An Established Scholar Review Towards Kansei Engineering for Railway Product Design

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Abstract. Innovation from creative product design has become essential to the success of many companies. The products marketed must be specially distinguished from others to meet user demands. Consumers will prefer products that suit their needs and the visual impression that the product gives to their emotions or subjective feelings. With the demands of market competition regarding product innovation, it is necessary to apply new product development methodologies, such as emotional design or Kansei engineering. The application of Kansei engineering will have an impact on the design specifications of transportation and railway products based on consumer feelings and demands. The method employed in this writing is the literature review, intending to make existing data understandable and useful. Papers that applied KE types I, II, III, and IV as data sources were taken. Based on the study results, it can be concluded that each paper has its advantages and disadvantages, both in terms of the number of respondents and the stages of analyzing the data. It is also very important to propose a prototype design to ensure that the research results match expectations and needs.

Keywords: Product design · emotion · kansei engineering · railway · visual impression

1 Introduction

Transportation is a major need for society due to the high level of mobility. Moreover, in developing countries, there has been an increase in transportation due to increased population density. This is a big opportunity for manufacturers of private transportation, such as motorcycles and cars, and public transportation, such as trains. However, in facing competition between producers, the design of transportation products must pay attention to competition, the design process, and marketing [1]. Consumers will prefer products that suit their needs and the visual impression that products give off or the feelings it evokes. Product appearance is the first thing that is seen and can attract customer attention. Attractive beauty or aesthetic value can result in the possibility of a high number of purchases. Likewise with transportation, besides the visual impression, the design is also centered on the user experience during the trip so that users are loyal to this transportation [2]. Therefore, an instrument is needed to translate the user's feelings towards the design of transportation products, known in the field of "emotional design" [3].

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One methodology for translating user emotions is carried out by affective engineering, or "Kansei engineering," developed in 1970 at Hiroshima University. Kansei engineering comes from "Kansei," which is a Japanese word that has the meaning of consumer feelings and a psychological picture of the product. Kansei engineering technology allows these images with feelings to be used in new product development. Kansei engineering is "technology translating consumer feelings from products into design elements" [4]. This methodology aims to produce new products based on the demands of customers or users. There are four principles related to Kansei technology, namely understanding the feelings of consumers themselves about products in terms of economics and psychological estimation; identifying the characteristics of product design based on consumer desires; building Kansei engineering (KE) as a technology based on ergonomics, and adapting product design to changes in society today or trends that are happening in society [5].

Kansei engineering consists of four types. The steps in implementing this methodology start by collecting feeling words, or Kansei words, from the product and selecting the most relevant ones. Then determine the properties in the form of items and categories so that product design samples can be made. After that, a questionnaire was conducted to determine respondent's preferences for the sample design, and data analysis was carried out. Kansei engineering has been applied to many manufacturers and has proven its success, for example, in the products of the transportation industry, namely Mazda, Porsche, and Hyundai [6].

Several types of Kansei engineering continue to be developed and identified into four types: KE types I, II, III, and IV. Kansei engineering type I product identification and development that connects affective needs and products. The results of type I KE are visualized as a concept tree. Then, KE type II uses mathematical, statistical tools or fuzzy logic. KE type III provides design solutions using modelling and databases applied to the initial sketch and re-analyzed with a new design. KE is also known as the hybrid Kansei. The last one is KE type IV visualizing the results of design recommendations using virtual reality (VR) [2]. However, it is currently unknown which type is the most ideal for researching the design of transportation products, especially trains.

The purpose of this writing is that the existing data from the research papers become useful information related to the application of Kansei engineering types I, II, III, and IV. The results of this paper can be used as a reference in applying the Kansei engineering methodology for transportation and railway products, as well as how to produce prototype proposals for further evaluation.

2 Literature Review

2.1 Kansei Engineering

Kansei engineering was introduced by Professor Mitsuo Nagamachi in 1970. Kansei engineering is a technology that combines Kansei (emotions and feelings) with engineering disciplines. KE is used in product development to get consumers and their satisfaction by analyzing human feelings and emotions and connecting those emotions and feelings to product designs. Kansei engineering aims to develop products based on consumer feelings [7]. Pampering customers is now a critical issue for long-term producer businesses [8]. As a product development methodology, Kansei engineering can be defined as a methodology for translating human psychological processes into existing products or new design concepts [9]. Consumer needs for a product are not only in terms of functionality or usability but also emphasising emotional needs.

2.2 Kansei Types

The following types of Kansei Engineering will be discussed according to sources [6].

a) Type I Kansei Engineering
   The first type of Kansei engineering is the most common and easiest to apply. The method is to break down the main concept of a product into more details that will be applied to the design characteristics of the product. An example of applying this type of engineering to transportation is the Mazda Eunos Roadster (MX5). Type I KE focuses on identifying and developing products that address the affective needs of users, so it can be applied to public transportation such as trains.
b) Type II Kansei Engineering
   Type II KE, according to Nagamachi [6], has a slight difference from type I KE, which applies the concept to the physical character of the design. Whereas in KE type II, engineering is used to translate user emotions towards products with the help of computerized systems such as genetic algorithms and fuzzy logic. From the collected Kansei words, multivariate statistics were analyzed to find the relationship between the Kansei words and the design elements that will be stored in the database.
c) Type III Kansei Engineering
   Type III KE according to Nagamachi [6] is often called a kansei hybrid system because the product development process is carried out forward and backward. This happens because in developing a product it is necessary to analyze the concept as well as an initial picture or sketch that is entered into the user interface (can be compared to a database) so that by using KE type III the Kansei words desired by the user can be predicted.
d) Type IV Kansei Engineering
   Type IV, according to Nagamachi [6], uses technological assistance such as VR (virtual reality) to provide a visual picture and see interactions with designs that have been made. The first step is almost the same as type I, namely studying the lifestyle of users or target markets, then collecting Kansei words or words that describe images. After that, it is analyzed and translated into a design, which is then incorporated into the VR system. Here, users can enjoy real design and enter a virtual space.

2.3 Stages of Kansei

The steps in applying kansei engineering according to [9] cited by [10] are explained as follows:

a) Domain Determination
   The initial stage is to look for findings that will be applied in research. One way is to select target products that are determined by type, function, etc.

b) Semantic Differential Scale

The product that has been determined is then searched for adjectives representing and describing the product domain. These words can reach hundreds and are collected from various sources that can be taken from journals, books, and previous research results. The scale used is from theory [11], namely the form of this semantic differential in the form of adjectives and opposites arranged in line with a scale of 1–5. Later in the questionnaire, respondents gave answers in the range of positive to negative.

c) Property Creation

In kansei engineering, properties are product parts, which consist of product design elements (items and categories). What is meant by items is a certain characteristic in the design, while the categories are small groups within each item. Items and categories will be applied to the initial design visual sampling. The main design elements consist of the required elements.

d) Data Testing

Starting with the validity test to find out what will be measured and how precise the measurements are, the reliability test is to find out the level of truth of the test (data that can be trusted). After collecting the questionnaire data, the data is tested, and if it is declared valid and reliable, a regression analysis is performed to determine the relationship between the Kansei words and the items and their categories. Data analysis is different for each study; for example, according to [11], regression analysis is carried out to predict how far the dependent variable's value changes if the independent variable's value is changed. It also aims to determine whether there is an influence of two or more independent variables on the dependent variable.

Table 1. Articles Selected for Identification

Author	Title	Kansei Type
Sakya Nabila Hapsari, Teddy Sjafrizal, Rino Andias Anugraha.	Designing Train Passenger Seat by Kansei Engineering in Indonesia	Type I KE
Lei Xue, Xiao Yi, Ye Zhang.	Research on Optimized Product Image Design Integrated Decision System Based on Kansei Engineering	Type II KE
Hidayah W. N, Yahaya S. H, Sihombing H, Salleh M. S, Abdullah A.	Customer Preferences in Car Design using Kansei Engineering and Cubic Bezier Curve	Type III KE
Qianwen Fu, Jian Lv, Shihao Tang, Qingsheng Xie.	Optimal Design of Virtual Reality Visualization Interface Based on Kansei Engineering Image Space Research	Type IV KE

2.4 Selected Articles

Below are the 4 articles identified. Articles were selected based on suitability with four types of Kansei engineering and have objects, namely transportation and railway products (Table 1).

3 Results and Discussion

The discussion is carried out by identifying papers based on three categories: the issues discussed, research methodology, and research results. In addition, the four papers were compared to find out the differences and similarities, as well as the advantages and disadvantages.

The first research, entitled "Designing Train Passenger Seat by Kansei Engineering in Indonesia," was written by Sakya Nabila Hapsari, Teddy Sjafrizal, and Rino Andias Anugraha.

3.1 Problems in the Research

The problem stems from traffic congestion caused by high transportation in developing countries, resulting in changing the habit of switching to using public transportation as a solution to the problem. One of the public transportation is the train which has its track so that the travel time is more efficient. Likewise, designing public transportation services for the community requires perspectives from various user groups. In designing a public transportation product, a person-centred perspective in designing services may be derived from the travel experience itself. Travel experience determines passenger loyalty in using public transportation. Solving the problem in this research is done by Kansei engineering. This methodology combines the functional and emotional aspects of user requirements as the level of quality to be achieved.

3.2 Research Methodology

This research is the application of Kansei Engineering Type I. The subjects in this study were 96 respondents who were given a questionnaire and asked questions using interview techniques to get Kansei words. The methodological stages carried out in this study started with identifying target customers and collecting Kansei words. Then determine the product concept that will be further developed and break down the concept into physical characteristics. The third step is applying the physical design, which combines design concepts with Kansei's words. The final step is a technical translation with data collection and analysis.

Methods of data analysis using the Spearman-Rho validity test and the Cronbach Alpha reliability test. Next, evaluate the semantic differential by pairing Kansei words with likert scales. Factor analysis helps classify the results of the Kansei words. Finally, the analysis was carried out with the support of Kaiser-Meyer-Olkin (KMO) and Barlett's test and principal component analysis (PCA).

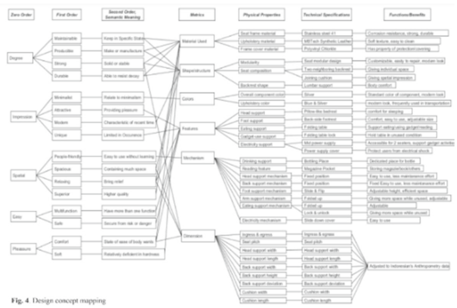

Fig. 1. Design Concept Tree

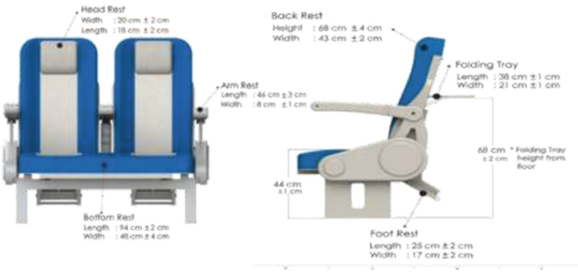

Fig. 2. Visualization of Proposed Train Passenger Seat Designs

3.3 Results

The results of this study are in the form of a concept tree-like Fig. 1, design specifications for train passenger seats. The specifications from the results of data analysis are a synthetic leather cover, modular design, equipped with a folding table, blue-silver colour, and according to anthropometry. These specifications are also considered based on 16 selected Kansei words that are valid and reliable: convenience, user-friendliness, multi-functional, soft, safe, relaxed, spacious, easy to clean, superior, strong, manufacturable, modern, unique, attractive, and durable. Figure 2 is a visualization of train passenger seat design recommendations.

The second study entitled "Research on Optimized Product Image Design Integrated Decision System Based on Kansei Engineering" written by Lei Xue, Xiao Yi, Ye Zhang.

3.4 Problems in the Research

Trends in the development of industrial design towards more efficient, intelligent and systematic. Meanwhile, product design pays more attention to improving user experience. With the increasing demand for user experience design, user perception-centric design will become an important factor affecting product design.

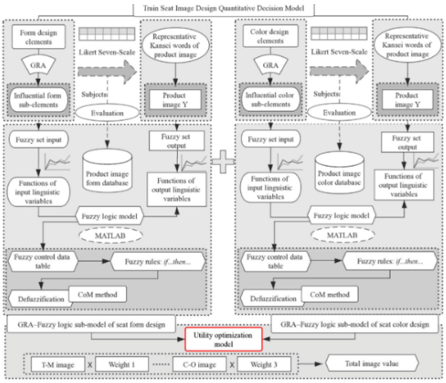

Fig. 3. Quantitative decision model train seat drawing design.

Fig. 4. 3D Visualization of Train Passenger Seat Designs

3.5 Research Methodology

This type of research is quantitative research with data collection methods, namely by experiment. The object in this study is the passenger seat of the train. The data analysis method was carried out using Gray Relation Analysis (GRA), which is a fuzzy logic sub-model according to Kansei engineering type II. The application of fuzzy logic in this study can be seen in Fig. 3.

3.6 Results

The results showed that the type II KE system was effective in predicting product image and optimizing the product image design process. An experimental study was carried out using a railway seat design. The results show that the system has better performance to improve product image. Designers can effectively plan product designs for a particular product image. The resulting product visualization made in 3D is shown in Fig. 4.

The third study entitled "Customer Preferences in Car Design using Kansei Engineering and Cubic Bezier Curve" written by Hidayah W. N, Yahaya S. H, Sihombing H, Salleh M. S, Abdullah A.

Table 1: Name of Car Design for City Cars

No.	CAR BRAND	No.	CAR BRAND
1	Perodua Axia	11	Suzuki Splash
2	Mitsubishi Mirage	12	Toyota Etios Liva
3	Toyota Aygo	13	Opel Adam
4	VW Polo	14	Ford KA Studio
5	Hyundai i10	15	Fiat 500
6	Nissan Micra	16	Geely Panda
7	Aston Martin Cynet	17	Kia Picanto
8	Chevrolet Spark	18	Peugeot 108
9	Datsun Go +	19	Fiat Punto Evo
10	Honda Brio	20	Cherry QQ

Table 2: Name of Car Design for Sedan Cars

No.	CAR BRAND	No.	CAR BRAND
1	Alfra Romeo	11	Kia Quaris
2	Aston Martin	12	Lexus GS
3	Audi A4	13	Mazda 3
4	Audi S6 Avant	14	Mercedes Benz E
5	BMW 5 Series	15	Mitsubishi Lancer
6	BMW F80 M3	16	Proton Preve
7	Chevrolet Cruze	17	Proton Saga FLX
8	Ford Mondeo	18	Subaru Legacy
9	Honda Accord	19	Toyota Camry
10	Hyundai Sonata	20	Toyota Vios

Fig. 5. List of City Car and Sedan Car Products

3.7 Problems in the Research

This study is focused on meeting customer needs and also finding out customer trends before making a design. This study aims to determine and analyze consumer preferences for car design using a mathematical concept known as the Bezier curve. This approach is used as part of a study to differentiate and study consumer loyalty through consumer preferences in designing cars.

3.8 Research Methodology

This type of research is quantitative, with a data collection method of distributing questionnaires to 66 respondents (45 male respondents and 21 female respondents). The 30 kansei words applied to the initial designs shown are photos of 20 city car products and 20 sedan car products, whose types are shown in Fig. 5. Data analysis method using Cubic Bezier with GeoGebra software.

3.9 Results

The most comfortable car for City Cars and Luxury for Sedan Cars is the most preferred by respondents, while in car design, respondents have chosen Toyota Aygo (FV1), Hyundai i10 (FV3) and Chevrolet Spark (FV5) for City Car. As for Sedan Cars, the three car designs chosen by respondents were the BMW F80 M3 (FV2), Mazda 3 (FV3) and Mitsubishi Lancer (FV5).

The latest research entitled "Optimal Design of Virtual Reality Visualization Interface Based on Kansei Engineering Image Space Research" written by Qianwen Fu, Jian Lv, Shihao Tang, Qingsheng Xie.

3.10 Problems in the Research

Organizing design elements effectively requires virtual reality (VR), provides an evaluation method for the design process, and builds a cognitive model of the user's image space. The first is studying user cognition and design features in VR systems through the Type IV Kansei engineering method. Quantitative theory and regression analysis are used to analyze the design elements of human-computer interaction interfaces using VR systems. Combined with complex methods, to summarize the relationship between design features and analyze the important design features that affect the user's perceptual image.

Fig. 6. Virtual Reality Process

3.11 Research Methodology

The methodology used in Kansei Engineering Type IV goes through almost the same stages as KE Type II. Beginning with collecting Kansei words. Then set properties in the form of item and product categories. The difference lies in the method of data collection. In KE type IV, data collection is carried out using VR assistance after making the initial design. Respondents use VR tools and can feel directly like they are in the design that has been made. The visual impression that is achieved is more real and easy to operate. To connect to a VR device, 3D software such as Skethup or Rhinoceros is needed which is controlled by the VR system application according to the product brand, for example Oculus. The VR process can be seen in Fig. 6.

3.12 Result

The application of KE in the visualization of VR systems is expanded and integrated into VR research, which is guided by cognitive psychology theory and KE theory. The relationship between the design elements of the VR system and the user's perceptual cognition is analyzed. Then, a spatial model of the user's perception of the VR system of cognitive image resources is constructed. The KE function model was formed using quantitative theory and multiple regression theory. The similarity between the calculated value and the actual value is around 97%, thus the formed VR mathematical model is significantly related.

3.13 Discussion

The application of Kansei engineering in four journals by applying different types of Kansei has its own advantages and disadvantages, but KE type II is good enough and ideal for representing the design process, developing innovations for products, and making prototypes for design proposals. Research on previous trains with KE type II was also carried out [12], with the aim of determining the visual impression of the interior design of the train compartment based on user preferences using the Kansei engineering method. The development of compartments or sleeper trains with bulkheads is needed because it supports domestic tourist trains. The results of the study show that the Kansei words that are the respondents' preferences for train compartments are comfortable, luxurious, unique, fun, simple, and modern. While the most favourite design according to user preferences is the third design (D03) which has a visual impression of a minimalist theme, a green colour palette, painting decorations, glossy, and the dominant finishing

Fig. 7. Favorite Train Compartment Interior Design

is HPL with wood motifs, shown in Fig. 7. From the identification carried out, the use of KE types is returned to the direction of research and adapted to the type of object to be studied because each type of KE has its own advantages and disadvantages.

4 Conclusion

Kansei engineering is applied to various transportation and rail products and has proven to be successful in accommodating customers' emotions and desires. Thus, manufacturers can create innovative products for a marketing competition. This methodology is divided into four types: Kansei engineering types I, II, III, and IV. The application of Kansei engineering starts by determining the product domain, and then finding and defining words (Kansei words) that represent or describe the product. After that, a questionnaire was carried out on the design samples that had been treated according to their properties. The final stage is to test the data to find out which items and categories have the most influence. Kansei engineering is used in product design development to get customer satisfaction, namely by analyzing human feelings, and emotions, and connecting those feelings and emotions to the product design. Based on the results obtained, each identified paper has its own strengths and weaknesses. The Kansei methodology procedure is ideal if it is adapted to the object to be studied. It is also very important to recommend design concepts and prototypes to ensure that research meets expectations.

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