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DEVELOPING A METHODOLOGY AROUND BUILDING CO-CREATED PRODUCTS AND PRODUCTS WITH PERSONALITY

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Abstract: *In the specialized literature, there are many approaches regarding the development of co-created products, without a clear methodology and specific methods for various product categories. The authors propose a methodology structured in five stages, with a total of 25 steps, which allow the intervention of customers in all stages of product development. First, a preliminary design of the methodology is carried out in which the products are divided into seven classes and the five stages are established. In the framework of the detailed design, the steps of each internship are established, as well as the specific tools and methods that can be applied, of which the most relevant ones are selectively presented in this paper.*
Key words: *methodology, stages, creating, development, co-design, co-creation*

1. INTRODUCTION

One of the most important aspects of product development is mass customization, currently facilitated by the flexibility of manufacturing technologies and by the spectacular advances of additive manufacturing. In this context, there is the question of consumer involvement in the creation of the product, to a greater or lesser extent depending on the product category. This is how the concept of co-created product appeared [1], one in which the consumer has an essential contribution to the creation of the value of goods and services by contributing with their own needs, desires, demands, requirements and emotions. Thus, the concept of product with personality appeared [2, 3] which raises the issue of emotional relationship between the user and the product [9].

In the specialized literature [7, 10, 11, 12] there are numerous approaches regarding the development of co-created products such as, for example, the 12 Co model developed by Vargo and Lusch [16] and the four categories of co - creations highlighted by Rindfleisch and O'Hern [10] according to the possible combinations between user contributions and their selection methods: Collaborating - open contribution and selection made by the client; Tinkering – open contribution and selection made by the company; Co-designing - fixed contribution and selection made by the client; Submitting - fixed contribution and selection made by the company. In relation to these developments, from the studies carried out by the authors, there are several remarkable shortcomings which can be summarized as follows:
- There is no general approach, differentiated by product category, the approaches in the literature being mostly particular cases; - The tools through which the client can intervene in the conception, design and realization of the products are very poorly represented;

It is necessary to design a unified co-created product development methodology similar to product development methodologies devised by Ulrich and Epingher [15], Phal and Beitz [13], etc. In relation to these aspects, the authors have designed a general methodology for the development of co-created products, one that is flexible, adaptable for many product categories, as well as concrete, detailed tools for each stage and steps, through which the client/user can intervene in the product development process.

Obviously, customer/consumer intervention in product development can generate additional manufacturing costs. This will be one of the future research directions: how the product cost

will be influenced and what cost models can be applied in the context of market competition.

2. PRELIMINARY DESIGN OF THE METHODOLOGY

Preliminary design of the methodology started from the general principles of a methodology [4, 5]. The stages of the methodology were established based on the relationship between the parts and the whole, considering the analytical component - the study of the whole through decomposition and the synthetic component in which the constitution of the stages is carried out and phases by synthesizing the multiple activities that the client intervention entails in the development of a product. To design the methodology, seven product classes were designed according table 1.

Table 1

The seven product classes

Class	Name	Description and examples
Class 1	Complex factory-type products	Small factory from all areas of mechanical processing containing one or more sections; The client/beneficiary can collaborate in the realization of the project; Production type: unique
Class 2	Complex products - Production Sections	Production departments, workshops, flexible cells, etc. The client/beneficiary can collaborate in the realization of the project; Production type: unique
Class 3	Complex equipment products	Complex equipment made to order: processing systems by combined processes, water jet cutting, CNC machines made in a modular way, etc.; The client/beneficiary can select modules; Unique/small series
Class 4	Simple equipment and devices	Relatively simple industrial equipment and devices; The client/beneficiary can be involved in all stages of development; Small/medium series
Class 5	Complex consumer products	Relatively complex consumer products such as: refrigerators, washing machines, vacuum cleaners, etc.; The client/beneficiary can be involved in all development stages; Medium/large series
Class 6	Simple consumer products	Wide range of simple consumer products such as: household products in the kitchen, in the garden, furniture, etc. The client/beneficiary can be involved in all development stages; Large/mass series (mass customization).
Class 7	Service type products	All categories of services; The client/beneficiary can be involved in all stages of development; Large/mass series (mass customization).

The application of the methodology involves the intervention of two groups for the co-creation process: group A (narrower) – experts in the field and group B (broader) potential customers/users. The degree of intervention of each group depends on the class to which the product belongs and each stage of the application of the methodology.

To establish the preliminary structure of the methodology, the model presented in the paper [6] was adapted according to that shown in figure 1. The developed methodology was structured in a five stage design process with the purpose of being carried out in collaboration with potential customers and product users. The first three stages represent the co-creation of the product and in the last two stages it can be considered that the actual co-design of the product is carried out.

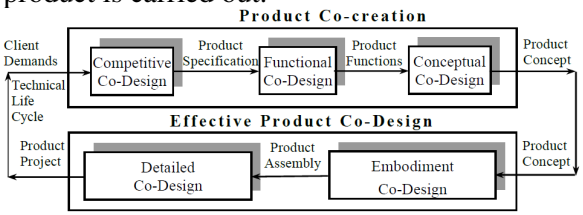

Fig. 1. Stages of product co-development (adapted from [6]).

3. DETAILED DESIGN OF THE METHODOLOGY

For each of the five stages of the methodology (figure 2), the detailed structure consisting of stages, phases, steps have been established and various tools have been developed to allow the intervention of the client/user in the development of the product.

3.1 Competitive co-design of the product

The first stage of the methodology, the competitive co-design of the product, consists of three steps. In the first step, the need is established, the opportunities are analyzed (market, legislative, political, financing, research, etc.) and the Generalized Potential Product (GPP) is established, for which a special analysis sheet is drawn up. The GPP concept can be defined from the point of view of the final result (potential = new or improved) and from the point of view of the degree of generalization (for example, let's study not a telephone but a communication system, not an automobile but a system of transport, etc.), so that we can study the evolution of the product over a long period

of time. In GPP analysis it is very important to study the need (general framework, definition), classification and definition of the product, systemic analysis, the environment in which it operates, interaction with the user and the study of the historical evolution of GPP from past times to the present.

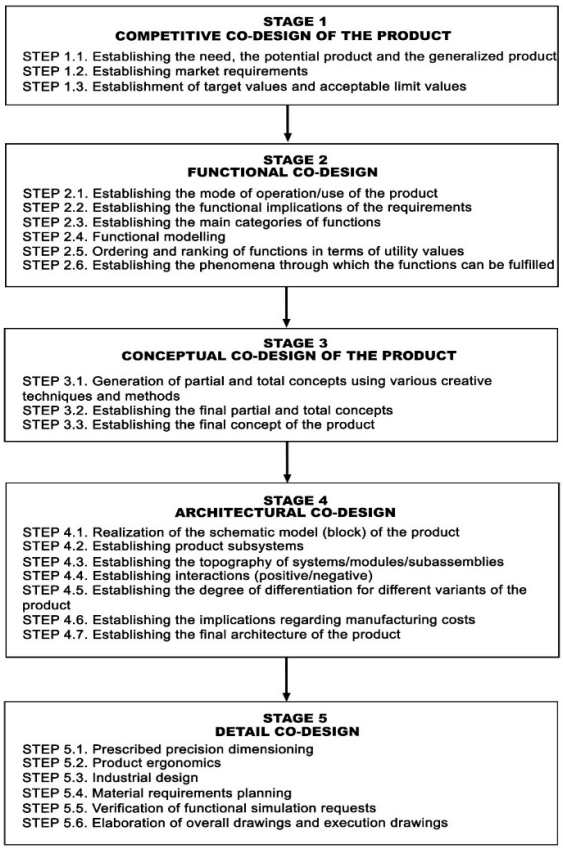

Fig. 2. Detailed methodology.

Co-establishing the market requirements of the main stakeholders - clients, users, consumers - represents the second step that involves gathering the voice of the customer by establishing the requirements. For this, well-known techniques are used in product development, such as interviews, questionnaires, and focus groups. But, within the methodology developed by the authors, there are some differences in approach compared to the classic product development methodologies, the most important of which are:

- Customer requirements are considered dynamic, evolving according to certain laws established by the authors [14]; thus, the development team uses anticipated requirements based on these developments;
- The importance scores for each requirement result as an average of the scores given by potential customers or by experts:

$$N_{Cm} = \frac{1}{q_m} \cdot \sum_{k=1}^{q_m} N_{mk} \quad (1)$$

where N_{Cm} represents the importance grade for the requirement, C_m, q_m - the number of customers who assigned importance grades, N_{mk} –the importance grade assigned by each respondent for the C_m requirement.

- For class 1-4 only group A is active and for class 5-7 only group B is active, both groups awarding grades with the help of specially built applications.

In the third step called: co-establishment of target values and acceptable limit values, a study will be conducted regarding competing products, carefully analyzing both the performance of other products existing on the market, as well as establishing the list of specifications and characteristics of competing products.

After this phase, the co-establishment of the correlations between the requirements and the specifications/characteristics will be carried out using a series of tools that contribute to the achievement of the results, for example by using the central part of the quality house where the correlations between requirements and characteristics result as an average of the values given by groups A and/or B (figure 3).

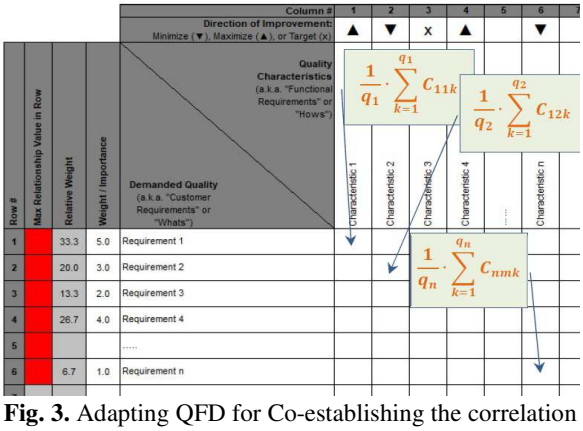

Fig. 3. Adapting QFD for Co-establishing the correlation between requirements and features.

Regarding the co-establishment of target values and acceptable limit values, three strategies will be applied as follows: the Taguchi classification, the best value of the competition

and the average of the values given by customers, again involving the two target groups and the development team (Table 2).

Table 2

Definition of specification categories

Strategy		Target values	Acceptable limit values
Strategy #1. Taguchi classification	GTB	Infinite	-
	STB	0	-
	NTB	N	[N-LLD_L, N+ULD_L]
Strategy #2. The best value of the competition	GTB	The highest value of competing products	The average of the maximum values of competing products
	STB	The lowest value of competing products	The average of the minimum values of competing products
	NTB	Average nominal values of competing products, N_m	[N_m - LLD_L, N_m + ULD_L]
Strategy #3. Co-created products: average of values given by customers	GTB	Average of maximum values given by customers	Average of minimum acceptable values given by customers
	STB	Average of minimum values given by customers	Average of maximum acceptable values given by customers
	NTB	Average of nominal values given by customers, N_c	Deviations [N_c - LLD_c, N_c + ULD_c]
GTB-Greater the better; STB-Smaller the better; NTB-Nominal the better; N-Nominal value; LLD-Lower limit deviation; UDL-Upper limit deviation			

Also, in this last step, the characteristics are classified according to Kano's model (basic, performance and delightful characteristics). Mathematical modelling of the dependence between requirements and features or specifications involves the establishment of functions, of possible (iso)morphisms between the group of requirements and the group features, as well as modelling with Kano and If-Kano models [8, 14].

3.2 Functional co-design of the product

As for the second stage, it presents the functional co-design and contains six steps with the objective of establishing how the product can be used correctly.

In the first step, the type and degree of interaction of the user with the product is defined, which can fall into one of the following variants: passive product-active user, interactive product or active product, passive user. The way of using the product will then be evaluated, checking whether the product's performance matches expectations, along with its capacity, reliability and subjective enjoyment of use.

In the second step of this stage, the functional implications of the requirements will be decided. Here, only the development team will be involved, followed by the establishment of the main categories of functions that will be done in the third step. Functional modeling consists of setting global functions, main functions, subfunctions and critical functions using the FAST-Function Analysis and System Technique in which only the development team will contribute, without input from customers or other target groups.

The ordering and ranking of the functions considering the value of use will be achieved by establishing the degree of involvement and the specific activities assigned to the development team and the target groups A and B.

In the sixth step of this stage, the development team will establish the phenomena through which the functions can be fulfilled.

3.3 Conceptual co-design of the product

The co-design of the product concept is the third stage that includes the step of co-generation of partial (for each function) and total (for the entire product) concepts using various techniques and creative methods developed by the authors.

The co-generation of concepts using the QFD-TRIZ-TAGUCHI synergy is one of the tools in which the problem will be described, after which the corresponding QFD sections will be completed. Later, the contradictions related to quality that will be established according to the TRIZ philosophy, the formulation of the contradictions based on the solutions given by the first target group (A), and finally the generic and specific conceptual solutions will be set up, thus obtaining partial and total concepts.

The nine-window diagram technique will be used, which is a study of the historical evolution of the product to realize the co-generation of the concepts. The co-generation of concepts using the classic indicators of ideality represents another tool in which the ideality indicator will be calculated by surveying the members and

having the two target groups (A and B) asses them using marks.

Concept generation will be also done using the CREAX indicators, thus making the calculation of the ideality indicators without the involvement of the product users.

The co-generation of concepts using the Law of Evolution of Technical Systems will be achieved by using a tool through which the two target groups, the group of specialists in the field and the group of users without knowledge in the field will be involved. Also, we can use physical contradictions and SU-FIELD analysis to generate concepts.

The establishment of partial and total concepts will be done as follows: by establishing the partial conceptual solutions, morphological analysis of the partial concepts and establishing the nomenclature of total concepts, sorting the concepts, and establishing the optimal concept. To establish the optimal concept, a tool, currently being developed by the authors, based on the AHP method can be applied. In this process, evaluation grades are assigned by the members of group A and/or B.

3.4 Embodiment co-design of the product

Stage 4 represents the embodiment co-design process classified in seven steps and consists of collaboration with the customers, starting from the realization of the schematic model of the product. The second step contributes to establishing the product subsystems which is carried out during its ten phases, by creating modular or integral models, determining the degree of modernization, determining the (sub)assemblies that will be provided standardized and finally, deciding the degree of simplicity. Proposals for unification, standardization and normalization will then be made, and then consumable elements and those subject to wear will be discovered. Finally, the degree of flexibility, reconditioning, reuse, remanufacturing and, in the end, the degree of adaptation will be established.

The third step consists of establishing the topography of subsystems/modules and subassemblies, followed by the fourth step which is forming interactions. Deciding the degree of determination for different product variants is an important step in which the best product variant is chosen from all those developed in the previous stages and steps.

It is necessary to elaborate an approximate preliminary calculation of the costs needed for the manufacturing process, by estimating the resources involved such as: human, energetic, technological resources, and the possibility of attracting sponsors to facilitate the smooth progress of the entire development project.

The last step of this stage establishes the final architecture version of the product.

3.5 Detailed co-design of the product

The detailed co-design is divided into seven steps. Here, the work is to be carried out with minimum costs and maximum efficiency, by analyzing in advance the adaptation of the user to the product and of the product to the user. The authors are currently conducting research on the influence of customer intervention on the cost variation of co-created products. One of the solutions is to keep some fixed modules and the intervention of customers through co-creation only on certain modules, depending on the product category. In steps three and four, the types of materials used to make the final products and the industrial design are defined.

After these steps are completed, the verification of the requests and the simulation of the mode of operation will be fulfilled.

4. CONCLUSION

The presented methodology is structured on five stages, with a total of 25 steps and allows the involvement of potential customers and users in all stages of a product's development, while introducing new concepts such as competitive co-design, functional co-design, conceptual co-design, architectural co-design and detailed co-design. The methodology can be easily adapted for any product, from simple products to complex turnkey factory ones. For this, seven product classes were designed and for each class the degree of intervention of potential customers/users was determined. For the application of the methodology, specific tools were created for Co-establishing the relative importance of requirements, Co-establishing the

correlation between requirements and characteristics, Co-establishing target values and acceptable limit values using the Taguchi method and Kano's model, establishing the evolution over time of requirements and characteristics using the nine window diagram technique, co-generation of concepts using the eight laws of the evolution of technical systems and the 40 inventive principles, etc. The developed methodology will be piloted on at least three products from different classes.

5. ACKNOWLEDGEMENT

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DEZVOLTAREA UNEI METODOLOGII DE REALIZARE A PRODUSELOR CO-CREATE ȘI A PRODUSELOR CU PERSONALITATE

Rezumat: În literatura de specialitate există multe abordări cu privire la dezvoltarea produselor co-create, fără a exista metodologie clară și metode specifice pentru diverse categorii de produse. Autorii propun o metodologie structurată în cinci etape și 25 de pași, care permite intervenția clienților în toate etapele dezvoltării produsului. Se realizează mai întâi o proiectare preliminara a metodologiei în care produsele sunt împărțite în șapte clase și se stabilesc cele cinci etape. In cadrul proiectării detaliate se stabilesc pașii fiecărei etape precum și instrumentele și metodele specifice care pot fi aplicate, dintre care în prezenta lucrare se prezinta selectiv cele mai relevante.

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