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Desk and Chair Design of Elementary School using Kansei Engineering and Conjoint Analysis

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Abstract: The aim of this research is to determine the items and categories that must be considered in desk and chair design for elementary school. Two important aspects must be considered in desk and chair design. The first aspect deals with functional performance and the second deals with the stylistic aspect. This research discusses the stylistic aspect in desk and chair design. Kansei engineering is used to capture the image of a design emotionally while the conjoint analysis is used to determine the importance weight and utility of the items and categories respectively. Seven kansei words for chair and for kansei word for desk are considered in this research. From the analysis, it is found that based suchon global imp suchort suchance weight, number of legs and accessories are considered as two most important factors in chair design. While number of legs and surface material are considered as the most imp suchort suchant factors in desk design such.

Key words: Desk and chai design, suchelementary school, Kansei engineering, conjoint analysis, weight

INTRODUCTION

Sophisticated customers have forced companies to shift their strategy from product-out to market-in strategy (Nagamachi, 1995). Product-out is a strategy in which a manufacturer produces their product based on its own design strategy regardless of customer's preference and demand. On the other hand, market-in strategy is a product resulted from a study about customer's desire and preferences. Hence, companies need to understand their customer better and develop and improve their designs for more satisfaction of them (Demirtas *et al*., 2009). In general, a product has two important aspects of design in the view of its customers: functional performance and stylistic desire (Tseng *et al*., 2012). Functional performance usually deals with the physical dimensions of the product which must be fit with the user's anthropometry, while the stylistic desire deals with the aesthetic like shape, colors and other related factors which have strong relationship with the emotion of the customers. Student's desk and chair have attracted many researchers mainly in their functional performances. One of the important functional performances of the student's desk and chair is to prevent the students from the risk for suffering health-related problems (Parcells *et al*., 1999). The health-related problems such as pain in back shoulder, leg and eyes are caused by the mismatch between student's desk and chair and their anthropometry. The mismatch analysis of school desk and chair has attracted many researchers from many countries. For example, Gouvali and Boudolos (2006) and Agha (2010) determined a substantial frequency of mismatch of student's desk and chair in Greek and Gaza Strip Palestine respectively, especially for desk height, seat height and seat depth. In New Zealand, Kane also found high mismatch between desk and chair dimensions and student's anthropometry and proposed a new desk and chair design. Some researchers concerned with the desk and chair standard in their country. After carefully analysis to the student's anthropometry, it was concluded in (Castellucci *et al*., 2010) that a size mark must be added to the current Potuguese standard. Motmans evaluated the size marks of European design standard draft of prEN 1729 and suggested that anthropometric group gives better fit than school grades group. Recently, a research was conducted to compare the mismatch between existing desk and chair, Indonesia National Standard and proposed dimensions in Indonesia (Rosyidi *et al*., 2014).

Erdogmus and Koc (2011) conducted a research to determine the relationship between the quality of classroom physical environment and student's motivation. It is well known that higher student's motivation in learning will have a significant impact on

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their performance. In their research, several important elements were identified which have important role to student's motivation. One of the elements that influence the students' motivation is the student's desk and chair. Hence, to be successful in student's learning, both functional performance and the stylistic desire of a product must be considered. Kansei Engineering is a design methodology that has been widely used in product design especially to capture and understand the image of a product from the emotional perspective of the customers. Kansei Engineering is defined as a technology that translates a customer's feeling of a product to the design elements (Nagamachi, 1995). Kansei is a Japanese word which means customer's psychological feelings and image regarding a new product. Kansei Engineering has several operational steps: kansei words identification, items and categories determination, customer's assessment and statistical analysis. Kansei Engineering has been applied in designing many products to explore the emotion and feeling of customers regarding of a product. For example, Lin *et al.* (2003) conducted a study to determine the preference and image of classic chairs. Demirtas *et al.* (2009) applied Kansei Engineering to determine the optimal product styles of kitchen faucets. Noor *et al.* (2008) conducted a research to identify the signature feelings of online-shopping website in an attempt to incorporate the affective or emotional appeal in the website design.

This research attempts to develop desk and chair design concept especially for public elementary school students in Indonesia. From our prior observations and analysis, there are two problems in the desk and chair design form elementary school in Indonesia. The first problem deals with the functional performance in term of high mismatch between the desk and chair and student's anthropometry (Rosyidi *et al.*, 2014). The second problem deals with the shape, color and aesthetics aspects of the design in which the existing desk and chair are in classical shape and color. We have addressed the first problem in the research of Rosyidi. In this study, we make an attempt to address the second problem by designing a new concept of desk and chair for elementary school students using Kansei Engineering. Conjoint analysis is used in this research to determine the value of a design concept in the view of customer's preference. Kansei Engineering and conjoint analysis are not new methods in solving design problems. Hence this paper is similar with the research by Demirtas *et al.* (2009) but with different product. The other difference is that this study uses factor analysis as a method to group the kansei word into several groups and uses the results of the analysis in second step data collection. From the conjoint analysis we will find the important weight of each design element and its relationships with the kansei words.

MATERIALS AND METHODS

Survey method and respondents: The objects of this research are desk and chair for public elementary school. Lembaga Penelitian dan Pengabdian Kepada Masyarakat (The Institute for Research and Community Services) Universitas Sebelas Maret Surakarta, Indonesia acknowledged and approved the methods in this research. Since it is very difficult to make a survey to the students of elementary school due to lack of their understanding about the kansei words, we decided to make the elementary school teachers as the survey sample. We assumed that the teachers have an understanding about several psychological aspects regarding the students' preferences and they are also the decision maker in purchasing such desk and chair for their schools. So the teacher's preferences will also represent the student's preferences. A letter of consent was sent to the head master of each school to get permission in conducting the research.

Before taking the data, we asked the teachers whether they can participate in this research. If the answer is yes, then a questionnaire is given to the teacher. The data was taken at teacher's office in school rest time so the teachers can fill in the questionnaire voluntarily. In this research we used non-probability sampling technique called purposive sampling. The sample size of this research consists of 112 teachers from 5 elementary schools in Surakarta, Indonesia: SDN Cemara Dua, SDN Mangkubumen Kulon, SDN Mangkubumen Kidul, SDN Mangkubumen Lor and SDN Purwosari. Two questionnaires are developed in this research. The first questionnaire is used to determine how the respondents rate the stimuli in the form of existing desk and chair design based on the kansei word pairs. The second questionnaire is used to determine the respondent preferences regarding the new desk and chair design.

In the first step, we collected kansei words from several sources and found 21 kansei words for desk and 22 kansei words for chair. The first questionnaire is developed which consists of kansei word pairs and existing desk and chair design using 5-scales of semantic differential. In this first questionnaire we include 3 samples of elementary school desks and chairs that have already been exist in the market. The results from the first questionnaire are then analyzed using factor analysis to reduce the dimensionality and simplify the next analysis. From the factor analysis, we found a small

number of factors which will constitute the 21 kansei words for desk and 22 kansei words for chair. The factor analysis resulted in 4 factors for desk (durable, easily cleaned, assembled and simple) and 7 factors for chair (easy to clean, durable, customizable, simple, colorfull, easy to assemble and formal). Those factors will be included in the second questionnaire with the new desk and chair designs.

In developing the new desk and chair designs, we firstly decomposed the desk and chair into items and categories. The items and categories for the desk has been determined as follows: the number of legs (2 or 4 legs), frame material (metal or wood), colors (1 or 2 colors), seat shape (curve and rectangular), backrest shape (curve or rectangular) and accessories (handhold or bag rack). The items and categories for the desk has been determined as follows: the number of legs (2 or 4 legs), frame material (metal or wood), colors (1 or 2 colors), drawer and surface material (wood or plastics). In an effort to reduce the data collection burden on respondents, Steckel *et al*. (1991) suggested to use orthogonal array to construct stimulus sets. Using the orthogonal array, L16 is used in this research for chair design and L8 is used for desk design.

Kansei engineering: As we briefly explained in study 1, Kansei Engineering is a design method to capture the feeling and image of customers regarding a product design. The first step in Kansei Engineering is to identify the kansei words. Magazines, scientific papers from journals, experts opinions are the common sources of those words. Afterwards, the respondents are asked to choose the kansei words according to their emotions and feelings about the product under investigation. In Kansei Engineering, semantic differential which is used to measure how consumers feel about a product which is typically evaluated on a scale of 1-5, 1-7 or 1-9 according to negative-positive word pairs. Based on the process, Kansei Engineering can be divided into three types: type 1-3 (Nagamachi, 1995). Type 1 Kansei Engineering is also called category classification in which a Kansei category of a product is broken down in the tree structure to get the design details. In more specific, this type outlines the concept of a product into a more detailed concept by identifying the target, determining the product concept, detailing the product concept and determining the physical design characteristics. In Type 2 Kansei Engineering, a computerized system with the expert system is used to transfer the customer's feeling and image to the design details. Four databases are used in this type: kansei, image, knowledge and color/shape. Kansei Engineering Type 3 uses a mathematical model to obtain the ergonomic outcome from kansei words which implies a kind of logic similar to the rule-base.

Conjoint analysis: Conjoint analysis is a statistical tool that can be characterized as the application of design of experiments to marketing decisions (Gustafsson *et al*., 1999). Conjoint analysis means decompose a product into part-worth utilities or values of a set of individual evaluations, or discrete choices from, a designed set of multi-attribute alternatives. It has become the method of choice for quantitative preference measurement and is considered among the major contributions of marketing science to marketing practice (Louviere, 1988). Using this method, a product is decomposed into several attributes and each attribute has several levels. The combinations of attributes and levels will constitute the products that will be assessed by the respondents. Respondents are then asked in a survey to rank or rate their preferences for various profiles of these products or services (Netzer *et al*., 2008). This method has been applied to solve many preference problems such as packaging of food products design, plastic packaging company Silayoi and Speece (2007), kitchen faucet design (Demirtas *et al*., 2009) and product-line design (Kotri, 2006).

RESULTS AND DISCUSSION

From the results of factor analysis, we determined 4 factors for desk (durable, easily cleaned, assembled and simple) and 7 factors for chair (easy to clean, durable, customizable, simple, colorful, easy to assemble and formal). Those factors, along with the desk and chair designs resulted from the orthogonal arrays are included in the questionnaire. The designs of desk and chair can be seen in Fig. 1 and 2 respectively.

Table 1 and 2 show the results of conjoint analysis for chair and desk respectively which can be seen in the last page of this paper. From Table 1 the determinant items for kansei word "safe" are the number of legs and accessories with the importance values of 64.34 and 19.96, respectively. From Table 1 the determinant items for kansei word "safe" are the number of legs and accessories with the importance values of 64.34 and 19.96, respectively. The categories that give the greatest value estimates for those items are 4 legs, bag rack, hand hold and bag rack with the values of 0.638, 0.141 and 0.168 respectively. For kansei word "colorful", the colors and accessories are the determinant of this kansei word. The categories that influence this kansei word the most are 2 colors and hand hold and bag rack. For kansei word "strong", the legs, frame material and accessories are the determinant factor of this kansei word. The categories that

Table 1: Results of conjoint analysis of chair designs

Kansei Words	Items (Imp.Weight)	Category (utility)	Kansei words	Items (Imp. Weight)	Category (utility)
Safe	Frame material (8.26)	Metal (0.082)	Colorful	Frame material (7.28)	Metal (-0.061)
		Wood (-0.082)	Wood		(0.061)
	Colors (0.57)	1 Color (0.006)		Colors (71.17)	1 Color (-0.599)
		2 Colors (-0.006)			2 Colors (0.599)
	Legs (64.34)	2 Legs (-0.638)		Legs (2.53)	2 Legs (0.021)
		4 Legs (0.638)			4 Legs (-0.021)
	Seat (1.83)	Curve (-0.018)		Seat (1.33)	Curve (-0.011)
		Rectangular (0.018)			Rectangular (0.011)
	Backrest (5.68)	Curve (0.058)		Backrest (3.12)	Curve (-0.026)
		Rectangular (-0.058)			Rectangular (0.026)
	Accessories (19.16)	None (-0.212)			None (-0.114)
		Handhold (-0.097)		Accessories (14.56)	Handhold (0.009)
		Bag Rack (0.141)			Bag Rack (-0.009)
		Handhold and Bag Rack (0.168)			Handhold and Bag Rack (0.131)
Strong	Frame material (22.07))	Metal (0.198)	Adjustable	Frame material (19.35)	Metal (0.052)
		Wood (-0.198)			Wood (-0.052)
	Colors (2.65)	1 Color (-0.024)		Colors (10.02)	1 Color (-0.027)
		2 Colors (0.024)			2 Colors (0.027)
	Legs (53.07)	2 Legs (-0.475)		Legs (3.49)	2 Legs (-0.009)
		4 Legs (0.475)			4 Legs (0.009)
	Seat (1.12)	Curve (0.010)		Seat (11.89)	Curve (0.032)
		Rectangular (-0.010)			Rectangular (-0.032)
	Backrest (5.03)	Curve (0.045)		Backrest (35.66)	Curve (0.096)
		Rectangular (-0.045)			Rectangular (-0.096)
	Accessories (16.06)	None (-0.161)		Accessories (19.58)	None (-0.054)
		Handhold (-0.044)			Handhold (0.006)
		Bag Rack (0.079)			Bag Rack (-0.002)
		Handhold and Bag Rack (0.126)		Handhold and Bag Rack (0.051)	
	Frame material (22.75))	Metal (0.112)	Modern	Frame material (29.82)	Metal (0.314)
	Simple	Wood (-0.112)			Wood (-0.314)
	Colors (8.77)	1 Color (-0.043)		Colors (7.53)	1 Color (-0.079)
		2 Colors (0.043)			2 Colors (0.079)
	Legs (21.73)	2 Legs (-0.107)		Legs (31.71)	2 Legs (0.334)
		4 Legs (0.107)			4 Legs (-0.334)
	Seat (2.67)	Curve (-0.013)		Seat (6.46)	Curve (-0.068)
		Rectangular (0.013)			Rectangular (0.068)
	Backrest (6.23)	Curve (-0.031)		Backrest (1.48)	Curve (0.016)
		Rectangular (0.031)			Rectangular (-0.016)
	Accessories (37.87)	None (0.186)		Accessories (22.99)	None (-0.204)
		Handhold (0.016)			Handhold (0.081)
		Bag Rack (-0.014)			Bag Rack (-0.157)
		Handhold and Bag Rack (-0.187)		Handhold and Bag Rack (0.281)	
Formal	Frame material (15.87))	Metal (0.066)			
		Wood (-0.066)			
	Colors (6.59)	1 Color (-0.027)			
		2 Colors (0.027)			
	Legs (50.89)	2 Legs (-0.213)			
		4 Legs (0.213)			
	Seat (0.00)	Curve (0.000)			
		Rectangular (0.00)			
	Backrest (4.192)	Curve (0.018)			
		Rectangular (-0.018)			
	Accessories (22.46)	None (-0.031)			
		Handhold (-0.104)			
		Bag Rack (0.084)			
		Handhold and Bag Rack (0.051)			

give the greatest value estimates for this kansei word are 4 legs, metal and hand hold and bag rack respectively. The determinant items for kansei word “adjustable” are backrest shape, accessories, frame material, seat shape and colors. Curve backrest, handhold and backrest, metal frame metarial and curve seat give the greatest value estimates for this kansei word. Accessories, frame material and number of legs are the determinant for kansei word “simple” with the greatest value estimates are given by no accessories, metal and 4 legs. For kansei word “modern”,

Table 2: Results of conjoint analysis of desk designs

Kansei Words	Items (Imp.Weight)	Category (Utility)	Kansei Words	Items (Imp. Weight)	Category (Utility)
Durable	Frame material (32.06)	Metal (-0.168)	Easy to assemble	Frame material (7.28)	Metal (0.081)
		Wood (0.168)			Wood (-0.081)
	Colors (15.79)	1 Color (-0.082)		Colors (71.17)	1 Color (0.031)
		2 Colors (0.082)			2 Colors (-0.031)
	Legs (22.97)	2 Legs (-0.120)		Legs (2.53)	2 Legs (0.034)
		4 Legs (0.120)			4 Legs (-0.034)
	Surface material (29.19)	Wood (0.153)		Surface Material (1.33)	Wood (-0.181)
		Plastics (-0.153)			Plastics (0.181)
Easy to clean	Frame material (8.44)	Metal (-0.016)	Simple	Frame material (4.68)	Metal (0.016)
		Wood (0.016)			Wood (-0.016)
	Colors (11.04)	1 Color (0.021)		Colors (16.19)	1 Color (0.056)
		2 Colors (-0.021)			2 Colors (-0.056)
	Legs (14.94)	2 Legs (-0.029)		Legs (72.30)	2 Legs (-0.251)
		4 Legs (0.029)			4 Legs (0.251)
	Surface material (65.58)	Wood (-0.126)		Surface Material (6.84)	Wood (-0.024)
		Plastics (0.126)			Plastics (0.024)

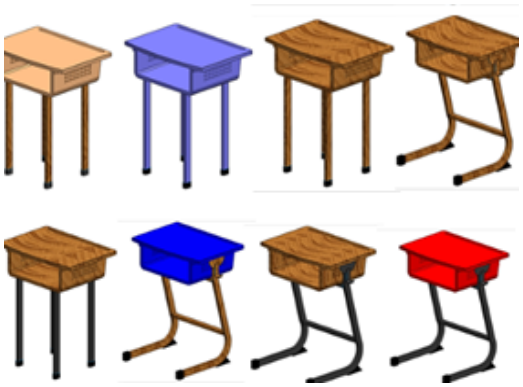

Fig. 1: Desk designs

Fig. 2: Chair designs

the greatest importance values are given by legs, frame material and accessories with 2 legs, metal and hand hold and bag rack give the highest value estimates for those items respectively. For kansei word "formal", the items that gives the highest importance values are number of legs, accessories and frame material with the highest value

Table 3: Global importance weight for chair items

Items	Chair
Frame material	0.179
Number of colors	0.153
Number of legs	0.325
Seat shape	0.036
Backrest shape	0.088
Accessories	0.219

Table 4: Global importance weight for desk items

Items	Desk
Frame material	0.175
Number of colors	0.131
Number of legs	0.301
Surface material	0.393

estimates are given by 4 legs, bag rack and metal respectively. From Table 2, items frame material, surface material and number of legs constitute the kansei word "durable" for the desk design with the highest impacts are given by wood for both frame and surface materials and the desk with 2 colors is valued higher for durability than 1 color. For kansei word "easy to clean" and "easy to assemble", the highest importance value of the items is given by surface material made from plastics. While for kansei word "simple" the highest importance value of items is given by number of legs in which 4 legs gives the highest value of utility estimate.

Table 3 and 4 show the results of normalization to determine the global importance weights of each item for both desk and chair. From Table 3 we can see that items number of legs and accessories constitute the highest importance weight for chair items. Items frame material and number of colors constitutes the second rank group for chair items while backrest and seat are considered as the least importance items. The importance weight of the items will determine how the items will influence the preference of the designs. It means that legs and accessories have the greatest influence in chair design preference, frame material and number of colors has moderate influence while backrest shape and seat shape give the least influence in chair designs. In Table 4, we

can see that surface material and number of legs give the greatest influence to the desk design preference, while frame material and number of colors give moderate influence in desk design preference.

CONCLUSION

In this research, we developed the designs of desk and chair for elementary school using kansei engineering and conjoint analysis. Seven kansei words are used for chair and four kansei words for desk. The results show that for kansei words of chair, the highest determinant of categories for kansei words safe, colorful, strong, adjustable, simple, modern and formal are given by 4 legs, 2 colors, 4 legs, curve backrest, no accessories, 2 legs and 4 legs, respectively. For kansei words of desk, the highest importance value for kansei word durable is given by wood material, easy to clean and easy to assemble by wood surface material while simple is given by 4 legs. From the global weights the most important factors that must be considered in the chair design are number of legs and accessories. For the desk design number of legs and surface materials are considered to be the most important factors.

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