an effort to adapt it to the field of product design. The sustainability ideality tool [7] was modified to fit the terminology associated with design brief composition. A trial run was performed with implementation of the model in a classroom. After understanding and processing its weaknesses and features and examining what, if any, changes would be necessary, the model was updated forming the ideality "WHAT" model for product design. Finally, the model was presented in a diagram (Figure 1) to clarify its use.

2.3 Test case description – demonstration of the model

The ideality "WHAT" model for product design was tested with students in the third year of their B.Sc. in a program for Mechanical Engineering in Product Design. This program integrates mechanical engineering and product design combining project-oriented courses from both the faculties of Engineering and Design. Students benefit from synergic processes through critical and creative thinking. In this project-oriented course, we implemented the full methodical process of New Product Development (NPD). Each project begins with the composition of a self-brief and research of the "WHAT", followed by the "HOW". The engineering-oriented components integrate examination of alternative mechanical solutions and calculations followed by implementation and work with hands-on prototypes. The ideality "WHAT" model was presented in full and students were asked to use it when addressing a design challenge.

Design challenge background: Parents in Western cultures who wish to teach their children to ride a bicycle are exposed to a variety of bicycles, each designed for a different developmental stage. As a result, parents find themselves purchasing numerous bicycles, which both costs them money and takes up space. An ideal solution to this problem is a single bicycle that can be used for a long period of time and be easily modified according to the child's needs at each stage. Ideal device features include: ease of use, storage, weight and mobility. The design task was defined as the development of a multi-stage design concept for a children's bicycle.

2.4 Results

The students used the ideality "WHAT" model for product design, focusing on a variety of user scenarios. During the creation of the design brief, the model served as a thought framework, forcing the students to consider wide range of product aspects, aiming to discover the potential characteristics for future functionalities of the bicycle. Their focus on the **"WHAT"** created a crucial difference in their thought process, when it prevented them from dealing first with the **"HOW"** of the solution. The discussion developed and brought up the option of innovative product qualities; for example, as seen in Figure 3, a suggestion was made that injuries could be prevented and in the main ideality category of reducing costs, the concept of a "gyroscope precession" system was suggested as a method for injury prevention through improvement of balance and stability and as an alternative to training wheels. Additional features that arose and that are not described in figure 3 include: a feature for

avoiding emotional harm (frustration), physical harm (injuries), shortening the learning time for balance skills using bicycle feedback regarding the cycling performance. The method uses a (vocal) self-feedback system that covers both the emotional and physical aspects by providing the cyclist with information about stability, balance and integration with the environment (to prevent bicycle accidents). The same qualities mentioned above can also be associated with the challenge of stopping and starting pedaling. This feature, which identifies the ideal location for the pedals according to the rider's needs, is likely to be particularly effective for younger children

By implementing the ideality "WHAT" model for product design, the students developed and expanded upon ideas and product qualities that would likely not have arisen without the use of the model. Some of the more common qualities that had been previously identified by traditional brief composition methods were expanded and re-defined using the "WHAT" model. For example: conservation of energy in the system through the use of heat energy, etc. The model promoted innovation and helped the students reach new areas of thinking beyond the regular anchored thought processes. In addition, the model strengthened and promoted sustainable models for evaluating the use of the life cycle of the product, using multiple functionality and preventing damage to the system.

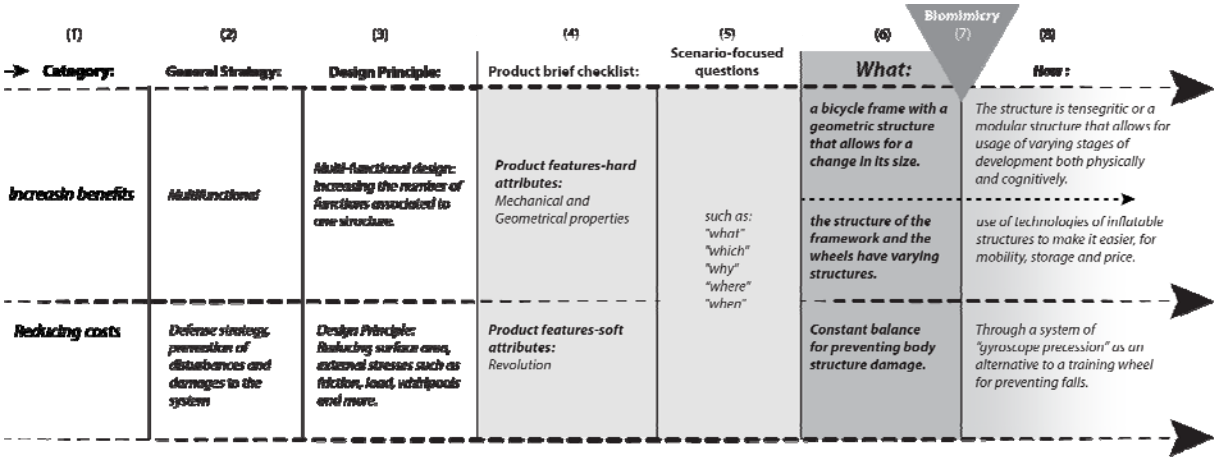

Figure 3. A Part of the case Study Diagram

2.5 Discussion

The "WHAT" model provides a path for following today's changing demands, complex environment and varying sustainability needs. Firstly, it addresses one of the major obstacles of the brief composition process and the tendency to focus more on the "HOW" and less on the "WHAT**"**. The model serves as a compass for defining and expanding upon the "WHAT" factor during the composition of the design brief, while promoting innovative thinking in terms of the "HOW". Though the model does not provide specific methods for the "WHAT" realization, it directs the user towards an ideal place of profitability alongside sustainability. In addition, the model expands upon the identification, examination and evaluation of new attributes that affect the scope of the project brief. Some of these attributes are sustainability attributes derived from the relation of ideality and sustainability. It also promotes creativity that stems from the use of a multidisciplinary approach. This creativity is necessary to manage changes and intricacy [12]. Furthermore, the model is flexible and can be adjusted to various projects by changing the design brief being examined. The objective of the model is to develop the "WHAT" as a crucial, strategic asset that allows the designer to reach decisions, by selecting the relevant attribute for the objective and target audience. The model provides systematic expansion, capable of adapting to every user scenario method, even prior to application of the Bio-mimicry process (7), and serves as an in-depth, revolutionary approach in the design brief formulation process. Designers that work using a flexible method tend to produce better solutions [4].

While the client's brief is a tool for coordinating expectations, specifying constraints and a maintaining a platform for collaboration between the designer and the customer, the design brief describes and explains the design problems and lays out their significance and any possible solutions for the defined objectives. It serves as a map of the future product, allowing for optimization as early as the design stage. Therefore, the model is important and bears significance in the formation of the design brief. The brief determines the distance to the objective while the designer determines the manner in which that objective will be reached [13]. Consequently, it is crucial to keep the brief updated throughout the

project with any insights and decisions that arise and that might affect the quality of the project. The solution though is always performed within the design brief.
The "WHAT" model is solution-oriented. Solution-oriented strategies have proven to be the most effective methods for handling design problems that have been ill defined [2]. It is also function oriented, increasing useful functions and decreasing harmful functions, based on the ideality framework.
These model characteristics mentioned above suggest a new design approach that can address the fast-paced changes, complexity and sustainability demands that exist today.

3 SUMMARY AND CONCLUSIONS

The “WHAT” model is a Bio-inspired ideality tool that can be used by the product designer to formulate and fine-tune the project brief according to the “ideality" strategies and principles found in nature [6]. This tool can be adjusted to create an ideal product design brief by serving as a compass for focusing on the “WHAT” essence of a design and improve the analysis and synthesis stages. The check list helps the designer form more in-depth strategies and concepts for an ideal design that is well correlated to sustainable design. As we define the model's initial attributes, it exposes us to alternative innovative implementations, which as a result create a wide platform depicting the possible methods for reaching the “HOW”. This aspect of the model serves as the means for finding a stand-out solution that integrates the values of sustainability into society. The model is built from a methodical approach and is appropriate for B.Sc. students of Product Design. Students of Mechanical Engineering may also benefit from this model. Innovation in sustainability projects certainly stand to benefit from this model by improving the thinking stages based on Nature’s wisdom.

4 SUGGESTIONS FOR CONTINUED RESEARCH: FROM NATURE TO NATURE

The "WHAT" ideality model stems from a bio-inspired approach and ends up with a Bio-mimicry approach. We suggest further exploration of the integration of the Bio-mimicry approach (stage 7 in Fig.3) to address design challenges defined by the "WHAT" model in the product brief in order to reach ideal form and function. More studies are required to evaluate and expand upon the "WHAT" model for different fields including architecture, and other engineering disciplines.

REFERENCES

[1] Fitzgerald D. P., Herrmann J. W., Sandborn P. A., Schmidt L. C. 2005. *Beyond tools: a design for environment process*. International Journal of Performability Engineering, 1, 105.
[2] *Engineering design methods-strategies for product design*, Fourth Edition by Nigel Cross 2008. pp.1-74
[3] John Chris Jones, *Design Methods Seeds of Human Futures 1970*, John Wiley and Sons, New York and Chichester, pp. 1-362
[4] Kindlein et al, 2003 and Fricke 1996, at *Engineering design methods-strategies for productdesign*, Fourth Edition by Nigel Cross 2008
[5] Benyus J. 1997. *Biomimicry: Innovation Inspired by Nature*. Quill. New York.
[6] Helfman, C.Y., Reich, Y., Greenberg. S., *Sustainability strategies in nature*, in 7th Design & Nature Conference, Opatja, 2014.
[7] Helfman, C.Y., Reich, Y., *Introduction of the ideality tool for sustainable design*, in InternationalConference on Engineering Design (ICED), Milan, 2015. (Accepted).
[8] Altshuller, G., *The Innovation Algorithm*, TRIZ, Systematic Innovation and Technical creativity. Worcester, MA: Technical Innovation Center, Inc. 1999.
[9] Lawson, B., 1980, *How Designer Think*, The Architectural Press, London.
[10] Umeda Y, Nonomura A, Tomiyama T. (2000*) Study on lifecycle design for the post mass production paradigm*. AI EDAM Vol. 14, Iss. 2 April 2000, pp 149-16
[11] *Product design Methods and practices*- Henry W. Stoll. 1999 by Marcel Dekker, Inc.
[12] www.ted.com/speakers/sir_ken_robinson
[13] *Innovation By Design*, Battula Kalyana, Cakravarthy, Janaki Krishnamoorthi, 2013 Lessons-book part IV product brief.