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# THE CHALLENGING PHASE OF CONCEPT SELECTION INTEGRATED WITH THE CUSTOMERS' JUDGEMENT NOTICED BY THE KANO MODEL

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**ABSTRACT**
The paper describes how to correlate the results obtained by a customer survey performed by the Kano model and the choices made by concepts selection using scoring technique in order to identify the more promising design alternatives created by a design team.
The need to correlate these results is extremely important during the design activity performed by students in a course of Product Development, because this can guarantee that the final decision is taken on the basis of a right comprehension between designers and customers.
The frequency of the Kano model attributes and extent of satisfaction are put in relation with the scoring that the design team assigned to each design characteristic. Comparing these elements the design team can evaluate their choices and modify or better specify the design solution from the early stage of design.
The discussion of the methodology is supported by a study case related to the design of "a pedal vehicle on which a new electronic device can be tested for the recovery of kinetic energy when braking".

*Keywords: Concept selection, Customer satisfaction, Kano model, Scoring, Correlation coefficient.*

## 1 INTRODUCTION

Typically during product development the concept generation phase is followed by concept selection among several design alternatives. Methodologies like screening and scoring, pointed out in the context of multi-criteria decision making methods, can lead to solutions that might not identify the more promising ideas, since in some cases the suggested solution might tend to gratify the feeling of team members. This latter aspect is more evident when the procedure is performed by students, during the course of product design, even this may occur also in real life when stakeholders are invited to identify the selection criteria and quantify the weight associated with each of them. The risk to limit the choice only on the basis of scoring results consists in confirming decisions made non-objectively, or complying with the typical defect of the new designer, where the fixation [1] on some kind of solutions limits the widest design research.
Being ill conditioned [2], the design problem presents many solutions and, in this context, students must be solicited to undertake a wide-ranging investigation. At the same time, they must be educated in the "ethical" selection of the most promising solutions, assessing each of them as objectively as possible.
The integration of the customer satisfaction paradigm during this phase of concept selection can provide further insight to students/designers in order to validate definitely the main characteristics that the product under development must have.
The Kano methodology for customer satisfaction provides this kind of answer. With the help of sketches of each of the design alternatives, after selecting those that have been passed to scoring, a questionnaire should be submitted to a group of customers. Each question is proposed in both a positive and a negative manner, in order to identity the aspects that can be considered innovative, traditional or usual.
From the answers received and classified following the Kano categories, each team of students can choose the best design alternative more consciously or to improve further those which have already

been selected, introducing the characteristics that customers have assessed as more attractive. The comparison between the ranking of the design alternatives obtained from scoring and the results of the Kano survey can reveal the presence of contradictions in the selection made.
The present paper describes this kind of activity, performed during the course of Product Design and Development held this year at the University of Calabria (Italy). The methodology to compare scoring and Kano model results is suggested and the educational aspects are underlined.

## 2 GENERAL ORGANIZATION OF THE CREATIVE CONTEXT

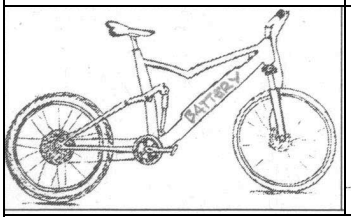
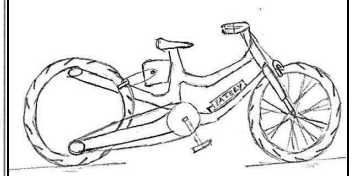
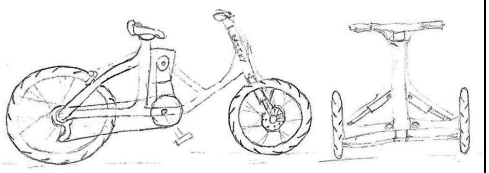
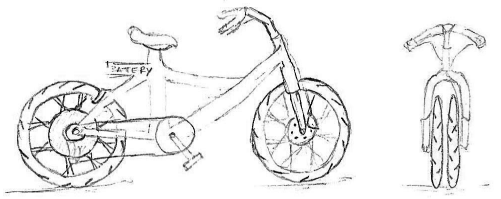
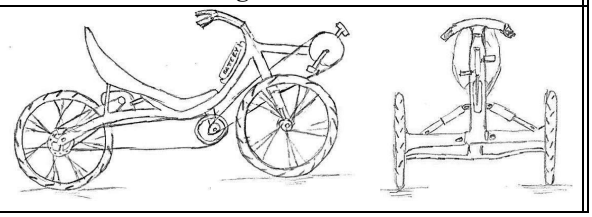
The following will be focused on the product that has been developed this academic year during the Course of Product Design and Development: "an E-bike, or rather, a pedal vehicle on which can be tested a new electronic device for the recovery of kinetic energy when braking". The choices of one project team will be discussed as an example of application of the methodology.
During the course, students have to generate many possible solutions and choose among them and continuously trade off for the definition of product component main characteristics. In the literature, many methods have been suggested to aid the design process and many of them can be profitably used for single phases determined by domain-specific views. Several road maps can be followed according to the personal attitudes of designers and the degree of stakeholder involvement. The road map of the course involves the following ordered steps: Identification of Task, Market Analysis and Customer Needs, Product Functional Analysis by means of clustered graph and tree, Concept Generation (brainwriting by 6-3-5 method) and Concept Selection (screening and scoring), Product Architecture, Customer Satisfaction (Kano model), Axiomatic Design, QFD-Quality Function Deployment (House of Quality), Design for Assembly-Manufacturing-Environment, Robust Design (Taguchi method), Detail Design, Design Structure Matrix (DSM).
The more creative phases are concentrated in the so-called "concept generation". For this purpose each design team must have clear the context in which the solution must be sought. The needs that the team has identified from a survey have to be classified and a certain number of needs are chosen as criteria on which the design solution are ranked. The most interesting practice to recognize customer needs is by means of interviews. The passage from the survey to the identified needs is generally not simple, and some interesting hints from the survey might be neglected with serious loss of useful information. In an educational context many of the skills typically used by a marketing agency cannot be employed, also because the course is on product design and not on marketing. At the same time, every design solution has to be conceived on the basis of some hints derived from customers. It is for this reason that students must have some smattering on this matter. In Table 1 the more frequent characteristic elements derived from the interviews are reported. The customer needs are identified, translating all the attitudes recognized during interviews into a reduced number of classes, as suggested by Ulrich and Eppinger [3].

*Table 1. Customer needs identified after a survey by interviews*

| Customer Needs | Frequency | Customer Needs | Frequency |
|---|---|---|---|
| Handiness | 8 | Limited weight | 7 |
| Compactness | 6 | Easy of movement | 7 |
| Comfortable suspension | 4 | Reliable brakes | 5 |
| Reducing physical strength | 7 | Reliability and functionality | 10 |
| Reduced price | 5 | Ergonomics | 15 |
| Standard configuration | 5 | Ease of maintenance | 5 |
| High performance | 8 | Aesthetics | 7 |
| Sustainability | 2 | Safety | 6 |

During concept generation, each design team must conceive new devices on the base of the functional requirements associated with the customer needs that have been selected. This will give designers the right input in order to address the creative effort towards new kinds of design solution. In Table 2 the sketches of five design solutions are reported, derived from a session of brainwriting method, followed by a joint discussion and decision, made after the classification in a morphological matrix of all materials produced.

*Table 2. The five solutions conceived after concept generation*

| Design solution #1 | Design solution #2 | Design solution #3 |
|---|---|---|
|  |  |  |
| **Design solution #4** | **Design solution #5** | |
|  |  | |

## 3 CONCEPT SELECTION PHASE

For selecting among several design alternatives, concept selection generally uses a set of evaluation criteria to which a score ranging from 1 (lowest level) to 5 (highest level) is assigned. As suggested in [3] the relative importance of the customer needs can be established by two basic approaches: 1) relying on the consensus of the team members based on their experience with customers; 2) basing the importance assessment on a further customer survey. In the course, students followed the first approach and associated a weight with each evaluation criteria by means the first order AHP method [4], which pairwise compares the criteria that have been deduced from the customer needs. In Table 3 the ranking of all 5 design solutions is reported. In the evaluation criteria also one element that characterizes the nature of the hypothetical firm that could build the E-bike is considered: the weight 0.15 for "ease of manufacture". This extra element is introduced to familiarize students with the possible difficulties that peculiar technologies associated with each design solution can affect the final result.

*Table 3. Concept scoring*

| Evaluation criteria | Weights | Solution #1 | Solution #2 | Solution #3 | Solution #4 | Solution #5 |
|---|---|---|---|---|---|---|
| Limited weight | **0.092** | **4** (0.368) | **4** (0.368) | **2** (0.184) | **2** (0.184) | **1** (0.092) |
| Comfortable suspension | **0.106** | **5** (0.530) | **2** (0.212) | **5** (0.530) | **3** (0.318) | **4** (0.424) |
| Reliable brakes | **0.132** | **5** (0.660) | **3** (0.396) | **5** (0.660) | **4** (0.528) | **4** (0.528) |
| Reducing physical strength | **0.102** | **3** (0.306) | **4** (0.408) | **4** (0.408) | **3** (0.306) | **4** (0.408) |
| Reliability and functionality | **0.140** | **4** (0.560) | **1** (0.140) | **2** (0.280) | **3** (0.420) | **2** (0.280) |
| Ergonomics | **0.106** | **4** (0.424) | **4** (0.424) | **4** (0.424) | **4** (0.424) | **5** (0.530) |
| Aesthetics | **0.096** | **4** (0.384) | **5** (0.480) | **4** (0.384) | **4** (0.384) | **2** (0.192) |
| High performance | **0.076** | **3** (0.228) | **3** (0.228) | **2** (0.152) | **2** (0.152) | **2** (0.152) |
| Ease of manufacture | **0.150** | **5** (0.750) | **2** (0.300) | **2** (0.300) | **3** (0.450) | **2** (0.300) |
| Total score | | **4.210** | **2.956** | **3.322** | **3.166** | **2.998** |

## 4 CUSTOMER SATISFACTION BY KANO MODEL

Kano's model has proved able to play an effective strategic role in determining the specific quality of a product or service. In the model, positive (functional) and negative (dysfunctional) questionnaires are conducted to collect the satisfaction difference per item from the interviewees, and to judge the specific quality of each item represented according to the "Kano's evaluation form" proposed by Kano et al. [5]. Each item (or attribute, feature, characteristic) of the analyzed product can be classified in the following six quality categories: **A**ttractive quality; **O**ne-dimensional quality; **M**ust-be quality; **I**ndifferent quality; **R**everse quality; Questionable result (**Q**).

To construct the questionnaire, it is necessary to formulate a pair of questions for each product feature for which it is desired customer feedback. The first question is called the functional question and is worded in a format similar to the following: "If [the product] satisfied [feature x], how would you

feel?" The second question is called the dysfunctional question and it is worded in a format similar to the following: "If [the product] did not satisfy [feature x], how do you feel?"
For each question, the interviewees can answer in one of five different ways (1) I like it; (2) It must be; (3) I am neutral; (4) I can live with it; (5) I dislike it. By combining the two answers in the Kano evaluation table, the items of the product can be classified into one of the six quality categories.
In Figure 1 the Kano conceptual model is represented with only the major categories: **A**ttractive, **O**ne-dimensional and **M**ust-be.

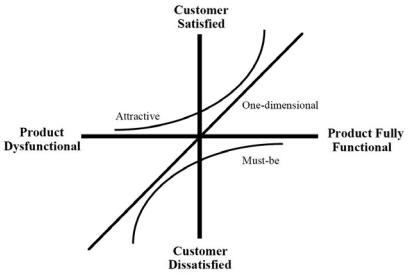



*Figure 1. Kano conceptual model*

Recently several authors have correlated QFD (Quality Function Deployment) and Kano model. Wu et al. [6] used a Kano-based evaluation procedure for innovative design in QFD for identifying attractive customers' need and then to help assess concepts. Sireli et al. [7] incorporated the results of Kano model into QFD providing a step-by-step methodology. Tontini [8] provided the integration of the Kano model in the QFD introducing an adjustment factor in substitution of the relative importance of customer needs in QFD. Chaudha et al. [9] suggested a modified version of the improvement ratio according to Kano results. Yuan and Guan [10] correlated the results obtained by AHP and Kano model to design a personalized wheelchair on the basis of different grades of individualized wheelchairs.

## 5 INTEGRATION BETWEEN CONCEPT SELECTION AND KANO MODEL

During the design activity of this year the students have discussed in group how to conduct the interviews for the Kano model. They decided to interview the people who were consulted in the previous survey. This phase was extremely interesting, first of all, because the team would have been judged by the same group of people which was surveyed earlier and to whom they had to show the fruit of their work. At the same time, they had to define a set of questions from which they would have received useful information in order to confirm or modify the choice about the best design solution they had already decided.

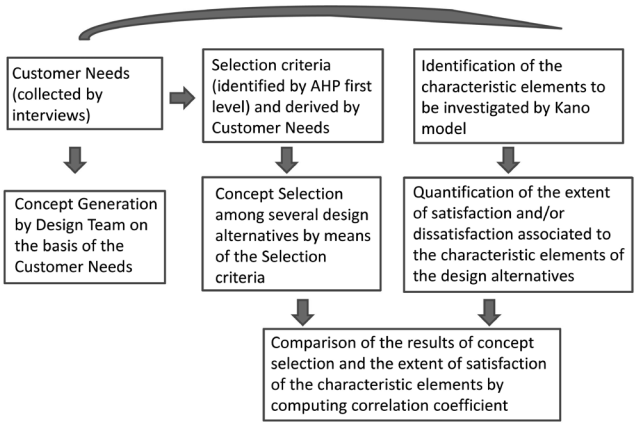



*Figure 2. Model for comparison of concept selection and Kano model*

This second step gave students the consciousness to have built several solutions that could be presented to potential clients. The first consideration of being judged by the same people interviewed from the beginning of the design process allows them, in a certain sense, to realize that they had been able to build something interesting. The second consideration derives from the comparison of the Kano model results with concept selection, verifying whether the judgements are in agreement. This

activity is summarized in Figure 2, with the identification of each activity and the flux of information among them.
The results obtained from the Kano model must be careful compared with those derived from concepts selection. This is a very interesting phase because designers can discern if the design alternatives they have positively assessed, on the basis of the selection criteria, are also those that the customers have considered as attractive.
Several combinations can happen, as listed below:

1. The selected solution agrees with customer satisfaction;
2. The selected solution does not agree with customer satisfaction;
3. A characteristic that satisfies customers is not present in the selected solution.

In order to compare the results, the extent of satisfaction (eq.1) and dissatisfaction (eq.2) must be computed.

$$\textit{Extent of satisfaction} \quad (A+O) / (A+O+M+I) \tag{1}$$

$$\textit{Extent of dissatisfaction} \quad (-1)\ (O+M) / (A+O+M+I) \tag{2}$$

*Table 4. Results of Kano model related to Design solution #1*

| Characteristic elements | A | O | M | I | R | S | TOTAL | GRADE | Extent of satisfaction | Extent of dissatisfaction |
|---|---|---|---|---|---|---|---|---|---|---|
| Electric motor on the rear wheel | 7 | 5 | 1 | 3 | 2 | 1 | 19 | A | 0.750 | -0.375 |
| Battery hidden in the frame | 6 | 8 | 0 | 3 | 2 | 0 | 19 | O | 0.823 | -0.471 |
| Comfortable seat | 5 | 8 | 2 | 4 | 0 | 0 | 19 | O | 0.684 | -0.526 |
| Aesthetics | 9 | 7 | 0 | 1 | 2 | 0 | 19 | A | 0.941 | -0.412 |
| Suspensions | 9 | 4 | 1 | 1 | 4 | 0 | 19 | A | 0.867 | -0.333 |
| Disc brake | 8 | 7 | 0 | 4 | 0 | 0 | 19 | A | 0.789 | -0.368 |
| Reliable and Ease of maintenance | 4 | 9 | 0 | 5 | 0 | 1 | 19 | O | 0.722 | -0.500 |

The results reported in Table 4 are related to a survey of 19 people in relation to Design solution#1. In it, the frequency of the customer satisfaction attributes corresponding to the answer received to the two questions in functional and dysfunctional form is classified. For example, showing the sketches of the solution, and considering the first problem (in the first line), the questions were: (functional) How would you feel if the electric motor is on the rear wheel?; (dysfunctional) How would you feel if the electric motor is not on the rear wheel? The combination of both answers from all interviewees gave a predominance of the attractive (A) attribute (seven times) and the extent of satisfaction of 0.75.
In general, a degree of general satisfaction appears for Design solution #1, taking into account that four attributes are considered attractive (A) and three one-dimensional (O). Also, the extent of satisfaction is generally high for each characteristic element.
In order to compare the results of the Kano model and scoring, the computation of an average value of extent of satisfaction and dissatisfaction is suggested. For Design solution #1 the average of extent of satisfaction is 0.80 and the average of extent of dissatisfaction is -0.43. In Table 5 this is presented for all Design solutions. The average value must be considered just for this global comparison among these two contexts (inner evaluation: by design team using concept scoring and outer evaluation: by customers using Kano method). A further comparison must be made comparing each characteristic element of scoring and the answer to the questions that in the Kano model can be associated with this.
With this finer analysis it can emerge that also in a design solution, which globally is not considered attractive, there may be present a single aspect that touches customer feeling. In this case the design team is in time to evaluate whether to include that characteristic in the design solution, leading to a further improvement.
Therefore, points 1 and 2 of the list can be easily identified by the global comparison, even point 3 can be identified by a finer analysis.
The average values reported in Table 5 can be used to provide designers with a further suggestion, if they really assessed consciously all design alternatives during scoring. In fact, the correlation coefficient $r$ can be computed, evaluating the relation that exists between the averages of satisfaction and dissatisfaction and concept scoring. In the first case, among extent of satisfaction and scoring, there is a strong correlation of $r = 0.975$. In the second case, among extent of dissatisfaction and scoring, there is no correlation $r = -0.012$.

*Table 5. Relation among Kano model coefficients and scoring rating for all design solutions*

| | Average of Extent of satisfaction | Average of Extent of dissatisfaction | Scoring |
|---|---|---|---|
| Design solution# 1 | 0.80 | -0.43 | 4.210 |
| Design solution# 2 | 0.33 | -0.38 | 2.956 |
| Design solution# 3 | 0.52 | -0.37 | 3.322 |
| Design solution# 4 | 0.52 | -0.35 | 3.166 |
| Design solution# 5 | 0.38 | -0.46 | 2.998 |

## 6 DISCUSSION AND CONCLUSION

On the basis of the correlation coefficient, the design team can now be sufficiently confident to have taken the right decision if they globally judged the design alternatives in the same sense as the customers answered to the Kano questionnaire. In the case of Table 5 this is evident.

At the same time, the comparison of the data collected in Table 4 (obviously similar Tables have been built for each design solution) and those present in the columns of Table 3 associated the same solution gives a further insight into the single characteristic element of each design solution. This comparison allows the design team to investigate how all the elements are considered. Furthermore, if some of these elements are evaluated as extremely attractive, the design team can now consider whether and how to include them in a different design alternative. From the educational point of view, this comparison is basic in order to guarantee students having assessed and decided for the right choice. In fact, considering the ill conditioned nature of the design activity, there is no way to know whether the decision was made properly.

In conclusion, it can be said that both activities of concept selection by scoring and customer satisfaction by the Kano model must be pursued conjointly. This gives more validity to the assessment made by the design team and all the stakeholders might decide with more consciousness from the early phases of design.

In the near future, the correlation model that has been described in the paper will be formally pointed out and specified in a procedure.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