International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Occupant Behaviours And Preferences Toward Comfort Level and Energy Use In Building

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Abstract: ***The expeditiously growing world energy use has already increased the concerns over supply difficulties, consumption of energy resources and environmental impacts. Malaysian Government has spent about RM 2.5 billion for public buildings energy cost every year including nearly RM 400 million was spent for public universities energy cost alone. The study conducted to investigate the effect of occupant's behaviour and preference that may affect comfort level and energy use in university buildings. A survey carried out to identified occupant's behaviour and comfort related to energy consumption in the building. Sets of the questionnaire were prepared to be distributed among occupants of the building understudies. Based on the result, occupants prefers to have automated system for both lighting and ventilations to achieve comfort level in the classroom. Furthermore, highly correlated for automated system for both lighting and ventilation are consistently preferred by occupants; which indicate that occupants have consistently agree on automated system compared to standard switching. It could be concluded that occupant's behaviour and preference can affect the energy use in the buildings.***

Index Terms**:** ***Comfort level, higher education building, occupant's behaviour, occupant's preference.***

I. INTRODUCTION

In developing countries like Malaysia, energy efficiency and sustainability are considered as the most important policies and strategies for energy efficient buildings and environmental sustainability. The extensive use of energy rises the concerns about supply difficulties, consumption of resources and environmental impacts [1]. Based on Malaysia Energy International Hub (MEIB) [2], electricity is the second highest consumed as a resource after natural gas as energy resources in the year 2017. The trend of final energy consumption in Malaysia recorded increase annually for every year [3] which in five major sectors i.e., agriculture, commercial, transportation, industrial and residential.

Revised Manuscript Received on 30 July 2019.

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Energy is often used more than necessary because of lack of control for energy use in the buildings, where the inconsistency behaviours of the occupants is a major contributor [4][5][6].

Occupant's behaviour refers to the user's interaction with the building system to control the internal environment for achieving a healthy and comfort condition [7].There are three different categories of occupant's behaviour. First is related to only the presence of the occupant, secondly, related to the manual interaction with the appliances and lastly, related to the interaction between the occupant and building with an automatic system [8]. Occupant's behaviour or preference plays an important role in buildings energy consumption and is the main contributor to the energy consumption in a building [8]. Previous studies have found that the occupant's behaviour is associated with how the occupants use energy inside the building. Al-Mumin (2003) [9] investigate the occupancy pattern and operation schedule by field survey on 30 residences in Kuwaiti. Then, the building simulation (ENERWIN) has been performed based on those survey information and results showed that the annual electricity consumption increased by 21% compared to the ideal conditions. The result reflects that Kuwaiti occupants tends to leave the lights on when the rooms is empty and prefer to keep the room cooler with lower air-conditioner temperature which is at 22 ^{o}C. Hassan (2014) reported that one of the challenges for achieving the desired goal toward energy efficiency of the building is the inconsistency of the behaviour of the occupants [5]. The is because to the building energy behaviour was influenced by many factors, i.e., building construction, weather condition, thermal property, physical materials used, lighting, HVAC and the occupancy and their behaviour [10].

On the other hand, thermal comfort is considered as one of the important factors to achieve satisfaction for occupants within indoor environment [11]. Thermal measurement and thermal comfort survey surveys conducted in university building in Fukuoka, Japan [11]. Through the investigation, 34% of occupants prefer slightly cooler conditions in buildings and 50% of the occupants did not want to change the thermal environment in building. However, no critical issues to discomfort was recorded due to the occupants could tolerate with the indoor environmental conditions by adapting behaviourally by making modification such as drinking water, switching on the fans and activities that can satisfy their thermal comfort. This indicates that adjusting occupants behavior towards comfort will affects the energy use in building.

Meanwhile, rapid development for public and private universities produce a great impact on educational development in the future but also increase energy demands [12]. Due to the high expenditure in every years for electrical consumption in Malaysia, the Malaysian Ministry of Education (MoE) and The Malaysian Ministry of Higher Education (MoHE) recommended to all educational institutions to commit and take the responsibility to save energy which also the effort to implement energy saving programs in government buildings [13]. The growing interest in sustainability declarations in higher education institutions, as universities plays a role in creating a sustainable future.

Malaysian Government has spent about RM 2.5 billion for public buildings energy cost every year including nearly RM 400 million was spent for public universities energy cost alone [14]. However, if the energy consumption in the university buildings can reduced up to 10%, the estimated cast of saving will be around RM 40 million per year which indicates a significant amount of reduction. The aim of this study is to understand the behaviour of occupants in a public university building, specifically in Malaysia. The study has been conducted to investigate the effect of occupant's behaviour and preference that may affect the comfort level and energy use in the classroom.

II. METHODOLOGY

A. Selection of Case Study

The study was conducted in one of public university in Malaysia namely *Universiti Tun Hussein Onn Malaysia* (UTHM), Batu Pahat, Johore, Malaysia. The university is located at the southern part of Malaysia with the populations of students of about 16,000 that including undergraduate and postgraduate students.

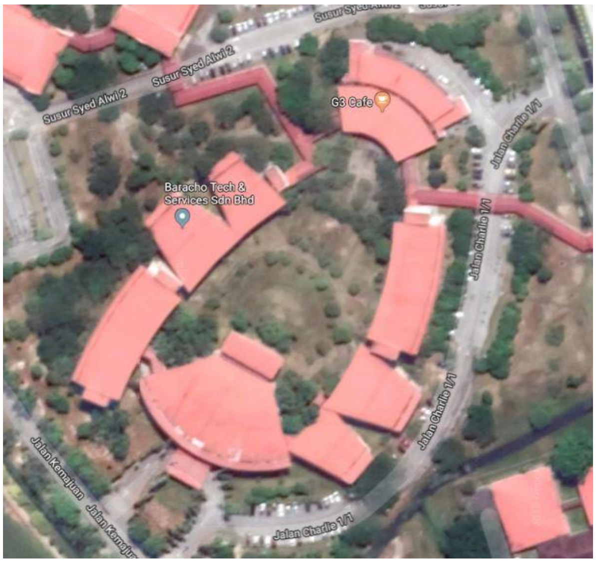

Figure 1: Lecture Complex A building in UTHM, Johore, Malaysia on Google Maps [15]

Specifically, the building of Lecture Complex A was selected as a case study, which represented as a lecture facilities building as shown in Figure 1. Lecture Complex A was the largest and most recent lecture facilities in UTHM. This building was consisting of the major room such as a lecture classroom and tutorial classroom as shown in Figure 2(a) and (b).

(a) Lecture classroom

(b) Tutorial classroom

Figure 2(a) and (b): Main type of classroom in Lecture Complex A building

B. Questionnaire

The data collection was conducted through questionnaire survey. The questionnaire was designed and distributed to the respondents to investigate their behaviour and preference toward comfort level in Lecture Complex A building related to energy use. The surveys are carried out by sending out invitations to a consistent amount of building occupants which are representative of the building population [16]. This content of questionnaire is focusing on the usage of lighting and ventilation system, which frequently used by the occupants in the lecture and tutorial classroom.

The questionnaires consist of relevant questions to achieve the objectives of this study. The questionnaire form consists of four part which as shown in Table 1.

Table 1: Content of questionnaire

Section	Question type
A	Respondent's information
B	Review of respondent's behaviour related energy usage in university building.
C	Respondent's comfort level of room in university building.
D	Comment or suggestion

As for section A using, the multiple-choice options were given as for the respondent background's information. Likert scale was applied in Section B and C in order to measure attitude, usual or standard format consist of series of statements, i.e., 1-Strongly disagree, 2-Disagree, 3-Neutral/Undecided, 4-Agree, 5-Strongly Agree [17].

Meanwhile, for Section D, an open-ended format was given for comments and suggestions.

In order to secure the reliability of this study, the Coefficient of Cronbach alpha for the questionnaire has been validated. The analysis was conducted using IBM Statistical Package for Social Science (SPSS) Version 23 software. The result of Cronbach alpha of this study is 0.805, which indicates reliable.

C. Field survey

The field survey was conducted in April 2018 in which during the active semester. This questionnaire was distributed to 254 occupants out of 750 occupants, which represented whole population in Lecture Complex A buildings. The amount of occupant selection for the survey was refers on Krejcie's and Morgan's (1970) [18] selection of sample size for questionnaire.

III. RESULT AND DISCUSSION

A. Occupant's behaviour, preference and comfort level

A mean ranking analysis was conducted on the occupant's behaviour and preference to investigate the response of occupants toward lighting and ventilation system in Lecture Complex A building. The range of mean score values for "agree" was determined to be more than 3.5, while 3.0 to 3.49 are considered as "partially agree/disagree" and mean score value less than 3.0 is deliberated as "disagree". Based on the results on Table 2, it was observed that occupants agree to have automated system that switches the air conditioner on and off scores the highest which is ranked 1st with mean value of 4.01. The result followed by the occupants agree to have automated system for lighting to switches on/off by occupants at 3rd rank with mean value of 3.97. The behaviours of occupants mainly affect the energy consumption for example partially switch off the air conditioner when leaving the room ranked 5th with mean score of 3.47. On other hand score of 3.14 for occupants partially switch off the lights if not use and puts in 6th ranked. Moreover, occupants partially prefer natural ventilation during a day ranked 7th. Unfortunately, 8th ranked with mean score of 2.96 shows the occupants disagree on having natural lighting during a day. The 9th and 10th ranked performance were recorded with low mean values for both preferences in standard switch for lighting and air conditioner which mean value of 2.66 and mean value of 2.64 respectively. The distinct choice was made by occupants in the building to choose automated system than standard switching. The mean ranking was presented in Table 2.

Table 3 shows the mean ranking of comfort level for occupants in Lecture Complex A building. The usage of lighting in the room satisfied for activities for comfort level was ranked 1st with mean value of 3.59 which shown the occupants agreement. While, second ranked scored by comfort level for suitable temperature for occupants with mean value of 3.4 which indicates the occupants partially agree with the temperature in the classroom. Subsequently, occupants not agree on satisfaction on the amount of glare from natural lighting in the classroom with mean value of 2.70 (ranked 3rd). Despite this, occupants also disagrees with satisfaction of amount of natural ventilation in the classroom and ranked last with mean value of 2.63

Table 2: Mean Ranking For Occupant's Behaviour And Preference In Lecture Complex A Building

No	Behaviour/Preference	Mean	Rank
1	I prefer to have automated system that switches the air conditioner on	4.01	1st
2	I prefer to have automated system that switches the air conditioner off	4.01	1st
3	I prefer to have automated system that switches the light off	3.97	3rd
4	I prefer to have automated system that switches the light on	3.97	3rd
5	I switch off the air conditioner when I leave the room	3.47	5th
6	I switch off the light if not use	3.14	6th
7	I prefer natural ventilation during a day	3.01	7th
8	I prefer natural lighting during a day	2.96	8th
9	I prefer to switch off the light on/off with a standard switch	2.66	9th
10	I prefer to switch off the air conditioner on/off with a standard switch	2.64	10th

Table 3: Mean Ranking For Comfort Level In Lecture Complex A Building

No	Comfort level	Mean	Rank
1	The usage of lighting in the classroom are satisfied for activities	3.59	1st
2	Temperature in the classroom are suitable for occupants	3.40	2nd
3	I satisfied with the amount of glare from natural light in my classrooms	2.70	3rd
4	I am satisfied with the amount of natural ventilation in my classrooms	2.63	4th

B. Discussion of findings

The findings of this study shows that occupant's behaviour and preference toward comfort level in Lecture Complex A building. As a result, the occupants agreed to have an automated system on the air conditioner because of occupants does not have the accessibility to control the air conditioner in classroom.

Although, occupants claimed that with automated system for air conditioner could makes the classroom environment more consistent and stay comfort level for temperature, which cannot be compared with other people [19].

Besides that, manual system for air conditioner can be accessed by occupants to control the temperature as compared to the automated system for air conditioner. However, it required occupants to take efforts on switching on/off air conditioner and take control the defaults which can affect the efficiency of the air conditioner system by time.

Furthermore, occupants also agree to have an automated system for lighting because the system only runs in occupant's presence which can contributes for energy saving approach. Automated system for both lighting and ventilation system potentially reduce energy consumption [20]. It only operates when occupant's presence was detected, which means energy can be used efficiently. In addition, Lecture Complex A building used full artificial lighting as the main lighting system and natural lighting cannot afford to lighten the area in the lecture hall.

The value of mean was recorded partially for occupants switch-off the air conditioner when leaving the room which mean almost 50% of occupants switch off the air conditioner when leave the classroom and 50% does not do. In order to apply energy efficiency, occupants should switch off the air conditioner when leave the classroom. Thus, behaviour of occupants in this case study are advisable to have automated system on ventilation system which help to monitor the usage of energy use. Highly agree on switching off the air conditioner. This approach reduces the energy wastage on a ventilation system that occupants frequently leave the room without switching off the air conditioner [21].

Based on the occupants, if the lighting and thermal comfort were sufficient, it more desirable to switch it off. Similarly, occupants also partially switch off the lighting system when leave the classroom which indicates approximately half of the populations in the building switch off the lighting when leave the classroom. The result shows that occupants less awareness on managing energy. This result shows no contrary on preference of occupants agree on having automated system for lighting system.

Overall, the occupants agree on automated system, and low mean value for manual switching for both ventilation and lighting system. The behaviour of occupants shows occupants are less awareness about energy management which can contributes to the energy consumption in the building. While, the preference of occupants in the building for lighting and ventilation system shows positive energy saving effect toward sustainable development.

In term of comfort level, most occupants claimed that temperature condition and lighting condition were important to sustain productivity in the area. Every classroom should provide lighting and ventilation system facilities to ensure the comfort of occupants during the class. Occupants agree that lighting are satisfied in the classrooms because every classroom in the building provide a significant amount of light that satisfied the occupants. In the same way, every classroom received a different amount of glare from outside, there are certain classroom have windows and no window in the classroom. Occupants with spectacles claimed that they need sufficient light to able to see clearly but if the amount of lighting was sufficient [22] and explained reasons for occupants to agree that usage of lighting in the room are satisfied for activities. Then, occupants partially agree on temperature in the classroom are suitable for occupants. This happened because occupants claimed that when the classroom are full of occupants, the temperature is increase drastically and while classroom are empty, the temperature drop drastically which it related to technical issues.

In contrary, occupants disagree on satisfaction in natural ventilation and natural lighting which means almost all the occupants not agrees with the environment inside the classroom if the classroom works based on natural ventilation and natural lighting. Besides, classrooms are built in closed area for teaching and learning which not suitable for natural ventilation and natural ventilation.

C. Consistency of occupant behaviour and preference

Pearson Correlation was introduced in this study. It measures the extent of variables tend to change together. It also provides a 'unitless' value for measurement between two variables that glazing from -1 (perfectly negative association) to 0 (no association) to +1 (perfectly positive association) [23]. The correlations analysis aim to indicate the consistency for each behaviour and preference correlates to each other. Table 4 represents the summary of significance for correlation. The value of Pearson correlations which is more than 0.500 are considered as significance.

Table 4: Correlations Between Each Behaviour/Preference

		I prefer to have automated system that switches the air conditioner on	I prefer to switch the air conditioner on/off with a standard switch	I prefer to have automated system that switches the light off	I prefer to have automated system that switches the light on
I prefer to have automated system that switches the air conditioner off	Pearson Correlation Sig. (2-tailed) N	.900** .000 150	Not Significant	.878** .000 150	.885** .000 150
I prefer to have automated system that switches the air conditioner on	Pearson Correlation Sig. (2-tailed) N	Not Significant	Not Significant	.785** .000 150	.813** .000 150

I prefer to switch the light on/off with a standard switch	Pearson Correlation Sig. (2-tailed) N	Not Significant	.662** .000 150	Not Significant	Not Significant
I prefer to have automated system that switches the light off	Pearson Correlation Sig. (2-tailed) N	Not Significant	Not Significant	Not Significant	.974** .000 150

** 2-tailed Pearson correlations

Refers on Table 4, it has been shown that occupants have highly positive correlation for preferences to have automated system that switches the air conditioner off with automated system switch on (r=0.900). It indicates that occupants consistent to have automated system for air-conditioner on/off in the classroom. Besides, there also highly positive correlation are justified that occupants are consistently prefer to have automated system for lighting on and off (r=0.974). Based on the correlations, occupants consistent to agree on having both lighting and ventilation installed in automated system. Moreover, highly positive correlation shown occupants have a consistency on preference on automated system for switch on/off both lighting and ventilation which are 0.878, 0.885, 0.785 and 0.813 respectively.

Nevertheless, strong correlation are recorded to have standard switch for lighting and ventilation (r=0.662). Despite that, correlations value for automated system are far better consistency than standard switch. To sum up, this study shows automated system have more significance than standard switch to achieve comfort level in term of behaviour and preferences in Lecture Complex A building.

IV. CONCLUSION

This paper investigated the occupant's behaviour and preference toward comfort level in Lecture Complex A building in UTHM, Johor, Malaysia. University students were selected as occupants in the building. The summary of the results discusses as below:

1) Based on the results, occupants prefer to have automated system for both lighting and ventilations to achieve comfort level in the classroom.
2) The results also shows that only half of occupants have a positive behaviour towards energy use in building (i.e., switch off air conditioner when leave room, switch off the light if not use, and use natural ventilation). This indicates that the level of awareness on energy preservation are still low among the respondents
3) Most of occupants satisfied with the comfort level of lighting system and only partially agree on the thermal condition in the classroom.
4) Furthermore, highly correlated for automated system for both lighting and ventilation are consistently preferred by occupants which indicate that occupants have agree that automated system are better than standard switching especially for energy efficient in building.
5) Occupant's behaviour and preference can affect the energy use in the building. Hence, the objective of this paper was achieved.

This study were mainly focused on the behaviour and preference of occupants toward comfort level in university building. However, there is large gap regarding behavioural and preference between other types of higher educational building in the university that has not yet discovered such as laboratories, faculty, lecture offices and etc. Hence, the novelty of this paper is study of occupant's behaviour and preferences focusing on classroom in university building.

Therefore, it is recommended for the future studies should be considered the behaviour and preference of occupants to achieve energy sustainability in the buildings.

ACKNOWLEDGMENT

This work was supported by Postgraduates Research Grants (GPPS) No. H293 and TIER 1 No. H187 as Graduated Research Assistant (GRA). This work also part of the research activities of *University Tun Hussein Onn Malaysia* (UTHM), Batu Pahat, Johore, Malaysia.

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