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Efficiency and resilience in product design by using morphological charts

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Abstract

The paper presents the possibilities and results of using either brainstorming or morphological charts for the development of new products in the field of smart furniture. In order to ensure the best possible match between product characteristics and customer requirements and to shorten development time in terms of resilience, an application of morphological charts is presented. The process started with potential customer polling. The obtained data was centralized and processed as shown into morphological matrices and the results were validated within conceptual design experiments. Similarly, a pure brainstorming based incremental design solution is presented, as well as a combined approach, integrating both methods. Analyzed by several professionals in furniture design, the models resulted from the experiments show the potential of each method with respect to market targeted by a start-up furniture company.

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1. Introduction and set-up

In the paper [1], the authors conducted a study upon the concept and definition of smart furniture, arguing the need to base new product development in this field on the requirements expressed or inferred by the customers. In a conclusion to their work, the authors of [1] propose a statement which summarizes the modern approaches in the field and will also serve as basis of thought for the current undertaking, which is meant to improve the appeal of

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smart furniture in terms if usefulness and aspect: "Smart furniture is the furniture which brings added value, functionality, comfort and elegance to fit every personalized requirement issued by the user".

The morphological analysis, also known as the morphological chart or box, is "a general method for structuring and investigating the total set of relationships contained in multi-dimensional, usually non-quantifiable, problem complexes" [2]. It was first proposed by Fritz Zwicky, a Swiss astronomer. According to [3], the use of morphological charts in generating conceptual designs is characterized by efficiency (i.e. large number of designs with limited data and under time constraints) and the ability to produce early results. The morphological chart consists of a table layout, which couples together the desired product functions (left-hand side) with the possible solutions for each of them (right-hand side), list in as much detail as possible its technical future characteristics/specifications [3].

Brainstorming is a classical method to elicit creativity in a group or theme setting, and it is very often encountered in design, advertising, architecture and so on. The practice is also incorporated as part of many problem solving processes. One might say, that this method is also the "workhorse" in new product development, based on its sheer volume of usage.

Given this context, the authors of this paper set out to experiment the efficiency of morphological charts in new product development in the field of smart furniture production. This endeavor matches similar scientific preoccupations focused on the results produced by morphological analysis in such fields as: architecture/interior design [4], automotive components [5], management sciences [6] or education [7].

To achieve the above stated goal, there were formed three teams of three designers each, having as task to design a new product, each using different approaches. For a better analysis on the effectiveness of morphological charts in producing the desired results in term of user satisfaction, the following arrangement has been implemented in an experiment meant to study the results than can be achieved in producing a smart desk that incorporates advanced IT&C devices and gadgets within a classical furniture piece framework.

Table 1 Teams organization

Team number	Team 1	Team 2	Team 3
Development method	Morphological charts	Brainstorming sessions	Morphological charts built after brainstorming sessions
Requirements	Customer	Design team	Customer and design team

2. Experiment and Results

In the scientific literature there are algorithms or methods that use morphological charts, in particular for prioritizing the functions listed, resulting in a final product with a maximum score, the best product. In this paper the morphological charts are thus designed that, by combining the functions listed in the table there are generated different concepts not with different scores but with different use - for example the manager desk will have all the features incorporated, and the programmer desk will have only the job-specific functions. In their vision the authors consider that an important characteristic for smart furniture is multi-functionality.

The following section describes the results from a case study conducted by the authors within the project: "Research for the development and implementation into production of innovative furniture", contract no. 12 P01 001 13 C3, beneficiary Smart Furniture SRL Cluj-Napoca, partner Technical University of Cluj-Napoca.

For the first team, in a preliminary stage a number of over 20 people were interviewed, who were asked to specify their requirements for their ideal office desk. The information has been gathered by researchers with economic background, but it is recommended to be done by personnel from marketing department. This data was processed and centralized by design and technology engineers, to form a morphological chart. By combining the functions and the modules new products with different properties are generated; this stage requires the involvement of production staff.

For smart office desk the morphological chart is shown in Table 2 and some conceptual models resulting from combining functions from chart are shown in Figures 1 and 2. The combination of orange labeled cells is assembled

in the 3D model shown in Figure 1, the green one in Figure 2. Of course, the chart provides more solutions for further combination of the functions listed in the table.

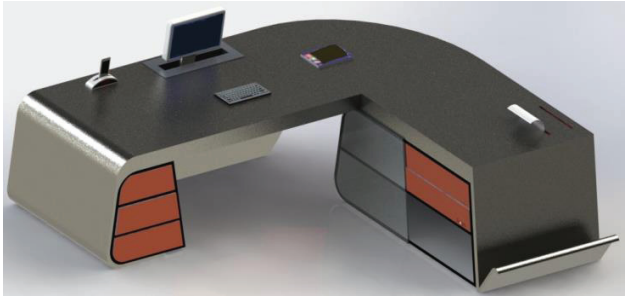

Fig. 1. Smart office desk – Team 1 - model 1 (red)

Table 2 Smart office morphological chart

Functions	Solutions				
Computing technologies	Charging socket for laptop	Computer integrated (40x40x20 cm)			
	Model 2	Folding display	Display integrated into the countertop	Model 1	
Access control	Fingerprint	Smartphone QR code		Keyboard password	
Ergonomics	Height adjustment	Inclination adjustment			
Communications technologies	Telephone		Fax		
Multimedia	Speakers		Video projector	Keyboard integrated into the countertop	Wireless keyboard
Storage space	Drawer		Cabinet		
Writing/Paperwork	Printer		Scanner	Paper shredder	

As it originates from the product identification line, the desk has integrated computer, display and keyboard, fingerprint access control, document storage space, telephone, fax, printer, scanner, speakers and a video projector. This product is suitable for managers. To get further variants of this type of product further morphological charts can be created, detailing sub-functions, e.g. for the document storage space the security can be based on fingerprint recognition or smartphone code.

The model described in Figure 2 shows the combination of functions that are best suited for programmers and project engineers: charging socket for laptop, access control with smartphone recognition, height and inclination adjustment, speakers integrated in desk structure.

In parallel, the second team had to develop also a smart office desk but using only brainstorming sessions, this resulted in the model presented in Figure 3.

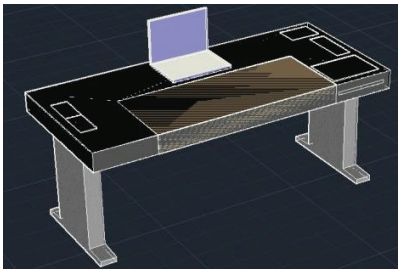

Fig. 2. Smart office desk - Team 1 - model 2 (orange)

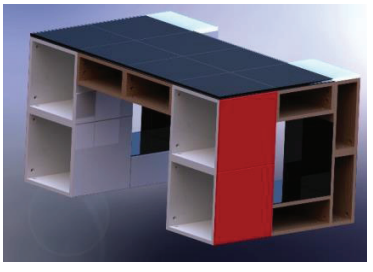

Fig. 3. Smart office desk – Team 2

This product does not have a precise destination, but is based on an important feature for smart furniture, modularity, so the desk may take different configurations at different times. The integration of IT & C specific equipment can be made easy due to the cubicle structure.

The third team used as a working tool the morphological charts, but based on both brainstorming sessions and interviews. The resulted morphological chart based on brainstorming sessions and integrating the customer requirements is shown in Table 3. In this case also it can be obtained several variants by combining the functions. Just varying the shape, many different products can be generated instantly, therefore combining different materials and functions a large number of new products can be generated. Taking this into consideration, it is clear that the morphological charts + brainstorming approach can be used for mature products that want to be "reinvented". In the paper is given an example in Figure 4.

As it can be seen in the morphological chart below and the presented 3D model, this proposal has borrowed the concepts from all the previous ones:

- It is a corner desk with a particle board structure (this time with no supporting framework);
- It integrates many office functions based on the use of IT&C elements that extend the capabilities of a regular laptop or computer;
- It has a semi-modular construction, as a part of the devices can be attached or changed at will (e.g. lamp, clock, speakers), but some others are fixed (e.g. printer-scanner or motion tracking device).

Table 3. Smart table morphological chart

	Solutions				
Functions	Charging socket for laptop ☐	Computer integrated	Printer ☐	Scanner ☐	Lamp ☐
	Motion tracking device ☐	Keyboard integrated	Speakers ☐	Video projector	Clock ☐
Shape	Cubic	Plan “L” type ☐	Plan “I”	Plan “T”	Plan “U”
Materials	Wood	PAL ☐	Plastics	Glass	Metal

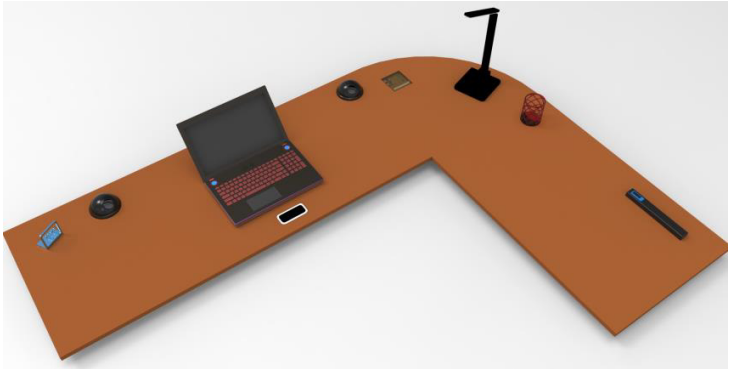

Fig. 4. Multifunctional table – Team 3

This model is based on multi-functionality and modularity, and can incorporate in different forms smart functions that are detachable and can be replaced or upgraded.

3. Conclusions

The paper presents the approach of morphological charts for new products development in the field of smart furniture. For this purpose, a comparative methodological experiment was set-up to discriminate between using classical methods for new product development and using morphological charts. Also, a combined approach of the two methods has been tested at the same time to assess its usefulness

Staff from marketing, design and manufacturing departments have been involved to process the information collected from end-users, while R&D and production engineers have been used for the brainstorming and morphological chart phases. The results of the three tests conducted were reviewed by a team made of researchers in the field of quality assurance, manufacturing technologies and senior industrial designers. The outcomes were evaluated based on their merits in terms of technical functionality, visual and tactile harmony and estimated customer response.

From a quantitative perspective it should be noted that using morphological charts more models are designed at the same time (see the productivity of Team 1 vs. Team 2). In terms of quality the morphological charts have the advantage that the designers have in front of them all data and they are able to improve the overall product quality through slight changes on some functions described in the chart (see Team 1 and Team 3 results).

The main conclusion that emerges from the experiment is that when the focus (as in this case) is to incorporate as many functions in a new and smart product, the authors of the paper recommend to follow these steps which make up the combined approach: interviewing consumers, refining the information by experienced personal, introduction the needs identified into the brainstorming sessions, centralizing all data in the form of morphological charts. The method presented in the paper is very accessible and produces an improved merger of "form and function", or, in our case, utility and aspect, yielding a superior visual comfort.

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