Design improvement of multifunctional seatbelt by using integrated kano model and quality function deployment

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Abstract. Increasingly developing technology makes human easier to carry out the life, and one of them is in the transportation sector. The high number of vehicle accidents causes losses to the passenger so that it requires safeguards to minimize these losses, one of the ways is by using a seat belt. This study aims to design a voice of customer-based seat belt using integrating Kano model and Quality Function Deployment (QFD) produced by an innovative product, namely "Multifunctional Seat Belt for Vehicle Safety". Through the distribution of questionnaires, 8 attributes are needed in the design of the seat belt. The results of the Kano Model analysis show that 2 attributes fall into the indifferent category which is then eliminated because the presence or absence of these attributes does not affect customer satisfaction. The other 6 attributes are portable, can store items, can hold the body while sleeping, can warm the body, there are pads on the sides of the head, and adjustable strap. These attributes are entered into the QFD framework until phase 1 to obtain a priority sequence that is useful in the production process later. In addition, MUSES is designed with anthropometric approach which is using 5 dimensions so that it is ergonomic for users.

1. Introduction

The rapid development of era has led to an increase in the role of technology and transportation in human life. With the transportation system, people are able to travel from one place to another faster and easier. The development of transportation equipment must also be accompanied by security to ensure passenger safety.

The World Health Organization (WHO) published a report namely The Global Report on Road Safety which stated that around 1.25 million people in the world died in 2013 due to traffic accidents. In 2014, the number of car accidents occurred in Indonesia as many as 42,197 [1].

To be able to help avoid accidents, transportation means are generally equipped with security equipment in the form of seat belts. From the various accidents that have occurred in various countries, it is clear that the seat belt is the most important security device in protecting motorists and passengers when an accident occurs [2].

Based on the results of a questionnaire distributed, it was found that the customers need a practical seatbelt for use when riding a couched vehicle that is not only for private vehicles but also can be used for public transportation. However, not all public vehicles currently provide seat belt such as public trains and buses, which of course can be so dangerous. It was also found that the community not only needed security in travel but also comfort.
Looking at the existing problem, MUSESA "Multifunctional Seat Belt for Vehicle Safety" an innovative seatbelt that is practical to be used for driver or passenger that is not only for private vehicles but also for public transportation. There are several features in MUSESA product to make it easier and more convenient for users like portable, the availability of body warmer, additional pockets, strong and comfortable to use while sleeping, and the availability of disclaimer pillows on each side of the head.

In this research, integration of Kano Model and Quality Function Deployment (QFD) will be used to produce features that are in accordance with customer desires so that customer satisfaction can be fulfilled. Integration of the two methods was carried out because it was proven to be able to improve the deficiencies of each method resulting in effective output [3], especially in improving seatbelt design.

2. Methods

2.1. Data collecting
In this study, data collection was carried out in several stages. The first stage is the stage of distributing questionnaires with open questions to get Voice of Customer (VoC) to 70 respondents. VoC obtained is then re-asked using the Likert 1-5 scale so that the instrument can be tested. The second stage is distributing Kano questionnaires to determine customer preferences. The third stage is the distribution of QFD questionnaires to determine the level of importance, level of satisfaction, and benchmarking. In addition, to produce ergonomic products, MUSESA is designed using an anthropometric approach so that anthropometric measurements are carried out directly on 30 respondents. All respondents involved must meet the inclusion criteria: 18-25 years old, male and female, work as students and ever using seatbelt.

2.2. Instrument tests
The data obtained from the results of the first questionnaire were tested by instrument tests in the form of validity and reliability test to ensure that the data taken was representative enough to describe the actual conditions so that data could be further analyzed reliably. Using the significance of two-tailed 0.05 with dF = 70 - 2 = 68, it is found that the data are valid if the value of Pearson correlation > r table (0.235). The data are said to be reliable if Cronbach's Alpha > 0.60 [4]. In this research, the validity and reliability test is done by using SPSS 22 software.

2.3. Data processing
Valid and reliable attributes are then categorized based on the Kano theory whether it is categorized as must be, attractive, one dimensional, or indifferent. The categorization is then given a value called K-Value which is categorized as must be (M) = 0.5, one dimensional (O) = 1, attractive (A) = 1.5 and indifferent (I) = 0 [5]. Attributes that fall into the indifferent category will be eliminated immediately, while others will be hybridized into QFD. The QFD process carried out in this study only reached phase 1, this was based on the aim of the study which is only until the design of the alpha prototype using SolidWorks.

Product specifications are based on the results of anthropometric calculations to obtain ergonomic seatbelt. Before the anthropometric calculation is carried out, the normality test is done first to find out the average sample whether it has approached the midpoint of the population and fulfill the requirements of the normal distribution so that it represents the population. Some dimensions used in the design of MUSESA products are TBD (sitting shoulder height), LB (shoulder width), RS (stretch of elbow hand), DPK (chin to top of head), and LK (head width).
3. Result and discussion

The results of the distribution of questionnaire stage 1 to 70 respondents obtained 15 attributes which were then given re-asked to give a rating for instrument test analysis. After the instrument test, 8 valid and reliable attributes were obtained. Valid attributes (Pearson Correlation > 0.235) are shown in Table 1 and the results of the reliability test calculations use SPSS shown in Table 2.

| Code | Attribute                        | Pearson Correlation |
|------|----------------------------------|---------------------|
| A1   | Portable                         | 0.635               |
| A2   | Can store items                  | 0.453               |
| A3   | Can hold the body while sleeping  | 0.567               |
| A4   | Can warm the body                | 0.672               |
| A5   | Has attractive colors            | 0.417               |
| A6   | There are attractive decorations | 0.383               |
| A7   | There are pads on the sides of the head | 0.433 |
| A8   | Adjustable strap                 | 0.587               |

Table 2. Reliability test result.

| Cronbach’s Alpha | Standardized Alpha |
|------------------|--------------------|
| 0.6791           | 0.6140             |

The attributes that pass the instrument test become the voice of customers that will be analyzed next. The 8 attributes above will then be analyzed using Kano Model and QFD framework until first stage.

3.1. Kano model results

Based on the results of the Kano questionnaire which contained functional and dysfunctional questions from the 8 attributes, the results recapitulation can be seen in Table 3.

| Code | Kano Model Category | Total | Category | Worse (-) | Better (+) |
|------|---------------------|-------|----------|-----------|------------|
| A1   | A                   | 30    | A        | 0.466     | 0.566      |
| A2   | A                   | 30    | A        | 0.466     | 0.633      |
| A3   | M                   | 30    | M        | 0.7       | 0.433      |
| A4   | O                   | 30    | O        | 0.6       | 0.6        |
| A5   | I                   | 30    | I        | 0.466     | 0.333      |
| A6   | I                   | 30    | I        | 0.433     | 0.3        |
| A7   | O                   | 30    | O        | 0.566     | 0.566      |
| A8   | M                   | 30    | M        | 0.733     | 0.433      |
3.2. House of quality 1

Data related to level of customer satisfaction, level of importance, benchmarking and K-Value are all integrated into the House of Quality 1 framework included with Voice of Engineer (VoE) to meet Voice of Customer (VoC) which can be seen in Figure 2. Based on the results of HoQ 1, a ranking of useful attributes is obtained at the production stage where the manufacturer will prioritize first rank in meeting its performance quality followed by subsequent rankings.

Figure 2. House of quality 1.
3.3. Product description
As the name implies, MUSESA is a multifunctional seatbelt that has innovative features such as available pockets to store important items for transportation passengers so that they are easily stored and safe from theft. In addition, there are points electrified by battery resources so that they can warm passengers when they are cold on the way. Therefore taslan is used as a MUSESA base material which is heat-resistant, at the same time waterproof and comfortable to use. The strap is also adjustable so that it can be adjusted for different passenger sizes. Figure 3 shows the design of MUSESA product.

![Figure 3. Design of MUSESA.](image)

MUSESA is designed to be portable so that it is easy to carry wherever the user wants because transportation can be in the form of trains, planes, and even public transportation. In order to be portable, MUSESA is designed to be pumped when it wants to be used and can be deflated when not in use so that a small pump is also available to be easily carried. Figure 4 shows how it is folded and Figure 5 shows the product specification of MUSESA.

![Figure 4. MUSESA in folding mode.](image)

![Figure 5. Product specification of MUSESA.](image)
3.4. Anthropometric approach

Anthropometry can be expressed as a study relating to the measurement of the human’s body dimensions so that the products developed are in accordance with the dimensions of the human body [7]. Products that are designed based on anthropometric measurements from a certain group of people can increase the ergonomics of the tool because it fits averagely with the size of the users. Anthropometric data were compiled from direct measurement to 30 respondents. A normality test is performed using SPSS software first. The results can be seen in Figure 6 for calculations & Figure 7 for anthropometric implementation overview. After H₀ criteria are accepted for all dimensions (Sig. > 0.05), the dimensions are used and the results of anthropometric calculations presented in Table 4.

Table 4. Anthropometric calculations.

| No. | Dimensions | Percentile | Calculation Result (cm) |
|-----|------------|------------|-------------------------|
| 1   | TBD        | P₅₀       | 57.7                    |
| 2   | LB         | P₉₅       | 44.8                    |
| 3   | RS         | P₉₅       | 85.2                    |
| 4   | DPK        | P₅₀       | 23.3                    |
| 5   | LK         | P₉₅       | 17.9                    |

Figure 6. Normality test.

Figure 7. Anthropometric implementation overview.
4. Conclusions
This research produced an innovative product to help the community to get safety and comfort in driving with seatbelt support called MUSESA. Some of the main features include having a bag to store passenger goods while on the go to make it safer and more comfortable, portable so that it can be used in several different vehicles, can warm the user's body, have a bearing beside the user's head, and adjustable strap. The results of the Kano model show that there are 2 attributes that are included in the indifferent category that must be eliminated, 2 must be attributes, 2 attractive attributes, and 2 one dimensional attributes. The QFD results are limited to the HOQ 1 stage. From HoQ 1, there is a priority sequence that is useful for manufacturers at the later stages of production where the priority of the most important is there are seatbelt measured as width as upper body with adjustable strong binder, removable straps and seatbelt can be deflated, there are storage bags, seatbelt is made to spread to the upper shoulder, and there is electricity in the seat as a body warmer. MUSESA is also designed with an anthropometric approach as a basis for determining product specifications which use 5 dimensions of the human body to make it an ergonomic product.

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