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IMPACT OF INFEASIBLE CONFIGURATIONS ON CUSTOMER PERCEPTION IN TERMS OF MASS CUSTOMIZATION

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Abstract: *In generally, producers in many industrial sectors will need to adopt their manufacturing strategies toward mass customization. In order to be competitive, they will tend to increase their product options to satisfy diverse customer needs. However, there are many cases that producers offer wide variety of products that can be customized through optional components or their features while some options are restricted. As it is more or less known, such infeasible options can actually make customers unhappier. Therefore it seems to be needed to study the impact of infeasible offers on the customer´s perception. The aim of this article is to explore the impact of restricted combinations on the students´ preferences during exams. In the conclusion, the results of the experiment will be presented.*

Key Words: ***Waste entropy, Positive complexity, Negative complexity, Infeasible configurations, Design platforms, Customer preferences, Decisions***

1. INTRODUCTION

The marketing strategists claim, that customer value is fundamental to both profit-seeking companies and nonprofit organizations. So, creating major customer value is a reasonable condition for a company to survive in a competitive market and to has a leadership position in mass customized environment [1]. Mass customization brings to the customers a wide range of product variations. Sellers always want to satisfy individual customer´s needs by offering all product configurations, but some configuration are not possible.

The aim of this article is to investigate perceptions of consumers, when they are choosing product configurations in presence of restricted options. In this paper it will be consider about specific experiment when customers are represented by sudents and product configurations are represented by test questions. More specifically the article aims to respond to the following two questions:

RQ1*: Do users prefer to use customization platforms which have restrictions in choices (and thus can presents infeasible configurations) or customization platforms that do not have restrictions in choices (and thus do not present infeasible configurations)?*

RQ2: ***What is the impact of restrictions on the customer's decision making when they are choosing their preferred (as regards choice restriction) platform?***

In order to answer to these two question an experiment is performed on students during the school semester. This experiment takes advantage from the notion of waste entropy and from the Koechlin's philosophy. The paper is structured in 6 section. In sections 2, 3, and 4 a number of theoretical notions useful to understand the placement of the paper and to understand the experiment are provided. Section 5 presents the experimental part of the work by explaining how the experiment has been performed and by presenting its results. Finally, section 6 draws some conclusions.

2. RELATED WORK

Today, mass customization is becoming more and more popular. According to Crandall [2], it has many characters. To the customer, it is a store with an indescribable variety of products, to the seller, it is the way to satisfy customer with never-ending wide offer of products and services. However, on the other hand, very high volume of product variety has negative effects on productivity [3,4]. Wide product variety could also frustrate customers who may have difficulties of making a decision from high product offer [5, 6]. On the one side, the high product platform range results to a positive variety-induced complexity, but on the other side, it may involve in negative cost implications, in possible planning problems and in the manufacturing systems. One essential aspect of product variety management in mass customization is to find optimal product variety range. Some researchers are interested in the finds ways to reduce the product variety range. [7, 8, 9]. Product variety is frequent related to product platform problem, where configuration conflict problems are related to product configurations with restricted components. Product platform is defining as a group of design components in all family of products [10].

Extent of product platform can be determined by several approaches such as:

1. the quantitative method to determine the number of scalable platforms, where multiple factors determine optimal platform extent and their conflicts,

2.the multi-platform problem of that all manufacturing companies face when offering many product variants,

3. the integrated platform,

4.the approach based on analyzing variability models, which identifies essential, dispensable and highly required by other features or highly incompatible with the rest features [11, 12, 13, 14].

Infeasible configurations might be hidden by using algorithm-based product configurators [15, 16, 17, 18]. Complexity metrics based on the entropy will be used as for decision-making in variety management instead of the numbers of product configurations.

3. DESCRIPTION OF THE NOTATION »WASTE ENTROPY«

Part of the process, where are named all product configurations, Krus [19] defined as a *design space (H_x)* and this part include two spaces *constrained design space (H_c)* – there are only product configurations which are possible to choose from and *waste design space (H_w)* – there are impossible product configurations. Next picture in Fig.1 shows the relationship between these three spaces in two different cases, when ratio between waste and positive complexity is shown.

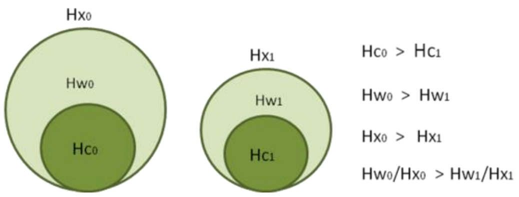

Fig. 1. *Relationship between two platform types*

H_x is amount of all products, but the amount is not the same in both cases ($H_{x0} \neq H_{x1}$), because in the second case, waste complexity is eliminated. H_c is possible number of products offered to customer and H_w represents the amount of infeasible product configurations.

The main object of this paper is to identify the product platform, which is optimal. In this case, we consider about infeasible product configurations to determine the optimal product platform by comparing the ratios between infeasible product configurations and all possible product configurations without restrictions. Absolute amounts of product configurations will be used and applied by entropy-based complexity methodologies [20]. Positive and negative complexity will be defined in this part of paper according to product configurations and measured by information theory based on entropy, where P_i is the probability of the occurrence in n-state [21]:

$$H_d = \sum_{i=1}^{n} P_i \log_2 P_i \tag{1}$$

Differential information entropy of the probability density function *p(x)* for continuous signals has been expressed as:

$$H_c = \int_{-\infty}^{\infty} p(x) \log_2 (p(x)) dx \tag{2}$$

Design information entropy was adopted by Krus [18] for multidimensional case:

$$H_x = \int_{-\infty}^{\infty} p(x) \log_2 (p(x)S) dx \tag{3}$$

where D - design space within the particular design x, S – the size of the design space expressed as:

$$S = \int_D x dx \tag{4}$$

Information entropy of the design for general multivariable case is expressed as:

$$H = \log_2 \frac{S}{s} \tag{5}$$

where *s* - the region of uncertainty for the final design of validated system architecture.

Each particular design *x* with regards to its design space has information entropy H_x [18],:

$$H_x = \log_2 n_s \tag{6}$$

Where H_x - entropy of complete design space, n_s - the amount of unique design alternatives (complete design space) that are results of a combination of product configurations.

Many configurations variants are not real due to attendance of constraints. So, information entropy expressed as H_c - constrained design space can be calculated as follows:

$$H_C = \log_2 n_v \tag{7}$$

Where n_v –the number of feasible design alternatives.

Higher number of all possible design configurations has more positive effect on customers than smaller constrained design space. Consequently, entropy of constrained design space could be maximized for the purpose of mass customizated environment. Entropy of constrained design space could be recognized as positive complexity and the rest of the design space could be represented as negative complexity (waste entropy of design space) [19] and it can be calculated by the equation:

$$H_W = H_X - H_C \tag{8}$$

Optimalization of the product design platform apply negative entropy based on product design platforms comparison. Percentage ratios between positive complexity H_c and negative complexity H_w will be measured for all platforms. It will be needed the amounts of all possible product configurations without restrictions and all possible product configurations with restrictions.

Feasible and infeasible product configurations in the original design platform - D_0, which represents an existing product design platform to customers. The number of unique product design configurations n_{s0} shows combinations of product components and n_{v0} is a number of feasible product design configurations.

We further assume to remove selected component(s) from the platform D_0, which is in conflict with other component(s). Then, D_0 can be transformed into a new state with n_{s1} for all unique product design configurations and n_{v1} for feasible product configurations is expressed as platform D_1.

The design platform D_1 is modified into D_2 by reducing components. It is possible to continue in the reduction of components.

To compare two design platforms against each other, e.g. D_0 and D_1, the following two equations are proposed [22]:

$$\Delta H_{W_{0,1}} = \left| \frac{H_{W_1}}{H_{W_0}} - 1 \right| \tag{9}$$

$$\Delta H_{C_{0,1}} = \left| \frac{H_{C_1}}{H_{C_0}} - 1 \right| \tag{10}$$

Then, if $\Delta H_{w0,1} > \Delta H_{c0,1}$ => design platform D_1 is more preferable for mass customization (MC) than D_0. To compare between three alternative design platforms, the following sub-procedure can be used. Let us suppose that design platforms D_1 and D_2 are more preferable for MC than D_0, based on criteria:

$$\Delta H_{w0,1} > \Delta H_{c0,1}, \tag{11}$$

$$\Delta H_{w0,2} > \Delta H_{c0,1} \tag{12}$$

Then, in order to select more preferable design platform between D_1 and D_2 the following three criteria can be used [23]:

I. If $\Delta H_{w0,1} - \Delta H_{c0,1} > \Delta H_{w0,2} - \Delta H_{c0,2}$ => design platform D_1, is more suitable than D_2.

II. If $\Delta H_{w0,1} - \Delta H_{c0,1} < \Delta H_{w0,2} - \Delta H_{c0,2}$ => design platform D_2, is more suitable than D_1.

III. If $\Delta H_{w0,1} - \Delta H_{c0,1} = \Delta H_{w0,2} - \Delta H_{c0,2}$ => both design platforms D_1, and D_2 are equally preferable for buyers.

Subsequently, by using a software based algorithm a selection of optimal design platform can be carried out.

4. ANALOGY WITH KOECHLIN´S PHYLOSOPHY

Koechlin was tested people, who live and behave by the fixed rules to show how syndrome E affects everyday life of chosen people by experiment. What is syndrome E? E is an abbreviation for evil and syndrome is a group of characteristics of a specific disorder. Syndrome E is an evil syndrome, which brings badness. It causes the set of negative changes in a part of brain, which called prefrontal cortex.

Koechlin was study conducting of human brains during all experiment. Experiment was focused on the defining strict rules in the group of selected people. If people respected the rules, everything was alright, but after some time, the several selected rules were changed. People started feel frustrated. Simpler parts of the brain are responsible for respecting the rules. And higher part of the brain – prefrontal cortex is responsible for control their decision-making and behaviour. It stopped impulses from simpler parts of the brain [24]. Change of strict rules arises human behaviour. These changes are responsible for change human moral from nonviolent into violent behaviour [25]. Prefrontal cortex is responsible for important functions such as planning complex cognitive behaviour, emotions, decision-making, solving problems, expressions of personality, coordinating social behaviour and differentiates between conflict thoughts, good and bed, what is better and the best, what is the same and what is different, how are the future effects of today's activities - humanity. Without this part of the brain we cannot be able to set up any live goal [26].

In terms of mass customization customer has always possibility to choose from whatever product, it represents *design space* and if customer cannot choose from all products, but only from constrained amount, then it is represented as *constrained design space*. *Waste design space* is represented by infeasible product configurations. Therefore, there is parallelism between syndrome E and waste complexity. People use learned rules and they behave according to the certain rules, they always do the same things, same activities. But, if there will be sudden change in these rules and some restrictions, people would feel frustrated about it.

5. IMPACT OF INFEASIBLE CONFIGURATIONS ON CUSTOMER´S DECISION

Given the outcome of the Koechlin´s experiment , the volunteers gave priority to tasks according to their preferences instead of tasks where restrictions were given. For evaluation parallels with mass customization in product selection, it will be used the experiment to confirme the similarity of selection according to customer´s own preferences.

5.1. Experiment description

The experiment was applied to students of 3rd Bc. and 1st Ing. Year. Students were writting exams during semester. All students finished 5 exams, which consisted of four groups of tests A, B, C and D. Test A contains 20 questions with 3 restrictions (eg . Student could choose to simultaneously question number 1 and 5). Test B consisted of 18 questions (where one restricted pair of questions was eliminated), while the other two remain restrictions stayed in test paper. Test C included 16 questions, where only one restriction was remained and test D was not limited to, a student could choose any of the 14 questions without considering the restrictions. Before each test, the student received a printed paper which contains four groups of questions and with restricted options. The student has to choose any test and any 4 questions from this selected test. If a student selects test A, B or C, he has to consider about restrictions. If student selects a test D, he can chooses any 4 questions without considering the restrictions.

The sample size of the tests written by students was 667. The choice of restricted questions was still random. In case of analogy, we consider about tests A , B , C and D as design platforms D_0, D_1, D_2 and D_3 and test structure with restricted questions is shown in Fig.2.

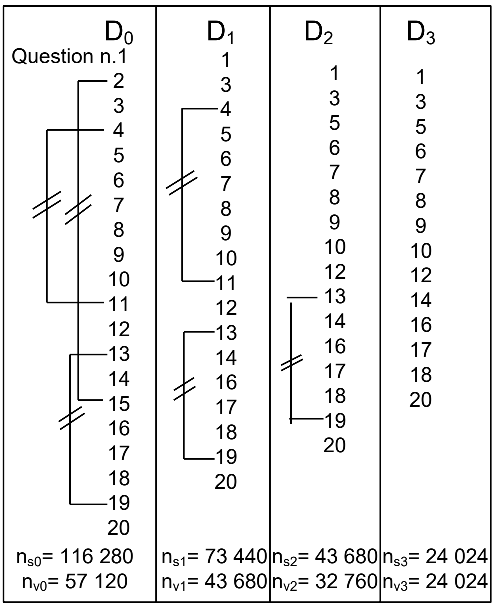

Fig. 2. *Test structure expressed by four design platforms*

In the table above n_v represents number of viable design alternatives and n_s is number of design alternatives (complete design space).

5.2. Experiment results evaluation

The following table (Table 1.) shows process of writting exams during the semester divided into two study subjects.

Table 1. *Experimental results of two study subjects*

Platform - Test	Study subject 1		Study subject 2		
	1. Test	2. Test	1. Test	2. Test	3. Test
D_0 - A	15	19	45	52	42
D_1 - B	13	11	23	11	17
D_2 - C	10	20	15	7	7
D_3 - D	97	95	51	58	59

The overall results of the experiment are shown in the next table (Table 2.).

Table 2. *The overall results of the experiment*

Platform - test	Number of Students
D_0 - A	173
D_1 - B	75
D_2 - C	59
D_3 - D	360
Sumary	667

The percentual number of students who chose a particular platform (test) is shown in cake diagram in Fig. 3.

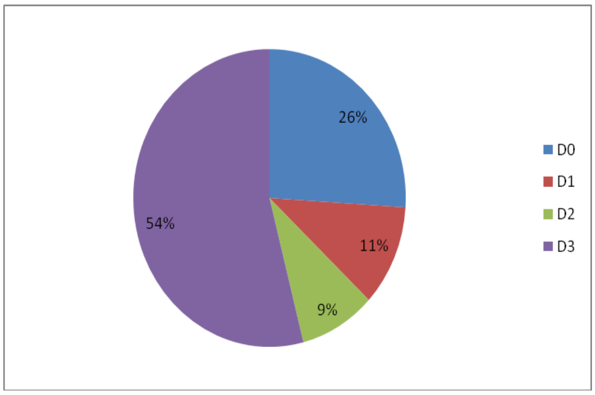

Fig. 3. *The experimental results expressed by percentual number of students choosing tests.*

6. CONCLUSIONS

By the given results of the experiment, we can state the following conclusions and answer to the research questions:

1. Students preferred to choose the platform D_3 (group D - 14 questions), where there are no restrictions according to their own preferences. Then we can answer to the first research question (RQ1), if we put the needed data (n_s , n_v) into the decision software based algorithm, the most ideal platform in view of the decision algorithm is platform D_3 with no restrictions.

2. In terms of mass customization , customers prefer the ability to configure their product with no limitations according to their prefeences, while in the commercial sector pays: Our customer is always right. So, it is better if the sellers offer customers a product whose configurability is without considering restrictions.

In summary, the restricted options have a negative impact on the customer, where the customer rather preferes choice without restrictions. It is the answer to the second research question.

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