



Application of Kano Model in evaluating indoor environment qualities of university libraries

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This paper explores the latent relationship between the Indoor Environment Qualities (IEQ) with the overall University library users' satisfaction. The study was conducted on central libraries of five West Bengal state government aided universities situated in Kolkata. The study followed an exploratory research design and used questionnaire for data collection from 755 library users. Statistical analysis of responses revealed that the overall library user satisfaction cannot be predicted merely by IEQ parameters through linear regression model, even though strong and significant correlations exist between them. Consequently, the study has shown how effectively the Kano model of customer satisfaction can be applied to properly unveil the relationship. The assessment framework outlined and presented in this study can act as a foundation for librarians and future researchers in evaluating IEQs of Libraries.

Keywords: Indoor Environment Quality, Kano Model of Customer Satisfaction; Library User Satisfaction, University Libraries

Introduction

With the growing awareness and importance of environment and sustainability related challenges, there has been a growth in literature on this topic during the previous few decades. Antonelli¹ has shown that the library literature on environment and sustainability related issues has gradually increased since the 1990s. Considering the vastness and multidimensionality of the research topic, previous researchers mostly focused their approach by considering one or a few selected sub-topics.

Indoor Environment Quality (IEQ) is considered as one of the most important issues. Leaman and Bordass² reported direct linkage between IEQs and the library occupants' overall satisfaction. Further, Humphreys and Nicol³ identified that occupants who are satisfied with their workspaces overall IEQ are more productive. The IEQ of commercial buildings and their respective occupants' overall satisfaction is well studied⁴⁻⁶. On the contrary, studies on non-profit making buildings, such as libraries, remain under explored.

This study aimed at investigating the latent relationship between individual IEQ parameters with the overall satisfaction of university library users. An exploratory research method was used which involves a questionnaire survey of library users. The Kano

model of customer satisfaction was employed to unveil the relationship between the IEQ parameters and users' overall satisfaction, and to categorize and evaluate the individual IEQ parameters.

Review of literature

Indoor environment quality (IEQ) consists of physical environmental attributes such as thermal comfort, indoor air quality (IAQ), acoustic comfort, visual comfort etc. Huang et al⁷ conducted a controlled field survey to determine the acceptable range of each environmental element as well as the combined effects of several factors of IEQ and found that thermal and acoustic comforts of the office buildings were good predictors of occupant satisfaction.

IAQ, being an important IEQ factor has been widely studied and results showed that it had a tremendous impact on occupants' health and performance⁸⁻¹⁰. The combined influence of heat and noise on behavioral measures of human performance in an industrial setting was investigated by Hancock and Pierce¹¹ who measured the degree of human performance vulnerability to combined thermal and acoustic impact. Martellotta et al¹² conducted subjective and objective surveys in southern Italy supermarkets to investigate how thermal, acoustic,

visual and air quality conditions contribute to satisfaction of workers and discovered that light intensity and temperature had a significant impact on satisfaction.

Hwang and Kim¹³ measured the luminance levels of working planes and windows at Samsung Corporation headquarters and found that daylight is a significant contributor in improving dwellers' psycho-physical health and productivity, and this finding was further validated by Jin et al¹⁴. Mendell and Heath¹⁵ observed how the negative impact of poor IEQ can induce health problems and cause poor performance of school students.

According to Anderson and Mittal¹⁶, the relationship between product or service quality attributes and customer satisfaction is not necessarily linear, which indicates that a change (increment or decrement) in product or service quality does not always commensurate to a change in customer satisfaction. To address this anomaly, Kano¹⁷ propounded a theory which was originally based on the motivation-hygiene theory of Herzberg and it looked beyond the linear relationship of product or service quality and customer satisfaction that properly unveils the multidimensionality of the relationship.

Kano employed a methodology which classifies each customer requirements into a specific category of quality attributes based on its ability to stimulate and/or avoid extreme dissatisfaction if not fulfilled¹⁸. Since its introduction, the Kano Model of customer

satisfaction has grown in popularity in the field of marketing research, and it has been experimentally confirmed in multiple studies¹⁹. With the passage of time the Kano model's application also grew to include more and more areas outside of marketing research, such as studies investigating job satisfaction and customer satisfaction^{20,21}, evaluating service qualities of transport system²², highlighting healthcare quality attributes that influence patient satisfaction²³, service quality and tourist satisfaction in the tourism Industry²⁴, e-learning service quality of a commercial bank²⁵, analysis of features for mobile security applications²⁶, evaluating virtual reality applications for interior design software²⁷ and so on.

Using Kano model, the product or service quality attributes can be classified under one of the following six categories (Fig. 1).

Attractive quality attribute: If this attribute is present, the customer is satisfied, but if it is not, there is no dissatisfaction.

One-dimensional quality attribute: This attribute has a linear relationship with customer satisfaction, meaning that the more the attribute is met, the higher the level of satisfaction.

Must-be quality attribute: Customers are dissatisfied when this attribute is missing, but it does not contribute to customer satisfaction when it is present.

Indifferent quality attribute: An attribute that has no effect on customer satisfaction or dissatisfaction.



Fig. 1 — The graphical representation of Kano Model (adapted from Lai and Wu²²)

Reverse quality attribute: If this attribute is present, it causes customer dissatisfaction, and its absence results in customer satisfaction.

Questionable quality attribute: There is a contradiction in the user's response to this attribute^{20,22,28,29}.

Literature review reveals that the IEQ has a definite impact on occupant satisfaction. It also depicts that Kano model has a wide range of application spread across numerous fields and previous research have empirically validated it. This study aims at applying Kano model to evaluate the IEQ parameters in context of user satisfaction of Indian university libraries.

Objectives of the study

- To explore the underlying relationship between indoor environment qualities and overall library user satisfaction;
- To study how the Kano Model of customer satisfaction can be applied in evaluating indoor environment qualities of university libraries; and
- To develop an assessment framework of indoor environment qualities for university libraries.

Hypotheses

To investigate the latent relationship between indoor environment quality and overall library occupant satisfaction, the following presumptions are made by the researchers before conducting the study.

Hypothesis 1: The selected IEQ parameters and the overall satisfaction of occupants are positively correlated with each other.

Hypothesis 2: There are significant differences in one or more IEQ parameters among all the studied universities.

Hypothesis 3: The overall occupant satisfaction can be predicted as dependent variable, through all the selected IEQ study parameters set as independent variables, to represent a linear regression equation.

Methodology

Research design

The study follows exploratory research design. According to Kumar³⁰, “This type of study is conducted to explore an area where very little is known or to investigate the possibilities of undertaking a particular research study.” The primary goal of exploratory research design is to create a problem for more detailed examination or to develop working hypotheses from a practical standpoint, and it

must be adaptable enough to accommodate various facets of the topic under investigation³¹. The above characteristics of exploratory research design have made it suitable for adoption in this study.

Scope and coverage

The study includes six university central libraries of five state government aided universities situated in Kolkata, namely University of Calcutta, Jadavpur University, Presidency University, Rabindra Bharati University, and Aliah University [both the Park Circus and Newtown campus included, as the Aliah University has two separate University Central Libraries], which were established in or before 2010. To ensure similarity in terms of funding, infrastructure, user base, organizational structure, etc., the study did not consider central or private universities.

Sampling

The sample population for the study was selected using the quota sampling technique. Quota sampling is a non-probability sampling design in which the number of components in a population density is either unknown or cannot be determined individually, and it is particularly useful when taking random samples from individual strata is too expensive³¹. The quota was set to 5% of total library users for each university separately and the survey process was continued until the desired number of surveys (quota) was fulfilled for each university. Total 813 Library users across all the six University Central Library campuses were approached for the survey and out of which 755 valid responses were received (Table 1).

Framing of the questionnaire

The questionnaires were in two parts. Questions in Part I were based on an earlier web-based occupant

Table 1 — Distribution of study population and sample size

University	Library users	
	Study Population (approx.)	Selected quota (5%) for the study
University of Calcutta (CU)	2500	125
Jadavpur University (JU)	3600	180
Presidency University (PU)	2000	100
Rabindra Bharati University (RBU)	2000	100
Aliah University [Park Circus campus] (AU1)	2500	125
Aliah University [Newtown campus] (AU2)	2500	125
Total	15100	755

survey questionnaire for IEQ designed by Zagreus et al³², which were empirically validated by further research works^{33,34}. Part I included 19 IEQ related questions (grouped under 8 categories) and one overall IEQ satisfaction related question. The questions of Part I were graded on a five-point Likert type scale, where options ranged between highly satisfied (1) to highly dissatisfied (5). Part II comprised of questions relating to the application of Kano model. Against all the 19 IEQ parameters of Part I, respondents were instructed to choose one of the six options to answer one functional and one dysfunctional scale (as proposed by Kano). Those six options are: 1. Delighted, 2. Expect it and like it, 3. No feeling, 4. Live with it, 5. Do not like it, and 6. Other (Table 2).

Data collection

The data collection process for the study took place between January to December 2019. For the survey, the researcher waited in front of the University Central Libraries and approached library users who had just exited from the libraries. All the necessary assistance to fill up the questionnaire was extended to participants as and when required.

Data analysis

The data were analyzed and represented using PSPP statistical software. The questionnaire sets were tested using the Cronbach’s alpha coefficient to estimate the reliability of the questionnaire’s internal consistency. After getting satisfactory results from the reliability test, the analysis was further continued with Pearson’s Correlation of coefficient test to validate the first Hypothesis. Then One-way ANOVA test was applied on the user data sets to test the second Hypothesis. To test the third hypothesis,

one linear regression analysis was performed. For analyzing the responses of Part II of the questionnaire, functional and dysfunctional scales were tabulated separately in Microsoft Excel using Kano’s Evaluation table (Table 3).

An individual occupant’s response against Kano Questionnaire (both for functional/present and dysfunctional/absent groups) for each IEQ parameters was classed or classified into one of the various available Kano categories using Microsoft Excel, as mentioned in Kano’s Evaluation table. The classification process can be understood simply by following an example.

If an individual respondent registers his answer against a question in the functional scale by opting, "Expect it and like it " and in dysfunctional scale as "Live with it", then both the responses of two scales converges in a cell of the Kano’s evaluation table which contains "I", viz. that IEQ feature against which the question being asked is classified in the "I" or "Indifferent" Kano category.

Table 3 — Kano’s evaluation table

Present Question Response (Functional scale)	Absent Question Response (Dysfunctional scale)				
	Delighted	Expect it and like it	No feeling	Live with it	Do not like it
Delighted	Q	A	A	A	O
Expect it and like it	R	I	I	I	M
No feeling	R	I	I	I	M
Live with it	R	I	I	I	M
Do not like it	R	R	R	R	Q

A, O, M, I, Q, and R represents Attractive, One-Dimensional, Must-be, Indifferent, Questionable and Reverse respectively. (Adapted from Gitlow²⁵)

Table 2 — Questionnaire structure

Sections	Enquiry item	Checkpoints include	Scale
Part I	Satisfaction of IEQ items	Temperature, Humidity, Rate of Ventilation, Freshness of air, Odor, Day Light, Visual Comfort, Overall Light, Indoor Noise, Outdoor Noise, Free Interaction, Privacy, Comfortable Furniture, Space & Mobility, Interior Decoration Window View, Colors & Textures, Cleanliness & Maintenance, Overall Satisfaction	(Likert type scale) Highly Satisfied=5 Moderately satisfied=4 Can’t judge=3 Moderately Dissatisfied=2 Highly Dissatisfied =1
Part II	Kano Questionnaire for IEQ Parameters	If a particular IEQ item was present, then how it felt by occupants (Functional question) If a particular IEQ item was absent, then how it was felt by occupants (Dysfunctional question)	(as propounded by Kano) 1. Delighted 2. Expect it and like it 3. No feeling 4. Live with it 5. Do not like it 6. Other

Next, the determination of individual IEQ parameters into a particular Kano category by User responses of a particular university was ascertained by the most frequent response received among all Kano categories viz.

Kano Category = maximum (A, O, M, I, Q, R).

The Center for Quality Management further revised the Kano Classification formula which is as follows:

Kano category = Maximum (A, O, M) if $(A+O+M) > (I+Q+R)$

Or

Maximum (I, Q, R) if $(A+O+M) \leq (I+Q+R)$

[Where, A, O, M, I, Q, R represents Attractive, One-Dimensional, Must-be, Indifferent, Questionable and Reverse respectively]²⁵.

This study followed the revised formula and classified all IEQ parameters accordingly. For example, in a cumulative response of the CU User group against an IEQ item ‘Temperature’ in Table 4, it can be observed that the maximum frequency received under the first three category heads i.e., under ‘Attractive’, ‘One-Dimensional’, ‘Must-be’ and therefore, the condition $(A+O+M) > (I+Q+R) = (18+19+72) > (12+4+0)$ is satisfied, and the function Maximum of (A, O, M) is executed. As “Must be”

includes maximum number of response (72) frequencies, it is thus ascertained as final Kano category.

Reliability of research

If a measuring instrument produces consistent results, then only it is considered reliable³⁵. The internal consistency of the questionnaire responses was statistically tested by using Cronbach’s alpha coefficient on both the questionnaire sets. The reliability statistics for the 20 questionnaire items for the user dataset resulted 0.73. The values of each item for the Cronbach's alpha, if item deleted test performed varied from 0.70 to 0.73, which indicated that the questions passed the reliability test.

Results

Correlation test results

Pearson correlation coefficients were used for the correlation analysis, which analyzed the correlations between IEQ parameters and the overall satisfaction of the user. A Pearson correlation coefficient value greater than and less than 0 indicates a positive or a negative correlation respectively. From Table 5, it is evident that all IEQ items are positively and moreover most of them are significantly correlated at 0.05 level of significance with the overall library occupant satisfaction. Hence, the Hypothesis 1 is proved true.

Table 4 — Example of Kano classification

IEQ Items	Attractive	One Dimensional	Must be	Indifferent	Questionable	Reverse	Kano classification
Temperature	18	19	72	12	4	0	Must be

Table 5 — Correlation analysis

	Overall Satisfaction	Thermal Comfort	Air Quality	Lighting	Acoustic Comfort	User Privacy	Furnishing Layout	Aesthetics	Cleanliness Maintenance
Overall Satisfaction	1.000								
Thermal Comfort	.924 ^a	1.000							
Air Quality	.926 ^a	.964 ^a	1.000						
Lighting	.880 ^a	.909 ^a	.904 ^a	1.000					
Acoustic Comfort	.933 ^a	.962 ^a	.961 ^a	.919 ^a	1.000				
User Privacy	.842 ^a	.876 ^a	.865 ^a	.838 ^a	.884 ^a	1.000			
Furnishing Layout	.929 ^a	.963 ^a	.963 ^a	.917 ^a	.973 ^a	.878 ^a	1.000		
Aesthetics	.884 ^a	.912 ^a	.912 ^a	.981 ^a	.923 ^a	.839 ^a	.921 ^a	1.000	
Cleanliness Maintenance	.888 ^a	.919 ^a	.922 ^a	.901 ^a	.929 ^a	.876 ^a	.925 ^a	.902 ^a	1.000

^aSignificant at 0.05 level, Pearson Correlation Sig. (2-tailed), N=755

Table 6 — ANOVA analysis

		Sum of Squares	df	Mean Square	F	Sig.
Thermal Comfort	Between Groups	3.94	5	.79	1.72	.127
	Within Groups	342.79	749	.46		
	Total	346.73	754			
Air Quality	Between Groups	3.99	5	.80	1.82	.106
	Within Groups	327.80	749	.44		
	Total	331.79	754			
Lighting	Between Groups	6.83	5	1.37	2.92	.013
	Within Groups	350.53	749	.47		
	Total	357.36	754			
Acoustic Comfort	Between Groups	3.78	5	.76	1.66	.141
	Within Groups	340.60	749	.45		
	Total	344.38	754			
User Privacy	Between Groups	6.50	5	1.30	2.63	.023
	Within Groups	370.49	749	.49		
	Total	376.99	754			
Furnishing Layout	Between Groups	3.81	5	.76	1.72	.128
	Within Groups	332.97	749	.44		
	Total	336.79	754			
Aesthetics	Between Groups	5.55	5	1.11	2.35	.039
	Within Groups	353.36	749	.47		
	Total	358.91	754			
Cleanliness & Maintenance	Between Groups	7.83	5	1.57	3.31	.006
	Within Groups	354.11	749	.47		
	Total	361.94	754			
Overall Satisfaction	Between Groups	4.67	5	.93	2.01	.076
	Within Groups	348.82	749	.47		
	Total	353.50	754			

ANOVA test results

Since the data were collected from more than three independent groups (universities), one way ANOVA test was employed to test statistically significant differences among IEQ parameters between the groups. From Table 6, it is evident that IEQ parameters: ‘Lighting’, ‘User privacy’, ‘Aesthetics’ and ‘Cleanliness and Maintenance’ were significantly different among all ($P < 0.05$). Therefore, the ANOVA test results are consistent with the Hypothesis 2 of this study.

Regression test results

Finally, linear regression analysis was conducted to predict the overall user satisfaction as a dependent variable through all the IEQ study parameters selected as independent variables. From Table 7, IEQ variable: Lighting, User Privacy, Aesthetics and Cleanliness Maintenance didn’t fit into the linear regression model ($P > 0.05$). Therefore, Hypothesis 3 of this study is rejected. This study finding corroborates previous research results^{36,37}, which identified that each attribute (study parameters) performance asymmetrically and nonlinearly impacts on overall satisfaction.

Table 7 — Regression coefficients of overall satisfaction for the user

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.33	.05	.00	6.10	.000
Thermal Comfort	.15	.06	.15	2.68	.007
Air Quality	.21	.06	.21	3.70	.000
Lighting	.04	.06	.04	.61	.539
Acoustic Comfort	.34	.06	.34	5.40	.000
User Privacy	.02	.03	.02	.56	.577
Furnishing Layout	.16	.06	.16	2.54	.011
Aesthetics	.02	.07	.02	.30	.762
Cleanliness Maintenance	.03	.04	.03	.84	.402

Kano Classification of IEQ items

From linear regression analysis, it is found that the relationships between the overall user satisfaction and the individual IEQ factors are not a linear one, and that is why the Kano model of customer satisfaction based on a classificatory approach was adopted in this study. Table 8 contains the outcome after applying the Kano classification method (see methodology section)

Table 8 — Kano classification of IEQ Items

IEQ Items	CU	JU	PU	RBU	AU1	AU2
<i>Thermal Comfort</i>						
Temperature	Must be	One Dimensional	One dimensional	One Dimensional	Must be	Must be
Humidity	One dimensional	Must be	One dimensional	One Dimensional	One dimensional	One dimensional
<i>Air Quality</i>						
Rate of Ventilation	One dimensional	One Dimensional	Must be	One dimensional	Must be	One dimensional
freshness of air	Must be	One Dimensional	One dimensional	Attractive	One dimensional	One dimensional
Odor	Indifferent	One dimensional	One dimensional	Indifferent	Attractive	Must be
<i>Comfortable light</i>						
Day light	One dimensional	Indifferent	Indifferent	Attractive	Attractive	One dimensional
visual Comfort	Must be	Must be	Must be	Must be	Must be	Must be
overall light	One dimensional	One Dimensional	Must be	Must be	One dimensional	One dimensional
<i>Acoustic Comfort</i>						
Noise from inside	One dimensional	Must be	One dimensional	One dimensional	Indifferent	Indifferent
Noise from outside	One dimensional	Must be	Must be	Must be	One dimensional	Indifferent
<i>User Privacy</i>						
Free interaction	Must be	Must be	Must be	One dimensional	Attractive	Attractive
visual privacy	Indifferent	Attractive	Attractive	Indifferent	Must be	One dimensional
<i>Furnishing and Layout</i>						
furniture & Workstations	One dimensional	One dimensional	Must be	One dimensional	One dimensional	One dimensional
space & mobility	Must be	Must be	One dimensional	Must be	Indifferent	Attractive
<i>Aesthetics</i>						
Interior Decoration	Attractive	Attractive	Attractive	Indifferent	One Dimensional	One Dimensional
View from windows	Indifferent	Indifferent	One dimensional	Indifferent	Indifferent	Attractive
Colors & textures	Attractive	Attractive	Indifferent	Attractive	Must be	Indifferent
<i>Cleanliness & Maintenance</i>						
Cleanliness	Must be	One Dimensional	Must be	Attractive	Must be	Attractive
Maintenance	Must be	Must be	Must be	Must be	One Dimensional	One Dimensional

on the user response datasets of all the studied universities in a comparative tabular representation.

From Table 8, out of 19 IEQs of CU, 7 are classified as ‘One dimensional’ as well as ‘Must be’, 3 are ‘Indifferent’, and remaining 2 are ‘Attractive’. Similarly for JU, ‘One dimensional’ and ‘Must be share’ equal number of IEQs (7), rest of them are ‘Attractive’ (3) and ‘Indifferent’ (2). For PU, 7 IEQs are grouped into ‘One dimensional’, 8 into ‘Must be’, 2 into ‘Indifferent’ and remaining 2 into ‘Attractive’ category. For RBU, ‘One dimensional’ contains 6, ‘Must be’ includes 5, ‘Indifferent’ holds 4, and remaining 4 belongs to ‘Attractive’ category. For AU1, ‘One dimensional’ category enlists 7, ‘Must be’ enlists 6, ‘Indifferent’ enlists 3, and remaining 3 are ‘Attractive’. For AU2, the numbers of ‘One dimensional’, ‘Must be’, ‘Indifferent’, and ‘Attractive’ categories are 9, 3, 3, and 4 respectively. It is evident that none of the IEQs are classified into the last two Kano Categories i.e., ‘Reverse’ and ‘Questionable’.

Conclusion

The study has attempted to explore the effects of IEQ dimensions of university libraries on overall satisfaction of the users. To do that the study shown that the overall occupant satisfaction cannot be predicted merely by IEQ dimensions through linear regression model, even though strong and significant correlations exist between them. Consequently, the study tried to explain the underlying effects of IEQ dimensions on overall satisfaction by applying Kano model after considering the theoretical similarities.

The study found that the Kano classification significantly differs for an Individual IEQ factor across universities among users which indicate that it is by and large dependent on the individual University library’s users’ feelings and perceptions about the IEQs. The model assessment framework followed in this study will not only help library administrators to properly unveil the relationships of independent variables (dimensions of IEQ) with the dependent variable (overall occupant satisfaction) but also will

measure the odds of Library's IEQ dimensions through the checkpoints used in the questionnaire, and that too in a very economical way.

Implementing Kano model applications in the assessment framework will enable the library administrators to explore the complex relationship between IEQ factors and the overall occupant satisfaction to better understand the user needs related to library IEQs. This is particularly useful for taking immediate as well as long term improvement decisions. It also provides scope for library administrators to work in tune with architects, engineers, and interior decorators to make library's indoor environment more ecofriendly, user-friendly, and ultimately sustainable by communicating the survey results to them and act accordingly. The study may work as a foundation and guide for future researchers to conduct similar kind of research, especially in India, with greater scope and deeper level of investigation.

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