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Perception of the thermal environment in high school and university classrooms: Subjective preferences and thermal comfort

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Abstract

This work shows some of the results of a field study about environmental comfort investigations in classrooms. In this project thermal, acoustic, visual and air quality aspects were analysed in a number of classrooms—13 classrooms at four different high schools of the *Provincia di Torino* and four typical medium-sized university classrooms of *the Politecnico di Torino*, Italy. The investigations were carried out during the heating period. Both field measurements and subjective surveys were performed at the same time during the regular lesson periods.

This paper focuses on thermal comfort, which may have a significant effect on the students' performance, in terms of attention, comprehension and learning levels.

The measurement campaign consisted in measuring the thermal environment parameters—air temperature, mean radiant temperatures, air relative humidity and air velocity. Through these data, the thermal comfort Fanger's indices (predicted mean vote (PMV), and predicted percentage of dissatisfied (PPD)people) were calculated, the actual people clothing and metabolic rate being known.

The subjective survey involved questions on the thermal environmental perception. They basically investigated the thermal environment acceptability and preference. Moreover, a judgement based on the typical seven point thermal sensation scale (Fanger 7-points scale) was also asked. Through the elaboration of the questionnaire data, the actual percentage of dissatisfied (PD) people of the felt thermal environment was evaluated.

The judgements about the thermal environment were compared with the results of the field measurements. Moreover, the subjective mean votes were compared with the thermal environment perceptions in terms of acceptability and preference.

Keywords: Indoor environmental quality; Thermal comfort; Classrooms; Objective approach; Subjective approach

1. Introduction

Healthy and comfortable microclimate conditions are essential for any type of environment but, in particular, schools are a category of buildings in which a high level of environmental quality may considerably improve occupants' attention, concentration, learning, hearing and performances [1,2].

The first scientific studies about the effects of the thermal environment quality in classrooms on the students' performances began around the middle of 1950. An interesting review of the results of these first studies, lots of them performed as field studies, is gives in the work of Pepler and Warner [3]. After this period, the birth of the Fanger theory about thermal comfort based on the results from a fully controlled climate chamber [4], broke the developing of new field researches on thermal comfort. But the growing interest in the last years about the adaptive theory of thermal comfort [5,6] has again stimulated researches by field studies aimed at qualifying the thermal environment both objectively (by measurements) and subjectively (by occupants judgments).

The base of the adaptive approach is the conviction that a person, consciously or unconsciously, plays an active role in creating the thermal environment conditions that he

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prefers, and he does not suffer passively the environmental conditions imposed by the surrounding ambient [5,6]. The adaptive approach suits very well not fully conditioned buildings in which people have some opportunities to modify the surrounding thermal environment (varying set-point room temperature, changing the posture, adjusting the metabolic rate, etc.) [8].

It is important to notice that the new proposed version of the most relevant standards about thermal comfort, that are ISO/DIS 7730 [9] and ASHRAE Standard 55 [10], have begun to acquire the concept of adaptive comfort in the evaluation of thermal comfort of a not fully conditioned indoor environment [11].

Moreover, the recent studies on adaptive comfort approach qualify the thermal comfort not only by asking a judgement about the thermal sensation, but also by investigating the acceptability and preference of the indoor thermal condition with respect to conditions corresponding to thermal neutrality [12,13].

This tendency of preferring certain thermal environments was already argued by McIntryre [14] In his studies, he found out that people of warm climates may prefer what they call a "slightly cool" environment and, on the contrary, people of cold climates may prefer what they call a "slightly warm" environment. Moreover, people in naturally ventilated indoor environment are comfortable within a range of microclimate values that is larger than in a fully conditioned indoor environment [5,6]. Recent field studies in classrooms confirmed the results [15,16].

The importance of field studies, especially in investigation concerning the adaptability of people, comes from the need of investigating thermal comfort responses within the naturally occurring context. On the contrary, as previously highlighted, the classical methodology of assessing thermal comfort comes from results from researches on fully controlled climate chamber. The typical approach for field studies consists of administrating a questionnaire to a group of occupants while the investigator records certain macroclimatic parameters [7]. In this situation, people's answers refer to the very thermal environments to which they are subjected in their everyday life [17].

The defence of the field study approach to thermal comfort depends largely on what has been named "experimental realism" of the field methodology [18].

Such an investigation methodology is very important in classrooms, that are an example of indoor environment in which the adaptive opportunities are quite limited during the lessons period, but they are free during the hourly lesson breaks.

In fact, students have to spend lots of time in listening and understanding lessons, remaining sitting at their desk. Moreover, the freedom of students in modifying and adjusting their activity level according to the thermal environment is, to a certain extent, limited during the lesson time, as well as the possibility to change the functioning parameters of the HVAC systems or to open/close the windows. But the same actions are free during the lessons breaks.

The adaptive actions of the students to modify the microclimate parameters may include adding or removing layer of clothing, opening or closing windows, moving sun shading devices, etc. [19].

In this context, the Building Physics and Indoor Environment Engineering Research Group (see http://www.polito.it/ftarch) of the Department of Energy (DENER) of the *Politecnico di Torino*, is carrying out a research project focused on environmental comfort in Italian school buildings. Thermal, visual and acoustic comfort and air quality (IAQ) are analysed in classrooms by means of measurements (objective approach) and questionnaires filled in by students and teachers (subjective approach) [20–22]. The field campaigns are performed during the lesson periods. This paper focuses on the results from the thermal comfort field investigations in high school and university classrooms.

The aim of the study was to find out significant tendency and correlation between the subjective perceptions and measured environmental parameters, applying a new investigation methodology based on both objective and subjective surveys for in field evaluation of thermal comfort.

2. Method

2.1. Object of the study

The aim of the study was to investigate the thermal environmental quality in high school and university classrooms by means of both an objective and a subjective approach.

The objects of study were four university classrooms of the Politecnico di Torino and a number of classrooms in four high school buildings of the Provincia di Torino, Italy.

The classrooms were selected in order to give a representative sample of typical high school and university Italian classrooms. All the classrooms are medium-sized and parallelepiped-shaped.

The four examined classrooms of the Politecnico di Torino are located at "Via Boggio" campus (three classrooms—3N, R5, R6), a new building in a residential area at the border of Turin downtown, next to the headquarter of the Politecnico di Torino, and at the "Valentino Castle" campus (one classroom—4) next to a historical castle which is the headquarter of the Architecture Faculty, located in the downtown.

The four high schools of Provincia di Torino were located three in Turin suburban city settings ("C. Levi", "B. Vittone" and "A. Gramsci") and one in Turin downtown ("Regina Margherita").

The main features of the classrooms are summarised in Table 1.

The study was performed during the heating period, that in Turin ranges from 15th October to 15th April. In particular, the investigations were carried out from the end of January to April 2002.