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A HYBRID MULTIPLE ATTRIBUTE DECISION-MAKING (MADM) PROCEDURE FOR DEVELOPING STRATEGIES TO ENHANCE STUDENTS' SATISFACTION OF UNIVERSITY HOSTELS

ANATH RAU KRISHNAN
Labuan Faculty of International Finance
Universiti Malaysia Sabah

MAZNAH MAT KASIM
ENGKU MUHAMMAD NAZRI ENGKU ABU BAKAR
School of Quantitative Sciences
Universiti Utara Malaysia

Abstract

This paper offers a new, hybrid multiple attribute decision-making (MADM) procedure which can be employed to quantitatively develop the optimal strategies for inflating students' satisfaction of university hostels. The procedure uses: the systematic random stratified sampling approach for data collection purpose as students dwelling in hostels are 'naturally' grouped by block and gender, factor analysis to extract a large set of hostel attributes into independent factors, the Sugeno measure for characterizing the type of interaction shared by the hostel attributes within each extracted factor, the Delphi method for obtaining a well-agreed importance ranking on the extracted factors and finally, a non-linear fuzzy prioritization (NLFP) method for determining the weights of the independent hostel factors. The feasibility of the proposed procedure is illustrated by conducting a real evaluation involving Universiti Utara Malaysia (UUM) hostels. The proposed procedure has the ability to identify the actual factors influencing students' satisfaction along with the weights of the factors and the type of interaction shared by the attributes within each of these factors and thus enable the management of a university to make better-informed decisions pertaining to the strategies.

Keywords: *Better-informed decisions, hostel satisfaction, interactive hostel attributes, multiple attribute decision-making, Sugeno measure.*

Introduction

In the current higher education scenario, the management of a university should be ready to develop and execute all the potential strategies to stay ahead of their rivals in the highly competitive global marketplace (Hemsley-Brown & Oplatka, 2006) as a means to unceasingly boost the enrolment of both local and international students. Many universities are trying to obtain a competitive advantage by offering pleasurable campus housing or hostels as campus accommodation appears as one of the primary aspects taken into consideration by the students before choosing a university to pursue their tertiary education (Oppewal, Poria, Ravenscroft & Speller, 2005). Apart from creating a competitive advantage, providing satisfying hostels is essential to assure the students are being more socially attuned and actively participating in extracurricular or campus activities (Rinn, 2004). Besides, the hostels which meet the students' expectations are believed to have the potential in increasing the students' enthusiasm and performance in academia (Amole, 2005; De Araujo & Murray, 2004; Moos & Lee, 1979). Also, students who are satisfied with their hostels usually express a higher sense of attachment (Khozaei, Hassan & Khozaei, 2010) and thus, tend to re-enroll or further their studies in the same university.

In short, it is really essential for the universities to timely understand the actual needs of the students in order to determine the efficient strategies that can be executed to assure the students are residing in a pleasing hostel environment. However, identifying the optimal strategies is somewhat challenging as this task usually demands the consideration of multiple evaluation attributes, as can be found in Adewunmi, Omirin, Famuyiwa and Farinloye (2011); Amole (2009); Hassanain (2008); Khozaei, Ayub, Hassan and Khozaei (2010); Najib, Yusof and Osman (2011). In addition, there are only limited types of quantitative approaches that have been proposed in aiding the universities to develop better strategies in offering a pleasing hostel life for their students. Besides, most of the past quantitative studies simply averaged out the importance rates given by the students with respect to each hostel attribute and the decision on the strategies were merely made based on the average score attained by each attribute (Hassan, Al Kodmany & Aarab, 2014; Khozaei, Hassan & Ramayah, 2011).

Therefore, this paper aims to propose a new, hybrid MADM procedure which enables the universities to quantitatively identify and implement a set of optimal strategies that could assure a satisfying hostel-living experience for their students.

The paper is organized as follows. Firstly, the significance of this paper is explained. Secondly, a short review on the Sugeno measure, fuzzy number and NLFP are presented. Thirdly, the proposed MADM procedure is introduced. Fourthly, the feasibility of the proposed procedure is demonstrated through a real evaluation involving UUM hostels. Finally, the contributions of the paper and recommendations for future studies are highlighted.

Literature Review

Sugeno Measure

In the multi-attribute analysis, the concept of monotone measure has been used to quantitatively characterize or express the interactions shared by the evaluation attributes (Angilella, Greco, Lamantia & Matarazzo, 2004; Beliakov & James, 2011; Grabisch, 1996; Zhang, Zhou, Zhou & Chen, 2014). Sugeno or λ- measure which was introduced by Sugeno (1974) emerges as one of the monotone measures that is making progress into various real applications such as that presented in the studies conducted by Liou, Chuang and Tzeng (2014), Liou, Hsu and Chen (2014), and Pasrija, Kumar & Srivastava (2012) due to its ease of usage and modest degree of freedom features (Ishii & Sugeno, 1985) where the interaction parameter, λ can be simply identified via equation (1) by only providing the information on the individual weights of attributes.

$$1 + \lambda = \prod_{j=1}^{n}(1 + \lambda g_j) \quad (1)$$

Note that $gj = g\lambda\ (c_j)$, $j = 1, ..., n$ in equation (1) implies the individual weights of attributes. The type of interaction shared by the attributes can be described based on the value of λ (Gürbüz, Alptekin & Alptekin, 2012; Hu & Chen, 2010).

a) If - $\leq \lambda < 0$ then, it interprets that the attributes, $c_j = \{c_1, c_2, ..., c_n\}$ are sharing sub-additive effects (redundancy). This means a significant increase in the performance of the target can be achieved by only simultaneously enhancing some attributes in c_j which have higher individual weights.

b) If $\lambda > 0$ then, it implies that the attributes, $c_j = \{c_1, c_2, ..., c_n\}$ are sharing super-additive effects (synergy support). This means a significant increase in the performance of the target can be achieved by simultaneously enhancing all the attributes in c_j regardless of their individual weights.

c) If $\lambda = 0$ then, it indicates that the attributes, $c_j = \{c_1, c_2, ..., c_n\}$ are non-interactive.

Fuzzy Numbers

In the process of solving MADM problems, some prior information or preferences from experts are normally required especially for the purpose of deriving the weights of evaluation attributes. Conventionally, the experts are required to express their preferences based on crisp scales or numbers. However, it is somewhat insensible to force them to exactly or precisely indicate their preferences based on crisp scales as human judgments or thoughts are usually incorporated with uncertainty (Kahraman, 2008; Zimmermann, 2000). Thus, they actually tend to express their preferences via natural languages or linguistic terms (Onut, Kara, & Isik, 2009) such as 'unimportant', 'important', 'very important' and 'extremely important' instead of using crisp numbers (1,2,3,...).

In fuzzy MADM analysis, the experts are allowed to express the required prior information or preferences in linguistic terms. Later, each of these linguistic preferences is then quantified into appropriate fuzzy number in order to mathematically capture the uncertainty that usually is embedded in linguistic estimations (Akdag, Kalaycı, Karagöz, Zülfikar, & Giz, 2014; Kahraman, Cebeci, & Ulukan, 2003; Zadeh, 1965; Zimmermann, 2001). Fuzzy number is a generalization of the basic number which comprises of lower (l), upper (u) and most optimal (m) values which best represent a linguistic term. Two often used fuzzy numbers are known as triangular (TFN) and trapezoidal fuzzy number (TrFN) (Ilangkumaran, Karthikeyan, Ramachandran, Boopathiraja & Kirubakaran, 2015; Hadi-Vencheh & Mokhtarian, 2011) and they can be actually denoted by (l, m, u) and (l, m_1, m_2, u) respectively. Figure 1 shows the graphical representation of TFN and TrFN (Lee, 2005).

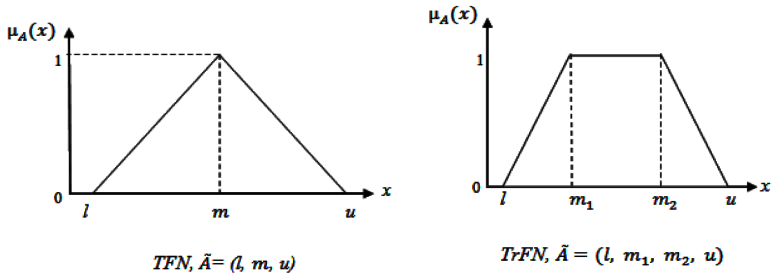

Figure 1. Triangular and trapezoidal fuzzy numbers.

With regards to Figure 1, $\tilde{A}$ represents the fuzzy number of a linguistic term A. The degree to which an element x belongs to a set or linguistic term A is characterized by that usually ranges from 0 to 1. If the element x really belongs to A then, $\mu_A (x) = 1$ and if it clearly does not belong to A then, $\mu_A (x) = 0$. The higher the membership value of $\mu_A (x)$, the greater is the belongingness of an element x to the linguistic term A.

NLFP Method

NLFP (Mikhailov, 2003) is a method used to identify the weights of independent elements which are compared in a pair-wise matrix. The merits of using NLFP can be summarized as follows.

Firstly, this method permits the preferences over the pair-wisely compared elements to be expressed through linguistic terms. These linguistic preferences are then quantified into their respective fuzzy numbers by adhering to a predetermined fuzzy AHP scale in order to mathematically capture the uncertainty that is usually embedded in the linguistic judgements.

Secondly, in order to avoid using reciprocal judgments (lie between $\tilde{9}^{-1}$ and $\tilde{1}^{-1}$) which could lead to rank reversal problems, this method only requires the experts to provide an assessment whenever an element a is equally or more preferred than b. If it is found that a is less preferred than b then the assessment should be done opposite where b is compared to a.

Thirdly, the weights of elements and consistency value of the pair-wise matrix can be derived simultaneously (Hadi-Vencheh and Mohamadghasemi, 2011) by simply solving the suggested non-linear optimization model (2), which can be constructed based on the fuzzy pair-wise matrix.

$$\text{Maximize } \mu \tag{2}$$

Subject to;

$$(m_{ab} - l_{ab})\mu w_b - w_a + l_{ab} w_b \leq 0,$$

$$(u_{ab} - m_{ab})\mu w_b + w_a - u_{ab} w_b \leq 0,$$

$$\sum_{j=1}^{n} w_j = 1, w_j > 0, j = 1, \ldots n$$

With regards to equation (2) l_{ab}, u_{ab}, and m_{ab} denote the lower, upper and most probable values of the fuzzy preference of an element *a* over *b*. Meanwhile, wj represents the weight of element j and μ implies the consistency index of the pair-wise comparison matrix. Positive μ value indicates that the assessed pair-wise matrix is being consistent and negative value implies inconsistency where in this circumstance, a reassessment of the pair-wise matrix may be required.

Methodology

The implementation of the proposed MADM procedure entails the following phases. In the first phase, all the possible or relevant attributes that could influence the students' satisfaction of the accommodation offered by the university that is being studied are identified. In the second phase, a questionnaire is designed as an instrument to collect the required data for the evaluation where the selected students (or respondents) are requested to indicate their general perceptions on how important each attribute is in determining their satisfaction, based on a preset Likert scale. The systematic random stratified sampling approach can be utilized in selecting the respondents for the survey purpose as the students dwelling in hostels are usually or 'naturally' clustered by block and gender.

In the third phase, the collected data is factor analyzed in order to extract the larger set of hostel attributes into fewer, independent factors. It has to be emphasized that although the factors are independent of each other, the attributes within each independent factor are still being interactive to each other.

In the fourth phase, the interaction parameter, λ of each factor is identified in order to understand the type of interaction shared by the attributes within each factor. The process of identifying λ values can be summarized as follows. Firstly, the experts are requested to linguistically express their own opinions on the individual importance or contribution of each attribute towards its corresponding factor. Based on these linguistic terms, one of the eight fuzzy conversion scale as suggested by Chen and Hwang (1992) is selected in order to quantify the offered linguistic judgments into their respective fuzzy numbers. Further details on the principle of choosing the appropriate scale can be found in Chen and Hwang (1992). Then, the corresponding crisp values for each of these fuzzy judgments are identified using a fuzzy scoring method as suggested in Chen and Hwang (1992). Subsequently, the average individual importance $\bar{I}_{jp}$ of an attribute j corresponding to factor p can be determined using equation (3).

$$\bar{I}_{jp} = \frac{1}{z}\sum_{e=1}^{z} I_{jep} \qquad (3)$$

Suppose $E_e = \{E_1, E_2, ..., E_z\}$ represents the experts involved in the analysis, then based on equation (3), I_{jep} denotes the crisp importance of attribute j with respect to factor p that is derived from expert e and z implies the total number of experts involved. These average values actually represent the individual weights of attributes, $g_j = g_\lambda(C_j)$, $j = 1, 2, ..., n$. With the available individual weights, equation (1) can be then applied in order to find the interaction parameter, λ of each factor.

In the fifth phase, NLFP is used to assign the weights of the extracted factors. However, prior to constructing the required optimization model (2), this proposed procedure suggests the usage of the Delphi method so a single pair-wise matrix which is almost agreed by all the experts involved in the analysis can be obtained. The Delphi method refers to a process of achieving consensus on a particular matter through several rounds of discussion or assessment involving anonymous experts (Hartman, 1981; Hill & Fowles, 1975; Sung, 2001). With regards to this procedure, in the first round of the survey, the anonymous experts are requested to rank the extracted hostel factors based on their importance together with adequate justifications. In the second round, the responses from the other experts are shared with each expert (without revealing the identity of the other experts) and they are allowed to make any changes on their initial preferences after reviewing the ranking and justifications given by the other experts. The survey is repeated until a consensus is achieved where at this stage, by considering the ranks and reasons given by all the experts, a single pair-wise matrix is assessed using linguistic terms. The linguistic terms in the pair-wise matrix are then converted into their corresponding fuzzy numbers based on a predetermined AHP scale. The suggested non-linear optimization model (2) is then formulated and solved in order to derive the weights of factors and the consistency values of the pair-wise matrix.

In the sixth phase, based on the weights of the extracted factors and the type of interaction shared by the attributes within each factor, the optimal strategies for enhancing the students' satisfaction of the hostels can be developed. The proposed hybrid MADM procedure can be summarized as shown in Figure 2.

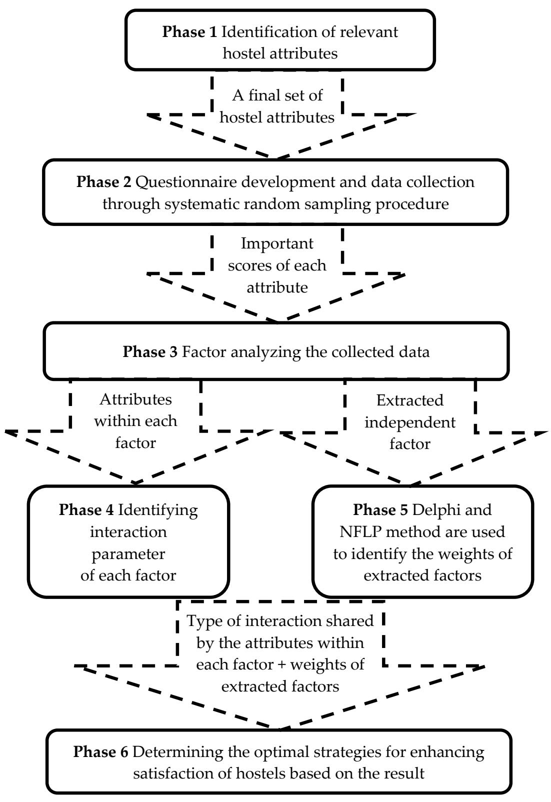

Figure 2. Proposed hybrid MADM procedure.

Real Application

In the effort to test the workability of the proposed procedure, this paper has focused on quantitatively identifying some efficient strategies in enhancing the students' satisfaction of UUM hostels. With the help of five experts who are familiar with UUM student accommodation, 22 attributes as shown in Table 1 were finalized for carrying out the analysis. Meanwhile, the questionnaire designed for the data collection purpose was structured into two main sections. The first section was to allow the respondents to specify their level of satisfaction of each attribute with respect to their own hostel; the second section was to let the respondents indicate their general views on the importance of each hostel attribute for a student (however, for this study, only the data from the second section were used).

Prior to conducting the actual survey, the questionnaire was pretested with a small group of students and based on their feedback, some alterations were made to the questionnaire. Some puzzling terms were replaced with simpler words. The actual data collection process was then conducted using the revised version of the questionnaire.

This study narrowed its target respondents to local undergraduate students. The respondents from each hostel were selected using a systematic random stratified sampling approach; the students living in each hostel were naturally clustered by block and gender. The respondents from each 'cluster' or block were then selected by using the systematic random sampling approach where the students residing in every tenth room in the block were chosen for the survey purpose after randomly selecting the first room on the first floor. Before offering the questionnaires to the respondents, a few screening questions were asked to ensure that they were local undergraduates who were really staying in the hostel and not there for visiting or other reasons. Out of 966 the students who were approached, based on the chosen sampling method, only 702 students agreed to participate in the survey. By adhering to the rule of '10 observations per attribute', the sample size of this study (N = 540) could be claimed to be ample for performing meaningful factor analysis.

The total respondents were composed of 60.4 per cent females and 39.6 per cent males where the majority of them were Malays (67.5%), followed by Chinese (14.4%), Indians (11.7%), and others (6.4%). 55.6 per cent of them were first and second year students and 44.4 per cent were third and fourth year students.

The respondents were assisted throughout the answering process and this assured that the questionnaires were fulfilled completely. The survey was scheduled and conducted after 5pm as usually the students would be free from classes or any other campus activities after this point of time. The survey took almost three weeks to be completed with the assistance of two male and female postgraduate students.

Table 1

Set of Hostel Attributes

No.	Attributes	Descriptions
1	Hostel's exterior	Attractive landscape and exterior design.
2	Distance to university facilities	Distance to university facilities such as library, post office, book store, bank, mini market, and sports complex.
3	Bus	Frequent and prompt bus service, hospitable drivers.
4	Room population	The room is not too crowded.
5	Security system	Effectiveness of security guard, and availability of CCTV surveillance.
6	Safety	Availability and condition of fire extinguishers, smoke detectors and handrails for stairs.
7	Room size	Room is spacious.
8	Fees	Fees per semester are reasonable, value for money.
9	Cafeteria	Fresh, hygienic, variety of food at reasonable price, cleanliness of cafeteria etc.
10	Maintenance service	The defective facilities and equipment in room are fixed promptly after the complaint is made/ effectiveness of service.
11	Cleaning service	The cleanliness level of toilets, corridors, exterior of building are well maintained.
12	Physical condition of room	Ventilation, lighting, furniture, and painting.
13	Wi-Fi accessibility	Good Wi-Fi connection, accessible everywhere within the hostel.
14	Computer lab facility	Organized, computers are in good condition, availability of printing service, etc.

(continued)

No.	Attributes	Descriptions
15	Study room facility	Quite, clean, encouraging environment to study, etc.
16	Accessibility to ATM	Easy to get to the nearest ATM.
17	TV facility	Quality of TV, number of TVs available, availability of ASTRO channel packages.
18	Laundry facility	Laundry room and washing machines in good condition, suitable and enough space to dry laundry, etc.
19	Sports facility	Variety of sports facilities within hostel, good condition of futsal /netball court / other sports facilities within hostel.
20	Management	Satisfaction of principals', fellows', and administrative staff's services.
21	Washrooms and toilets	Well-equipped, privacy is secured, sufficient number of toilets, spacious and comfortable toilets.
22	Students representative committee (SRC)	SRC really conscious of students' problems and needs, organizing valuable and interesting programs for students throughout the semester.

Before factor analyzing the large dataset on the importance of attributes obtained through the second section of the questionnaire, the appropriateness of the data for factor analysis was verified with the aid of the SPSS software. The inspection of the correlation matrix disclosed the presence of many coefficients of 0.3 and above. Besides, the Kaiser-Meyer-Oklin (KMO) value of the dataset surpassed the recommended value, 0.6 and Bartlett's Test of Sphericity reached statistical significance as the p-value was below 0.05. These three conditions indicated that the dataset was suitable for factor analysis.

By performing factor analysis, the large set of hostel attributes was clustered into five independent factors. The result of the factor analysis for this study can be recapped as follows (refer to Table 2). Extraction through principal component analysis showed the presence of five common factors with eigenvalues exceeding one, explaining 30.014 per cent, 8.487 per cent, 5.667 per cent, 5.522 per cent, and 5.291 per cent of the variance respectively. Varimax rotation was then performed for better interpretation of these five common factors. Five attributes, 'cleaning', 'washrooms', 'maintenance', 'management', and 'SRC' which showed higher loading at factor 1 was renamed as service factor (f_1). Meanwhile, 'TV', 'laundry', 'ATM', 'sports', and 'study room' which had higher loading at factor 2 was relabeled as 'facility' factor (f_2). 'Population', 'size', 'physical', 'lab', and 'Wi-Fi' which were grouped into factor 3 was identified as convenience factor (f_3) and 'bus', 'distance', 'cafeteria', 'exterior', and 'fees' were classified as value for money factor (f_4). Lastly, 'security' and 'safety' which had higher loading at factor 5 was renamed as precaution factor (f_5).

Table 2

Result of Factor Analysis

Total Variance Explained				Rotated Component Matrix					
Component	Initial Eigenvalues			Attributes	Component				
	Total	% of Variance	Cumulative %		1	2	3	4	5
1	6.603	30.014	30.014	Cleaning (C_{11})	.749				
2	1.867	8.487	38.501	Washroom(C_{21})	.717	.379			
3	1.247	5.667	44.169	Maintenance (C_{10})	.612				
4	1.215	5.522	49.691	Management (C_{20})	.602	.341			
5	1.164	5.291	54.982	SRC (C_{22})	.527				
6	.929	4.222	59.204	TV (C_{17})		.786			
7	.871	3.961	63.166	Laundry (C_{18})		.723			
8	.777	3.530	66.696	ATM (C_{16})		.665			
9	.768	3.489	70.184	Sports (C_{19})		.638			
10	.710	3.225	73.410	Study room (C_{15})		.435			.346
11	.649	2.949	76.359	Population (C_4)			.673		
12	.594	2.701	79.060	Size (C_7)			.647		.412
13	.582	2.644	81.704	Physical (C_{12})	.409		.583		
14	.570	2.591	84.295	Lab (C_{14})			.561	.412	
15	.515	2.339	86.635	Wi-Fi (C_{13})			.547	.427	
16	.490	2.229	88.864	Bus (C_3)	.307			.650	
17	.476	2.163	91.027	Distance (C_2)		.329		.649	
18	.458	2.082	93.109	Cafeteria (C_9)	.449			.453	
19	.427	1.941	95.050	Exterior (C_1)				.453	.448
20	.391	1.779	96.829	Fees (C_8)			.355	.391	
21	.375	1.705	98.535	Security (C_5)					.756
22	.322	1.465	100.000	Safety (C_6)					.684

Meanwhile, based on the linguistic judgments from the experts, the 11-point scale as shown in Table 3 was chosen to aid the process of identifying the individual weights of the attributes. The linguistic judgments from the experts, conversion of these judgments into their respective crisp values and the identification of the final individual weights of the attributes as well as the interaction parameter, λ of each factor using equations (3) and (2) respectively are summarized in Table 4.

Table 3

11-point Fuzzy Conversion Scale

Linguistic terms	Fuzzy numbers	Corresponding crisp values identified *via* fuzzy scoring approach
Exceptionally low (EL)	(0, 0, 0.1)	0.045
Extremely low (ExL)	(0, 0.1, 0.2)	0.135
Very low (VL)	(0, 0.1, 0.3, 0.5)	0.255
Low (L)	(0.1, 0.3, 0.5)	0.335
Below average (BA)	(0.3, 0.4, 0.5)	0.410
Average (A)	(0.3, 0.5, 0.7)	0.5
Above average (AA)	(0.5, 0.6, 0.7)	0.590
High (H)	(0.5, 0.7, 0.9)	0.665
Very high (VH)	(0.5, 0.7, 0.9, 1)	0.745
Extremely high (ExH)	(0.8, 0.9, 1)	0.865
Exceptionally high (EH)	(0.9, 1, 1)	0.955

After achieving consensus through the Delphi method and by adhering to a nine-point fuzzy AHP scale (refer Table 5), a fuzzy pair-wise matrix as shown in Table 6 was obtained. It can be noticed that since the 'value for money' was found to be less important than the 'precaution' factor, the evaluation was done vice versa to avoid using reciprocal values. Based on the fuzzy pair-wise comparison, the suggested nonlinear optimization model (2) was constructed and solved with the aid of the EXCEL Solver. The following result was obtained: weight of service factor, $w_1 = 0.374$; weight of facility factor, $w_2 = 0.309$; weight of convenience factor, $w_3 = 0.147$; weight of value for money factor, $w_4 = 0.065$; weight of precaution factor, $w_5 = 0.106$; consistency index, $\mu = 0.634$. The value of μ implied that the pair-wise comparison matrix was consistent.

Table 4

Identification of Interaction Parameter, λ

Factors	Attributes	Degree of Importance (in linguistic terms)					Importance (in crisp values after defuzzyfying fuzzy numbers)					Final individual weights	λ
		E_1	E_2	E_3	E_4	E_5	E_1	E_2	E_3	E_4	E_5		
Service	Cleaning	VH	AA	A	BA	A	0.745	0.590	0.500	0.410	0.500	0.549	-0.956
	Washroom	BA	A	VL	A	ExL	0.410	0.500	0.255	0.500	0.135	0.360	
	Maintenance	H	A	H	A	H	0.665	0.500	0.665	0.500	0.665	0.599	
	Management	H	EH	ExH	A	L	0.665	0.955	0.865	0.500	0.335	0.664	
	SRC	ExL	EL	ExL	ExL	EL	0.135	0.045	0.135	0.135	0.045	0.099	
Facility	TV	EL	VL	EL	ExL	ExL	0.045	0.255	0.045	0.135	0.135	0.123	0.035
	Laundry	VL	VL	VL	ExL	VL	0.255	0.255	0.255	0.135	0.255	0.231	
	ATM	ExL	VL	EL	ExL	ExL	0.135	0.255	0.045	0.135	0.135	0.141	
	Sports	VL	BA	VL	L	A	0.255	0.410	0.255	0.335	0.500	0.351	
	Study room	ExL	ExL	VL	EL	ExL	0.135	0.135	0.255	0.045	0.135	0.141	
Convenience	Population	ExL	L	A	L	ExL	0.135	0.335	0.500	0.335	0.135	0.288	-0.943
	Size	A	BA	BA	A	H	0.500	0.41	0.410	0.500	0.665	0.497	
	Physical	VH	H	A	AA	BA	0.745	0.665	0.500	0.590	0.41	0.582	
	Lab	ExL	L	VL	L	VL	0.135	0.335	0.255	0.335	0.255	0.263	
	Wi-Fi	H	A	A	H	H	0.665	0.500	0.500	0.665	0.665	0.599	
Value for money	Bus	ExH	A	AA	BA	A	0.865	0.500	0.590	0.410	0.500	0.573	-0.972
	Distance	BA	BA	L	L	A	0.410	0.410	0.335	0.335	0.500	0.398	
	Cafeteria	H	A	A	AA	A	0.665	0.500	0.500	0.590	0.500	0.551	
	Exterior	L	ExL	AA	AA	BA	0.335	0.255	0.590	0.590	0.41	0.436	
	Fees	H	A	VH	H	AA	0.665	0.500	0.745	0.665	0.59	0.633	
Precaution	Security	H	H	AA	A	AA	0.665	0.665	0.590	0.500	0.59	0.602	0.140
	Safety	A	BA	L	L	VL	0.500	0.41	0.335	0.335	0.255	0.367	

Table 5

Fuzzy AHP Scale

Linguistic terms	Corresponding TFNs	Descriptions
Equally important	= (1, 1, 2)	Two factors contribute equally.
Slightly important	= (2, 3, 4)	One factor is slightly favoured over another.
Strongly important	= (4, 5, 6)	One factor is strongly favoured over another.
Very strongly important	= (6, 7, 8)	One factor is very strongly favoured over another.
Extremely important	= (8, 9, 9)	One factor is most favoured over another.
The intermediate values	= (1, 2, 3), = (3, 4, 5), 6 = (5, 6, 7), = (7, 8, 9)	Used to compromise between two judgments.

Table 6

Fuzzy Pair-wise Comparison between Hostel Factors

	Service	Facility	Convenience	Value for money	Precaution
Service	(1,1,1)	(1,2,3)	(2,3,4)	(4,5,6)	(3,4,5)
Facility		(1,1,1)	(1,2,3)	(3,4,5)	(2,3,4)
Convenience			(1,1,1)	(2,3,4)	(1,2,3)
Value for money				(1,1,1)	
Precaution				(1,2,3)	(1,1,1)

Discussion of the Result

Through the proposed method, with the help of factor analysis, it was discovered that the actual factors that influence students' satisfaction of hostels are service, facility, convenience, value for money, and precaution aspects. However, it was understood that the prioritization of these factors are as follows: service (0.3738) > facility (0.3093) > convenience (0.1466) > precaution (0.1057) > value for money (0.0645). Therefore, in order to enhance the students' satisfaction, a hostel can simply focus on the four crucial aspects; service, facility, and convenience factors that are independent of each other.

The interaction parameter, λ= -0.956 indicates that in order to improve the hostel's performance in terms of the service factor, it is enough to simultaneously enhance some of the attributes which have higher individual weights; management and maintenance. In other words, by only enhancing management and maintenance, a significant improvement in service can be achieved. The experts involved in the analysis accepted this fact by stating that a good management and maintenance team can ensure the other attributes within the factor are at the satisfactory level. According to them, a good management team often monitors the cleanliness level of the hostel and motivates the SRC to frequently organize fruitful activities for the students. Besides, a caring management and effective maintenance team timely ensures the washrooms and toilets are in good condition.

Meanwhile, λ= 0.035 implies that in order to significantly improve the hostel's performance with respect to the facility factor, all the attributes within the factor need to be enhanced simultaneously regardless of their individual weights; TV, laundry, ATM, sports amenities and study room.

Lastly, λ= -0.943 shows that in order to attain drastic improvement in the convenience factor, it is sufficient to concurrently enhance some of the attributes which have higher individual weights; physical condition of the room and Wi-Fi accessibility. According to the experts, good furniture arrangement, ventilation, painting, and lighting have the capability to form a spacious and comfy in-room environment even if the room is small (refers to 'room size' attribute) or crowded (refers to 'room population' attribute). Besides, the current trend in education which largely relies on internet facility, a fine Wi-Fi accessibility would enable the students to access the required information from any corner of the hostel and reduce the students' dependency on computer labs and also ensure them not to be concerned too much about the quality of the lab service.

Conclusion and Recommendations

The contributions of this paper can be recapitulated as follows. Firstly, a new hybrid MADM procedure is introduced to aid the universities on quantitatively identifying more efficient strategies for heightening the students' satisfaction of their hostels. The procedure offers some worthwhile information to the management of a university such as the key factors that determine the students' satisfaction of the hostels, the prioritization on these factors and the type of interaction held by the hostel attributes within each of these factors which subsequently permit the management to implement the identified strategies with better confidence. Secondly, in the process of illustrating the feasibility of the proposed procedure, this paper has offered solutions for a real problem where a set of appropriate strategies to enhance the students' satisfaction of the UUM hostels were identified.

For future research, the proposed procedure can be further expanded so it can be used to evaluate the performance of various hostels by measuring the overall satisfaction score of each hostel with the aid of any suitable operators which can model the interactions between the hostel attributes during the aggregation process. Besides, since the presented real application was only based on the perceptions of local undergraduate students of UUM, future research could broaden the types of respondents involved in the analysis by taking into consideration the participation of foreign and postgraduate students in order to attain a more representative result. Also, apart from the hostel satisfaction problem, the proposed procedure can be applied in other domains where the strategies need to be developed or decided by considering multiple attributes. However, the sampling approach may vary based on the objective of the research or target population.

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