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Gender Differences in Perception of Indoor Environmental Quality (IEQ)

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Abstract. There are many factors creating the internal environment of the building. These factors could be biological, physical, or chemical, and they determine the indoor environmental quality. This contribution investigates the gender differences in occupants' perception on various aspects of indoor environmental quality (IEQ). There are many studies, how the conditions of the indoor environment affect the users' performance, health, or comfort. Generally, women are more likely to have symptoms of SBS, such as fatigue, headache, irritated or dry eyes, nose and throat, and skin symptoms. Assessments of user´s perception were carried out at the Institute of Technology and Business situated in the city of České Budějovice, South Bohemia, Czechia. The panellists (students) indicated their immediate evaluation on eight continuous scales regarding air acceptability, odor intensity, thermal comfort, humidity comfort, visual comfort, color comfort, noise load and total satisfaction. Then the percentage of dissatisfied people (PN) was estimated. The gender differences in perception of indoor environmental quality were analysed. This knowledge is necessary and useful to develop appropriate strategies to create and maintain a sustainable internal environment for education and training. Understanding the perception of the quality of the inner environment by students is essential to increase the performance and productivity of not only students but also the academic staff. The long-term low indoor environment quality can lead to poor productivity, performance and ability to learn. It is also necessary to take into account the health of students and also academic staff in the context of the hygiene of the internal environment.

1. Introduction

In urbanized and industrialized areas, people spend up to 90% of their time indoors [1]. It is clear that the quality of life is determined by the quality of the indoor environment. The indoor environmental quality (IEQ) is defined by a number of factors. These factors could be biological, physical, or chemical [2]. Indoor environmental quality evaluates the entire indoor environment of buildings. This includes all factors that affect occupants' health, comfort and well-being [3]. There are a number of studies aimed at evaluating the quality of the indoor environment with regard to comfort and health [4-7]. Strategies for addressing IEQ include those that protect human health, improve quality of life (well-being), and reduce potential risks and pollution. Exposure to pollutants in the air may provide a certain health risk. The long-term unsatisfactory indoor environment is associated with Sick Building Syndrome (SBS). Understanding the perception of the quality of the indoor environment by students is essential to increase the performance and productivity of not only students but also the academic staff. The long-term low indoor environment quality can lead to poor productivity, performance and ability to learn. The best way to ensure a suitable indoor environment is to eliminate or at least minimize pollutant resources and manage their distribution. In addition to the building materials themselves, electrical appliances are also a source of pollutants (VOCs, odors) [8].

The general assumption is that women are more sensitive to the colder thermal environment than men. Men get morphologically different from women. Men are characterized by greater average body weight, greater musculature, and a higher skin area to weight ratio [9, 10]. Gender-related differences in body morphology affect the thermoregulation processes and perceived quality of the environment. Generally, women are more likely to have symptoms of SBS, such as fatigue, headache, irritated or dry eyes, nose and throat, and skin symptoms.

2. Method

Assessments of user´s perception were carried out at the Institute of Technology and Business situated in the city of České Budějovice, South Bohemia, Czechia. Ten different university classrooms are selected for sensory assessment of indoor environmental quality. Two of the observed university classrooms are computer classrooms. Two classrooms serve as lecture halls for more than 200 listeners. One of them is equipped with a forced ventilation system. One classroom serves as a laboratory. The walls and ceilings are fitted with a classic internal plaster with white paint. Flooring is synthetic smooth flooring - linoleum. The windows are new, plastic with a shading system of internal blinds. The classroom equipment is classical and includes tables, chairs, whiteboard, computer and projector. Measurements took place in October under favourable climatic conditions. During the measurements, the mean outdoor air temperature is 15.86°C and the mean outdoor relative humidity is 63.74%. The mean outdoor concentration of CO_2 is 645 ppm.

Before the assessment, the students were instructed on to using the scales. There is no restriction on the distribution of gender or smoking habits. The age ranged from 20 to 25 years. All panellists are university students. Overall, 299 students were interviewed. The panellists are dominated by men (246; 82%). The small proportion of women (53; 18%) is due to the common composition of students in technical fields (Civil Engineering).

The panellists stay outdoor odors before the assessments. Before the lesson, the panellists indicated their immediate evaluation on eight continuous scales regarding air acceptability (AA), odor intensity (OI), thermal comfort (TC), humidity comfort (HC), visual comfort (VC), color comfort (CC), noise load (NL) and total satisfaction (TS). The scale of air acceptability is divided into 2 separates scales with end-point clearly acceptable (+1) / just acceptable (0) and just unacceptable (0) /clearly unacceptable (-1). The scale of odor intensity has five levels of intensity odor: 0 no odor, 1 slight odor, 2 moderate odor, 3 strong odor, 4 very strong odor and 5 overwhelming odor. According to ASHRAE the scale of thermal comfort has 7 levels: +3 hot, +2 warm, +1 slightly warm, 0 neutral, -1 slightly cool, -2 cool, - 3 cold. The humidity scale has five levels: 2+ too humid, +1 slightly humid, 0 just right, -1 slightly dry and -2 too dry. The range of perceived visual levels has five levels: +2 too bright, +1 slightly bright, 0 just right, -1 slightly dark and -2 too dark. The noise load scale is divided into five levels: 1 no noise, 2 slight noise, 3 acceptable noise, 4 strong noise and 5 intolerable noise. The scale of perceived colors applied in the interior has 5 levels: +2 too high, +1 high, 0 just right, -1 low, -2 too low. The scale of overall satisfaction includes 5 levels: +2 too high, +1 high, 0 just right, -1 low, -2 too low. The limit answers (maximum values of each scale) are regarded as discomforts in this study. Then the percentage of dissatisfied (PN) was estimated.

3. Results and discussions

The satisfaction levels of perceived quality by gender is shown in figure 1, where AA is air acceptability, OI is odor intensity, TC is thermal comfort, HC is humidity comfort, VC is visual comfort, CC is color comfort, NL is noise load and TS is total satisfaction. According to constructed boxplots, the perceived quality of indoor environment parameters is comparable without major differences between men and women. For better clarity, mean values of perceived quality of IEQ parameters and percentage of dissatisfied (PN) are considered.

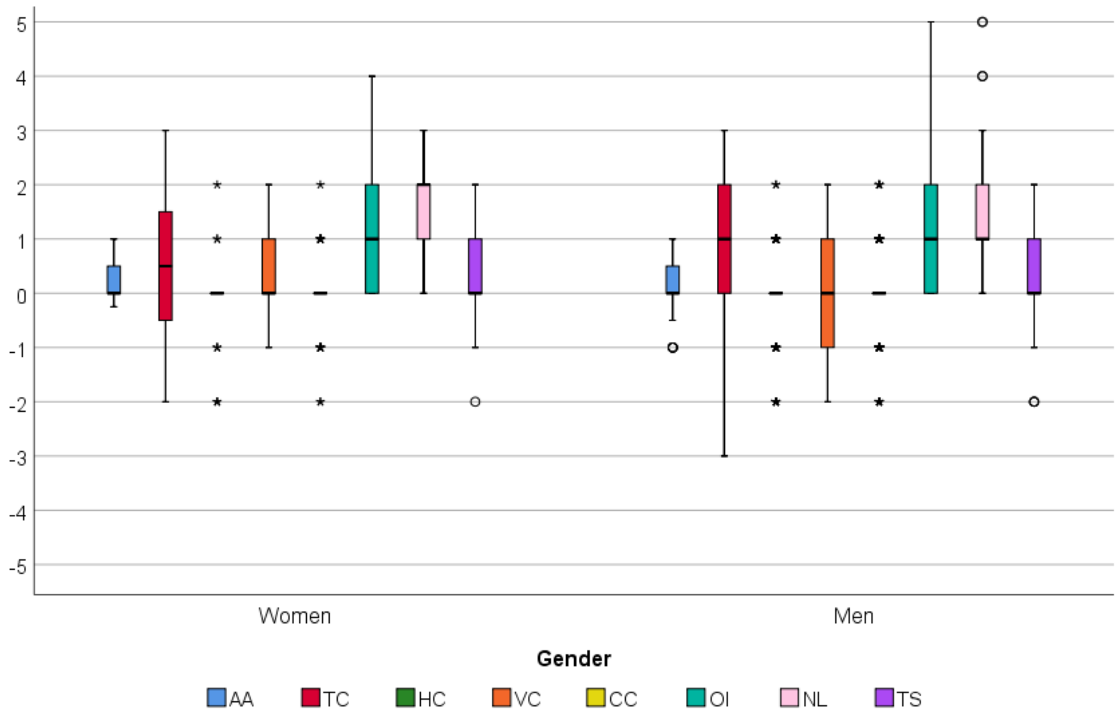

Figure 1. Perceived indoor environmental quality by gender

3.1. Mean satisfaction level

Figure 2 shows the mean satisfaction rating for monitored parameters of indoor environmental quality by gender. Mean satisfaction rating of indoor environment parameters by gender are also included in table 1.

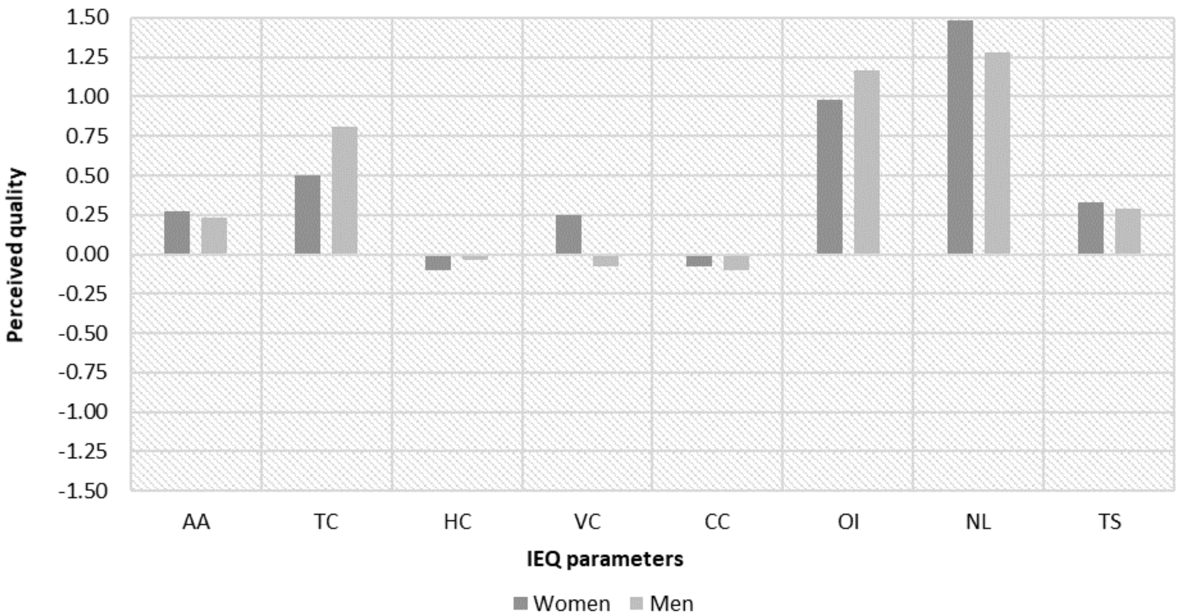

Figure 2. Mean satisfaction rating of indoor environment parameters by gender

Gender differences in perceived quality in terms of air acceptability, humidity comfort, color comfort and overall satisfaction are minimal. The mean values of thermal comfort show that women perceive the indoor environment as cooler than perceived comfort for men. Men have a negative perception of visual comfort, while for women, visual comfort is still acceptable. The perceived color of the interior is negatively evaluated by both men and women. The mean values of odor intensity indicate slight odor. Men perceive odors more sensitively than women. Conversely, the noise load is more acceptable to men. The mean values of total satisfaction are positive. The quality of the indoor environment is acceptable for both men and women.

Table 1. Mean satisfaction rating of indoor environment parameters by gender

		AA	*TC*	HC	*VC*	CC	*OI*	*NL*	*TS*
Gender	Women	0.274	0.500	-0.100	0.250	-0.080	0.980	1.480	0.330
	Men	0.233	0.810	-0.040	-0.080	-0.100	1.170	1.280	0.290
	Δ	0.041	-0.310	-0.060	0.330	0.020	-0.190	0.200	0.040

Legend: air acceptability (AA), odor intensity (OI), thermal comfort (TC), humidity comfort (HC), visual comfort (VC), color comfort (CC), noise load (NL) and total satisfaction (TS)

3.2. Percentage dissatisfied with the indoor environmental quality

Percentage of dissatisfied is widely regarded as a meaningful and practical metric in perceived indoor environmental quality because it can be readily interpreted as an expression of the number of potential dissatisfactions. Percentages dissatisfied of indoor environment parameters by gender are illustrated in figure 3. Table 2 expresses percentages dissatisfied by gender.

Four of the eight observed indoor environmental quality factors express greater dissatisfaction among women. These are humidity comfort, visual comfort, color comfort and total satisfaction. Other factors are dominated by dissatisfaction among men. Women are most dissatisfied with visual comfort (9.43%) and humidity comfort (7.55%). Also, men are significantly dissatisfied with visual comfort (4.88%). Furthermore, they are significantly dissatisfied with color comfort (4.88%) and humidity comfort and thermal comfort. The smallest values of dissatisfaction are monitored for the air acceptability and noise load.

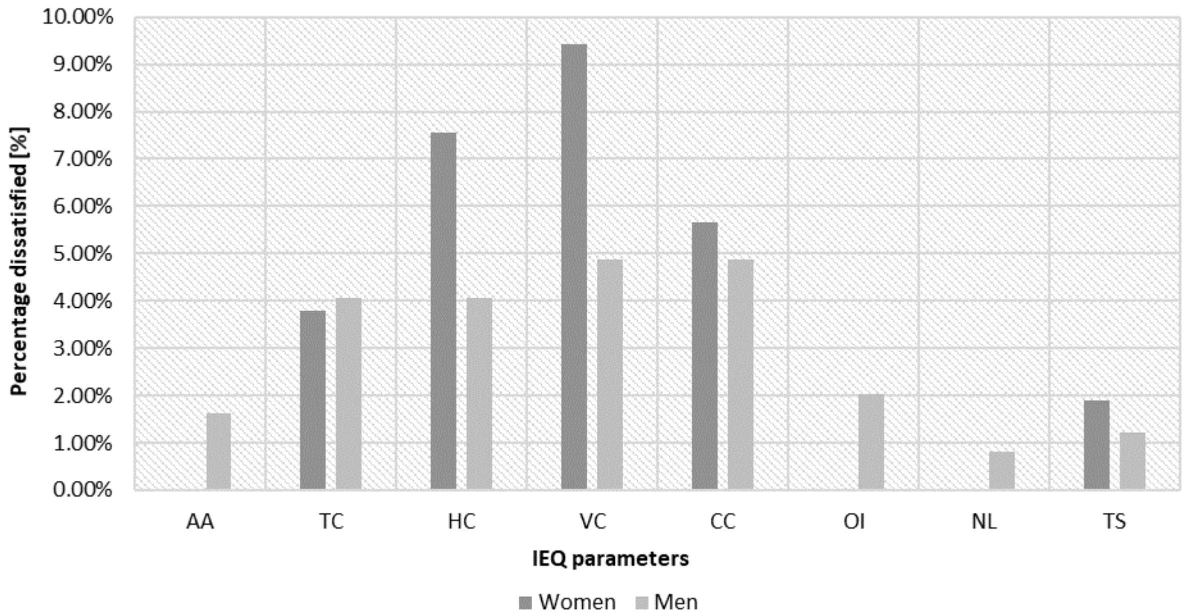

Figure 3. Percentage dissatisfied of indoor environment parameters by gender

Table 2. Percentage dissatisfied with the IEQ factors by gender

		AA	*TC*	HC	*VC*	CC	*OI*	*NL*	*TS*
Gender	Women	0.00%	3.78%	7.55%	9.43%	5.66%	0.00%	0.00%	1.89%
	Men	1.63%	4.07 %	4.07%	4.88%	4.88%	2.03%	0.81%	1.22%

Legend: air acceptability (AA), odor intensity (OI), thermal comfort (TC), humidity comfort (HC), visual comfort (VC), color comfort (CC), noise load (NL) and total satisfaction (TS)

3.3. Correlation between gender and IEQ parameters

The correlation determines the relationship of dependence of two continuous random variables. Two random variables correlate if certain values of one variable tend to co-occur jointly with certain values of the other variable. The relationship between two continuous random variables X and Y with unknown distribution can be expressed using the Spearman correlation coefficient [11, 12]. The Spearman correlation coefficient is a nonparametric correlation coefficient that is robust to outliers and generally deviates from normality, because like many other nonparametric methods it only works with the order of observation. Unlike the Pearson correlation coefficient, which describes the linear relationship of variables, the Spearman correlation coefficient describes how well the relationship values corresponding with the monotonic function, which may of course be non-linear.

IBM SPSS statistics version 25 was used to analyse the data. Table 3 shows the results of Spearman's Rank-Order Correlations between gender and IEQ parameters. Statistically significant correlation at 5% significance level was not found in any of the monitored internal environment parameters. The perceived quality of the indoor environment is not affected by gender.

Table 3. Spearman's Rank-Order Correlations between gender and IEQ parameters

		AA	*TC*	HC	*VC*	CC	*OI*	*NL*	*TS*
	Correlation Coefficient	0.003	0.092	0.047	-0.102	-0.030	0.073	-0.102	0.002
Gender	Sig. (2-tailed)	0.956	0.110	0.422	0.078	0.601	0.209	0.079	0.970
	N	299	299	299	299	299	299	299	299

Legend: air acceptability (AA), odor intensity (OI), thermal comfort (TC), humidity comfort (HC), visual comfort (VC), color comfort (CC), noise load (NL) and total satisfaction (TS)

4. Conclusions

The goal of sustainable construction is energy efficiency, environmental friendliness and sustainability. Green sustainable buildings provide better indoor environments with less energy consumptions and it has achieved a vigorous growth in recent years. It is essential that building users are satisfied in their indoor environment. Since students spend quality time in school trying to learn, it is important to study the effects of their classroom environment on their health and performance. It is generally known that women are more sensitive to the perceived quality of the indoor environment. However, this fact has not been proven in the study. Based on the results of this study, the results of the correlation analysis show that there is no statistical relationship between gender and internal environment factors such as temperature, humidity, noise, air acceptance, odors, visual comfort and color of indoors.

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