

The thermal perception of students and adaptive use of environmental controls in a hybrid-ventilated classroom

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1 Introduction

Hybrid ventilation is characterized by its alternative use of natural and mechanical (i.e. air-conditioning, AC) ventilation (IEA, 2000). In Taiwan, hybrid ventilation system is used as a predominant means of promoting thermal comfort in the classroom owing to its occupant-controlled attribute. Here we present a study that investigated the thermal perception of students and their use of environmental controls in two hybrid-ventilated classrooms, each adopting a different strategy of AC use management. In the study, the status of the thermal environment, the thermal sensation of the students, and the patterns on the use of environmental controls (including window-opening, fans and AC) were simultaneously observed and cross-analyzed to realize the influences of the strategy employed in AC management on the thermal perception of students and the utilization of AC.

2 Materials/Methods

The study was conducted in the classrooms of a high school and of a university, both located in central Taiwan. The AC use in the high school employed a fee-for-service mechanism that allowed the students to gain entire control of AC (self management), whereas in the university the AC use was controlled by the school and would be activated when the local ambient temperature (temp) reached a threshold (central management). The AC operated in both locations was a split system with no ventilation from the ambient air. The study was performed from May to June of 2010, 5 days a week when the classroom was in session. The subjects surveyed were the students of an age of 15-16 in the high school and of an age of 18-22 in the university. Microclimatic variables including air temp, relative humidity, globe temp, and wind speed

were monitored continuously on-site using a temp/humidity datalogger and a thermo-anemometer, both operated in accordance with the ISO 7726 requirements on evaluating the status of thermal environment (ISO, 1998). Five spots in the classroom and one outside were selected as points of climatic monitoring. When the classrooms were in use, a thermal sensation survey was conducted to assess the students' perception toward the thermal environment and to record their use of AC by the hour. The perception was gauged as ranks in thermal sensation, comfort, acceptability, and preference of the occupants. The survey was conducted twice a day, once in the morning around 10 am and the other in the afternoon at about 2 pm.

3 Results and Discussion

Figure 1 shows how the AC was used as a part of hybrid ventilation during the investigated period in the classrooms employing different managerial schemes controlling AC use. While the upper/lower bounds of operative temp (T_o) corresponding to the use of hybrid ventilation were approximately the same under both schemes, the air temp set to activate the AC and the hours accumulating on the AC use were significantly different, suggesting a greater thermal adaptability of the AC users under self management to the change in the environment.

When the hours of AC use under different management schemes were compared to the respective total hours of hybrid ventilation use, the percentage of AC use in self management was found to be substantially lower than that of central management (Figure 2), corresponding to the earlier inference that the fee-for-service characteristic of the self management scheme was conducive to lowering the AC use.

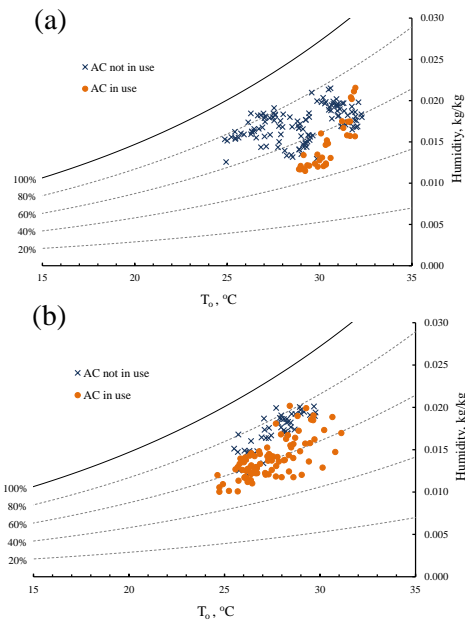


Figure 1: Air-conditioning (AC) use in hybrid ventilation in relation to status of thermal environment in classrooms exercising: (a) self management; (b) central management.

In addition, a comparison between the hours of actual AC use and those projected based on the adaptive comfort model in ASHRAE Standard 55 (ASHRAE, 2004) revealed that under the central management scheme the actual AC use was much greater than the level would be required of for reaching thermal comfort.

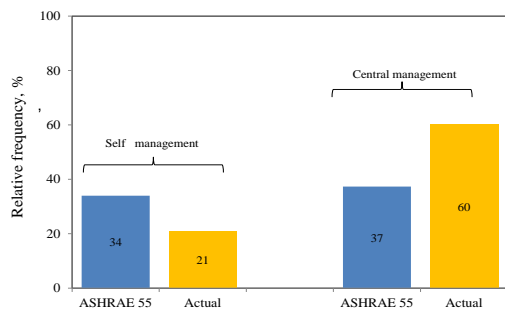


Figure 2: Actual use of air-conditioning under self vs. central management compared to projections based on ASHRAE standard 55 thermal comfort criteria.

Figure 3 compares the distributions of thermal sensation of AC users under the self vs. central management schemes. To better visualize the sensitivity of thermal perception in response to alteration in a thermal environment, the thermal sensation votes (TSVs) were grouped by T_o at intervals of 0.5°C , and then weighed by sample

size and linearly regressed to the T_o . At high T_o , the TSVs under both managerial schemes were close to each other. However, as T_o decreased the TSVs between these managerial groups differed significantly, with the occupants in the self management group being more sensitive to the thermal status change, possibly attributed to the heightened awareness of the occupants in the self management group toward the financial burden in association with AC use.

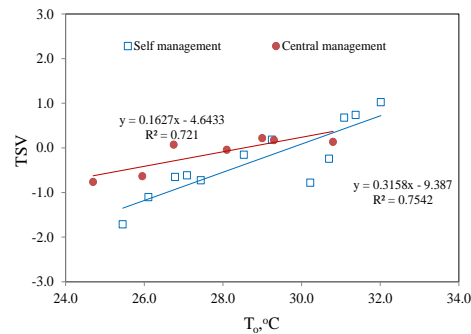


Figure 3: Distributions of thermal sensation vote (TSV) against operative temperature (T_o) under self vs. central management (presented in dots) and their linear regressions (in solid lines).

4 Conclusions

The study findings indicated that the mechanism employed in managing AC use played a significant role in how the students reacted to the status of indoor thermal environment. We suggest that the centralized AC management currently practiced in many schools at Taiwan target a higher threshold temp for AC use so to reduce the energy cost while maintaining an adequate level of thermal comfort.

5 References

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