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## Indoor Environment Quality (IEQ): Temperature and Indoor Air Quality (IAQ) Factors toward Occupants Satisfaction

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**Abstract.** In Malaysia, the demand for green building kept rising from year to year. The design concept of the green building which provides better indoor environment to make occupant more comfortable and healthier. The Green Building Index (GBI) as a rating system in Malaysia was used to evaluate the environmental design and performance of a building by the occupant, due to that, it is used for this research to investigate the relationship between the indicator of the Indoor Environment Quality (IEQ) and occupant satisfaction's element in a private university in Sarawak. The building occupants are the most important feedback to determine the occupant's satisfaction level for IEQ within the campus. A quantitative method was applied to reach the objectives by using simple random sampling. A total of 254 copies of the questionnaire survey form were distributed to respondents at School of Business and Management (SBM) and School of Built Environment (SBE) in the university. However, there are only 238 responds are usable for this research. The result shows that the temperature (57.0%) and the indoor air quality (66.7) in IEQ's indicator had moderate positive and significant relationship with thermal comfort, and ventilation respectively.

### 1. Introduction

Nowadays, a green building concept in our lifestyle is considered important due to the fact that green building fundamental is based on effective use of materials, land, energy, and water in order to minimize the resources used. In addition, Green Building also generates minimal waste to curtail negative environmental impacts. Furthermore, Green Building provides a good indoor environment to maximize productivity for its residents. Green building also is perceived as an enhancement, repairs, or develops the usual environment to decrease life cycle costs [1].

Green Building is a building that can tolerate or improve in the region of the environment; life and harmonize quality; conserve energy, resources and recycling materials; decrease the amount hazardous substances; and the local and worldwide ecosystem throughout the whole building life-cycle. Therefore, a Green Building can be called as a sustainable building. On the other hand, many of the education institutes are spending billions of dollars into green building construction to showcasing their sustainability commitment [3]. The education institute creates social organization in society by matching people ideas, attitudes, habits, emotions, customs, and sentiments. Education institute transmits our ethnic values to the next generation [4]. Due to this, Malaysia education institutes also catches up on this trend to make and create their campuses more comfortable for study environment.



Since Malaysia launched the Green Building Index (GBI) in January 2009, the number of projects that have been certified by April 2019 are 488 projects, which include the education institution [5]. In the state of Sarawak, there is one of the education institute that implemented green building features within the campus, where this private university is the culmination of the Sarawak state's vision, the university through its futuristically planned campus and state-of-the-art facilities has achieved a GBI with "Platinum Index" rating in Malaysia university [6]. Although GBI certificate showed that the university is very effective in energy efficiency (EE), water efficiency (WE), and indoor environment quality (IEQ), but the GBI tool did not assessed how occupants feel while occupying the green building. Moreover, the research for satisfaction by occupant in the university is limited as to date. Therefore, in improving this gap, this research objective is intended to investigate the relationship between IEQ's indicator and satisfaction's element by occupant in the university and evaluate the satisfaction by occupant for IEQ's indicator.

### *1.1 Post Occupancy Evaluation (POE)*

POE is an important tool to evaluate the performance of the building by occupant. POE is a method to provide feedback throughout a building's lifecycle from initial concepts through to occupation. The POE are more focus in term of three broad areas, which are process, functional performance, and technical performance. By functional performance, the areas in environmental aspects such as temperature, indoor air quality (IAQ) were covered to evaluate the comfortable in term of thermal comfort, and ventilation. The method for assessing functional performance in POE was through questionnaires survey [7-10].

### *1.2 Indoor Environment Quality (IEQ)*

The indoor environment quality (IEQ) incorporates the conditions inside a building and their effects on occupants or residents. In addressing IEQ, the strategies included to protect human health, improve quality of life, reduce stress and potential injuries. In addition, IEQ's goal normally focus on providing stimulating and comfortable environments for occupants and minimizing the risk of building-related health problems. A better indoor environment quality (IEQ) can improve the lives of building occupants, increase the re-sale value of the building, and reduce liability for building owners, Anon [11]. Mujeebu [12] mentioned that the place with high indoor environment quality (IEQ) noticeably improves the occupant's health and mood, thereby increasing their productivity.

Moreover the indoor environment quality (IEQ) of the building is projected to be more comfortable and productive [13]. Thus, the preservation of Indoor Environment Quality (IEQ) in the building is significant to make occupants' comfortable and productivity [14]. Many researchers have been undertaken on temperature, indoor air quality (IAQ) as indicators of IEQ [15-18]. The performance by IEQ's indicator have influenced the satisfaction of the occupant in the building.

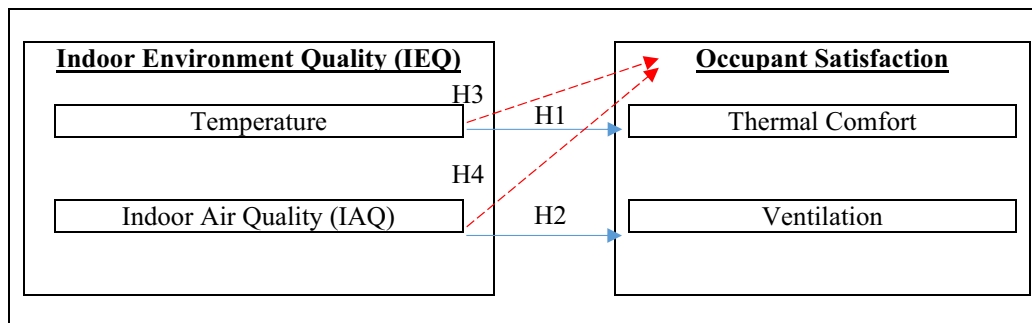
### *1.3 Occupant Satisfaction*

In assessing the overall comfort of occupant using indoor environment elements, the satisfaction of occupants in the building are the important element to ensure the building are comfort to the occupier. If the built environment is leading to negative impact on occupant satisfaction, then it is a matter of concern and could point to some design or technical flaw in the building system [19]. In many research studies, researchers have clearly established that performance with indoor environment quality (IEQ) of a building have a direct influence on the occupants satisfaction in term of thermal comfort, and ventilation [13-17].

### *1.4 Research Hypotheses*

The hypothesis to be tested for this study was shown on figure 1. Each of the IEQ's indicator (which are temperature, and IAQ) in occupant room has positive influence towards occupant satisfaction in term of thermal comfort and ventilation respectively. Moreover, the temperature and IAQ,

performances have positive influence towards overall occupant satisfaction in occupant room at the university.



**Figure 1.** Conceptual Framework Based on Research Hypothesis.

Hypothesis 1 : The temperature performance in occupant room has positive influence towards occupant satisfaction in term of thermal comfort.

Hypothesis 2 : The Indoor Air Quality (IAQ) performance in occupant room has positive influence towards occupant satisfaction in term of ventilation.

Hypothesis 3 : The temperature performance has positive influence towards overall occupant satisfaction at the university.

Hypothesis 4 : The Indoor Air Quality (IAQ) performance has positive influence towards overall occupant satisfaction at the university.

## 2. Methods

This research deployed a quantitative approach of questionnaire survey. Referring to the objective, the questionnaire survey method was used to investigate the relationship between IEQ's indicator and satisfaction's element by occupant, and to evaluate the satisfaction by occupant in the university. During site visit to the university, the population size for School of Business and Management (SBM) and School of Built Environment (SBE) were obtained. Accordingly, there were about 425 occupants and 326 occupants which comprising of students, academicians and administration personnel in both schools as of 2019. Therefore, the total population size for this research had nearly to 751 occupants in the university. The effective method of determining sample size is created by ever increasing to representative statistical sample [20]. Therefore, based on the sample size table, this research should at least have 254 respondents since the population size are 751 persons. The technique of the sampling was used for this research project is simple random sampling, which is one type of probability sampling. The simple random sampling was used due to the population (staffs and students) of the university has a known and equal chance of being selected as a subject in the questionnaire survey [21].

## 3. Results and discussions

### 3.1 Reliability Analysis

The higher the internal consistency reliability is when the value of Cronbach's alpha was closer to 1.0. [21,22]. When Cronbach's alpha coefficient for items measuring the concept in a variable less than 0.60, then the internal consistency reliability was considered to be poor. Perfectly, the Cronbach alpha coefficient of a variable should be above 0.7 to consider as acceptable variable. The coefficient of the Cronbach alpha exceeds 0.80 was considered as good consistent.

Table 1 tabulates the Cronbach's alpha for IEQ's indicators (which are temperature and IAQ) and occupant satisfaction's elements (that are thermal comfort and ventilation) as following. Accordingly,

the value of Cronbach's alpha coefficient for all variable were exposed significantly over 0.70. Hence, this considered that all variable is acceptable and consistent.

**Table 1.** Reliability Analysis on Variables of the IEQ and Occupant Satisfaction

Construct	Variables	Cronbach's Alpha
IEQ Variables	Temperature	0.873
	Indoor Air Quality (IAQ)	0.848
Occupant Satisfaction Variables	Thermal Comfort	0.760
	Ventilation	0.877

### 3.2 Respondents Profile

The data collection for this research study was started in August 2019 and collected from staffs and students in that particular university in Sarawak. Around 254 respondent's participants of this survey, there are only 238 responds are usable for this research. Based on the data collection in this research, most of the respondent are Chinese student with aged between 18 and 30 years old who studies at School of Business and Management (SBM) in the university. Majority of the respondents have certificate with above STPM level. Thus, most of the respondent can be considered had their knowledge with feeling about IEQ's indicator and occupant satisfaction's element for this research.

### 3.3 Main Findings

The descriptive statistical analysis for this research shown that the mean scores for IEQ's indicator and occupant satisfaction's element in this study is vary from 3.423 to 3.452. It meant that occupier in SBM and SBE in the university have a moderate mean value agreement to all item in IEQ's indicator and occupant satisfaction's element.

In correlation analysis for this study, the temperature performance (57.0%) was confirmed that it has moderate positive and significant relationship with thermal comfort. This meant that the occupant room have enough indoor temperature with stable mode will make occupier feel more comfortable and acceptable with room temperature. When occupant in the room have enough cool to sense for their skin, then occupier will feel comfort within this condition. Therefore, the temperature performance has influence on thermal comfort for the occupant in room within the university. Meanwhile, the result also indicates that the IAQ performance (66.7%) has moderate positive and significant relationship with ventilation. When occupant in the room have enough fresh and clean air to breathe, then the occupier will feel fresh with stable and good air flows. Thus, the IAQ performance has effect on ventilation for university's staffs and students to progress the task in the occupant room. Therefore, it can be said that the temperature and indoor air quality in occupant room at the university have moderate positive and significant relationship with thermal comfort and ventilation respectively. Hence, all hypotheses (H1, and H2,) as stated above are supported.

**Table 2.** The relationship between IEQ's Indicator and Satisfaction's Element

Hypotheses	Relationship	Findings
H1: Temperature with Thermal Comfort	Positive	Significant
H2: IAQ with Ventilation	Positive	Significant

Through multiple regression analysis, the result in this study indicated that temperature performance (9.1%) has insignificant effect on occupant satisfaction for overall occupant room in the university even it had moderate positive relationship between temperature and occupant satisfaction.

Whereby, result obtained in this research was contradicted resulted that occupant room have enough cool and indoor temperature did not make occupier to satisfy overall comfortable in that room [15]. Thus, the occupant room within the university need to improve the temperature performance so that occupier will be obtained great satisfaction when being in that area. On the other hand, result shown that IAQ performance (36.5%) has significant and moderate positive influence on overall occupant satisfaction in occupant room of the university whereby meant that occupant room have enough fresh and stream of indoor air will make respondent to satisfy overall comfortable. IAQ performance as the key reasons to effect occupant's satisfaction in the building [12]. Thus, the IAQ performance has important role to make occupier satisfied in overall indoor environment of the building when performing their task in the occupant room within the university. All in all, this conclude that, IAQ, was found to have moderate positive and significant effect on satisfaction by occupier in the university. For that reason, hypothesis 4 is supported. However, the temperature was found that has moderate positive relationship but insignificant effect on occupant satisfaction for occupant room in the university and eventually leads to hypothesis 3 was rejected.

#### 4. Conclusions

Green Buildings are considered important as less resources on the earth are used over the next thirty years. Green buildings are better and more effective on materials usage and minimal waste to reduce negative environmental impacts. A good indoor environment is provided by a good green building design concept. Accordingly, the objectives for this research is to investigate the relationship between IEQ's indicator and satisfaction elements by occupant in one of GBI Platinum Index higher education institution in Sarawak. Since IEQ is one of the criteria in GBI, then it is meant that the building is healthier and more comfortable in order to minimize negative impacts on occupants. This research concludes that, with good performance of IEQ in the buildings, it increased the occupant's satisfaction. On top of that, it also reduced liability, lowering operation and maintenance cost and also enhanced technology performance system. Future research for IEQ components should be extend to other variables and other GBI criteria in order to obtain the overall occupant's satisfaction of the university.

#### 5. Acknowledgments

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