

A quantitative evaluation of indoor environmental quality in refurbished kindergarten buildings: A Malaysian case study



Naziah Muhamad Salleh ^{a, b}, Syahrul Nizam Kamaruzzaman ^{a, *}, Mike Riley ^c,
Emma Marinie Ahmad Zawawi ^d, Raha Sulaiman ^a

^a Building Performance and Diagnostic, Faculty of Built Environment, University of Malaya, 50603 Kuala Lumpur, Malaysia

^b Building Technology Department, School of Housing Building & Planning, University Science Malaysia, 11800 Penang, Malaysia

^c School of Built Environment, Liverpool John Moores University, Liverpool, UK

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

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ABSTRACT

In Malaysia, the coverage of kindergarten education has improved dramatically in recent times, although many kindergartens are located in buildings that were not originally designed for that purpose. Indoor Environmental Quality (IEQ) is considered to be one of the most important factors affecting the physical development of children. Hence, it is essential to evaluate the indoor conditions of those kindergartens which are based in buildings that have been refurbished and adapted from their original purpose. It is posited that such refurbished environments provide sub-optimal IEQ for kindergarten use, which is reflected in user perception and satisfaction. This study presents the results of the IEQ investigations conducted in refurbished kindergarten buildings in Malaysia with the focus on identifying occupants' satisfaction with the various IEQ factors. The researchers aim to utilize the results of this work to develop a benchmark for analogous studies. 240 refurbished kindergarten buildings in Malaysia were studied to evaluate occupants' perceptions and levels of satisfaction. The results indicate that the occupants found Air Movement, Ventilation, and Freshness to be of a poor quality due to the high occupancy density. Noise was the least satisfactory IEQ factor due to the closeness of the kindergartens to main roads (external noise), as well as the small size of classrooms (internal noise). It was found that Colour and Attractiveness are the most important IEQ factors from the occupants' viewpoint. This study provides a practical benchmark for the conversion of buildings' usage.

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1. Introduction

Indoor Environmental Quality (IEQ) plays an important role in the comfort and efficiency of the occupants of indoor environments. Physical comfort refers to meeting the fundamental needs of occupants, such as adequate lighting and space allocation for each individual; psychological comfort involves the occupants' satisfaction of with their colleagues and management, and a feeling of enjoyment. Many studies [1–9] have identified the contribution of both physical and psychological factors to occupants' satisfaction in various workplaces. However, the concept of IEQ has gained more prominence as the lifestyle in developed countries has resulted in

people spending the majority of their time (approximately 90%) indoors [10]. School children spend about 30% of their time at school, and the indoor environment may well have an influence on their future development [11]. Although both adults and children are affected by poor IEQ, young children are arguably of greater concern due to their susceptible immune systems [1,2,12]. Among the different physical discomforts derived from poor IEQ, fatigue and the effects of sick-building syndrome have been reported as the most prevalent [2,13–16]. Studies also show that impairment to the health of students and teachers resulting from poor IEQ could influence students' performance, behaviour and productivity [2,4,6–9,17]. Uline and Moran [18] have reported a certain inability among academics to focus when the learning process is taking place in imperfect environmental conditions.

Due to the importance of IEQ in schools, many studies have identified building characteristics that affect the occupants' health and performance. These include indoor air quality, temperature,

* Corresponding author. Building Performance and Diagnostic, Faculty of Built Environment, University of Malaya, 50603 Kuala Lumpur, Malaysia. Tel.: +603 7967 6833; fax: +603 7967 5713.

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

odours or olfactory effects, visual aspects, acoustics, daylight and artificial lighting, ergonomics and space [1–3,19–24]. These factors, individually or in combination, influence the comfort of occupants in buildings, although occupants within the same environment often cite differing levels of satisfaction or dissatisfaction with these indoor conditions. One reason is that individuals respond differently to the same conditions; another might be that it is difficult to identify the direct factors affecting occupants' discomfort and health [5,25].

There is a dearth of information on occupants' perceptions of IEQ influences in refurbished kindergarten buildings in Malaysia. Hence this research sought to identify occupants' needs, satisfaction and comfort levels with reference to IEQ. The approach taken was to apply a method of Post-Occupancy Evaluation (POE) to identify and assess these. POE is the process of evaluating a building's performance in a systematic way once the buildings have been occupied. This study systematically applied POE to a sample of 240 kindergarten buildings, to gauge the perceptions of occupants relating to IEQ and to consider the impact of IEQ on occupant comfort and performance. The outcome of this process was used to inform an investigation into how well the refurbished kindergarten buildings meet the occupants' requirements.

The objectives of this study are: i) to determine the satisfaction level of the occupants of refurbished kindergarten buildings in terms of indoor environment, ii) to assess the importance of IEQ factors relative to overall satisfaction and comfort in these buildings, and iii) to identify any correlation between individuals' liking scores for individual IEQ factors and their overall perception of the indoor environment. The ultimate objective is to identify the most significant or critical IEQ factors affecting overall satisfaction in order to inform approaches to improving building design, performance and comfort levels. In addition, this should allow the creation of a set of benchmarks for appropriate IEQ in refurbished kindergarten buildings in Malaysia.

2. Refurbished kindergarten buildings in Malaysia

In the Malaysian context, the coverage of kindergarten education has improved dramatically in parallel with the government's policy of making kindergarten programmes compulsory [26]. Fig. 1 shows the number of private kindergartens in Malaysia registered with the Ministry of Education. As can be seen, there has been a remarkable rise in the number of private kindergartens, from 2461 in 2000 to 7550 in 2013 [27,28]. The Malaysian Government's goal of increasing the enrolment of young children (aged 4+ and 5+) in kindergartens from 67% in 2010 to 87% in 2012 has been achieved [28].

Many private kindergartens in Malaysia have been converted from housing, commercial or institutional buildings. Fig. 2 shows different types of premises converted to private kindergartens in

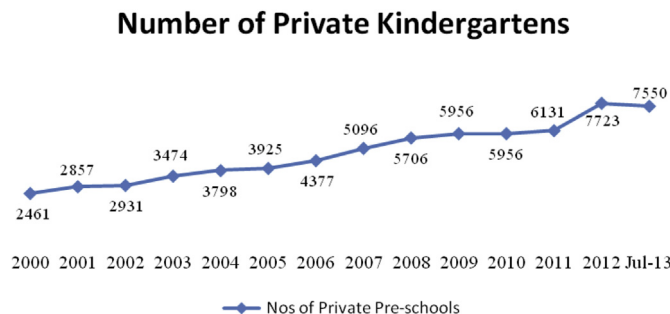


Fig. 1. Number of private kindergartens in Malaysia, 2000 to July 2013.

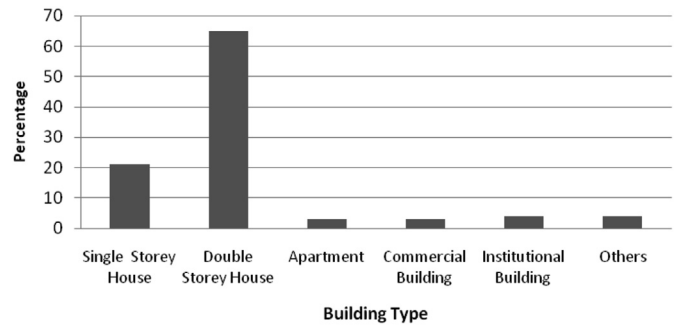


Fig. 2. Types of private kindergartens' premises in Kuala Lumpur.

Kuala Lumpur [25]. Of these, two-storey houses, followed by single-storey houses, represent the highest number of conversions, at approximately 65% and 21% respectively. Fig. 3 shows a typical private refurbished kindergarten building, in which the bedrooms of the two-storey house were converted into classrooms.

The number of pupils in the refurbished kindergarten buildings is usually up to 40, with 15–20 in each classroom. Each classroom is supervised by three teachers and two teaching assistants. Generally, each individual occupant in the classroom requires at least 2 m² of space [29], while the actual total space per room in a refurbished building is 9 m²–23 m². Fig. 4 illustrates a typical classroom in a refurbished kindergarten building.

The nature of the refurbished buildings also has implications in terms of location and the subsequent impact upon IEQ. Many kindergartens are located on congested streets, which can result in disruption of classes and affect the comfort of occupants. Assessment of IEQ factors in kindergartens located in such congested areas is both important and challenging.

3. Research methodology

This study investigates the IEQ of refurbished kindergarten buildings in Malaysia. 1000 kindergartens were randomly selected from the approved list of the Ministry of Education [27]. The kindergartens were selected according to the type of building (two-storey terrace, single-storey terrace, bungalow, institutional building), the total floor area (80 m²–420 m²), and the type of ventilation (natural and/or mechanical). First, letters were sent to



Fig. 3. Two-storey link house refurbished as a kindergarten.

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