



The effect of indoor environmental quality on occupants' perception of performance: A case study of refurbished historic buildings in Malaysia

Syahrul Nizam Kamaruzzaman^{a,*}, Egbu C.O.^b, Emma Marinie Ahmad Zawawi^c, Azlan Shah Ali^a, Adi Irfan Che-Ani^d

^a Building Performance & Diagnostic Department of Building Surveying, Faculty of the Built Environment, University of Malaya, 50603 Kuala Lumpur, Malaysia

^b School of the Built Environment, University of Salford, Maxwell Building, Salford, M5 4WT, England, UK

^c Centre of Research & Graduate Studies, Faculty of Architecture, Planning & Surveying, University Technology MARA, 40450 Shah Alam, Malaysia

^d Department of Architecture, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia (UKM), 43600 UKM Bangi, Selangor, Malaysia

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ABSTRACT

This paper presents an assessment of occupants' opinion of the internal environment of buildings, based upon their responses to questions relating to a range of discrete factors. The survey considers many aspects of the internal environment and seeks to gain occupants responses to each of these in terms of "User Satisfaction" and "Degree of Importance". The questionnaire utilised a seven-point bi-polar scale to score these responses against each of the factors. In addition, the questionnaire elicits a 'fingerprint' that combines up to 22 factors relating to satisfaction with the building. The study documents and considers aspects of the building environment for which the users noted that they were least satisfied as well as those that are considered by the occupants as being of most importance. It is critical that sustainable development results not just in resource conservation, but also in increasing productivity and occupant well-being within buildings. This study hopes to provide insight for the design community on the perceptions of occupants in relation to building performance based on indoor environmental quality (IEQ) criteria. It also seeks to add to the growing body of research on sustainable design and occupants' perception of IEQ.

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1. Introduction

It can be taken as axiomatic that the majority of people spend most of their time indoors and that various aspects of the indoor environment affect their well-being and performance in this context. Furthermore, the design of high performance, green buildings promises to provide a better and healthier environment for occupants. Research indicates that people spend approximately ninety per cent (90%) of their time indoors [1,2]. For many, therefore, the risks to health posed by exposure to indoor air pollution may be greater than those posed by outdoor air pollution.

Several earlier studies [3–7] document numerous factors that have been found to affect occupants' performance and well-being. These include, amongst others, exposure to nature and daylight, air quality, temperature, odours, noise and ergonomics as well as opportunities for social gathering, relaxation, and exercise. As a result of information arising from such studies, various models have emerged that seek to assess or measure these factors. Such

models include the Building Research Establishment Environmental Assessment Method (BREEAM) in the UK [8], the Leadership in Energy and Environmental Design (LEED) Green Building Rating System in the US [9] and the Hong Kong Building Environmental Assessment Method HK-BEAM in Hong Kong [10]. These schemes invariably incorporate assessments relating to a number of attributes of indoor environmental quality (IEQ); each of which carries credit points to contribute to the overall result.

Although some buildings may meet the recommended standards overall, occupants often still complain about various parameters. Day-lighting and thermal comfort contribute to better IEQ, and have a positive effect on an occupant's perception of productivity and performance [5]. More research needs to be conducted on this issue, especially with regards to buildings in Malaysia, to enable standards to be optimized for the benefit of the occupants. It is essential for these buildings to have a good IEQ, as it affects the productivity and health of the occupants of the building. It is also critical that sustainable development results not just in resource conservation, but also in increasing productivity and occupant well-being.

With a rising awareness of the role of the indoor environment on occupants' productivity and efficiency, there is increased interest

* Corresponding author. Tel.: +60 3 7967 6833; fax: +60 3 7967 5713.

E-mail address: syahrulnizam@um.edu.my (S.N. Kamaruzzaman).

Table 1

A seven-point scale of user satisfaction and user dissatisfaction; and level of importance and un-importance.

Do you like the...	How important is this in the design of your ideal office?
User Dissatisfaction User Satisfaction -3 -2 -1 0 1 2 3	Unimportant important -3 -2 -1 0 1 2 3
1. noise level	
Comments :	

in obtaining feedback from occupants and this is often obtained by using a questionnaire [11–15]. This study presents the results of an occupants' assessment carried out on six refurbished historic buildings in Malaysia using a questionnaire based assessment. The outcomes of the study should assist in identifying particular aspects of the environment that require adjustment and improvement, and aim to provide a better internal environment for the occupants.

2. Research methodology and methods

It is now common that, in addition to field measurements and expert opinions, feedback from building occupants often forms an integral part of an IEQ assessment exercise. The use of questionnaires provides one of the most economical and efficient ways to gather such information. Robson [16] noted that the survey method is one of the ways to obtain a standard and stable collection of data from a specific population. This approach was employed in this study because of the size of population, which covered the whole country. A mail questionnaire survey was identified as the most suitable method, through which respondents could be approached most easily and with minimum cost [17]. The mail survey was not only the easiest approach to obtaining research data but it has also been identified as the most popular method for such purposes in Malaysia, even though the chances of obtaining good response rate are still very low [18].

The assessment of occupants' perceptions of a building can provide valuable information about its performance and about overall satisfaction levels. With this in mind, a questionnaire that attempted to determine, reliably, the occupants' perceptions of their environment has been developed in the UK [19]. This questionnaire incorporates 24 factors relating to the internal environment and rates these in terms of 'User Satisfaction' and 'Degree of Importance'. An amended version of that questionnaire was used to undertake the study described here. Whilst the questionnaire that was used was similar to that generated in the UK, it is not entirely the same. The length and questions have been adapted and redesigned by excluding 2 factors to reflect the specific setting of the study and the local condition and the climate of Malaysia. A seven-point Likert scale for 'User Satisfaction' and 'Degree of Importance' was used for the questionnaire in this instance (Table 1). By combining all 22 factors relating to the internal environment of the building, the questionnaire can also be used to elicit a user satisfaction score and a fingerprint for building satisfaction.

2.1. Building descriptions

The survey that forms the basis of this study was carried out on six historic buildings in Malaysia, consisting of offices, hotels and public buildings in Peninsular Malaysia. Three of the buildings are in the capital city of Kuala Lumpur and three in Penang. The multi-site approach of case studies ensures that different context and setting of each building results in differing perspectives of end users which, in turn, is likely to produce a great diversity of opinions and justifications. The range of buildings within the study has

been restricted by several parameters, such as size, building operation and age to provide a coherent and comparable data set. The size of each historic building, based on the Gross Floor Area (GFA), is greater than 100,000 sqf. This threshold level was selected in order to ensure that the buildings included would provide valid reflection of the IEQ aspects that affect the occupant's perception of performance relative to historical buildings. In addition, the preliminary survey/records from Heritage of Malaysia Trust reveal that almost two-third of historical buildings in Malaysia have a GFA of more than 100,000 sqf. The buildings selected for the study were also required to be in 100% operation, especially in the case of building services items. This is because the feedback from occupants in the context of IEQ relates mostly to factors that are affected directly by the operation of building services. Due to limited budget for this research, only 6 buildings were used for the data collection. As shown in Table 2, these buildings were all British Colonial buildings with the architectural style of the Mogul (also known as Moorish or Indian Muslim style) influence; Tudor, Neo-Classical and Neo-Gothic. In order to retain the anonymity of the individual buildings, they have been designated as Historic Building 1, Historic Building 2, Historic Building 3, Historic Building 4, Historic Building 5 and Historic Building 6.

2.1.1. 'User Satisfaction Fingerprints'

The responses to the questionnaires allow the generation of a graphical representation of the totals for each answer. This is referred to in the context of this study as a "fingerprint" and normalises each question to a score between +100% and -100% [14,19–21]. The equation for this is:

$$FLS = 100 \left[\frac{\sum_{j=1}^m i_{j,k} l_{j,k}}{mi_{\max} l_{\max}} \right] \quad (1)$$

The third part of the analysis is similar to the second. However, by using the equation below, a normalised individual score for each person can be calculated.

$$FLS = 100 \left[\frac{\sum_{k=1}^n i_{j,k} l_{j,k}}{ni_{\max} l_{\max}} \right] \quad (2)$$

This score will be between +100% and -100%.

Table 2

Descriptions of the buildings used in the study.

	Building type	Architectural style	Built	No. of storey
Historic Building 1	Office	Neo Gothic	1912	2
Historic Building 2	Office	Neo Classical	1884	2
Historic Building 3	Office	Neo Classical	1907	2
Historic Building 4	School	Neo Classical	1904	3
Historic Building 5	Public	Neo Classical	1900	2
Historic Building 6	Hotel	Neo Classical	1926	2

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