



Assessment of Indoor Air Quality, Overall Comfort and Humidity Preferences in Educational Buildings – Differences in Room Users' Perceptions

Natalia Siwczuk^{1*}, Stanisław Honus², Lidia Dąbek³

¹Faculty of Environmental Engineering, Geodesy and Renewable Energy,
Kielce University of Technology, Kielce, Poland

<https://orcid.org/0000-0002-4003-3355>

²Faculty of Mechanical Engineering,

VSB – Technical University of Ostrava, Ostrava-Poruba, Czech Republic

<https://orcid.org/0000-0002-1039-2154>

³Faculty of Environmental Engineering, Geodesy and Renewable Energy,
Kielce University of Technology, Kielce, Poland

<https://orcid.org/0000-0002-1198-5445>

*corresponding author's e-mail: nkrawczyk@tu.kielce.pl

Abstract: This article presents an analysis of indoor air quality, overall comfort, and air humidity preferences in educational buildings, considering the subjective perceptions of occupants in the rooms. The results of measurements of microclimate parameters (air temperature, relative humidity) were compared with the occupants' subjective perceptions. The analyses of indoor environmental parameters focused on assessing differences in subjective assessment with regard to gender. The results show that, typically, more men than women considered their state (overall comfort) to be positive, and men were more likely to report slightly higher overall comfort than women at the same air temperature values. Generally speaking, women seemed to consider air quality poorer, while the relationship between overall comfort and indoor air quality was the same for women and men. Additionally, women seemed to rate the air humidity as drier.

Keywords: indoor environmental quality, indoor air quality, relative humidity, user perception

1. Introduction

In recent years, there has been a growing interest in indoor environmental quality and thermal comfort studies in buildings, as pointed out, for example, in (Ratajczak et al., 2023), especially in the context of proper energy management (Buyak et al., 2023; Dudkiewicz et al., 2021; Ratajczak et al., 2022). Among various buildings, educational buildings are particularly important because they host large groups of people for extended periods. Environmental conditions can significantly impact students' learning, concentration, and well-being. Indoor Environmental Quality (IEQ) is one of the key factors influencing the health, comfort, and cognitive performance of building occupants. It is particularly important in educational facilities because it directly affects students' and teachers' ability to concentrate, well-being, and work performance. Indoor environmental parameters – such as air temperature, humidity, air quality, noise, and lighting – create a complex system of interactions that shape the subjective experience of thermal comfort and overall satisfaction in buildings (Fanger, 1970, ISO 7730 2005).

The authors (Frontczak & Wargocki, 2011) emphasize that user perception is a significant complement to physical measurements. This stems from the fact that the subjective sense of comfort does not always reflect environmental conditions measured using sensors. Therefore, contemporary research approaches increasingly combine measurement data with user perceptions, providing a more comprehensive picture of indoor environment quality and its impact on people. In educational settings, differences in perceived comfort are particularly pronounced – learners in lecture halls have different expectations than those in laboratories or administrative offices. Research (Teli et al., 2012; Bluysen, 2017) shows that subjective assessments of indoor environmental quality often differ from the results of physical measurements. Understanding these relationships provides the foundation for designing environments that support effective learning and work.

Previous research indicates that numerous factors influence perceptions of the indoor environment. The authors (Maykot et al., 2018) indicated that women prefer higher air temperature regardless of ventilation type – both in air-conditioned buildings and in buildings with mixed ventilation systems. Other researchers (Buonocore et al., 2018) noted that at temperatures exceeding 30°C, increased relative humidity negatively affects subjective thermal sensations. Furthermore, the authors (Cao et al., 2016), analysing three climate zones in China, found that people living in warmer regions exhibit better adaptation to colder environmental



conditions. In their study (Luo et al., 2018), they conducted a literature review, emphasizing the importance of metabolic rate as one of the most important factors determining human thermal comfort. Results from other studies (Luo et al., 2016) confirm that increased metabolic rate is associated with changes in perception of thermal conditions and an increased sensation of warmth. The authors (Ma et al., 2022), on the other hand, focused on technical aspects, analysing the materials used in building thermoregulation systems in the context of their ability to transfer heat between the interior and the exterior. The presented research results clearly confirm that thermal comfort is a multidimensional phenomenon, shaped by both environmental physical parameters and individual user factors. Considering user perception, along with measuring microclimate parameters, is a key element in assessing the quality of the indoor environment, especially in educational buildings, where these conditions directly affect the well-being and productivity of occupants.

A study (Proot-Lafontaine et al., 2025) analysed the impact of a comprehensive energy retrofit of a 1970s school building on indoor environmental quality. The results showed that after the renovation, IEQ conditions significantly improved – including better temperature distribution and lower CO₂ concentrations in some rooms – confirming that technical measures can effectively support the comfort of school building users. Furthermore, the authors emphasized that even when technical standards are met, end users (students, teachers) may experience differences in environmental conditions, highlighting the importance of user perception as an important aspect of IEQ assessment. In recent years, there has been growing interest in indoor air quality in educational spaces, particularly in its impact on the health, comfort, and productivity of classroom users. The study (Canha et al., 2024) used inexpensive sensors to monitor multi-parameter environments in nine lecture halls in Portugal, covering 171 classes. The results showed that measurements often exceeded recommended standards for temperature (46% of cases) and CO₂ concentration (27%), although teachers' subjective assessments of IAQ did not always reflect actual conditions. Importantly, the only parameter that showed a statistically significant relationship with IAQ perception was temperature, while typical indicators such as CO₂ did not significantly influence user assessments. These findings highlight the need to combine environmental measurements with user subjective assessments.

At the same time literature emphasizes the importance of indoor environmental quality in educational facilities as a factor influencing students' well-being, health, and concentration. A study conducted in three public schools in Palestine (Baba et al., 2024) involving 331 students found that assessments of environmental conditions varied depending on the type of factor analysed. As many as 86% of respondents positively assessed lighting levels in classrooms, but significantly lower satisfaction rates were obtained for thermal and acoustic comfort. In a study conducted in Nepalese schools, the authors (Shrestha et al., 2023) found that the comfortable operative temperature for students in naturally ventilated classrooms was 26.9°C, with approximately 63% of students finding the conditions too hot and preferring a lower temperature. Furthermore, in a study conducted in the densely populated, dry, and hot climate of Egyptian Nasr City, the authors (Afifi et al., 2025) assessed indoor environmental quality in naturally ventilated classrooms and analysed student perceptions. The results showed that while most students expressed favourable opinions about desk layout, access to daylight, and natural ventilation, challenges with thermal comfort, external noise, and air freshness in rooms with closed windows remained. The results of this study highlight the importance of a holistic IEQ assessment that integrates factors such as temperature, air quality, and subjective user perception.

The article (Asif et al., 2022) describes a study of the influence of gender on perceptions of indoor thermal comfort in summer and winter, and compares methods for predicting comfort temperature. The study was conducted in Pakistan and included 971 participants (526 women and 445 men) of different age groups. The study aimed to determine whether gender differences in comfort temperature requirements vary across seasons and which temperature prediction methods best assess thermal comfort. The experimental results showed that women had higher comfort temperature requirements than men in both the summer and winter seasons. The study (Rupp et al., 2018) assessed the influence of individual factors, including gender, body weight, and ventilation type, on thermal sensations among room users. They found that men, overweight individuals, and those who spent more time in air-conditioned rooms experienced thermal discomfort more frequently than individuals with a lower BMI, women, and users of air conditioning who used it less frequently. These results confirm that, in addition to environmental conditions, individual user characteristics also play a significant role in shaping perceptions of thermal comfort.

Experiments conducted in Brazil (Maykot et al., 2022) showed that women tend to feel colder than men do. Generally speaking, comfort temperatures were statistically higher for women (24.2°C) than for men (23.5°C). Moreover, gender differences in thermal perceptions were observed. On the other hand, the study by Psomas et al. (2024) covered 375 dwellings in Sweden. The results showed no significant gender differences regarding the ratings of indoor environments. Males reported slightly higher satisfaction levels, while acoustic and thermal comfort showed the greatest gender variability. In a very recent paper (Yuan et al.,

2025), gender differences in subjective and physiological responses in combined acoustic and thermal environments (at different air temperature and sound pressure levels) were studied. It was reported that females had lower metabolic rates than men, with considerable differences especially visible at 18°C (up to 1.21 met lower at 80 dB noise). Moreover, females typically had lower mean skin temperatures but higher heart rates.

A literature review (Haselsteiner, 2021) showed that large differences between females and males were found (which were most evident in offices) regarding indoor temperature. Gender was also considered an influencing factor in satisfaction with humidity, air quality, etc. The author concluded that, based on the literature review, essential indoor environmental quality parameters vary widely between males and females.

A summary of the literature indicates that assessing indoor environmental quality requires consideration of both physical measurements of air parameters and user perceptions. Despite large data sets and analytical studies, some papers' findings contradict one another. The present article aims to clarify the problem.

2. Subject and Methods of the Study

The research covering indoor environmental quality was conducted in the university teaching buildings in Kielce. The study comprised two complementary stages:

- measurements of microclimate parameters in selected rooms,
- anonymous surveys, in which users assessed their subjective impressions of overall comfort, air quality, and air humidity.

Measurements of microclimate parameters, along with subjective assessments by room users, enabled a comprehensive analysis of indoor environmental conditions. In each room, a group of at least 10 respondents completed the questionnaire, which contained questions about their subjective assessment of the indoor environment. The results were averaged across a given room. At the same time, a microclimate meter collected data on the physical parameters (air and globe temperature, air humidity and velocity, CO₂ concentration, illumination). The aim was to determine the interrelationships between environmental parameters (namely, air temperature and relative humidity) and respondents' subjective assessments, and to identify differences in comfort perception across groups of teaching building users. The following relations are intended for analysis: overall comfort vs. air temperature, overall comfort vs. indoor air quality assessment, and humidity preference vote vs. relative humidity. Figure 1a shows one of the teaching buildings, where the study took place, while Figure 1b shows an example classroom with the microclimate meter.

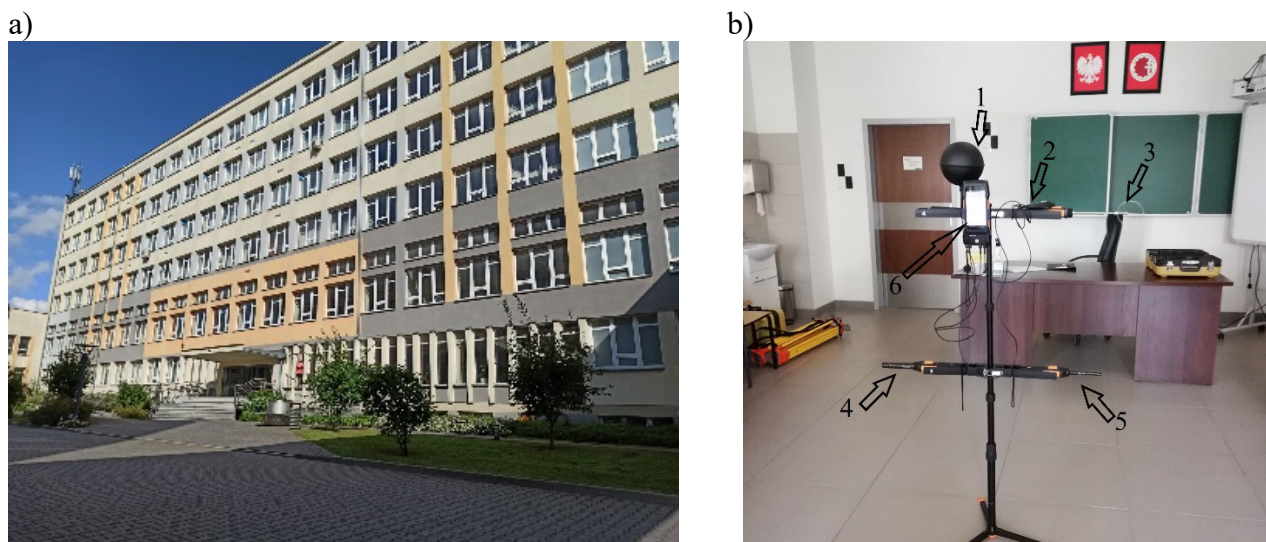


Fig. 1. Photos of a chosen educational building (a) and a classroom (b), where: 1 – globe temperature probe, 2 – light intensity probe, 3 – anemometer, 4 – CO₂ probe, 5 – air temperature and relative humidity probe

The study analyzed the perception of the indoor environment among the surveyed population. The indoor environment was assessed by 1302 users, including 640 women and 662 men. The average age of females was 22.9, with a standard deviation of 4.6, while that of males was 21.8, with a standard deviation of 2.7. Similarly, the BMI index was 22.1 kg/m² (standard deviation: 3.4 kg/m²) for women and 24.6 kg/m² (standard deviation: 3.3 kg/m²) for men. The number of people in the rooms ranged from 10 to 56, while the sur-

face area of the analysed rooms varied from 42.4 m² to 460 m². Each respondent could have participated in more than one test (but not on the same day). The number of times each participant completed the questionnaire (on different occasions) was not recorded. The volunteers were selected based on their willingness to participate in the study. The groups typically consisted of people of similar age occupying a specific classroom/lecture room (only some tests were held on weekends, when part-time students were present at the university).

The first step in initiating the study was to turn on the meter and place it in the center of the room at the seated occupants' height. The parameters collected from the enclosed environment were stabilized. After approximately 15 minutes, the results were recorded. During this time, surveys were distributed to respondents for completion and then collected for analysis. Combining objective measurement data with respondents' subjective assessments enabled a comprehensive assessment of indoor environment quality and the identification of factors influencing comfort perception in educational spaces.

Objective measurements were realized with a newly purchased microclimate meter (thus, factory calibration was still valid). Recording of the values of the physical parameters began about 15 minutes before the respondents filled in the surveys and occurred at a 1-second interval. However, the comparison of subjective and objective measurements was performed for the values recorded during form completion. Table 1 presents the measurement ranges and accuracies of the two parameters analysed in the present study (according to the manufacturer).

Table 1. Measurement details of the meter according to the manufacturer's data (www.testo.com, 2025)

No	Parameter	Measuring range		Measuring accuracy	
1	Air temperature	-20 – +70	°C	±0.3	°C
2	Relative humidity	0–100	%	±0.6+0.7% of the measured value	%

Participants needed only a few minutes to complete the surveys. One question on the questionnaire was about subjective overall comfort (well-being) in the rooms studied. When asked "How do you generally feel in this room?", the respondents were given five options: the positive values meant good ("+1") and very good ("+2"), "0" meant indifferent/neutral, while the negative values meant bad ("-1") and very bad ("-2"). The second question was "How do you rate the air quality in this room?". Ratings were made on a five-point scale ranging from "-2" (very poor) to "+2" (very good). Humidity assessment was based on the answers to the question "How do you assess air humidity" in the scale from "-2" (very dry) to "+2" (very wet"). Additionally, preference regarding this parameter was investigated ("How do you wish the air humidity to be?"), with the answers ranging from an increase ("+1") of humidity, keeping it unchanged ("0") to decreasing it ("-1").

The statistical analysis of the results involves the Student's t-test and the Fisher test. The presentation of the experimental data is accompanied by regression analysis (polynomial or linear) with information on the regression coefficients.

3. Results and Discussion

The present paper focuses on determining differences in selected indoor environment parameters by gender. The already mentioned paper by the authors (Orman et al., 2023) presented the results with the focus on differences in the type of buildings (traditional vs. intelligent ones) and regardless of gender, while the present paper applies the experimental database (regarding overall comfort and indoor air quality) for the analysis concerning the impact of gender.

First, the overall comfort of room users is assessed based on survey responses. Below is a chart (Fig. 2) showing the frequency counts of respondents' feelings regarding their well-being (overall comfort) – called "GSV" – General Sensation Vote.

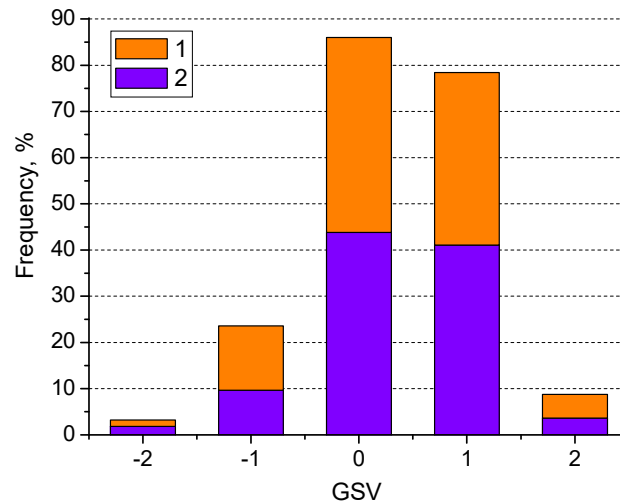


Fig. 2. Frequency of responses regarding their overall comfort (GSV): 1 – females, 2 – males

The rating scale ranged from negative values indicating poor well-being to positive values corresponding to good or very good well-being, with "0" indicating a neutral feeling. The largest number of respondents, both among men and women, selected the "0" answer – 43.81% of men and 42.19% of women, respectively – indicating a dominant feeling of neutrality towards indoor conditions. The second most common answer was "1" (good), given by 41.09% of men and 37.34% of women, confirming the generally positive sensation. A relatively small percentage of respondents declared very good well-being (value "2") – 3.63% of men and 1.16% of women. Negative feelings (values "-1" and "-2") appeared rarely – a total of 11.48% of men and 15.31% of women, which suggests that only a small proportion of users were dissatisfied with the indoor environment conditions. It can be seen that more men than women considered their state to be positive (the sum of responses "1" and "2").

To assess the impact of air temperature on the overall well-being of room occupants, the relationship between the General Sensation Vote (GSV) and air temperature was analyzed and presented in Figure 3. A non-linear relationship is visible: as temperature increases to approximately 23°C, GSV values increase slightly, indicating increased comfort and improved occupant well-being. Above this range, a gradual decline in GSV values is observed, indicating a worsening sense of comfort at higher temperatures. Differences between genders can be analysed with the paths of the fitting curves (3 and 4 in Figure 3). Men seemed more likely than women to report slightly higher overall comfort at the same air temperatures. The differences were lowest around the optimal temperature values (around 23°C) and became more pronounced at the beginning and end of the analysed temperature ranges.

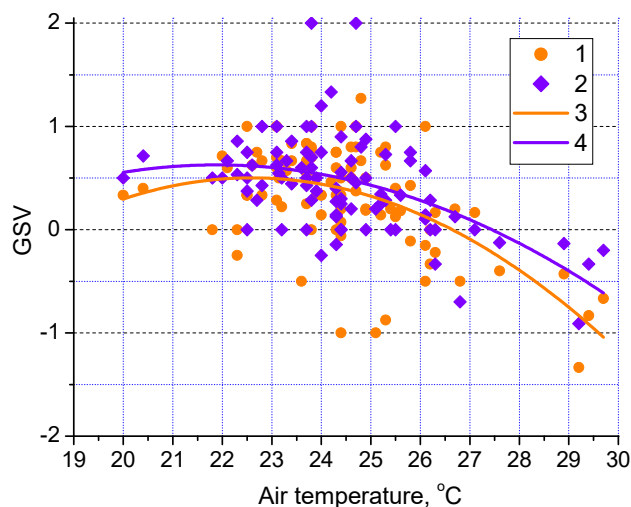


Fig. 3. Overall comfort (GSV) vs. air temperature: 1 – females, 2 – males, 3 – polynomial fit of experimental data (1), 4 – polynomial fit of experimental data (2)

The fitting curves were obtained using least-squares second-order polynomial regression. The obtained regression coefficients were 0.34 for women and 0.25 for men. For both female and male results, the absolute value of the Student t-test statistic exceeds the critical value (1.987). They are as follows: $|t| = 2.426$ for women and $|t| = 4.921$ for men, which indicates the statistical significance of the relationship between air temperature and overall comfort sensation.

Comparison of correlation coefficients for women and men using Fisher's exact test revealed a statistically significant difference between the analyzed groups ($Z = 5.009$; $p < 0.001$). This indicates that the relationship between air temperature and the feeling of well-being differs between women and men.

The results confirm that air temperature has a significant impact on overall comfort perception, and occupant perceptions are consistent with the typical thermal comfort ranges defined in the standard (ISO 7730 2005). Because the surroundings typically have lower temperatures than humans, we observe the phenomenon of thermal energy release to enable cooling. It occurs due to conduction, convection, and radiation (especially in low-temperature surroundings) and through evaporation in high-temperature environments. It results from the fact that phase change is a highly efficient mode of heat exchange (Chatys & Orman, 2017; Orman, 2014).

Indoor air quality is dependent on numerous environmental and operational factors. Reduced air quality can negatively impact occupant well-being, particularly during the heating season, when indoor air exchange could be limited. In such conditions, occupants are more likely to experience discomfort resulting from reduced air quality. Figure 4 presents the distribution of respondents' subjective assessments of classroom air quality, measured in response to the question: "How do you rate the air quality in this room?". Ratings were used to identify dominant occupant perceptions and to compare results by gender.

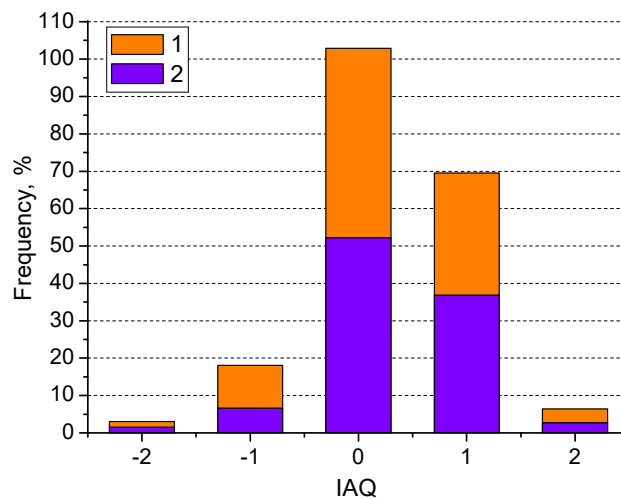


Fig. 4. Frequency of responses regarding indoor air quality (IAQ): 1 – females, 2 – males

The results indicate that the largest percentage of respondents rated the air quality as average (value "0"): 52.27% of men and 50.63% of women. The next-largest group rated the air quality as good (value "+1"): 38.86% of men and 32.66% of women, while a small percentage of respondents rated it as very good (value "+2"): 2.72% and 3.75%, respectively. In turn, 6.65% of men and 11.41% of women rated the air quality as poor ("-1"), and responses indicating very poor air quality ("-2") accounted for less than 2% of all ratings. Generally speaking, women seemed to consider the air quality as poorer. This may indicate that women are more sensitive to environmental factors related to air quality.

Perceived indoor air quality can significantly impact occupants' overall well-being. To verify this assumption, an analysis of the relationship between the subjective assessment of indoor air quality (IAQ) and respondents' overall well-being, expressed as the GSV index, was conducted in Fig. 5. The GSV index reflects occupants' level of satisfaction with environmental conditions. At the same time, IAQ refers to their subjective assessment of freshness, cleanliness, and overall air quality. Analyzing the relationship between these two parameters allows us to assess the extent to which perceived air quality influences overall indoor comfort.

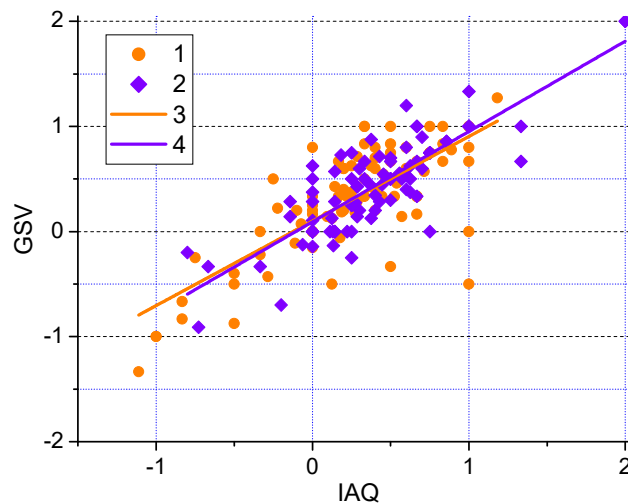


Fig. 5. Overall comfort of room occupants (GSV) vs. indoor air quality assessment (IAQ): 1 – females, 2 – males, 3 – linear fit of experimental data (1), 4 – linear fit of experimental data (2)

The figure above shows the linear relationship between air quality assessment (IAQ) and the occupant's overall comfort (GSV). The results clearly indicate a positive correlation between the analyzed parameters: as the subjective assessment of air quality (IAQ) increases (i.e., air quality is assessed higher), the GSV value also increases. This indicates that occupants rate their well-being more positively in rooms where the air is perceived as cleaner and fresher. The linear fits of the experimental data for both genders are almost identical – the relationship between overall comfort and indoor air quality is the same for women and men. At the same time, the results obtained might confirm that indoor air quality is a key factor in determining the well-being of room occupants. This aligns with a widely accepted view of the significant role of ventilation and air quality in shaping conditions conducive to well-being. It should also be noted that the well-being of indoor occupants is strongly linked to indoor environmental parameters, but can also be shaped by individual occupant preferences and the nature of activities performed at the time of measurement.

The fitting curves in Fig. 5 were obtained using least squares linear regression. The obtained regression coefficients were 0.57 for women and 0.71 for men. As in the previous case (see Fig. 3), the absolute value of the Student t-test statistic exceeds the critical value. They are as follows: $|t| = 11.007$ for women and $|t| = 14.819$ for men, which indicates the statistical significance of the relationship between overall comfort and indoor air quality.

Comparison of correlation coefficients for women and men using Fisher's exact test revealed no statistically significant differences between the groups ($Z = -1.590$; $p = 0.112$). This indicates that the relationship between subjective assessments of air quality and overall comfort is similar for women and men.

Another crucial parameter in the indoor air analyses is relative humidity. If this value is too low, problems may include dryness of the mucous membranes of the nose, throat, and eyes, as well as irritation and fatigue. A study (Krawczyk et al., 2023) reported symptoms such as dry eyes (19% of women and 9.1% of men) and dizziness (11% of men and 15% of women) in rooms with low humidity. Conversely, too high humidity can impede heat loss from the body through evaporation, leading to a feeling of shortness of breath and reduced thermal comfort. Therefore, the respondents' subjective perceptions of air humidity in teaching spaces (AHV – Air Humidity Vote) are now analyzed. The authors (Orman et al., 2024) considered experimental data from various buildings in their paper; however, they did not differentiate by gender and instead presented overall sensations for all people combined. This database will now be used for the analysis of the impact of gender. The results of the frequency count of the humidity assessment are presented in Figure 6.

Figure 6 presents the distribution of respondents' responses to the assessment of air humidity (AHV), broken down by gender. Values below zero indicate that the air in the room was perceived as dry, while values above zero indicate excessive humidity. Relative humidity values obtained during environmental measurements ranged from ca. 20% to ca. 65%. The majority of respondents considered humidity to be adequate ("0"), with almost 60% of men and less than 50% of women describing it that way. The opposite trend was observed in the responses "quite dry" ("-1"), with women (39.06%) more likely than men (31.12%) to indicate insufficient air humidity. Only a small number of respondents considered the air as too humid: 4.38% of women and 3.02% of men, while 6.41% of women and 6.04% of men indicated it was "quite humid". The relatively high percentage of people who rated conditions as too dry can be linked to the fact that, in many rooms, relative humidity dropped below 30%, which might have naturally influenced the subjective feeling

of air dryness. All in all, women rated the air humidity as drier. The obtained results are consistent with previous observations by the authors (Krawczyk et al., 2023), which indicated that too low air humidity can lead to discomfort symptoms such as dry eyes, hoarseness, and irritation of mucous membranes.

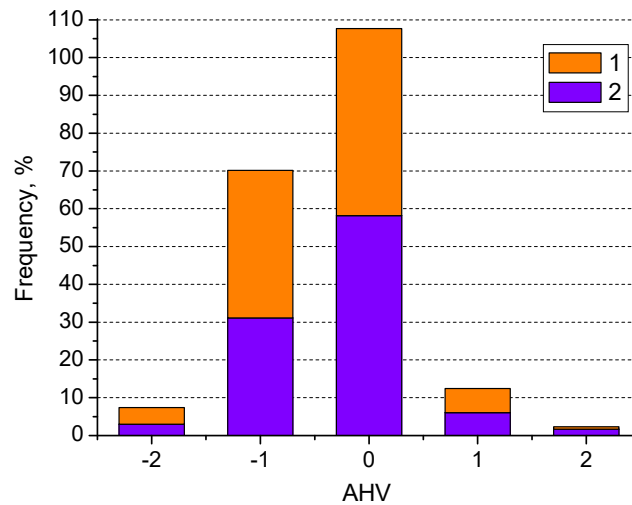


Fig. 6. Frequency of responses regarding air humidity vote (AHV): 1 – females, 2 – males

After assessing the current humidity conditions (AHV), respondents' preferences regarding the desired change in air humidity are now analyzed. The results are presented in Figure 7 as the Humidity Preferences Vote (HPV), reflecting the direction of the expected change in humidity as perceived by the people. The respondents could select one of three options: "-1" – the air should be drier, "0" – the humidity is adequate and does not require change, and "1" – the air should be more humid.

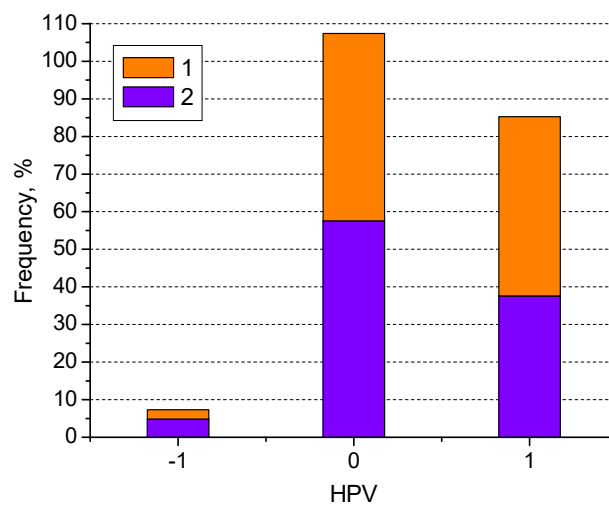


Fig. 7. Frequency of responses regarding air humidity preference (HPV): 1 – females, 2 – males

Based on the data presented in Figure 7, a clear analogy can be seen between the assessment of air humidity (Fig. 5) and preferences for changes in air humidity. A slight increase was observed for the "0" response – meaning no need to change humidity – compared to the previous graph. People who previously assessed humidity as too dry or quite dry most often chose "1" when asked about their preferred humidity level, indicating that indoor air should be more humid. This response was 49.84% among women and 58.16% among men. A relatively small percentage of respondents indicated a need to reduce humidity ("-1"), accounting for 2.5% of women and 4.83% of men. It should be noted that the percentage of women who preferred more humid air was slightly lower than among men, which is consistent with the previous results in Fig. 5, where women were more likely to report too-dry conditions.

A comparison of the AHV and HPV results showed that respondents consciously assessed the microclimatic conditions in their rooms. Those experiencing dry air declared a need for increased humidity, while those satisfied with current conditions expected no changes. To verify the impact of actual relative humidity values on the Humidity Preference Vote, Figure 8 is presented.

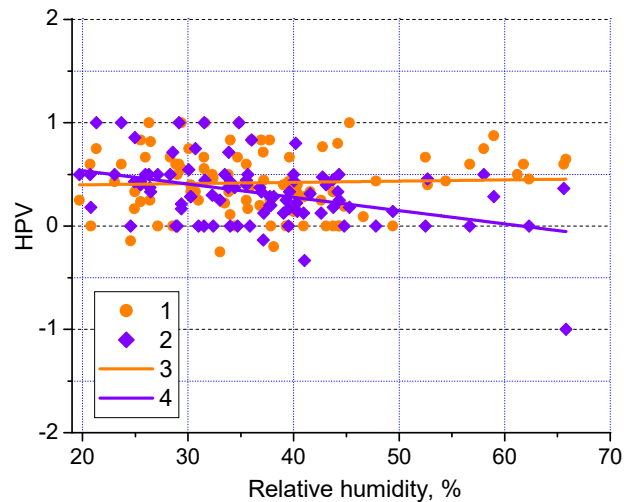


Fig. 8. Humidity preference vote (HPV) vs. relative humidity: 1 – females, 2 – males, 3 – linear fit of experimental data (1), 4 – linear fit of experimental data (2)

Theoretically, as relative humidity increases in rooms, people should opt for reduced humidity. Naturally, the opposite should be true in dry environments, where HPV should take more positive values. Such a dependence seems to be seen only in the responses provided by men. Here, a rise in humidity generates lower HPV values. On the other hand, the votes cast by women indicate that, regardless of relative humidity, their preferences remained unchanged. This aspect needs further analysis and may be considered in future studies, especially given that in the present dataset, no statistical significance was found between relative humidity and the Humidity Sensation Vote, and the linear fitting lines in Fig. 8 were provided for illustration purposes only.

A separate, but important, issue worth studying in the future is the proper integration of thermal comfort guidelines into the energy needs of buildings. It needs to be emphasised that energy management is crucial in the case of buildings as a whole (Jurišević et al., 2025), but also on a smaller scale (Kotrys-Działak & Stokowiec, 2023), with a possible use of renewable energy systems (Koshlak, 2025; Pilát et al., 2014; Wciślik & Kotrys-Działak, 2021).

A significant limitation of the present study is the narrow age range of the respondents. In the tests, university students participated (the majority aged 19–23). Moreover, some students completed the questionnaires several times, while others completed them only once. No data regarding the number of forms completed by each respondent was collected.

4. Conclusions

The analyses confirmed the consistency between objective environmental parameters and subjective user assessments. The following conclusions can be drawn:

1. Typically, more men than women considered their state (overall comfort) as positive. This sensation of well-being was linked to air temperature (although this relation cannot be considered strong). The highest GSV values were obtained at moderate temperature values of about 23°C. Moreover, men were more likely to report slightly higher overall comfort than women at the same air temperature.
2. Generally speaking, women seemed to consider the air quality as poorer. This may indicate that women were more sensitive to environmental factors related to air quality.
3. The relation of overall comfort vs. indoor air quality proved to be the same for women and men.
4. Women seemed to rate the air humidity as drier. Analyses of humidity preferences (HPV) demonstrated consistency between current assessments (AHV) and respondents' expectations.
5. The obtained results confirm that combining objective measurements of microclimate parameters with subjective occupant assessments is an effective tool for assessing indoor environmental quality in educational buildings. The research results may serve as a basis for developing operational and design recommendations for educational facilities, although further studies are necessary in this area.

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