Emotional User Experience in Web-Based Geographic Information System: An Indonesian UX Analysis

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Summary
In the discipline of design science, the integration of cognitive, semantic, and affective elements is crucial in the conception and development of a product. Affective components in IT artefacts have attracted researchers' attention, but little attention has been given to Geographic Information Systems (GIS). This research was conducted to identify emotions in web-based GIS, and determine design influences on the emotions using Kansei engineering (KE). In the evaluation procedure, ten web-based GIS were used as specimens, and 20 Kansei words were used as emotional descriptors in the Kansei checklist. 50 participants were asked to rate their emotional responses towards the specimens on the Kansei checklist. Principal Component Analysis was used to discover the semantic structure of Kansei, in which dynamism and spaciousness were identified. Significant Kansei concepts were identified using Factor Analysis, in which dynamic & well-organized, refreshing, spacious, professional, and nautical-look were identified. Partial Least Square analysis has assisted the research in discovering the significant design influence to the Kansei. These findings provide designers and other stakeholders with valuable knowledge for strategizing future web-based GIS designs that incorporate user emotions.
Keywords:
Emotional UX, Geographic Information System (GIS), Kansei Engineering

1. Introduction

User Experience (UX) and User Interface (UI) are crucial aspects of user satisfaction in system design. Emotional UX has been gaining interest among researchers, designers, and other stakeholders throughout the world. As the interaction between social, cognitive, and biological processes in emotion becomes more tractable, emotional concepts have been researched comprehensively using theories and methodologies.

In the context of Geographic Information Systems (GIS), the investigation into UX and UI is to provide information on the distribution of data in the form of geospatial data that provides value for the benefit of the users. Geographic Information Systems (GIS) are multidisciplinary systems that combine integrated data with geographical data (Hamidi, 2012). Several GIS studies have been conducted in the past, including mapping Raskin assistance (Leni, Azro, & Robinson, 2019), detecting crime (Munthe, 2021), and mapping the distribution of traditional Samarinda souvenir shops (Annugerah, Astuti, & Kridalaksana, 2016). Other studies have been conducted on regional assets, such as the Regional Asset GIS research at Cirebon City's Badan Pengelolaan Keuangan dan Aset Daerah (BPKAD), focusing on producing spatial data that depicts regional assets in the form of social and public infrastructure (Salam & Fahmi, 2019). Another study is the Utilization of Geographic Information Systems in Regional Tourism Development, which begins with data input and progresses through the stages of map creation, data manipulation, file management, query analysis, and output visualisation (Purnaweni & Riwayatiningsih, 2017).

However, it was argued in GIS that affective/emotional outcomes should be given more attention. An initial investigation into UX with web-based GIS reveals that the information delivered is boring and repetitive, less informative, and rigid, resulting in user dissatisfaction with information access, despite the fact that the information presented is critical to the users. Hence, the aim of this research is to provide understanding on emotional UX in web-based GIS, and provide a clue on the DE that affect the emotion. The study obtains the research data by evaluating users' Kansei responses to selected GIS specimens and then analyses the data to determine semantic space, significant Kansei structure, and association between the Kansei responses and the web-based GIS DE.

2. Research Background

2.1 User Experience

The word "UX" can refer to a variety of things, such as the usefulness of hedonic resources or the measuring of user attachment or feelings during encounters with

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technology (Nagalingam & Ibrahim, 2015). Analysis, business strategy, planning, concept, and participative design, as well as cultural and organisational changes, are all part of the UX process (Zaharias & Mehlenbacher, 2012). In certain circumstances, usability and interface design are considered identical with UX. The UX notion, on the other hand, is wider and more inclusive. According to ISO 9241-210, user experience (UX) is described as a user's perceptions and responses to a product, system, or service throughout its usage (Bevan, Carter, Earthy, Geis, & Harker, 2016). As a result, internal qualities of users, such as predispositions, expectations, requirements, motivation, and mood, may be characterised as subjective UX features (Zaharias & Mehlenbacher, 2012). So, UX can be summed up as a dynamic process that changes over time and has two key features: standard Human-Computer Interaction (HCI) usability and accessibility combined with hedonic and emotional design (Carneiro, Rebelo, Filgueiras, and Noriega, 2015; Zaharias and Mehlenbacher, 2012).

Therefore, UX includes cognitive components of activity as well as emotional design ideas and usability tests (Nogueira, Ferreira, & Ullmann, 2019). According to Bevan *et al*. (2016), cognitive aspects or distributed cognition is a complicated topic that is socially situated between technology and user interaction, considering the environment, human characteristics, and technical instruments. New issues for HCI specialists to deal with the advancement of interaction design come because of this conceptual shift in usability for UX (Nogueira *et al*., 2019). According to Nagalingam and Ibrahim (2015), academics are putting in a lot of effort to quantify UX on the web, especially when it comes to the subjective components that surface during web interactions.

2.2 Website Emotion

Emotions play an important role in human creativity and intellect, as well as logical human thinking and decision-making. Computers that will communicate organically and intelligently with humans must be able to perceive and express emotion at the very least (Lisetti, 1998). Rao (2016) argues that emotions play a significant part in every computer-related activity. Any interface that overlooks users' emotional state or fails to exhibit the proper mood can impair performance, highlighting the necessity of researching emotions in relation to technology (Brave & Nass, 2002). Users' emotions must be considered while developing information systems and services (Dufresne, 2010).

Studies on website emotion have been increasing in many areas, such as in computing (Donati, Mori, & Paternò, 2020; Hartono, 2019), education (Abdi & Greenacre, 2020; Nogueira *et al*., 2019; Turumogon *et al*., 2019; Yamamoto, Kawahara, & Tanaka, 2021), and business (Ashraf *et al*., 2019; Thakur & AlSaleh, 2020). In terms of emotion, Thakur *et al*. (2020) found that users feel sadness, anger, disgust, fear, elation, or happiness about the company's website when purchasing products and services. Studies by Donati *et al*. (2020) and Mori *et al*. (2015) discussed hate, anxiety, boredom, love, serenity, and fun. On the other hand, in terms of design features, Bufquin *et al*. (2020) discovered that the number of pictures boosts the satisfaction of visual processors, while extensive descriptions raise their stress). According to Mori, Paternò, and Furci (2015), it is not significant that colours are not regarded as a primary factor in eliciting emotions. Another research investigated links between emotion and the website background colour, header colour, footer colour, gallery, logo, main menu, multilingual feature, search bar, utilities bar, news section, other categories, link type, font sizes, and font colours (Ginting & Hadiana, 2018; Gomesheh, Zadeh and Kazemifard (2015); Turumugon et al., 2019).

2.3 Geographic Information System (GIS)

Sometime after HCI had been formalised as a research subject and usability had been established as a significant research area, interest in GIS concepts and interface design arose from the necessity to serve a broad range of user requirements and tasks. In research by Lew et al. (2010), even though there is a significant amount of unused white space on the right-hand side of the website, the search box is clearly visible. The limited map size, which is further obstructed by the legend, is, nonetheless, a considerable issue. Although a prior study by Skarlatidou, Cheng and Haklay (2013) showed that people prefer large map interfaces, it is unknown whether map size increases trust perceptions. Because it provides more spatial elements on the same map tile, a large map size aids spatial cognition. The need to drag the map is eliminated, as is the risk of losing any reference points while navigating the map. Previous research has connected satisfaction to trust and loyalty (Guinalı & Flavia, 2005), so it is thought that a larger map interface would provide users more power, confidence, and satisfaction, all of which would improve their trust in the system. Sometimes, being common may be one of the reasons why GIS looks dull to the user. Some tweaks in the interface of GIS may increase the favourable of users, such as a 3D projection. Research done by Li et al. (2015) found that the 3D city platform scored very well, showing that it is a good substitute for a 2D web map with a 2D spatial database.

In recent years, mobile GIS has had a major increase in popularity, and its typical usage context, namely professional GIS users such as surveyors and cartographers, has increased. Mobile geospatial applications that deliver location-based services are used by a larger and more diverse group of people. The human-computer interaction issues associated with GIS usage in a mobile setting lend themselves to a solution to this problem, focusing on the limited engagement modalities available to mobile GIS users, which can lead to an increase in interaction complexity.

3. The Method

The study collected two types of data: emotional responses (Kansei) of GIS users to Web-based GIS user interface (UI) and Web-based GIS DE. **Fig. 1** illustrates the research process. In began with instrumentation, in which divided to i) preparation of specimen, and develop DE matrix, ii) preparation of domain specific KW, and develop Kansei checklist, and iii) identify evaluation subjects.

Web-based GIS samples were chosen based on visible design differences and analysed using predefined specimen identification rules. To classify DE and attributes, such as colour, typography, and map attributes, a DE versus specimen matrix was used. This matrix was then used as the specimen analysis instrument. Based on the results of the analysis, 10 specimens were finally determined to be valid specimens using KE rules. **Fig. 2** depicts examples of web-based GIS specimens. KW were synthesised based on several sources, including the perceptions of researchers, GIS users, general users, and web designers. The synthesis was focused on domain-specific KW, which is a representation of the user's emotional experience. 20 KW were identified and composed into a checklist comprised of the KW on a 5-point SD scale.

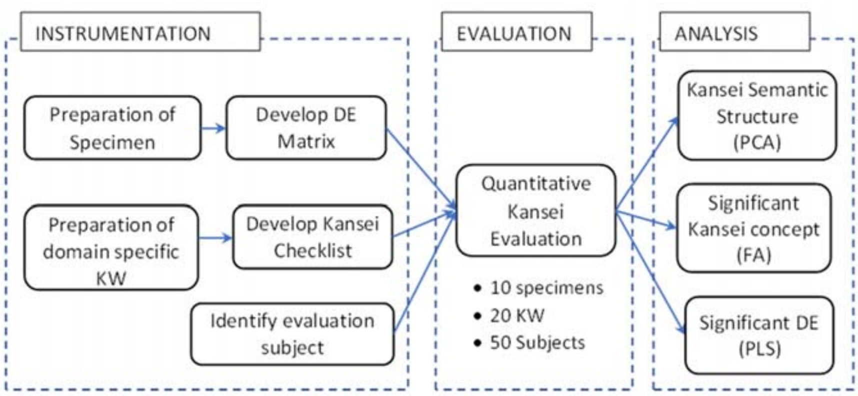

Fig. 1 The research process.

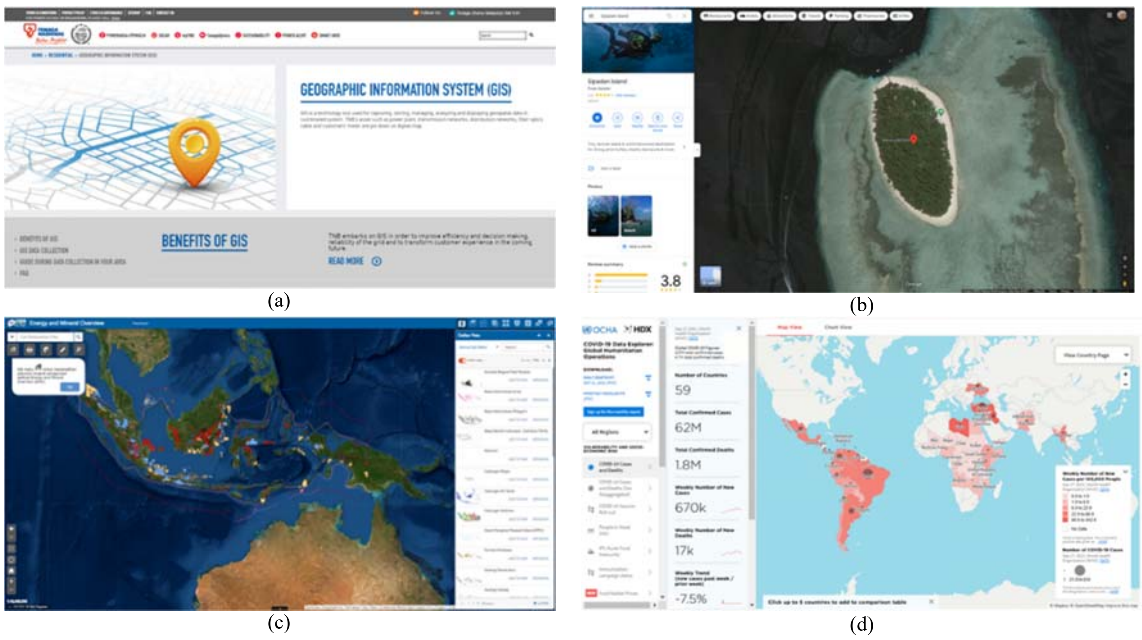

Fig. 2 Examples of Web-based GIS UI.

Purposive sampling was carried out among GIS users in Palembang, Indonesia. The study recruited 50 subjects based on the rules specified in KE to undertake specific target users (Lokman & Nagamachi, 2009), i.e., GIS users, as evaluation subjects in the study. Accordingly, fifty users with prior experience using Web-based GIS were recruited and participated as respondents in the Kansei evaluation procedure.

The ten specimens were shown to participants one by one on a computer screen in a systematic and controlled manner. Participants were asked to rate their emotional impressions on the Kansei checklist using the scale provided. The Kansei Words identified by Novianti *et al*. (2022) were used in the study, and these words were organised in a 5-point Semantic Differential (SD) scale to form a checklist. Specific rules were followed in the preparation of screenshots prior to the evaluations. They were also given the opportunity to become acquainted with the specimen before the evaluation began. To eliminate bias, the order of the KW in the checklist was also changed. Multivariate analysis was then performed to the averaged evaluation data to discover i) the semantic structure that forms from the evaluation results by PCA, ii) the significant Kansei concept that forms from the evaluation data by FA, and iii) the significant DE that are associated with the Kansei responses by PLS analysis.

4. Results and Discussion

4.1 The Semantic Structure

The research analysed the Kansei semantic structure for Web-based GIS by principal component analysis using the average evaluation result from the Kansei evaluation session. The result shows that the first principal component (PC1) (eigenvalue: 9.37, contribution ratio: 46.87%) can be represented as a spaciousness concept, and the second principal component (PC2) (eigenvalue: 3.66, contribution ratio: 18.32%, cumulative contribution ratio: 77.04%) is represented as an intenseness concept from the evaluation. Together, the first two principal components represent most of the data structure, which means the structure of Kansei words is highly influenced by the first two principal components. The remaining principal components have very little influence on the Kansei structure and can be ignored. The study then identified the semantic structure of Kansei words from the analysis results. The structure is illustrated by PC Loadings (**Fig. 3**). Figure 3 shows PC loadings for the first and second principal components from the evaluation result. The research could observe that Web-based GIS with a high score on the first principal component has a high characteristic of dynamism.

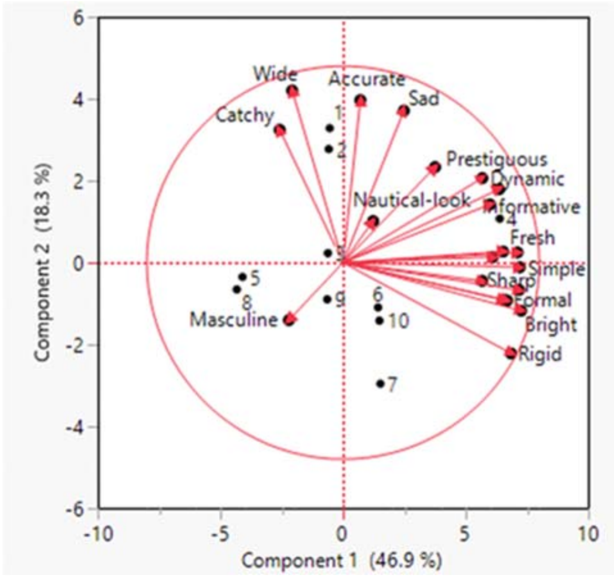

Fig. 3 The Kansei semantic structure.

The research, on the other hand, discovered that Web-based GIS with a high score over the second principal component has a high characteristic of spaciousness. Thus, PCA performed on the evaluation result has enabled the study to identify Kansei semantic structure and the mapping of Web-based GIS accordingly. The result enables the research to conclude that the Kansei structure on Web-based GIS has two components, which are dynamism and spaciousness. In addition, blending and balancing these two components is the basis for the new concept of Web-based GIS design.

4.2 The Significant Kansei Concept

The research discovered the significant concept of Kansei by the use of Factor Analysis (FA). **Table 1** shows the result of FA after varimax rotation (used to simplify variable interpretation). It is evident from the table that the first factor explains 29.27%, the second factor explains 22.50%, the third factor explains 15.47%, and the fourth factor explains 14.78% of the variables. These factors accumulated to 82.02% of the variables and represented the majority of the factor contributions. This shows that factors 1-4 have dominant influence on the respondents' Kansei. The proportion of variability explained by the rest of the factors are minimal (<2) and can be considered insignificant.

Table 1: Factor contribution table.

Factor	***Variance***	***Percent***	***Cumulative Percent***
1	5.854	29.27	29.27
2	4.4996	22.498	51.768
3	3.0945	15.473	67.241
4	2.9549	14.775	82.016
5	1.8434	9.217	91.232

Table 2: Factor loading.

Variable	*Factor 1*	*Factor 2*	*Factor 3*	*Factor 4*	*Factor 5*
Sharp	0.95732	-0.05169	-0.08697	0.02393	0.20989
Calm	0.77672	0.51940	-0.03001	-0.12537	0.06589
Formal	0.76902	0.43109	-0.07790	-0.15115	0.06814
Dynamic	0.75224	0.18695	0.23389	0.50209	-0.25413
Simple	0.74482	0.52208	-0.06088	0.10689	-0.09716
Rigid	0.73720	0.49347	-0.34664	-0.24672	-0.03503
Bright	0.71686	0.62195	-0.14275	-0.12836	-0.18108
Informative	0.67780	0.27464	0.09092	0.36226	0.26778
Fresh	0.21851	0.87035	-0.18019	0.26060	-0.15840
Cool	0.33769	0.76029	-0.24515	0.37110	-0.03624
Natural	0.40334	0.73824	0.30137	0.19103	0.31821
Well-arranged	0.55652	0.68506	0.01748	0.02099	0.43333
Gloomy	0.46426	0.59240	-0.41503	0.14063	0.37558
Catchy	-0.13488	-0.20563	0.90979	-0.00899	0.05973
Wide	-0.15157	-0.18105	0.89514	0.28238	0.20710
Prestigious	0.45411	0.35030	0.68746	0.05711	-0.32590
Masculine	-0.00745	-0.11634	0.41337	-0.86245	-0.21037
Accurate	-0.04992	0.03655	0.30727	0.91689	-0.11074
Sad	0.01353	0.33793	0.37614	0.71373	0.13828
Nautical-look	0.07526	0.02063	0.09199	0.06616	0.96218

Table 2 shows factor loading results in ascending order, which enables the observation of the significant Kansei. Variables that have a high score are perceived as significant factors in Web-based GIS design. The research set approximately 0.75 as the observation threshold. The tables show that the Kansei concept is structured by the first 4 factors. The first factor consists of sharp, calm, formal, and dynamic. The research labels this factor as a dynamic & well-organized concept. The second factor consists of fresh and cool, and can be represented as the concept of refreshing. The third factor consists of catchy and wide and is labelled as a spacious concept. The fourth factor is labelled as the concept of professional. Lastly, although the fifth factor contribution is small (1.84), there was an observable large loading score for nautical-look. Hence, the research suggests including the factor. These five factors explain 91.23 percent of all the data, and they are important ideas for designing a Web-based GIS that includes a Kansei concept.

Thakur et al. (2020) found that users feel sadness, anger, disgust, fear, elation, or happiness about the company's website when purchasing products and services for their business. Donati et al. (2019) and Mori et al. (2015) discussed hate, anxiety, boredom, love, serenity, and fun as the emotions measured in web interfaces. This research findings add to the body of knowledge, a new set of significant emotions in web-based systems: sharp, dynamic and well-organized, refreshing, spacious, professional, and nautical-look. This suggests that Web-based GIS should include these concepts in order to produce the desired result.

4.3 The Significant DEs

A Partial Least Square (PLS) analysis was performed to identify relationships between emotion and DE. The results were used to discover the influence of DE on each Kansei. In the research, three sets of data were used for this analysis, and they were: 10 sets of Kansei responses by 50 subjects; 10 Web-based GIS specimens; and the DE matrix. The investigation of DE in the earlier phase of this research has resulted in eight design attributes and 40 values. For PLS analysis purposes, all these elements were converted into dummy variables. **Table 3** shows instances of the PLS scores.

In order to determine the influence of DE on Kansei, the PLS range for each Kansei was calculated. The calculation of range enables the identification of design influence, based on the higher score as compared to the average range value. The results were then sorted based on descending order to show the highest to lowest influence of DE on each Kansei. **Table 4** shows the sorted results for influential DE for dynamic and well-organized, refreshing, spacious, professional, and nautical concepts.

The result suggests that to design a dynamic & well-organized Web-based GIS, the designer must set priorities to DE according to the higher to lower order influence, i.e., map style and colour, dynamic map, having left menu in picture form, having Google Earth feature, and so on. On the other hand, to design a refreshing Web-based GIS, the designer must set priorities to DE according to the higher to lower influence, i.e., map colour, dynamic map auto focus, top menu, icon style, footer font colour, and the rest follows.

Similar studies by Ginting and Hadiana (2018), Gomesheh, Zadeh and Kazemifard (2015), and Turumugon et al. (2019) found that the website background colour, header colour, footer colour, gallery, logo, main menu, multilingual feature, search bar, utilities bar, news section, other categories, link type, font sizes, and font colours have links to website emotion. However, they did not provide the specific design attributes and their significance to the emotion. This study, other than discovering the significant design elements that affect users' emotional UX, has extended the ability to discover specific and significant design attributes associated with the emotional UX. The analysis has also enabled the research to discover the design attributes that are most significant to a specific Kansei design concept. In a dynamic & well-organized Web-based GIS, for example, the map style should be digital, the map colour should be black-gray, the map dynamic auto focus should be to location, the left menu should be in the form of a picture and small, the map should have Google Earth feature, and so on. The specific design attributes that highly influence the users' emotional UX for each Kansei concept can be found in **Table 4**.

Table 3: Instances of PLS scores.

Design Elements	***Sharp***	***Formal***	***Simple***	***Informative***	***Dynamic***
Map Colour: Green-Yellow	-0.0064	-0.0164	-0.0015	-0.0103	0.0213
Map Colour: FullColour	0.0348	0.0532	0.0277	0.0017	0.0014
Map Colour: Pinkish	-0.0328	-0.0299	-0.0250	-0.0467	-0.0148
Map Colour: Reddish	0.0260	-0.0120	-0.0048	0.0529	0.0297
Map Style: Dynamic Auto Focus Location	0.0086	-0.0050	0.0177	0.0066	0.0453
Map Style: Dynamic Real Time Data	0.0093	-0.0148	-0.0003	0.0331	0.0331
Map Style: Dynami cCategorical Layer Map	-0.0302	-0.0423	-0.0263	0.0045	-0.0142
Map Style: Dynamic Map Variation	0.0097	0.0144	-0.0007	-0.0071	-0.0266
Map Style: Dynamic Interactif Scroll Info	0.0241	0.0262	-0.0017	-0.0002	-0.0054
Map Style: Dynamic Dot Locator	-0.0137	-0.0077	0.0044	-0.0087	0.0144
Map Style: Dynamic Area Locator	0.0126	0.0228	0.0353	0.0351	0.0305
Map Search Field: Yes	-0.0376	-0.0107	0.0049	-0.0395	-0.0182
Map Search Field: No	0.0376	0.0107	-0.0049	0.0395	0.0182

Table 4: The significant DE to Kansei.

Dynamic & Well-Organized	***Refreshing***	***Spacious***	***Professional***	***Nautical***
Map Type: Digital	Right-Menu Exist: Yes	Map Colour: Black-Gray	Left-Menu Picture: Yes	Map Source Data Info: Yes
Map Colour: Black-Gray	Right-Menu: Picture	Map Style: Dynamic Auto Focus Location	Left- Menu Picture Size: Small	Top-Menu Shape: Rounded-Rec
Map Style: Dynamic Auto Focus Location	Right-Menu Picture Size: Small	Top-Menu Position: Left	Map Google Earth: Yes	Map Colour: Black-Gray
Left-Menu Picture: Yes	Right-Menu Font Style: Sans-serif	Top Style: Icon	Top-Menu Position: Left	Map Lat/Lon: Yes
Left-Menu Picture Size: Small	Right-Menu Font Colour: White-Black-Blue	Footer-Font Colour: White	Top-Menu Shape: Rounded-Rec	Map Search Field: Yes
Map Google Earth: Yes	Header Font Style: Sans-serif	Top-Menu Bg Colour: Gray	Map Style: Dynamic Auto Focus Location	Top-Menu Position: Left
Header Font Size: Small	Map Style: Dynamic Auto Focus Location	Body Font Colour: Black-Blue	Body-Font Colour: Black-Blue	Body Style: One-column
Body Bg Style: Solid	Top-Menu Bg Colour: Gray	Header Position: Left	Map Colour: Black-Gray	Top-Menu Bg Colour: Gray
Footer Exist: Yes	Map Lat/Lon: Yes	Body Style: One-column	Map Style: Digital	Map Scroll Bar: Yes
Footer Font Style: Sans-serif	Footer: Exist	Top-Menu Shape: Rounded-Rec	Map Source Data Info: Yes	Top Style: Icon
Header Font Style: Sans-serif	Footer Font Style: Sans-serif	Map Zoom Scroll: Yes	Top Style: Icon	Body Font Colour: Black-Blue
Top-Menu Bg Colour: Gray	Top-Menu Position: Left	Map Zoom Button: Yes	Map Lat/Lon: Yes	Footer Position: Center
Right-Menu Exist: Yes	Map Type: Digital	Main Menu Ads: Exist	Right-Menu Exist: Yes	Map Style: Dynamic Auto Focus Location
Right-Menu Picture: Yes	Map Zoom Scroll: Yes	Map Lat/Lon: Yes	Right-Menu Picture: Yes	Footer Font Colour: White
Right-Menu Picture Size: Small	Map Zoom Button: Yes	Body Bg Colour: DarkBlue	Right-Menu Font Style: Sans-serif	Left Menu Font Colour: Blue-Black
Right-Menu Font Style: Sans-serif		Main Menu Bg Colour: White	Right- Menu Font Colour: White-Black-Blue	Left-Menu Exist: Yes
Right-Menu Font Colour: White-Black-Blue		Map Style: Digital	Right-Menu Picture Size: Small	Left-Menu Font Style: Sans-serif
Left-Menu Font Colour: Blue-Black			Footer Font Colour: White	Main Menu Ads: Exist
Map Zoom/Scroll: Yes				
Map Zoom Button: Yes				
Left-Menu Exist: Yes				

5. Conclusion

This paper has described the outcome of Kansei evaluation in web-based GIS. The research has successfully identified the significant concept of Kansei in web-based GIS, and the significant influence of DE on the respondents' Kansei using PCA, FA, and PLS analysis.

PCA has enabled the research to identify the Kansei semantic structure and specimens that correspond to the semantic space. On the other hand, FA has resulted in the significant concept of Kansei in web-based GIS as dynamic & well-organized, refreshing, spacious, professional, and nautical-look. The research observed that Kansei responses to Web-based GIS are characterised by dynamism and spaciousness, and this provides cues that the new concept of web-based GIS should blend and balance these two components. Additionally, PLS analysis has enabled the research to determine significant DE and their influence on Kansei responses. This provides cues to designers to design and develop future web-based GIS with targeted emotions.

Although there were some limitations due to limited samples, the result of the study provides valuable insight into the body of knowledge in emotional UX, and design strategies for web-based GIS. The limitations, however, opens door for future research, such as by employing larger sample size as well as comparative cultural aspects in order to enrich the findings and enhance the generalizability of the understood DE and its influence on the Kansei of web-based GIS users.

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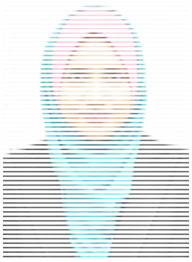

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