Preliminary Study of Kansei Engineering (KE) for Societal Performance in Sustainable Product Design

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Abstract: Nowadays, product development indicates that a product’s success in the market is determined by the inclusion of consumer’s technical needs for product design. However, implicit feelings and impressions by the consumers is quite challenging because they cannot be externally assessed. Therefore, the makers aim to figure out the factors that contribute to the purchaser’s fulfilments of their product. This paper introduces indicators that can be used to fulfil consumers’ needs specifically to handle the implicit needs of consumers in sustainable product design based on Kansei Engineering (KE) approach. KE is a Japanese design method used to translate feelings into product parameters and was used to look at the car design features of a consumer’s dream car. Preferences of four design features (safety, conveniences, car interaction, and size of capacity) were explored in a sample population of sixty university students through questionnaires. Seven kanseis/feelings elicited by phones were determined to be important to this group: (1) Dynamic, (2) Easy, (3) Elegant, (4) Personality, (5) Positive physical traits, (6) Sophisticated, and (7) Technology. This study chooses to explore the use of Descriptive Statistical and Correlation Component Analysis for statistical significance of the data set as the main method of analysis to determine whether there is a significant difference between the car design features and between the society’s rating of the car features through Kansei words. Utilizing the system will help another automobile plan that matches consumers’ needs to be proposed.

Keywords: Product design; Sustainability; Implicit needs; Kansei Engineering.

1. Introduction
Generally, product design plays a key role in the product development process for various purposes and can be approached in many different ways which evolve over time [1]. Evolutions in product design have led to many inventions, resulting in fairly good quality products flooding the market [2, 3]. Therefore, the competition is increasingly growing, forced by the demanding market. Producers strive to design products that stand out and attract consumers. Currently, consumer’s satisfaction and sustainable aspects (e.g., environment, economic and social) are equally important in determining the success of product design. However, product designer has thus far focused on social sustainability to a much lesser extent which is unfortunate, since not only can social sustainability practices help improve other aspects of sustainability, but all three dimensions are required to build a truly sustainable business [4, 5].

A significant amount of research has been generated in the last decades to support sustainable product development and help product design teams find engineering solutions to improve the environmental, economic, and social performance of products without compromising technical functionalities [6, 7]. Sustainable product design is about the implementation of sustainability considerations at the early stage of new product developments in order to produce a sustainable product. Baumann (2002) [8] identified more than 150 tools for ‘green product development’ that only focus on the environmental dimension.
of sustainability. Several researches have proposed sustainability frameworks that include all three dimensions, albeit with a greater emphasis on economic and environmental sustainability, and only a few have tried to examine social standards using empirical analysis [9].

Yang (2005) [10] identified product design as a strategic tool to be incorporated into sustainability solutions. Product design is responsible for ensuring that a design can produce a profitable product. Eco-design is a term for strategies that aim to integrate environmental aspects, and sustainable product design is more than eco-design, as it integrates the social aspect of the product’s life cycle along with consideration of environmental and economic aspects [11]. This strategy makes product design an important element in the creation of the product for achieving sustainable development.

Overall, there has been limited investigation validating programs and investments to enhance organizational and supply chain social sustainability [12, 13]. Tools do exist to help with strategic and subjective evaluations of sustainability dimensions in organizations and their supply chains [14], but there is much to learn from different fields of study to strengthen the organizational strategic justification and forecasting toolset. The economics literature provides substantial groundwork and tools available for environmental valuations that may be applicable to organizational and supply chain sustainability activities, both for internal organizational activities and across the broader supply chain players and actions. Therefore, the primary objective of this paper is to investigate the application of the Kansei Engineering (KE) method in discovering implicit consumers’ needs that specifically applied in product design.

2. Methodology
This section comprises an in-depth discussion about the methods utilized in this exploration. This section also discusses the development of Kansei Engineering with several issues related to implicit consumers’ needs that may influence sustainable product design. This method is described as a mental function, or more precisely, a higher function of the brain, and therefore it is implicit. For this study, KE Type II, KE Computer System is applied to compile databases and infer the main objective to support a computerized system that handles the process of interpreting consumers’ feelings and emotions regarding perceptual design elements, which is described at the end of this section.

2.1 Kansei Engineering Approach
The suitable type of Kansei that matches the research objective is KE Type II which is the KE Computer System (KES). KES is a computer-assisted system. KES is an expert computerized system that can be utilized to translate the consumer's feeling and image into the design details. The KES architecture has four databases which include the Kansei database, containing the majority of the words related to consumer feelings which are illustrative of the product; image database which contains contributory things in the design details in the interest of a specific Kansei word, knowledge-based which contains the rules expected to choose items of the design details closely linked with the kansei words, and design and colour database which contains the design details with the colours separated [15].

So far, KE has been introduced to multiple industries including the automotive, construction machinery, electric home appliance, office machinery, house construction, costume, and cosmetic industry [15]. Application to mobile and entertainment devices have also been more recently explored [16, 17, 18]. These studies sought to find the emotional elements that are deemed significant to consumers. In addition to that, they were able to determine which factors influence consumer’s impressions and which emotional tags were associated with each design element. If the model is found to be unsuccessful, the ‘semantic’ and ‘product element’ spaces should be updated until the model is able to yield reliable results as shown in Figure 1 which portrays a framework for the Kansei Engineering methodology. The basic idea is to describe the preferred features based on an earlier chosen domain which is the idea behind the product from two different perspectives, the semantic description and the description of product properties.
Each of these two descriptions spans a vector space. Subsequently, these spaces are merged with each other in the synthesis phase, indicating which of the product properties evokes which semantic impact. Only after these steps have been carried out, that it is possible to conduct the validity tests, including several types of post-hoc analyses. As a result of this step, the two vector spaces have been updated, and the synthesis step is able to run again. When the results from this iteration process are satisfactory, a model can be built describing how the semantic and the space of application are associated.

3. Results and Discussion

This section shows the results of the data analysis and evaluation of the research according to the research objectives. Statistical calculations were used to test the research objective which was the KE’s indicator for measuring the societal performance of product design using SPSS 20.00.

3.1 Application of Kansei Engineering for measuring societal performance of product design

In this study, an indicator was developed according to Kansei Engineering method. Figure 2 shows an indicator of Kansei Engineering for measuring the societal performance of product design. This indicator is created to facilitate the interpretation of a customer’s feelings and readiness in design by using the KE method. With the KE method, there are various ways and procedures to obtain the output of the customers’ desires. Therefore, with this indicator, the designer can easily analyse the feelings and requirements of the customers.

3.2 Case Study

The case study employed for this paper investigated a car as product design. There are seven car design features featured in this study after Questionnaire 1 was distributed. For Questionnaire 2, some design features had been explored to determine which ones will get the highest rating on the descriptive Kansei word.

3.3 Semantic Space analysis

From Questionnaire 1, 81 Kansei Words were collected from 60 participants. Furthermore, the KJ method was applied in this study to find a cluster of Kansei words by using an affinity diagram. The cluster name is based on the 10 Kansei affinity groups that have been selected from the previous study. In addition, 72 Kansei Words were collected from journals, magazines, and websites. Table 1 shows the cluster of Kansei Words after being combined from surveys and others (journals, magazines, and
websites). From that table, selected cluster name uses in the analysis and synthesis case study is based on the major words collected in the cluster name. Based on Table 1, seven cluster adjectives were selected (Dynamic, Easy, Elegant, Personality, Positive Physical, Sophisticated and Technology) because they have a high number of adjectives compared to the other group names.

**Figure 2.** A Framework for Kansei Engineering [13].

**Table 1.** The Set of Kansei Words related to the car

| Cluster Name       | Kansei Words                                                                 | Number of words |
|--------------------|------------------------------------------------------------------------------|-----------------|
| Adventurous        | Capable, Energetic, Extreme, Valiant, Vigorous, Modern.                       | 6               |
| Basic              | Common, Familiar, Plain, Simple, Standard, Typical                           | 6               |
| Creative           | Innovative, Inspiring, Persuasive                                            | 3               |
| Dynamic            | Beneficial, Brand-new, Changeable, Flexible, Functional, High Potential, Latest, New, Talented, Useful, Strong, Aerodynamic | 12              |
| Easy               | Easy-to-adapt, Easy-to-use, Just Nice, Manageable, Safe, Understandable, Easier | 7               |
| Elegant            | Advance, Charming, Deluxe, Exotic, Exclusive, Gallant, Genuine, Gorgeous, Graceful, Impressive, Magnificent, Mature, Sexy, Smart, Sophisticated, Sporty, Stylish, Trendy, Well-known, Chic, Cute, Beautiful, Elegant, Valuable, Fantastic | 25              |
| Personality        | Characteristic, Charismatic, Affordable, Low-Cost, Compact, Cheaper, Premium, Compatibility, Small, Low Maintenance | 10              |
| Positive Physical  | Firm, Fit for Gender, Good Colour Combination, Good Colour Tone, Good Condition, Good Design, Good Feeling, Good Looking, Good Pattern, Good Presentation, Good Quality, Good Shape, Good Style, Good Visibility, Near, Tidy, Well, Well-Decorated, Well-Designed, Durable, Comfortable, Colourful, Ergonomic, Stainless | 24              |
| Sophisticated      | Abstract, Branded, High Class, High Impression, Limited, Luxury, Stunning, Top-class, High Capacity, Future Design Technology | 10              |
| Technology         | Fast, Geometric, High Performance, High-Power, High-tech, Multi-function, Secure, Specialized, Systematic, User-Friendly, Eco-friendly, Speedful, Efficient, High Speed, Economical | 15              |
3.4 Product Element Space analysis

At this stage, the product components for this research were collected from journals, thesis, and websites related to the case study which ultimately is a dream car for the customers and consumers. The seven components of the product which are convenience, car interaction, car materials, the shape of the car, size of the car, capacity, and the safety features were assembled. Table 2 shows the source of relevant product components used in this study.

| Product components on this research | Related product elements from the sources | Sources or references |
|-----------------------------------|------------------------------------------|-----------------------|
| Shape of car                      | Shape of Phone                           | Thesis/Kansei Engineering and cultural differences in mobile phone design by Loni M. Watson |
| Car materials                     | Phone materials                          |                       |
| Convenience                       | Navigation Tools                         |                       |
| Size of capacity                  | LCD Screen size                          |                       |
| Size of car                       | Size of phone                            |                       |
| Car interaction                   | Phone Interaction                        |                       |
| Safety                            | Driver killed in Tesla self-driving car   | Headline News/ Driver killed in Tesla self-driving car crash ignored warnings, NTSB reports by Nathan Borney - Published 10:25a.m. ET June 20, 2017 |

From Questionnaire 1, the frequency of product components selected by the community is collected. There are 60 participants involved in selecting the best product components that they considered should be in their dream car. Only four design features were explored to determine which will obtain the highest ratings via the given descriptive Kansei words. This is because these four design features have higher frequencies than others, as illustrated in Table 3. Table 3 shows the list of product elements in the order of their frequencies.

| No. | Product Component | Frequency | Original Word List order |
|-----|-------------------|-----------|--------------------------|
| 1   | Convenience       | 35        | Safety                   |
| 2   | Car Interaction   | 34        | Convenience              |
| 3   | Car Material      | 22        | Car Interaction          |
| 4   | Shape of Car      | 21        | Size of Capacity         |
| 5   | Size of Car       | 22        | Car Material             |
| 6   | Size of Capacity  | 25        | Size of Car              |
| 7   | Safety            | 37        | Shape of Car             |

3.5 Synthesis Space

For the space mentioned above, the Semantic Differential Method is used in Questionnaire 2. In the following steps, the two spaces were merged, and a prediction model was built, connecting the semantic space and the space of product properties together. The predictive model produced the needs to be verified using various types of post-hoc tests. Subsequently, based on Questionnaire 2, the Satisfaction with Life Scale (SWLS) questions is analysed using the SPSS Statistic 20.00. The descriptive statistics method is shown in Table 4. The results show the mean and standard deviation of each SWLS question for 60 respondents.

3.6 Descriptive Statistics

Descriptive statistics are used in this study to describe a considerable amount of data that have been collected and translated into numeral values. This section discusses and analyses data that was gathered from SPSS 20.00 to determine descriptive statistics for scores of mean and standard deviation values.
Table 4 indicates the design features in terms of car safety. The findings indicate that the ‘Easy’ element with a mean value of 4.73 is the largest mean. The lowest mean value of 3.78 belongs to the ‘Sophisticated’ element. However, the highest SD value of 1.68 is obtained by the ‘Sophisticated’ element while the ‘Easy’ element has the lowest SD value of 1.22. For the car safety features, the ‘Easy’ element shows the highest result in terms of the mean, with a value of 4.73 and lowest standard deviation value of 1.22. The result also indicates that most of the respondents agree that the ease of operation is one of the important elements to look at before buying a car. The ‘Sophisticated’ element gains the lowest mean value of 3.78 and a standard deviation value of 1.68. This result shows that most of the respondents would not prefer a sophisticated look which is not beneficial to their car safety.

Table 4. Descriptive Statistics Result from SPSS Statistic 20.00

| Satisfaction with a Life Scale | Mean | Std. Deviation |
|--------------------------------|------|----------------|
| **Safety**                     |      |                |
| Dynamic                        | 4.70 | 1.253          |
| Easy                           | 4.73 | 1.219          |
| Elegant                        | 3.88 | 1.519          |
| Personality                    | 4.47 | 1.308          |
| Positive Physical              | 4.68 | 1.242          |
| Sophisticated                  | 3.78 | 1.678          |
| Technology                     | 4.37 | 1.377          |
| Dynamic                        | 4.25 | 1.492          |
| Easy                           | 4.18 | 1.546          |
| Elegant                        | 4.17 | 1.317          |
| **Convenience**                |      |                |
| Personality                    | 4.22 | 1.415          |
| Positive Physical              | 4.47 | 1.282          |
| Sophisticated                  | 4.20 | 1.388          |
| Technology                     | 4.42 | 1.430          |
| Dynamic                        | 4.63 | 1.301          |
| Easy                           | 4.67 | 1.284          |
| Elegant                        | 4.67 | 1.217          |
| **Car Interaction**            |      |                |
| Personality                    | 4.25 | 1.297          |
| Positive Physical              | 4.63 | 1.235          |
| Sophisticated                  | 4.47 | 1.142          |
| Technology                     | 4.48 | 1.200          |
| Dynamic                        | 4.42 | 1.381          |
| Easy                           | 3.82 | 1.578          |
| Elegant                        | 3.72 | 1.519          |
| **Size of Capacity**           |      |                |
| Personality                    | 3.77 | 1.544          |
| Positive Physical              | 4.12 | 1.508          |
| Sophisticated                  | 3.75 | 1.385          |
| Technology                     | 3.98 | 1.589          |

Total participant, N 60

3.7 Correlation Component Analysis

The Correlation Coefficient Analysis (CCA) is the measure of the strength of unity between the variables. In this study, the CCA is used to examine the similarities between the Kansei’s responses to the community about the design elements of the car.

As evidenced by the simple correlation, the similarity of the Kansei responses regarding the design elements of the car are presented. Table 5 shows the correlation of certain Kansei words in relation to the safety aspects of the design. For example, ‘Dynamic’ highly correlates with ‘Easy’, ‘Elegant’, ‘Positive Physical’ and ‘Sophisticated’, which means that the ‘Dynamic’ element in the safety of the car must be considered with the ‘Easy’, ‘Elegant’, ‘Positive Physical’ and ‘Sophisticated’ elements. The details are illustrated in Table 6, Table 7 and Table 8.
4. Sustainability result
To get the desired results, only the analysis method and case study were changed to achieve the study objective which is to improve the sustainable design of the product in societal performance. There are many aspects to consider when using “sustainability” in KE. Based on the case study in this research, the aspects considered are the safety of the car, the convenience of car, car interaction and the capacity. These aspects are the consumer demands for a new car model. If these aspects are considered, the sustainability of the car model will increase.
From a social sustainability perspective, if this car is successfully invented with the incorporation of certain design features (Safety, Convenience, Car Interaction, Capacity), the probability that the customers will be fully satisfied, and the number of car users will increase. Based on this study, the data collection from Questionnaire 1 shows that the percentage of the four design features mentioned above has a high rating. However, sustainability in economic and environmental terms will also increase as these aspects are considered.

5. Conclusion

When a designer starts to make new items, they have to investigate new shapes or components that speak to the consumer’s preferences which will satisfy their requests as well as their subjective preferences. Regularly while planning, fashioners utilize their innovative plan to develop a new outline for automobile design in light of their expertise and motivation. Nevertheless, consumers have their distinct language while depicting the proposed outline of their ideas.

The paper proposes a system that joins the surmising principles and Kansei with the execution of KE. The procedure empowers the identification of the outlined ideas and trademarks that approximates certain requirements of buyers to the motivations of the designers. The system has an intent to explore a technique for KE in by establishing verifiable purchasers’ needs and examining their relations to reasonable item outlines and to produce a method for estimating the societal execution of the item plan. By utilizing this system, another auto’s plan that matches the shopper’s needs can be designed while the greater part of the outline enables the purchasers to pick configurations exclusively delivered by a designer's aptitude and instincts.

The concept and framework presented in this paper are based on previous studies involving Kansei Engineering and emotional effects. Kansei Engineering is an important solution to induce human affective responses into new product design. Recent car designs concentrate on the societal performance of sustainable product design. However, the increasing consumer demands have led to the need for designers to introduce designs of cars that induce human emotions. Of course, there is always considerable risk in adopting Kansei Engineering. Other than the culture that is known to be different even in the same region, indigenous characteristic will also need to be taken into count. A wide range of features, categorized as performance, attraction, and essentials, have been decided to be applied to current product design. The result will then improve the sustainability of product design, with an increase in the development of a societal performance indicator by using KE approach. A handful of features are successfully determined throughout the process, which if applied to the product design, will significantly satisfy users and subsequently improve its sustainability.

Acknowledgments

The authors wish to thank the Universiti Tun Hussein Onn Malaysia (UTHM) for the financial support to this work.

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