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## Proceedings of the 4th Tarumanagara International Conference of the Applications of Technology and Engineering (TICATE) 2021

Jakarta, Indonesia • 5-6 August 2021

Editors • Benny Tjahjono, Soh Sie Teng, A. Ruggeri Toni Liang,  
Lenin Gopal, Hugeng Hugeng, Channing Chuang  
and Tresna Priyana Soemardi



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## **Preface: Proceeding of the 4th Tarumanagara International Conference of the Applications of Technology and Engineering (TICATE) 2021**

Dear our Distinguished guests, ladies and gentlemen,

It is such a great pleasure for me to welcome all the participants to the Fourth Tarumanagara International Conference on the Applications of Technology and Engineering (TICATE) 2021, In the concern of COVID-19 pandemic, this international conference is being held virtually from August 5<sup>th</sup> – 6<sup>th</sup>, 2021 from Campus I of Universitas Tarumanagara at Jl. Letjen S. Parman No. 1, Jakarta 11440, Indonesia. This international conference is held and organized annually by Universitas Tarumanagara in the field of technology and engineering whose proceedings will be published by AIP Publishing and will be indexed by Scopus.

As we all know, the goal of this conference is to provide a forum that facilitates the exchange of knowledge and experience of both practitioners and academics in the fields of the applications of technology and engineering. Under these circumstances, they can mutually share their findings. Despite the current condition of the Covid-19 pandemic, we are still holding this international conference with more than 300 presented papers. The authors of the papers come from 1) Australia, 2) Czech Republic, 3) Germany, 4) Indonesia, 5) Japan, 6) Malaysia, 7) Sweden, 8) United Kingdom, 9) Hongary, 10) Timor Leste, 11) Singapore, 12) Thailand, 13) Taiwan, 14) China.


I would like to take this opportunity to extend my appreciation to the following institutions. Firstly, this year's conferences become special due to the support from our Plenary Speakers, Associate Prof. Dr. Lenin Gopal, Curtin University Malaysia, Prof. Dr. Benny Tjahjono, Coventry University, United Kingdom, and our Invited Speakers, Dr. Ayub Ahmed Javenkar, VIT University, India, and Dr.-Ing. Juwono Prasetyo, Universiti Tun Hussein Onn, Malaysia. We are thankful for your wonderful cooperation. Each plenary speaker will be given 30 minutes to hold his presentation and followed by 15 minutes Q&A session. At the parallel sessions, each presenter is given 15 minutes to present his/her work followed by 10 minutes Q&A session about the related topic. The parallel sessions are opened to all participants. The participants, including presenters at the parallel sessions, are attending this virtual international conference from their corresponding countries mentioned above.

I would also sincerely say thanks to the organizing committee for their commitment, hard work and dedication, making this internationally reputable conference successfully realizable.

Finally, I would like to express my gratitude for the supports from our partners and the presence of distinguished speakers, authors, reviewers, and a number of active participants from several countries. I wish you all a wonderful and great conference. Thank you.

Assoc. Prof. Dr. Hugeng, S.T., M.T., SMIEEE  
Chairman

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**An affective university classroom design formula based on kansei engineering approach**  
A. N. Habyba; T. S. Dewayana; N. Rahmawati; D. Rhamanda  
*AIP Conf. Proc.* 2680, 020149 (2023) <https://doi.org/10.1063/5.0126036>

**Development of SCADA photovoltaic monitoring system**  
Shawn Daren Sasitharan; Naveeyindren Thangarajah  
*AIP Conf. Proc.* 2680, 020150 (2023) <https://doi.org/10.1063/5.0126971>

**The effect of temperature changes on photovoltaic surface against the output current of polycrystalline solar power plant**  
Andi Makkulau; M. Fikri; Samsurizal; Christiono  
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Classroom condition is an essential in the university learning process. The lecturers and students interact directly for several hours in it. Environmental classroom conditions directly affect the learning system. Next, it is a must to design a classroom that considers both physical and environmental conditions. The objective of this research is to formulate the university classroom design by Kansei Engineering approach. Ten kansei words were selected and resulted two design concepts namely "a good classroom with cool, clean lines" and "bright classroom". There are 7 physical elements (wall, chair and table color, chair table type, learning tool, ceiling design and furniture arrangement). The environmental conditions follow the criteria from previous research findings to achieve the best student's performance during the lessons. There are 5 of them to consider (noise

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**Tarumanagara International Conference  
on the Application of Technology and Engineering 2021**

**CERTIFICATE**  
OF ACHIEVEMENT

**Anik Nur Habyba**

for the contribution as

**PRESENTER**

Paper Title:

**An Affective University Classroom Design based on Kansei Engineering Approach**

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# An Affective University Classroom Design Formula Based on Kansei Engineering Approach

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**Abstract.** Classroom condition is an essential in the university learning process. The lecturers and students interact directly for several hours in it. Environmental classroom conditions directly affect the learning system. Next, it is a must to design a classroom that considers both physical and environmental conditions. The objective of this research is to formulate the university classroom design by Kansei Engineering approach. Ten kansei words were selected and resulted two design concepts namely “a good classroom with cool, clean lines” and “bright classroom”. There are 7 physical elements (wall, chair and table color, chair table type, learning tool, ceiling design and furniture arrangement). The environmental conditions follow the criteria from previous research findings to achieve the best student’s performance during the lessons. There are 5 of them to consider (noise level, illumination, humidity, ventilation and thermal conditions). Based on decision tree the formula of each design were resulted. The first concept of "good classroom" is strongly influenced by the color of the chairs, while the second concept of "bright classroom" is influenced by the type of chair used.

## INTRODUCTION

The classroom design is important in the learning process such as in a university. Lecturers and students interact directly for several hours in the classroom. The classroom with good condition and design are needed to improve student achievement. Previous research shown that physical classroom environmental effects on student's academic achievement and learning process. In addition to classroom’s structural environment (windows, plumbing, ventilation, and etc.), the classrooms’s symbolic settings (wall decor, objects that are displayed in classrooms) also affect student learning [1]. It is crucial to consider both the structural and symbolic classroom environment in the university classroom design. Student's as the primary user of the school is the most critical factor in the design process. Students' perception investigation is the first step to know the best classroom features such as thermo-hygrometry, acoustic and lighting comfort conditions [2].

Previously, some studies also have been conducted to assess the features of university classroom environmental conditions. Thermal-hygrometry comfort evaluation already done for university classroom [3], junior school classroom [4], and educational buildings [5]. Thermal comfort for each location is different depending on the season of the country, such as countries that have winter season [6] or tropical country [7]. Indonesia as a tropical country, also has its own thermal comfort for university classrooms. Classroom lighting affects the students impression of the class. Some types of lighting must be adapted to the type of learning. This study shows that the ergonomic aspects of the environment directly influence classrooms' affective design [8]. Kansei Engineering (KE) method was used in a previous study and found six affective characteristics in the classroom: functionality and layout, comfortable and pleasant, concentration and comfort, modern design, daytime and outdoor views where; these six factors can affect the satisfaction and experience of classroom users [9].

Mitsuo Nagamachi defines Kansei as responses that arise through the five senses. Analyzing Kansei users in the process of developing a product is not easy to do [10]. The emotional experience as an implicit customer need is

challenging to measure and focuses on product developers. Students are likened to university classroom users who must focus on determining the design. One method that can evaluate the affective needs of users is Kansei / Affective Engineering (KE). KE is a technology to assimilate human Kansei for a product and design variable [10]. Human Kansei means the user's psychological feelings or emotions towards a product. A conducive situation in the teaching and learning process is vital to achieving learning outcomes. Affective classroom design is a way to achieve the success of the learning process. The diverse classroom conditions in the Universitas Trisakti, Department of Industrial Engineering make the level of success in achieving the learning process not the same, for this reason it is necessary to evaluate the existing classrooms. This study aims to construct an affective classroom design formula to improve learning process outcomes.

## METHODS

### Data Collecting

This study selected a purposive sampling technique to collect the data and with several criteria of respondents as follows: (1) they are active students majoring in Industrial Engineering (2) they experienced in using the classroom at least one semester (3) they were willing to follow all the three questionnaires. Purposive sampling was chosen as a sampling technique with consideration of the importance of success in achieving the study objectives. The first questionnaire was collecting students' perceptions, and the important design elements. The second questionnaire was extracting the affective concept and the third questionnaire was selecting the best concept. In the last stage, design elements were identified from each sample and analyzed with the affective concept. The design formula were extracted in the last stage and can be used by Universitas Trisakti to improve the classroom design.

### Affective Design Concept Extraction

Kansei Words (KWs) obtained were reduced using Term Frequency-Inverse Document Frequency (TF-IDF). TF-IDF is a text mining method to show how important a KWs by seeing how many it appears in the questionnaire [11]. Word clouds were also used to describe KWs. Word size in word cloud indicates the appearance of words in a text collection [12]. The greater the KWs in the word cloud, the more often the KWs appears in the text collection. The word cloud is the same as the term frequency (tf). The term frequency (tf) counted how many each KW appears in the questionnaire. Document frequency (df) counted how many questionnaires that have the KW as the following equation:

$$idf(t, D) = \log \frac{|D|}{df(t, D)} \quad (1)$$

Finally, the TF-IDF was computed by the combination of the tf and the idf as follow:

$$tfidf(t, d, D) = tf(t, d) \times idf(t, D) \quad (2)$$

The KWs was chosen which has high tf-idf weight. The selected KW was used in the second questionnaire to see students' perceptions of the sample based on these KWs.

The design concept extraction was selected by analyzing the second questionnaire responds. Evaluation of KWs was obtained using a questionnaire carried out by the method of Likert scale and analyzed by using Principal Component Analysis (PCA). PCA is a statistical technique to extract information from large sets of variables correlation into several main components, without reducing the significance of the variability in the data set [10,13]. The main components is the affective design concept of the university classrooms. According to eigenvalue  $\lambda$ , some principal components (PCs) should be retained. Generally, the PCs which have eigenvalue above 1 were retained and became the design concepts.

### Classroom Design Formulation

The university classroom design elements were collected by literature study, and the first questionnaire responds. They were also chosen by considering the Industrial Engineering classroom condition and classified based on samples used. This study was done during a pandemic so the samples were collected from university website. The relationship between design elements and affective concepts was analyzed using decision tree classifier in Weka

3.8.1. Random tree is one of supervised classifier algorithm in Weka and an ensemble learning algorithm. This algorithm was introduced by Leo Breiman and Adele Cutler that has the ability to deal with classification and regression problems. It combines two algorithm in machine learning: single decision tree and random forest. In a random forest, each node is split based on the best among the subsets predictors are randomly selected on that node while on the tree with the best split between all variables [14]. Random set data (university classroom design elements) constructed a decision tree, affective concepts classified the data.

## RESULT AND DISCUSSION

### Affective design Concept

Kansei words were collected by distributing the first questionnaire to 30 active students majoring in Industrial Engineering. In this phase, 35 KWs were collected from the respondents which illustrated the university classroom design. The word clouds of KWs were built to visualize the KWs obtained from students' perceptions. The KWs which appears most often have the largest and most prominent size in the word clouds can be seen in Figure 1. The KWs appears most often are comfortable, cool, clean, neat, bright sequentially. The most words appear are comfortable (20), cool (18) and clean (15), these three words are most often mentioned by students among the 35 collected kansei words.



FIGURE 1. KWs word clouds

The 35 KWs were evaluated using TF-IDF. This method was used to select the most important KWs to students. Based on TF-IDF result, 10 KWs were taken in Table 1. The KWs have the biggest TF-IDF weight are neat (4.77), bright (4.71), clean (4.52) and complete (4.19) indicated by boldface in Table 1. All 10 KWs are mentioned at least 4 times by students.

### Figures (Second Level Heading)

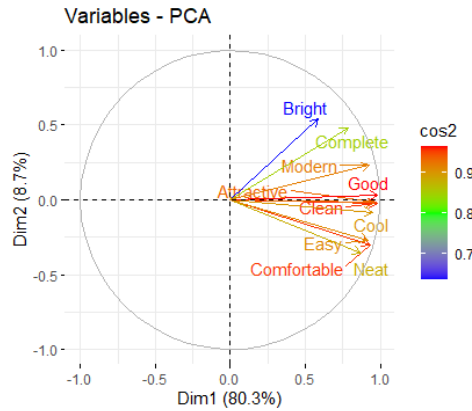
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**TABLE 1.** TF-IDF values

No	Kansei Words	TF	IDF	TF-IDF	No	Kansei Words	TF	IDF	TF-IDF
1	comfortable	20	0.20	3.97	6	<b>complete</b>	6	0.70	<b>4.19</b>
2	cool	18	0.22	3.99	7	attractive	4	0.88	3.50
3	<b>clean</b>	15	0.30	<b>4.52</b>	8	easy	4	0.88	3.50
4	<b>neat</b>	10	0.48	<b>4.77</b>	9	good	4	0.88	3.50
5	<b>bright</b>	9	0.52	<b>4.71</b>	10	modern	4	0.88	3.50

The second stage was extracting KWs to be the new affective concepts. The concepts were generated considering the PC. The PC sequentially retained according to the Kaiser’s criterion, in which the cumulative proportion of variance could explain at least a minimum of 70%-80% [15]. The result shows that PC1 have the total proportion of variance 80.35%. It means that the PC1 can be representing the variance of the Kansei words collection and has the highest eigenvalue (8.03). PC3 was also selected to be design concepts to make comparison concept design. The quality of each KW in interpreting dimensions (PC) can be seen by calculating the value of  $\cos^2$ . The KW which is closer to the midpoint of the plot is increasingly less important for PC1 [16]. The results of  $\cos^2$  KWs can be seen in Figure 2. The KWs good, clean, comfortable have the highest  $\cos^2$  word for PC1 on red color. The one and only KW that have difference color is bright with blue color, it identified as other PCs concept design. Based on several results above, PC1 translated to be good classroom design with cool, and clean lines for the first proposed concept design. The second concept design is bright, this design focus on environmental aspect of classroom design.











**FIGURE 2.**  $\cos^2$  plot

### Affective University Classroom Design Formula

The design elements of the university classrooms were taken from the literature review and questionnaire on the side of the respondents in the first stage. The design elements used were divided into two, namely physical design and environmental design. Physical design elements that can be used are seen in Table 2.

**TABLE 2.** University classroom physical design elements

Design elements	1	2	3	4	5	6	7
X1 Wall color	Colorful	Bone	Green	Light blue	Light gray		
X2 Chair dominant color	Colorful	Natur maple	Emerald	Black	Blue	Gray	Red
X3 Table dominant color	Colorful	Natur maple	Bone				
X4 Chair & Table Type	 Type 1	 Type 2	 Type 3	 Type 4	 Type 5		
X5 Learning tool	Projector	LCD screen interactive smart board					
X6 Ceiling design [9]	Drop ceiling	Artistic ceiling					
X7 Furniture arrangement [9] focusing on chair and table							

The criteria for each environmental design element was used as a reference in improving the classroom environment (Table 3). Some design elements are noise level, illumination, humidity conditions, ventilation condition and thermal conditions [9]. The needs of the classroom environment are different for each country, so the literature used is the results of classroom research for tropical countries.

**TABLE 3.** University classroom environmental design elements

Design elements	Criteria
X8 Noise level	For indoors, 55 dBA for maximum noise level and less than 65 dBA fo outdoors [17]
X9 Illumination	Classroom which uses LCD media, general lighting recommended is 250-300 lux with uniformity rasio 0.8 and limiting glare indet 19. The lights used in the classroom should be lamp with a neutral white light color. Type of lamp recommended for classrooms with height up to 3 m, is a TL lamp standard, TL U lamp, HQI less than 250 W, and HQI 250 W [18]
X10 Humidity conditions	Maximum 60% [19]
X11 Ventilation conditions	Ventilation rate 0.15 – 0.25 m/s and carbon dioxide (CO <sub>2</sub> ) concentration maximum is 1000 ppm for 8 hours [20]
X12 Thermal conditions	Good is 23°C, maximum acceptable temperature is 26.5°C [7]

Classroom design formulation was carried out by analyzing the relationship between the physical elements and the concepts. The samples elements were identified based on Table 3 and combined with students' perceptions. The 3<sup>rd</sup> questionnaire was distributed to see student perceptions (1-5 scale for strongly disagree-strongly agree) against samples based on two concepts. The random tree classifier was proposed for generated the design formula (Table 4). Seven important rules from “good classroom” are the black color of the chairs, the bone color of the table and the chair table arrangement (three lines). For “bright classroom”, eight important rules, namely chair type (type2, type3), chair color (black, gray) and ceiling (drop). The 1<sup>st</sup> concept of "good classroom" is strongly influenced by the color of the chairs, while the 2<sup>nd</sup> concept of "bright classroom" is influenced by the type of chair used.

**TABLE 4.** The most important category of classroom for the affective concept by Random tree

No	Good	Bright
1	Chair=colorful → good=strongly agree (1)	Chair type=type2, chair color=black → bright=strongly agree (2)
2	Chair=black , Table=bone, CT arrangement=three lines → good=strongly agree (1)	Chair type=type2, chair color=gray → bright=strongly agree (1)
3	Chair=blue → good=agree (2)	Chair type=type3, ceiling=drop → bright=strongly agree (1)
4	Chair=emerald → good=agree (2)	Chair type=type2, chair color=blue → bright= agree (2)
5	Chair=gray → good=agree (1)	Chair type=type5 → bright= agree (2)
6	Chair=nature maple, wall=bone, CT type=type3 → good=agree (1)	Chair type=type4 → bright= agree (1)
7	Chair=black , Table=natur maple → good=agree (1)	Chair type=type1 → bright= agree (1)
8		Chair type=type2, chair color=emerald, wall=green → bright= agree (1)

## CONCLUSION AND RECOMMENDATION

The university classroom process design was described based on Kansei process engineering. The KWs collected from 30 students and produced 35 different KWs. The 10 KWs were used to get students' perceptions of 13 university classroom samples. The results of the PCA analysis of 10 KWs found that “good classroom design with cool, and clean lines” and “bright classroom design” were the design concepts. The design elements were divided into physical and environmental design elements follow the criteria previous research findings to achieve best students performance during the lessons. There are 7 physical elements (wall, chair and table color, chair table type, learning tool, ceiling design and furniture arrangement). For environmental design elements, there are 5 elements to consider (noise level, illumination, humidity, ventilation and thermal conditions). Based on decision tree, the formula of each design concept was resulted. The first concept is strongly influenced by the color of the chairs, while the second concept is influenced by the type of chair used. With the limited use of design elements and samples in this study, it is better to make more exploration of them.

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