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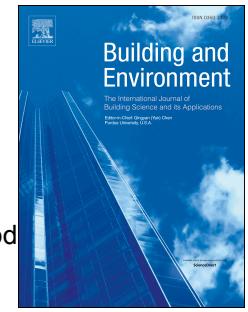

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Adaptive Thermal Comfort in University Classrooms in Malaysia and Japan

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Abstract

The range of students' classroom-based activities is generally restricted; therefore, individuals have limited options for adjusting themselves to the indoor thermal environment. This study investigated the comfort temperature and adaptive behaviour of university students in Malaysia and Japan. Classrooms in three universities (Universiti Teknologi Malaysia; Universiti Teknologi MARA, Malaysia; Kyushu University, Japan) were set to one of two conditions during the summer season: mechanical cooling (CL) mode, where AC was switched on for cooling purposes, and free-running (FR) mode, where AC was switched off. A total of 1415 students were surveyed. In Japan, 93.5% of the sample was male, while more even gender distributions were found in Malaysian samples. Additionally, clo values were generally higher amongst male respondents. In Japan, the mean comfort operative temperatures in FR mode was found to be 25.1°C, while in Malaysia it was 25.6°C. In CL mode, mean comfort operative temperatures were found to be 26.2°C and 25.6°C for Japan and Malaysia, respectively. Comfort temperatures in FR mode were compatible with Comité Européen de Normalisation (CEN) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards, while those in CL mode were mostly within Chartered Institute of Building Services Engineers (CIBSE) guidelines. While high proportions of students in both countries claimed that they did nothing to maintain their thermal comfort, the most common activity observed amongst Malaysian students was changing the AC temperature setting, due to the prevalence of CL in Malaysia.

Keywords: thermal comfort; classrooms; air conditioning; free-running; adaptive behaviour

1. Introduction

Developing nations will likely consume more energy than advanced nations by the year 2020, with buildings in tropical countries representing major energy users [1]. Studies have shown that in Malaysia, air conditioners (AC) account for 57% of total energy use in office buildings [2]; therefore, regulating their use has significant potential for energy saving. In contrast, Japan has one of the lowest electricity demand growth rates in Asia, despite having the second highest global demand for electricity [3]. After the 2011 Fukushima Daiichi disaster and the shutdown of all 10 GW nuclear power generators in Japan, the country has become highly dependent on fuel imports, and particularly liquefied natural gas (LNG), for meeting its energy needs [3]. In response to this reduced energy generation capacity, in May 2011 the Japanese government mandated a 15% peak power reduction for large consumers (*i.e.* users requiring more than 500 kW of power) and asked small commercial and residential consumers to follow suit [4].

Providing a comfortable and healthy microclimate is especially essential for educational buildings, in which high environmental quality can considerably improve occupants' learning performance [5–7]. For the sake of practicality, thermal comfort is usually controlled using simple design techniques, with ventilation, day lighting, and solar control today replaced by modern AC systems; however, the use of AC in educational buildings has complex and far reaching design implications involving energy costs, policy decisions, and occupants' well-being. As a result, more complete information about the standards that guide the design of AC systems and associated comfort in educational buildings is needed.

Previous studies have been performed in educational institutions at various levels, such as kindergarten [8–10], primary school [11-12], high school [13-14], and university [15-16]. However, each of these previous studies was unique, both in their research method and sample characteristics. For example, in some of the studies, ventilation modes were not defined. Meanwhile, most of the adaptive thermal comfort studies were focused on naturally ventilated buildings, but in reality, not many university buildings rely on natural ventilation only. Thermal comfort analysis can be used to identify the thermal perceptions of building occupants and to identify possible energy savings. Using this approach in developing countries, it is necessary to understand occupants' adaptive behaviour and thermal preferences vis-à-vis those in developed countries,

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