Inclusion of users’ material experience in sustainable product design: Case study of bio-based food packaging

S K Bak¹, N Sakundarini¹, and C M M Chin¹
¹Department of Mechanical, Materials, and Manufacturing Engineering, University of Nottingham Malaysia, Semenyih, 43500, Selangor, Malaysia

novita.sakundarini@nottingham.edu.my

Abstract. A user’s feeling plays a significant part in determining the success of a product design. This is because emotionally attractive design can arouse interest from a user and be able to meet his or her expectation during consumption. Nevertheless, it is hard to measure, evaluate and analyse this feeling since there is a discrepancy occurs between different user’s evaluation and lack of feasible process to be carried out. This paper presents a study on bio-based materials characterization based on users’ perception in the context of sustainable design, specifically for food packaging design. The aims of this study are to investigate the relationship of bio-based material’s characteristics and the user’s perception and develop a guideline for designers to integrate affective values into conceptual design and explore its linkage with material selection. The research approach breaks into two stages which are development of survey instrument and computer-based tool. Two surveys were carried out to obtain the affective values and the feelings evoked by the participants when they are presented with visual and tactile stimuli of the materials. Semantic differential scale and one sample t-test were used to perform the evaluation and analysis of the results. Based on the survey, significant affective values for each of bio-based materials can be identified as follow: sugar cane and starch-based materials is perceived as an eco-friendly material. Wood, paper, and palm leaf is perceived as natural material. PLA as elegant material and bamboo as strong material. This study’s quantitative method shows in detail the variation of users’ perception in terms of cognitive and affective and provide a useful proposed guideline that is applicable in any product design which involves with users’ emotional experience.

1. Introduction
Currently, the use of bio-based materials such as bioplastics and natural fibre composites increase tremendously in food packaging design due to the deployment of sustainability [1]. However, studies on how users perceive the bio-based materials in food packaging design are little known. Therefore, the characterization of their meaning is playing a dominant role specifically in material selection for sustainable food packaging design. One significant reason for this research is to promote the environmental-friendly packaging materials to minimize plastic pollution which can bring harm to the earth. Besides, the landfill problem can be reduced with the use of bio-based materials in food packaging products as they are suitable for the applications of 3R principles which are reduce, reuse and recycle in solid waste management by decreasing the amount of trash going into landfills [2]. Two approaches will be collaborated in this study which are Kansei Engineering (KE) method and Materials Driven Design Approach.
1.1. Kansei Engineering (KE) Method
This method is the process of linking the consumers’ emotional responses, also known as affective values, which includes the physical touch and psychological feelings to the properties of a product or service. It is the first to introduce a systematic investigation to translate customers’ feelings and demands into design elements [3] [4] [5]. The characteristics possessed by human can be classified into three major categories. The first category is cognitive characteristics which corresponds with typical ways of thinking, the second category is psychomotor characteristic which relates to typical ways of acting while the third category is affective characteristics which correlates with typical ways of feeling [6]. There are three specific criteria to be satisfied by affective characteristic such as intensity, direction, and target. Intensity refers to the strength of the feelings while direction relates to the positive or negative orientation of feelings and target refers to the object, idea, or activity that the feeling is being directed [6]. These criteria can be shown by the illustration of the continuum of feelings in Figure 1 such that five targets are presented, with participant 1 and 5 having the highest feeling intensity in opposite direction.

Figure 1. The continuum of feelings.

From this continuum of feelings, it shows that various type of people will response differently to a certain stimulus such that some people tend to have stronger intensity of feelings than others while some people are vice versa. Besides, different people will experience different feeling direction, i.e., participant 5 may feel tense (negative) with sharp objects while participant 1 may feel relaxed (positive) with them. Therefore, these variations of emotions elicited by participants towards the object will be the main purpose to obtain the bio-based characterization of users’ perception for sustainable food packaging design.

1.2 Material Driven Design Approach
This approach is to introduce materials at the starting point of the design process. It is about hands-on explorations and prototyping with materials. In contrast to the traditional design methodologies which are more towards sketching and visualizing, it acts as a driver of the creative “finding” process by evoking and concretizing ideas [7]. Therefore, this method is to develop more understanding of materials in design through a natural way of learning.

In product design, materials give intentional meaning of a product besides satisfying technical requirements. These considerations are taken into the field of design with different methods such as pleasure in design [8], design for experience [9], design for emotions [10] and multi-sensory design [11]. It is essential for product designers to include these concerns so that they can use materials in an efficient way to convey specific meanings. Therefore, design criteria such as cost, function, manufacturing processes, shape, availability, use and cultural aspects, characteristics of users, associations, meanings, emotions are taken into consideration in material selections for product design [12]. Besides, the meaning of a material can be brought up through the interaction between product aspects and material properties with reference to how and in which basis the material is used and who the user is, which will change from time to time [12].

In this study, the main objectives are (1) to investigate the characterization of bio-based materials based on users’ perception and (2) to develop guideline of selecting bio-based materials in sustainable food packaging design. In order to assist designers in selecting suitable bio-based materials through users’ perceptions, there are two stages of the development of guideline which are (1) survey instrument and (2) computer-based tool.
The survey instrument is a tool to implement a scientific protocol in a consistent way to obtain data from the respondents [14]. This stage involves the collection of data from the respondents to translate their feelings into design elements. Moreover, a computer-based tool developed by MATLAB is used to link each affective value to the material properties and allow the designers to choose suitable bio-based materials to be used on the food packaging design. This tool involves some coding process which acts as a system of interactive visual components for computer software [15]. It displays information that convey the results from survey instrument and allows designers to select suitable materials by interacting with the tool.

Approach of this research structured starting from implementation of survey instrument, followed by collection of results and data analysis using One Sample T-test. Then, the statistics data will be programmed through MATLAB software to develop computer-based tool. Finally, the guideline for designers to select materials will be discussed at the end of this paper.

2. Methodology
2.1 Design specification and variables
Designing the guideline for bio-based materials characterization based on users’ perception for sustainable food packaging design involves several stages which can be shown in Figure 2. The first stage is the data collection process through survey instrument where two surveys was conducted to evaluate the consumer’s understanding of affective values and feeling towards bio-based materials.

![Flowchart of methodology](image-url)
A pilot test is conducted to ensure the survey questions are clearly articulated and well interpreted by the respondents. The next stage is conducting the surveys. For the first survey, the design aspect linked to respondents’ affective values must be identified. This is the Type I application of Kansei Engineering [16]. The design aspect chosen must be related to bio-based materials in food packaging design which are sugarcane-based 3-compartment lunch box, wood cutlery, paper straw, starch-based cutlery, palm leaf plate, Polylactic Acid (PLA) cup and bamboo cup which are displayed in Figure 3.

The dependent variables for this survey are the intensity of the feeling (i.e elegant, natural and etc) elicited by the participants when presented with the choice of material. The independent variables here the list of affective values given to the participants to select.

The second survey is to relate an affective value to its material or sensory properties. The dependent variables are the sensory properties (i.e matte, hard, smooth and etc) of bio-based materials which is used in the food packaging design that are based on the sensory profile, shown in Figure 4 [13]. The independent variables are the significant affective values selected from the participants’ responses in the first survey.

![Figure 3. 7 types of bio-based food packaging products](image)

![Figure 4. Sensory profile diagram [13]](image)
2.2 Selection of participants
Two surveys were carried out and the participant profiles are as follow:
1. In the first survey, 82 Malaysian participants who are staying at Malaysia took part in the study. Majority of the participants are females (66%) from the age group of 24-29 years old.
2. In the second survey, 56 Malaysian participants took part in the study, where their responses will be used in creating the computer-based tool. 90% of them are students from University of Nottingham with age group of 24-29 years old while the rest are working adults in different occupation fields. 50% of the participants are females from age group of 24-29 years old.

2.3 Procedure
Before the pilot study is carried out, the domain of the study is required to be determined. In this research, food packaging products which are made of bio-based materials were chosen as the product domain. Then, the targeted respondents were selected such as the number of participants and the geographical area of study taking part in the survey. The questionnaires for two surveys were prepared by Google Forms as it is easy and simple to use. The purpose of each survey was explained to every participant and clear descriptions were provided in the questionnaires which act as an instruction to guide them.

In first survey, each participant was asked to rate the affective values for each bio-based food packaging products. For example, the images of each product were given as the visual stimuli. They were asked to evaluate their intensity of feeling by using 5-point Semantic Differential (SD) scale ranging from scale 1 to 5, as shown in Figure 5 [17]. This scale is used in survey to measure people’s feelings towards a certain object and allow a respondent to express a judgment using a scale of 5 points. In second survey, each participant was asked to touch each bio-based food packaging product and feel the texture through the direct interaction with the materials, which is Material Driven Design Approach. Then, they were asked to rate the sensorial properties (i.e Hard, Matte and etc) of each bio-based product that they think best associate with the tactile feelings on a 5-point SD scale, as shown in the example of Figure 6. In the later stage, a computer-based tool is designed for translating the affective values of bio-based materials into material properties.

![Figure 5. 5-point semantic differential scale of affective values for each bio-based material](image)

2.4 Designing the computer-based tool
Computer-based tool was designed to link each affective value of bio-based materials to the material properties and suggest suitable materials to be used in food packaging design for designers. It involved the design of a computer engine and database system to support Kansai process based on Type II
Kansei Engineering System [18]. This tool was generated with an App Designer function on MATLAB to design the layout of graphical user interface with the visual components and use the integrated editor to program its behaviour quickly [19].

The application interface was divided into three sections and was designed to be as convenient and simple for designers to use. In the first section, a dropdown menu with the list of affective values obtained from the first survey was created. The second section is the list of sensory properties of bio-based materials and was coded to be enabled if the ‘OK’ button of the dropdown menu in first section was pressed. Once the desired affective value was selected, only the sensory properties which were related to the affective value that are obtained from the first survey will be enabled for selection. For this stage, the dropdown menu will be disabled for another selection to pin down the designer’s choice and prevent overwriting of the coding. The coding to link the first section and second section were made based on the participant’s responses from the second survey of the study as it highlights on the significance of the existing cause and effect relationship between affective factors in users and design variables in Kansei Engineering [3]. Next, the third section will be the material suggestion list, where only the materials that satisfy the selected sensory properties will appeared after the ‘Select’ button was pushed. Each material name was programmed to display only if the sensory properties satisfy more than half (>50%) of the selected properties in the second section of the tool. This acts as a threshold to ensure the results are accurate.

A custom-made profile sheet for each material was created and coded to a separate pop-up window when their button is pressed. There are a complete set of specific information about the materials such as the sensory profile, description, eco-efficiency, material end of life and environmental impact, obtained from CES EduPack 2017. Besides that, an image for the material was attached for designers to act as reference.

![Figure 6. 5-point semantic differential scale of sensory properties for each bio-based material](image)

3. Results and discussion

3.1 Survey 1: Quantitative analysis of the affective values

The 5-point Semantic Differential (SD) scales evaluated by participants were analysed statistically to determine the most significant affective values in attributing the meaning to each bio-based material. A One Sample T-test was executed to compute importance of affective values for seven types of bio-based food packaging products which are sugarcane-based 3-compartment lunch box, wood cutlery, paper straw, starch-based cutlery, palm leaf plate, Polylactic Acid (PLA) cup and bamboo cup.

For sugarcane-based material, the overall mean score for 10 sets of affective values was taken as the test value for the one sample T-test. Bold items in Table 1 shows the affective values that showed scores significantly above or below the overall mean score (2.53). If the sig (2-tailed) is less than 0.005, it indicates there is significant difference from mean value. The significantly above the mean
score are shown with a minus sign (-). In this case, weak (2.84) and dull (2.88) were significantly higher (-) than the overall mean while eco-friendly (2.09) was significantly lower than the overall mean (i.e. sugarcane-based material was commonly weak, dull and eco-friendly). However, weak and dull affective values were eliminated as they were not suitable to be included in the computer-based tool due to their negative meanings.

For wood material, which is same as the previous material, the overall mean score for 10 sets of affective values was taken as the test value for One Sample T-test. Bold items in Table 2 show the affective value that got scores significantly above or below the overall mean score (1.77). In this case, natural (1.45) and healthy (1.49) were significantly lower than the overall mean while unimportant (2.04) was significantly higher than the overall mean (i.e wood material was commonly natural, healthy and unimportant. Unimportant was rejected due to its negative meaning.

Table 1. Results of the one sample T-test of affective values for sugarcane-based material

| Test Value | t   | df | Sig (2-tailed) | Mean |
|------------|-----|----|----------------|------|
| Elegant - Ugly | -0.126 | 82 | 0.900 | 1.76 |
| Natural - Artificial | -5.493 | 82 | 0.000 | 1.45 |
| Strong - Weak | 0.807 | 82 | 0.422 | 1.85 |
| High-quality - Low-quality | 0.869 | 82 | 0.387 | 1.85 |
| Special - Ordinary | 1.878 | 82 | 0.064 | 1.98 |
| Attractive - Dull | 1.371 | 82 | 0.174 | 1.91 |
| Healthy - Unhealthy | -5.072 | 82 | 0.000 | 1.49 |
| Vital - Unimportant (-) | 2.515 | 82 | 0.014 | 2.04 |
| Eco-friendly - Eco-unfriendly | -1.390 | 82 | 0.168 | 1.63 |
| Genuine - Fake | -0.404 | 82 | 0.687 | 1.73 |

Table 2. Results of the one sample T-test of affective values for wood material

| Test Value | t   | df | Sig (2-tailed) | Mean |
|------------|-----|----|----------------|------|
| Elegant - Ugly | -1.822 | 82 | 0.072 | 2.33 |
| Natural - Artificial | -0.220 | 82 | 0.826 | 2.50 |
| Strong - Weak (-) | 2.604 | 82 | 0.011 | 2.84 |
| High-quality - Low-quality | 1.155 | 82 | 0.252 | 2.66 |
| Special - Ordinary | 1.877 | 82 | 0.064 | 2.76 |
| Attractive - Dull (-) | 2.796 | 82 | 0.006 | 2.88 |
| Healthy - Unhealthy | -0.587 | 82 | 0.559 | 2.45 |
| Vital - Unimportant | -1.825 | 82 | 0.072 | 2.32 |
| Eco-friendly - Eco-unfriendly | -3.103 | 82 | 0.003 | 2.09 |
| Genuine - Fake | -0.598 | 82 | 0.552 | 2.45 |
Same quantitative analysis to obtain significant affective values for another five bio-based materials which are paper, starch-based, palm leaf, polylactic acid (PLA) and bamboo materials were carried out and the results were compiled and presented in Table 3.

Table 3. Compilation of significant affective values for seven types of bio-based materials

| Test value = 2.32 | t    | df | Sig.(2-tailed) | Mean |
|------------------|------|----|----------------|------|
| Hard - Soft      | 1.542| 56 | 0.129          | 2.52 |
| Smooth – Rough (-) | 4.176| 56 | 0.000          | 2.88 |
| Matte - Glossy  | -2.856| 56 | 0.006          | 1.89 |
| Not reflective - Reflective | -9.436| 56 | 0.000          | 1.30 |
| Opaque - Transparent | -16.807| 56 | 0.000          | 1.09 |
| Tough - Ductile | 1.765 | 56 | 0.083          | 2.63 |
| Light - Heavy   | -2.407| 56 | 0.019          | 2.02 |
| Moist – Dry (-) | 13.125| 56 | 0.000          | 4.25 |

3.2 Survey 2: Quantitative analysis of the sensory properties

For the second survey, same quantitative analysis was done. The 5-point sensorial scale evaluated by participants were analysed statistically to determine the most significant sensory properties belonged to each bio-based material. A One Sample T-test was performed again to evaluate significance of sensory properties for seven types of bio-based food packaging product.

For sugarcane-based material, the overall mean score for 8 sets of sensory properties was taken as the test value for the One Sample T-test. Bold items in Table 4 shows the sensory properties that obtained scores significantly above or below the overall mean score (2.32). If the sig (2-tailed) is less than 0.005 so it indicates there is significant difference from mean value. The significantly above the mean score are shown with a minus sign (-). In this case, rough (2.88) and dry (4.25) were significantly higher than overall mean while not reflective (1.30), opaque (1.09) and light (2.02) were significantly below than the overall mean (i.e sugarcane-based material was commonly rough, dry, not reflective, opaque and light).

Table 4. Results of the one sample T-test of sensory properties for sugarcane-based material

| Test value = 2.01 | t    | df | Sig.(2-tailed) | Mean |
|------------------|------|----|----------------|------|
| Hard - Soft      | 1.764| 56 | 0.083          | 2.29 |
| Smooth - Rough   | -0.532| 56 | 0.597          | 1.95 |
| Matte - Glossy  | -0.386| 56 | 0.701          | 1.96 |
| Not reflective - Reflective | -5.774| 56 | 0.000          | 1.41 |
| Opaque - Transparent | -24.034| 56 | 0.000          | 1.09 |
| Tough - Ductile | 1.451 | 56 | 0.152          | 2.23 |
| Light - Heavy   | -39.071| 56 | 0.000          | 1.04 |
| Moist – Dry (-) | 15.404| 56 | 0.000          | 4.14 |
For wood material, same steps were carried out and bold items in Table 5 show the sensory properties that got scores significantly above or below the overall mean score (2.01). In this case, not reflective (1.41), opaque (1.09), light (1.04) were significantly lower than the overall mean while dry (4.14) was significantly higher than the overall mean (i.e wood material was commonly not reflective, opaque, light and dry).

Same quantitative analysis to obtain significant sensory properties for another five bio-based materials which are paper, starch-based, palm leaf, polylactic acid (PLA) and bamboo materials were carried out. All the results obtained from One Sample T-test to determine the significant sensory properties were compiled in Table 5 below.

**Table 5.** Results of the one sample T-test of sensory properties for wood material

| Type of bio-based materials | Significant sensory properties |
|-----------------------------|-------------------------------|
| Sugarcane-based             | rough, dry, not reflective,   |
|                             | opaque, light                 |
| Wood                        | not reflective, opaque, light,|
|                             | dry                           |
| Paper                       | smooth, not reflective, opaque,|
|                             | light, ductile, dry           |
| Starch-based                | hard, smooth, glossy, reflective, |
|                             | opaque, light, dry            |
| Palm leaf                   | soft, rough, matte, not       |
|                             | reflective, opaque, ductile,  |
|                             | light, dry                    |
| Polylactic Acid (PLA)       | smooth, glossy, transparent,  |
|                             | light, dry                    |
| Bamboo                      | hard, smooth, not reflective, |
|                             | opaque, tough, heavy, dry     |

**Table 6.** Compilation of significant sensory properties for seven types of bio-based materials

| Type of bio-based materials | Significant affective values |
|-----------------------------|-----------------------------|
| Sugarcane-based             | Eco-friendly                |
| Wood                        | Natural, Healthy            |
| Paper                       | Natural, Eco-friendly,      |
|                             | Genuine                      |
| Starch-based                | Eco-friendly                |
| Palm leaf                   | Natural, Special, Genuine   |
| Polylactic Acid (PLA)       | Elegant                     |
| Bamboo                      | Strong, Attractive           |

Therefore, according to Table 3 and Table 6, the sensory properties for each bio-based material can be related to its affective value. The results from survey 1 can be linked to survey 2 which are shown in Figure 7. For instance, in the case of PLA material, the significant affective value obtained was elegant and the significant sensory properties obtained were smooth, glossy, transparent, light and dry.
Hence, it shows that an elegant bio-based material should perceive the sensory properties such as smooth, glossy, transparent, light and dry. This approach is based on the fundamentals of user experience, in the way of how human approach to materials, sense them and attribute meanings to them. The interaction with materials through products are significant as the sense elicited by the users can be evaluated and linked to material properties [7].

![Diagram](image)

**Figure 7.** The linkage of survey 1 to survey 2 in the case of PLA material

These statistics were coded into computer-based tool as a guideline to aid designers in food packaging product design. In the computer-based tool, designers can choose their desired affective values from the dropdown menu in first section, as shown in Figure 8(a). After ‘elegant’ was selected and ‘OK’ button was clicked, the sensory properties which were coded to link to the selected affective values were displayed in the second section, as shown in Figure 8(b). The designers can manipulate and select their favourite sensory properties by ticking the checkbox.

After ‘Select’ button was clicked, a suggestion list of suitable materials will appear in third section, in this case was PLA material which is shown in Figure 8(c). Figure 8(d) is to provide detailed material information for PLA material after clicking the material button.

This paper has introduced a useful guideline to enhance the affective design of bio-based materials in food packaging product. This experimental design approach has been implemented to achieve the optimal bio-based food packaging design by adding aesthetic attributes of materials in the material selection for designers while allowing users to interact with materials through products. The proposed method has been examined for the case of bio-based food packaging design. It has been demonstrated that the method has successfully improves the affective design problems of the bio-based food packaging products, i.e. the affective values and sensory properties of seven types of bio-based materials in food packaging design are determined in this proposed method and a computer-based tool is created for designers.

This proposed guideline is suitable for a multiple range of applications due to its simplicity and ease of implementation. It can be applied to any design problems which requires aesthetic attributes of material into material properties in product design. These benefits allow the proposed guideline to support many tasks involved to obtain users’ perception by providing a systematic method which is both efficient and flexible. However, this guideline has few limitations. It is found that the evaluation of certain feelings is hard to be determined sometimes. The significance of certain affective values and sensory properties have less influence, such that most of the respondents choose scale 3 (neutral) from scale 1 to scale 5 as their intensity of feelings. Thus, it is possible that the aesthetic attributes of materials might not have been enhanced through this approach.
4. Conclusions

In this study, it is proven that affective values can be included into sustainable product design, and one of them is in food packaging design. Based on the survey, significant affective values for each of bio-based materials can be identified for example sugar cane and starch-based materials is perceived as an eco-friendly material. Wood, paper, and palm leaf is perceived as natural material. PLA as elegant material and Bamboo as strong material. It showed that by selecting specific feelings evoked by the users when they visualize and touch the texture on certain component such as seven types of bio-based packaging products, the designers can manipulate the meanings by linking them to their material properties. The computer-based tool was designed with two research keys such as bio-based and perceptual aspects to help the designers in the material selection process to select the most suitable bio-based materials in food packaging design. This proposed design guideline covered the research area of bio-based in food packaging design, which was never done in the previous research. By adhering to the guidelines, it is possible to select the most suitable bio-based materials in sustainable product design without sacrificing user satisfaction by bringing benefits to the environment in future.

5. References

[1] A Nura 2018 Advances in food packaging technology-A review J. Postharvest Techno vol. 6 no 4 pp. 55–64.
[2] Our attitude can save the environment [Online] Available: https://www.nst.com.my/opinion/letters/2018/12/437694/our-attitude-can-save-environment [access 23 November 2020]
[3] S W. Hsiao and C H. Chen 1997 A semantic and shape grammar based approach for product design Studies vol 18 issue 3 pp 275-296.
[4] T Jindo and K Hirasago 1997 Industrial Ergonomics Application studies to car interior of Kansei engineering International Journal of Industrial Ergonomics vol 19 issue 2 pp 105-114.
[5] T Moulson and G Sproles 2000 Styling Strategy Business Horizons vol 43 issue 5 pp 45-52.
[6] L W Anderson and S F Bourke 2000 Assessing Affective Characteristics in the Schools, vol 1, no. 4.
[7] E Karana and V Rognoli 2014 Materials Experience: Fundamentals of Material and Design.
[8] P W Jordan 2002 Designing Pleasurable Products: An introduction to the new human factors, vol. 53, no. 9.
[9] H N J. Schifferstein and P. Hekkert 2008 Product Experience.
[10] P Desmet 2002 Designing emotions Des. J vol. 6 no 2 pp. 2–4.
[11] H N J Schifferstein 2011 Multi Sensory Design Proc. DESIRE’11 Conf. Creat. Innov. Des pp. 361–362.
[12] E Karana P Hekkert, and P Kandachar 2010 A tool for meaning driven materials selection Mater. Des., vol. 31, no. 6, pp. 2932–2941.
[13] E Karana 2009 Meanings of Materials.
[14] OBSSR e-Source - Sample Surveys - 6. Developing a Survey Instrument [Online]. Available: http://www.esourceresearch.org/eSourceBook/SampleSurveys/6DevelopingaSurveyInstrument/tabid/484/Default.aspx [access 23 November 2020]
[15] What is a GUI (Graphical User Interface)? [Online]. Available: https://www.computerhope.com/jargon/g/gui.htm. [access 23 November 2020]
[16] M Nagamachi 1999 Kansei Engineering and its Applications in Automotive Design SAE Tech. Pap.
[17] B Frey 2018 The SAGE Encyclopedia of Educational Research Measurement, and Evaluation.
[18] S T W Schütte, J Eklund, J R C Axelsson, and M Nagamachi Concepts, 2004 Methods and Tools in Kansei Engineering Theory. Issues Ergon. Sci., vol. 5, no. 3, pp. 214–231.
[19] MATLAB App Designer - MATLAB [Online]. Available: https://www.mathworks.com/products/matlab/app-designer.html. [access 23 November 2020]
[20] M Nagamachi 1995 Kansei Engineering: A new ergonomic consumer-oriented technology for product development International Journal of Industrial Ergonomics, vol 15 issue 1.
[21] K Bongard-Blanchy C Bouchard A Aoussat 2013 Limits of Kansei - Kansei unlimited International Journal of Affective Engineering vol. 12, no. 2, pp. 145–153.