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Regular and temporary occupants' perceptions of satisfaction in tertiary education buildings

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ABSTRACT

Despite the fact that buildings are designed to meet occupants' needs, many do not

There is little knowledge about occupants' satisfaction when diverse end users coexist in the same building. This paper presents the results of a survey administered to 1,013 occupants in 43 academic buildings in Spain, with the aim to reveal the perception of the indoor environmental quality and workplace ergonomics of both lecturers and students. The results revealed that light adequacy, cleanliness and acoustics in classrooms are perceived differently by lecturers and students. Results also revealed no gender differences in satisfaction with all aspects of comfort in classrooms. However, in offices, air quality, thermal sensation in winter and adequacy of space were perceived differently by male and female. The findings will be of interest for tertiary building maintenance, design teams and ergonomists to enhance comfort in both groups of end users.

Author keywords:

User satisfaction; Post-occupancy Evaluation; tertiary education buildings; indoor environment; gender difference; end user perception.

1 INTRODUCTION

Building managers need to ensure a safe, healthy, comfortable indoor environment and satisfy the needs and demands of occupants (Lai and Man 2017). Since people spend about 80–90% of their time indoors (Jensen and Maslesa 2015) and studies have indicated that some symptoms of discomfort in the indoor environment lead to a significant reduction in work performance (Li, Froese, and Brager 2018), there has increasing interest in this area in academic and practitioner literature on occupant satisfaction and building maintenance.

Tertiary institutional buildings, whether old or new, require maintenance and they constitute part of our most valuable asset, providing learners with shelter for study, work and leisure (Akinsola et al. 2012). Academic buildings are a good example of tertiary institutional buildings that have a wide range of spaces with different functions to support the daily activities (teaching, learning and research) of a variety of occupants (Muhammad and Sapri 2014). In these buildings, two types of occupants coexist: regular and temporary. Regular occupants are defined as those who work for a regular period in the building, while temporary users are those who use the services inside the building for short, irregular intervals (Bortolini and Forcada 2018). In academic buildings, regular occupants refer to staff, lecturers and researchers who have normally worked in a building or campus for more than ten years, while temporary occupants refer to students who studied in a building or campus for less than five years (Bortolini and Forcada 2019). While some activities are conducted individually in separate rooms, others need interaction and collaboration among lecturers and students in shared rooms (Muhammad and Sapri 2014).

Monitoring occupant satisfaction is an essential activity for FM teams, and it is recognized by today's building regulations. For instance, the WELL standard identifies the importance of monitoring occupant comfort and recommends Post-occupancy evaluation (POE) surveys once per year (WELL Building Standard 2014). However, as pointed out by Abisuga et al. (2020), it is a very challenging task to ensure the spaces of educational buildings meet users' needs. To do so, the first difficulty faced by facility managers is to identify their needs (Kamarazaly et al. 2013) because in these buildings, different users with diverse characteristics (age, activity, routines, gender) cohabit. Recent studies have reported that lecturers and students might have different perceptions of satisfaction in education buildings (Bortolini and Forcada 2019).

CABE (2005) demonstrated that building facilities have a great impact on how students and lecturers feel and behave while they are working or studying (CABE 2005). Other studies have shown that factors of environmental comfort can greatly affect the learning process (Ricciardi and Buratti 2018; Asif et al. 2018). Therefore, learning environments in educational buildings require special attention (Sadick and Issa 2018). The internal temperature of the work environment has a considerable impact on employee performance (Vimalanathan and Babu 2014), while learning rates are lower in thermally uncomfortable environments (Cui et al. 2013). Lighting quality was also one of the most important factors contributing to dissatisfaction, including the direct glare from the lights and from the sun and sky (Baird and Thompson 2012). Other studies have shown that a comfortable environment enhances the productivity of workers and this concept can be extended to students as well (Sarbu and Pacurar 2015). Both thermal sensation and air quality in classrooms greatly influence the learning capacity of students (Barret et al 2015; Ricciardi and Buratti 2018; Asif et al. 2018). Moreover, the feeling of satisfaction on the environmental conditions of classrooms was found to be improved when increasing the microclimate control (Nico et al. 2015). However, most thermal environments cannot satisfy all the individuals present (Fanger 1970), since each person has different characteristics, experiences and expectations.

Karjalainen (2012) and Maykot et al. (2018) reported that recent studies have found significant differences between men and women regarding thermal comfort. Nevertheless, conditions exist under which most individuals will have a positive sensation in relation to comfort. Although several studies demonstrate gender differences in thermal comfort, there are no reported studies on how groups of occupants (regular/temporary, men/women) perceive comfort in other relevant aspects such as air quality, lighting, adequacy of space, cleanliness, security and accessibility. Moreover, research on required facilities and indoor environmental quality is often limited to the perspective of managers, lecturers or staff (Beckers et al. 2016).

There are relatively few attempts that study physical learning environments and their impact on occupants in education buildings (Yang et al. 2013). To the best of our knowledge, no previous research investigated the differences of satisfaction about regular and temporary users in educational buildings. Some researchers have conducted studies on short-term occupants, such as guest satisfaction in hotels (Fountain et al. 1994). However, studies combining long-term (regular) and short-term (temporary) occupants' perceptions have not been conducted yet. In addition, studies of satisfaction surveys have tended to focus on commercial and residential buildings, whilst the academic buildings have received less attention (Riley et al. 2010).

The importance of testing the differences of satisfaction perception in academic buildings relies on the need to define building design practices that meet all end users' requirements. Based on the identification of this research gap, two hypotheses were defined for investigation in this study:

- H1: Perception of the indoor environmental quality and workplace ergonomics is different between lecturers (regular users) and students (temporary users);
- H2: The perception of satisfaction depends on the characteristics of end users.

This paper presents the results of a satisfaction survey on Indoor environmental quality (IEQ) and workplace ergonomics conducted in 43 academic buildings in Spain. The study combines all the information collected to analyse the differences between regular and temporary occupants' satisfaction and other groups of occupants, such as male and female, and occupants in different university campuses. The paper further discusses the main issues and thoughts emerging from research in this area to help researchers, building managers and design teams to establish building specifications using an occupant-centric approach.

2 METHODOLOGY

The research approach adopted in this study consisted of a Post-occupancy evaluation (POE) applied in a case study followed by statistical analysis. Building occupants are the best source of information on needs and comfort requirements (Frontczak et al. 2012). Therefore, the perception of satisfaction about building comfort should be obtained by questionnaire surveys that rank a set of criteria in levels of user satisfaction (Au-Yong, Ali and Ahmad 2014). POE surveys provide valuable insights into whether people are satisfied with the environmental conditions, which can be useful in measuring the extent to which a building is effectively promoting and protecting the health and comfort needs of its occupants (Preiser and Vischer 2005). Moreover, POE was chosen due to offer a wide range of activities and benefits, including the identification and evaluation of critical aspects of building performance, optimization of the indoor environment for users, the possibility to develop design guidance and criteria for more informed decisions about future building design, and opportunities to enhance the dialogue within design teams and their partners (Preiser 1995; Li et al. 2018).

A questionnaire survey was developed to evaluate IEQ aspects, such as visual, acoustic, thermal and air quality and several other factors such as adequacy of the space and cleanness of the most relevant building rooms. The questionnaire survey also evaluated the satisfaction with security, accessibility and building conservation aspects of the building in global. This questionnaire was administered to occupants of various university buildings and campuses in

Spain. The results of the questionnaire survey were then used to evaluate the correlation between these aspects and the perception of satisfaction in groups of occupants.

2.1. Questionnaire survey

The questionnaire survey (See Appendix A) included general respondent details, such as gender and age. Respondents were asked to select the building they work or study in and the years they have been working or studying in that building. Regular users were asked to include workplace characteristics, including the availability of personal control adjustments (e.g., curtain, windows, ventilation, thermostat and others).

Participants were contacted via email in October 2017 and asked to rate their satisfaction in relation to thermal sensation (TS) in winter and summer, air quality (AQ) in winter and summer, light quality, cleanliness, adequacy of the space and acoustic quality, providing a global evaluation for the previous winter and summer. The survey used a 5-point scale to rate occupants' satisfaction ranging from "very satisfied" (5) to "very dissatisfied" (1), with a neutral midpoint (3). These aspects were evaluated in relation to academic building zones, including classrooms, offices, corridors, restrooms, laboratories, conference rooms, study rooms and dining rooms. To understand the main causes of end user dissatisfaction with these zones, respondents were asked to identify reasons for dissatisfaction given the predefined options, and a text entry box was included for respondents to add other reasons.

Moreover, respondents were asked to rate their satisfaction in relation to the building's accessibility, state of preservation and security. Possible reasons for dissatisfaction with the state of preservation were predefined, and a text entry box was provided to add other reasons. Finally, respondents were asked to rate the level of general satisfaction within the building. An open-ended question was included that allowed respondents to comment on what they personally found relevant.

2.2. Sample

The sample included occupants from two university campuses in Spain. Campus 1 (Figure 1) is in an urban centre and consists of 25 buildings constructed around the 1990s. All the Campus buildings have a reinforced concrete structure, flat roofs and masonry facades. Although all the buildings are modular and have similar construction characteristics, their heating, ventilation and air conditioning (HVAC) systems are different. 60% of the buildings are heated by radiators. In these buildings no cooling system is integrated in classrooms while splits are installed in the offices. The rest of the buildings (40%) are both heated and cooled with fan-coils in all the building areas. Air renovation in all buildings is natural, by opening windows. Only few rooms and laboratories incorporate forced ventilation to fulfil air renovation standards.

Figure 1. Aerial image from Campus 1 (UPC, 2020a)

Campus 2 is located in a metropolitan area and consists of 18 buildings from a range of construction years, distributed in several blocks of the city (Figure 2). The newest building was constructed in 2011 and the oldest one at the beginning of the twentieth century. They were designed with heating systems only, and multi-splits have been incorporated over the years. The newest buildings have air-water systems for heating, air conditioning and ventilation.

Figure 2. Aerial image from Campus 2 (UPC, 2020b)

The average occupancy of those buildings mainly designed to teaching (80%) have a high occupancy density ($1.63 \text{ m}^2/\text{person}$), while the rest of the buildings (20%) which are designed to offices for both lecturers and staff have a relatively low occupancy density ($6.96 \text{ m}^2/\text{person}$).

2.3. Statistical analysis

Respondents' data and their satisfaction with the IEQ and workplace ergonomics evaluations were analysed by type of end user (regular vs. temporary), gender, campus occupants and years working in the building. A total of 1,013 satisfaction surveys were

completed, which was a large enough sample to achieve normality for statistical analysis.

The data were statistically analysed using the Statistical Package for the Social Sciences (SPSS) for Windows (version 17.00). Answers with missing data were eliminated from the analysis. Descriptive statistics such as percentages and the mean were used to summarize the respondents' characteristics.

Correlation analysis and the Chi square-test were used to evaluate the relationship between the respondents' satisfaction and their characteristics or the building characteristics.

2.3.1. Spearman correlation analysis

Spearman correlation (r_s) is a nonparametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale (Gravetter et al 2020). Spearman correlation analysis was used to evaluate the correlation between occupants' satisfaction and other quantitative variables (age of the respondents, years of working or studying in the building, age of the building). In this case, the satisfaction is ranked on an ordinal scale (1 - very dissatisfied, 5 - very satisfied). The sample correlation coefficient, denoted "r", ranged between -1 and +1 and quantified the direction and strength of the association between the two variables.

2.3.2. Chi-square test

The Chi-square (χ^2) test for independence is used to discover if there is a relationship between two categorical variables (Gravetter et al. 2020). A Chi-square test was used to determine the dependence between gender (male/female), type of occupant (regular/temporary), campus (campus 1/campus 2), rooms (office/classrooms/labs, etc.) and occupants' satisfaction with IEQ aspects. This test can be used to compare observed and expected frequencies. For a chi-square test, the null hypothesis is that the two sets of frequencies (i.e., observed and expected) are equal. The alternative hypothesis is that they are unequal. To identify variables with significant correlations at 95% confidence intervals, the Asymptotic Significance should be less than 0.05. The Asymptotic Significance, or p-value of the Chi-square determines the statistical significance of the relationship tested. If $p < 0.05$ this means that there is a statistically significant relationship between the two variables.

3 RESULTS

A total of 1,013 valid responses were received, of which 29.4% were regular users and 70.6% were temporary users. Considering both campuses, 36.2% of the respondents who were regular users were women and 63.8% were men (see Table 1). A total of 24.5% of respondents who were temporary users were women and 75.5% were men.

Table 1. Sample characteristics

N- Number of respondents (%)					
	Regular users	Temporary users	Campus 1	Campus 2	Total
Male	190 (63.8%)	540 (75.5%)	485 (75.1%)	245 (66.8%)	730 (72.1%)
Female	108 (36.2%)	175 (24.5%)	161 (24.9%)	122 (33.2%)	283 (27.9%)
Total	298 (29.4%)	715 (70.6%)	646 (3.8%)	367 (63.7%)	1,013 (100%)

Regular users are staff, lecturers and researchers who have mainly been working in that campus for more than 5 years (72.5%) and spend in average 40 working hours per week in the campus, 8 of that are dedicated to teaching while the rest are for class preparing, research activities of administrative work (Table 2). Regulars users are 48.11 years old in average and between 22 and 66 years old (Table 3). The offices of regular users vary among individual offices to 4 occupants per office. They all have natural lighting and ventilation.

Temporary users are students who use the campus' services for short and irregular intervals. 25% of the students have been studying in that campus for less than 1 year and 66.4% between 1 and 5 years. They normally have 25 hours of class per week while the rest is dedicated for studying. Some of them go home while others stay at the campus library or studying areas. Temporary users are 21 years old in average and between 17 and 46 years old. See Table 2 and Table 3.

Table 2. Differences between regular and temporary users

			Regular users		Temporary users	
			N	%	N	%
Year working/studying in that campus	Less than 1		23	7.7	179	25.0
	Between 1 and 5		59	19.8	475	66.4
	More than 5		216	72.5	61	8.5
Total			298		715	

Table 3. Age of the different user groups

Age (years)	Regular users	Temporary users
Average	48.11	21
Standard deviation	9.9	3.4
Minimum	22	17
Maximum	69	46

3.1. Overview of data analysis

3.1.1. General satisfaction

An overview of respondents' satisfaction with security, accessibility and building conservation aspects is shown in Figure 3. The general satisfaction of all respondents with the building they work or study in was between neutral and satisfied ($M=3.47$). A total of 45.8% of the respondents were satisfied with the building in which they work or study. Most of the occupants reported that they were neutral or satisfied (79.1%) with the building. Only 12.9% were not satisfied with the building in which they work or study.

Figure 3. End users' satisfaction with general aspects

In general, end users felt neutral about the security of the buildings (60.3%). The main cause of dissatisfaction with the security of the building was related to lack of control of access to the building. Although accessibility was the best-rated aspect (67.1% of the respondents were satisfied or very satisfied), some respondents complained about the difficulty of accessing some building zones when the lifts were not working properly or did not feel that the buildings met current accessibility legislation related to ramps or door width.

The main causes of dissatisfaction with the state of conservation were related to visual appearance (e.g., walls needing to be painted), windows and doors not working properly and HVAC equipment not working properly.

3.1.2 General satisfaction with building zones

Table 4 shows respondents' satisfaction with thermal sensation, air quality, lighting, cleanliness, adequacy of the space and acoustics in building zones.

Table 4. Satisfaction results by building zone

Aspect	M (Mean)							
	Offices	Classroom	Halls	Labs	Study areas	Conf. rooms	Toilets	Dining rooms
Winter TS	3.12	3.39	3.30	3.31	3.41	3.31	3.22	3.30
Winter AQ	3.18	3.29	3.52	3.42	3.44	3.42	3.29	3.21
Summer TS	3.11	2.57	3.28	3.15	3.14	3.15	3.43	3.16
Summer AQ	3.20	2.86	3.40	3.24	3.27	3.24	3.32	3.12
Lighting	3.61	3.75	3.58	3.66	3.78	3.66	3.61	3.50
Cleanliness	3.67	3.98	3.94	3.87	3.90	3.87	3.44	3.44
Space adequacy	3.54	3.51	3.77	3.52	3.65	3.52	3.51	3.25
Acoustics	3.18	3.47	3.58	3.62	3.42	3.62	3.57	3.27

Generally, cleanliness was the best-rated aspect in all zones of the buildings. The thermal sensation in summer was the worst-rated aspect, followed by the thermal sensation in winter and the air quality in summer.

In general, halls were the best-rated zones followed by conference rooms and study areas, while classrooms were the worst-rated zones followed by dining rooms. In classrooms, occupants reported dissatisfaction with the thermal sensation in summer and with the air quality,

and the most frequent reasons for dissatisfaction (70%) were stuffy air and the presence of odours. These results could be attributed to the fact that these classrooms mainly have heating but no cooling or forced ventilation.

Although respondents were generally satisfied with the light quality, the main reasons for dissatisfaction included: brightness of the sun and no possibility of regulating the lights. The most frequent reason for dissatisfaction with space quality was related to the lack of privacy in offices and the ergonomics of chairs and tables in offices and classrooms. Considering the acoustic quality, noise from people talking in the corridor and noise from HVAC equipment were the most frequent reasons for dissatisfaction in both offices and classrooms.

3.1.3. Satisfaction results by type of occupant

The satisfaction of regular and temporary occupants was compared for zones that both groups use (classrooms, laboratories and conference rooms).

Although the number of permanent users (lecturers) was lower than temporary users (students) and Chi-square is highly sensitive to the sample size and the small frequencies in the cells of tables, the expected frequency in all cells of the tables were higher than 5 (10.59), meaning that the number of cases per each subgroup was suitable according to Blyth (1970).

Regarding classrooms, lectures and students had similar level of satisfaction with the adequacy of the space, the TS in winter and summer, and the AQ in winter and summer. However, perceptions of light adequacy, cleanliness and acoustics varied depending on the type of user. The fact that the Pearson chi-square value under Asymptotic Significance was 0.000 and less than 0.05, indicates that satisfaction with these areas is perceived differently by lecturers and students. Figure 4 shows respondents' level of satisfaction with these aspects in classrooms, which differs among lecturers and students.

Figure 4. Respondents' level of satisfaction in several aspects in classrooms

Considerations of lighting, cleanliness and acoustics varied in the groups. Lecturers were more demanding than students. Regarding laboratories, lecturers and students had similar level of satisfaction with lighting, cleanliness, acoustics and the adequacy of the space. However, perceptions of TS in winter and summer and AQ in winter and summer varied depending on the type of user. The Pearson chi-square value under Asymptotic Significance was 0.000 and less than 0.05, indicating that satisfaction in these areas was perceived differently by lecturers and students.

Figure 5 shows respondents' level of satisfaction with aspects perceived differently by lecturers and students in laboratories.

Figure 5. Respondents' level of satisfaction with aspects perceived differently by lecturers and students in laboratories

The perceptions of TS in winter and summer and AQ in winter and summer in laboratories varied in the two groups. Both lecturers and students had similar level of satisfaction with all aspects relating to conference rooms.

3.2. Satisfaction results by gender

There were no gender differences in satisfaction with all aspects of comfort in classrooms, laboratories and conference rooms in which both males and females coexist. Neither for lecturers nor students. However, in offices that are only occupied by lecturers and staff, TS and AQ in winter and adequacy of space were perceived differently by male and female.

Although the number of females was lower than males and Chi-square is highly sensitive to the sample size and the small frequencies in the cells of tables, the expected frequency in all cells of the tables were higher than 5 (6.16), meaning that the number of cases per each subgroup was suitable according to Blyth (1970).

The fact that the Pearson chi-square value under Asymptotic Significance was 0.000 and less than 0.05, indicates that TS and AQ in winter and adequacy of space are perceived differently by gender (see Figure 6).

Figure 6. Respondents' level of satisfaction with aspects that were considered differently by gender in offices

The results of this study indicate that there are no differences in TS and AQ satisfaction between male and female in the summer. However, in the winter, female showed greater intolerance to the cold than male. The mean TS in winter in offices for men was 3.21 while for women it was 2.97. For air quality in winter, men had an average satisfaction rating of 3.25 and women of 3.06.

Regarding adequacy of the space, analysis of the survey results revealed that men are more satisfied with the office design of their workplaces than women (male 3.65, female 3.36).

3.3. Satisfaction results by campuses

In general, the results showed that respondents on Campus 1 were more satisfied with the classrooms than respondents on Campus 2. No differences were found in the level of satisfaction with offices on both campuses.

The TS in the summer for classrooms, laboratories and study areas was perceived differently on the two campuses (TS classrooms: Campus 1: M=2.74; Campus 2: M=2.28; TS labs: Campus 1: M=3.27; Campus 2: M=2.96; TS study areas: Campus 1: M=3.42; Campus 2: M=2.87). Occupants from Campus 1 were more satisfied with the thermal quality than occupants from Campus 2. The same was found of the air quality in summer (AQ classrooms: Campus 1: M=3.02; Campus 2: M=2.58; AQ study areas: Campus 1: M=3.51; Campus 2: M=2.87).

As previously described, Campus 1 facilities are newer than those of Campus 2. Therefore, a Rho Spearman correlation was carried out between the building construction year and the end users' general satisfaction. General satisfaction was found to be unrelated to age of the building ($r=0.191$, $p<0.01$, two tails and $r^2=0.0365$ [3.6%]).

The University facilities department manages the buildings on both campuses. A Computerised Maintenance Management System (CMMS) is used to manage maintenance activities. A Building Management System (BMS) is also used to manage energy systems (e.g., HVAC systems, lighting systems and hot water systems), which includes turning equipment on and off. Therefore, the main maintenance activities are addressed in the same way on both campuses. Probably, within general satisfaction we could also consider aspects such as location close to a big city, transportation and access to the building. Campus 1 is located in an urban

centre, with many public transport options and connection between roads, which might lead to a greater perception of satisfaction by the end user.

4. DISCUSSION

From the perspective of owners, designers and facility managers, the percentage of people who are dissatisfied with indoor environmental aspects of building areas and within groups of end users can be of practical use.

This study attempted to identify whether there was any difference in perception between types of occupants and gender in tertiary education buildings. The analyses of the questionnaire survey demonstrated that satisfaction with various comfort factors differed between type of end user and between gender.

4.1. Overview analysis

Halls, which are transient spaces where occupants do not spend long periods, were the best-rated space. In contrast, classrooms and offices, where end users spend most of their time, were the spaces where occupants were least satisfied, in general. Therefore, the time spent within a space might be a causal factor for occupant satisfaction perception. Consequently, designers might include this aspect in the early design phase. Facility managers and owners might also determine different temperature set points for transient spaces and thus reduce energy consumption without reducing occupants' satisfaction. However, HVAC, lighting systems and layout must be accurately designed, and proper control systems implemented in different zones of offices and classrooms where end users spend most of their working or studying hours and different satisfaction perceptions were found.

Generally, TS and AQ in winter and summer were the worst-rated aspects in most rooms. When tertiary buildings are designed, special attention should be paid to HVAC systems (Kwon et al. 2019). During the conceptual design phase of a building, many decisions are made based on energy performance, indoor quality and economic conditions. However, in the design phase, end users' requirements and satisfaction are not considered because there is no standard principle and a lack of actual information about their requirements and needs (Heydarian et al. 2017). When users are considered in the early design phase, the design approach may be different than in conventional design approaches in which users are not considered (Heydarian et al. 2017).

In general, summer TS and AQ were worse rated in classrooms than in other areas with low occupancy. Classrooms were the rooms with the worst AQ evaluation in summer. A high level of occupancy causes high levels of CO₂, which can be associated with the absence or insufficient use of ventilation systems (Griffiths and Eftekhari 2008). Therefore, AQ and ventilation systems should be focused on spaces with high occupancy. Existing regulations make it compulsory for new tertiary buildings to provide forced ventilation. However, most of the existing building stock still lacks forced ventilation (Bortolini and Forcada 2019). In fact, in the evaluated buildings, the classrooms mainly have heating but no cooling or forced ventilation. Achieving classroom ventilation by manually opening windows depends on outdoor conditions, including climatic conditions (i.e., wind speed, wind direction, and outdoor air temperature), as well as occupants' window opening behaviour (Sarbu and Pacurar 2015; Bortolini and Forcada 2019). Therefore, in high occupancy rooms, it is difficult to rely on manual windows opening for ventilation because all occupants must agree to open or close windows. Forced ventilation is then a better solution for air renovation in high occupancy rooms.

However, although with low occupancy density, offices were the spaces with the lowest

level of satisfaction in all aspects. The fact that regular end users spend most of their time in their workplaces makes them more demanding in terms of satisfaction.

4.2. Discussion of results by type of occupant

Classrooms and laboratories are areas where different types of end users coexist. The results of this study manifested that lighting, acoustics and cleanliness were perceived differently by lecturers and students in classrooms. Lighting is an essential performance indicator for students in classrooms, as it affects students' visual comfort and learning capacity. With the same lighting conditions, students require better lighting performance than lecturers because they need to visually adapt from short distance (study notes or laptop) to long distance (blackboard). However, results show that lecturers are more demanding in classrooms than students. This result could be associated with age. Older people have more problems with sight than younger people so they might be more demanding about visual aspects (Ferguson et al. 1974). Lighting control and adaption of lighting levels in classrooms might be implemented to bring comfort to both lecturers and students that coexist in these rooms.

The differences in the perceptions of regular and temporary occupants in terms of cleanliness and acoustics might be attributed to "forgiveness factors" (Leaman & Bordass 2007). End users accept different levels of performance depending on their expectations. Lecturers who have generally been working longer in a building than students, who occupy buildings for less than 5 years, are more demanding with their workplace because they expect to occupy it for many years, while students know that they will be in the building for a few years. Therefore, students might accept lower levels of comfort or building performance. For these satisfaction aspects no differences can be implemented in the same room.

End users' satisfaction in laboratories was also found to be different. Regular end users include lecturers and laboratory technicians who spend majority of their working days in these spaces. Previous studies identified spatial design as a critical aspect in assessments of laboratory facilities, including flexibility and responsiveness to users' needs, as well as availability of suitable laboratory support spaces (e.g., offices, special instruments and equipment rooms and storage rooms) (Mahmoud and Sanni-anibire 2018). The analysis of the questionnaire survey results found that end users were generally satisfied with these aspects and there was no difference in satisfaction perception between regular and temporary end users. However, perceptions of TS and AQ in summer and winter was found to vary between regular and temporary end users. Laboratories have strict HVAC requirements such as requiring 100 percent ventilated air, and no recirculated air can be used unless it is acceptable and allowed by code (Mahmoud and Sanni-anibire 2018). Laboratory technicians are aware of the special HVAC requirements and more critical when they are not fulfilled. They also spend longer periods in laboratories than students. Therefore, awareness of regulation requirements and the time spent in a room with high air ventilation requirements might be a key indicator of thermal and air quality satisfaction. For those big laboratories with different experimental areas, HVAC regulation and control systems might be implemented to address the different thermal sensation and air quality perception of both end users that coexist in this room.

The analysis of results reveals that regular and temporary end users of conference rooms have the same satisfaction perception in all aspects. The fact that conference rooms generally incorporate lighting and HVAC control might explain the high satisfaction perception by all groups in all aspects.

4.3. Discussion of results by gender

The thermal comfort sensation is not only influenced by air velocity, relative humidity, clothing insulation, metabolic rate and air temperature, as proposed by Fanger (1970), but also by other characteristics, such as gender (Maykot et al. 2018). According to Schellen et al. (2012) and de Dear and Fountain (1994), women tend to feel greater discomfort than men

under the same conditions. Although significant gender differences were observed in all IEQ factors in offices, with women being consistently less satisfied, no significant differences were observed in other areas of the buildings.

Interestingly, although female expressed lower satisfaction with TS and AQ in winter and with adequacy of the space, the overall rating of the workspace environment did not differ between gender. Previous studies also found that women are less satisfied with indoor thermal environment, and are more sensitive to indoor air problems such as stuffy air, draughts and dust (Erlandson et al. 2003; Choi et al. 2010; Kim et al. 2013).

The results of this paper are in line with Kim et al. (2013) who also found that there is an extremely significant difference in thermal satisfaction by gender in the cool season. Differences between the thermal comfort responses of females and males in field studies have sometimes been attributed to clothing differences between the sexes (Dear and Fountain 1994). Other studies (Beshir and Ramsey 1981) attribute the gender effect on thermal comfort to differences in metabolic rate between the two sexes. However, there might be other factors to consider, such as the type and characteristics of the offices.

Another interesting finding is related to the adequacy of the space. The analysis of survey results also revealed that male is more satisfied with the design of their workplaces than female (men 3.65, women 3.36). Although Kim et al. (2013) investigated gender differences in occupants' perceptions of various aspects of indoor environmental quality and found that women's satisfaction levels were consistently lower than male occupants for all evaluated aspects (including thermal comfort, air quality, lighting, acoustics, office layout and furnishings, and cleanliness and maintenance), to the best of our knowledge, no previous research found specifically that women are less satisfied than men with the adequacy of space in workplaces. The adequacy of space includes office design and more specifically 'desk location' and 'layout', and it is found to contribute most to occupants' satisfaction with their workplaces, regardless of gender (Kwon et al. 2019). Personal or occupational characteristics that are not related to the indoor environment, such as job-related stress, lack of control of work, low job pride resulting from a low position within the organisational hierarchy are factors that might impact these results (Kim et al. 2013). Other contextual and individual characteristics such as fitness, nutritional differences, ethnicity, culture and social class are aspects to consider in an evaluation of subjective satisfaction responses and determination of gender differences (Messing and Stellman 2005). Although offices tend to be designed as open spaces, HVAC control strategies must be designed to allow individual control of temperature. Small fan-coils or splits might be a good option to allow HVAC sectorisation within a big office. Space, layout and furniture might also be flexible to allow adaptation to the different occupants' comfort requirements. Future research will analyse the characteristics of end users and office layout to corroborate and find out the main causes of satisfaction differences between the sexes.

5. CONCLUSIONS

This paper presented the results of an indoor environmental and workplace ergonomics satisfaction survey administered to 1,013 occupants of 43 academic buildings in Spain. Various IEQ aspects such as thermal comfort, indoor air quality and acoustics along with other building factors such as adequacy of the space, ergonomics, security and state of preservation were evaluated. Respondents were asked to rate their satisfaction in several areas of the building they occupy.

This research demonstrated that end users of tertiary education buildings have varying comfort perceptions. The results revealed that rooms that are normally occupied such as classrooms and offices are those in which occupants were least satisfied, while people were more satisfied with transient spaces such as halls. The time spent in a room and the rate of occupancy were found to significantly influence the general level of occupant's satisfaction.

Therefore, designers must take higher attention to IEQ in offices and classrooms than in corridors or halls.

The results also revealed that regular users (lecturers and staff) tend to be less satisfied than temporary users (students) in rooms used by both groups (classroom, laboratories and conference rooms). Lighting satisfaction in classrooms is an aspect that was perceived differently by these groups. Therefore, lighting zoning control might be implemented to provide comfort to both end users of these rooms. Results revealed that in areas mainly occupied by lecturers such as offices, differences in thermal comfort, air quality and adequacy of spaces were manifested by gender. Flexible office layouts must be designed while HVAC zoning should allow end users determine different temperature setpoints and individual air renovation.

No differences were found neither between type of occupants nor gender in accessibility, security or building conditions. These comfort aspects are more objectively determined and more related to preventive maintenance rather than end user's perception.

The outcomes of this study reinforce the importance of designing adaptable spaces and providing user centric control of HVAC and lighting systems.

The findings of this study might help designers, facility managers and owners to focus on occupant-centric aspects when designing and managing tertiary education buildings occupied by different groups of occupants. Based on the results of this study, the design of education buildings should consider:

- High occupancy rooms such as classrooms must guarantee forced ventilation and accurate HVAC design.
- Lighting control systems must be implemented in classrooms to be adapted to both students and lecturers' requirements.
- Special attention should be paid to office design where regular occupants, who are the most demanding users, spend most of their working period.
- The office layout should be flexible to adapt to the different end users.
- Office space should incorporate zoning temperature regulation and ensure adequate air flow.
- The IEQ of rooms that are permanently occupied need to be carefully analysed and HVAC, acoustic and lighting systems designed to meet end users' comfort and satisfaction needs.

The main limitation of this study is the lack of monitoring of IEQ aspects (temperature, humidity, lighting and sound level). This information would help to determine the causes of dissatisfaction and objectify such a subjective aspect as comfort satisfaction. The number of interviews with regular occupants is also a limitation, if compared with the number of temporary occupants. However, the results were statistically significant, the study included a large number of interviewees and had a high response rate. A future step will cast to involve more regular participants in the survey. However, the high number of temporary users (students) is typical in education buildings.

Future research will analyse specific respondents' workplaces to detect potential bias in the analysis and find conditions under which most individuals will have a positive sensation in relation to comfort.

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4 REFERENCES

- Akinsola, O. E., Hussaini, P. O., Oyenuga, S. O., & Fatokun, A. O. (2012). Critical factors influencing facility maintenance management of tertiary institutional buildings in South West Nigeria. *Mediterranean Journal of Social Sciences*, 3(11), 489-496. Retrieved from <http://www.richtmann.org/journal/index.php/mjss/article/view/11412>
- Asif, A., Zeeshan, M., Jahanzaib, M. (2018). Indoor temperature, relative humidity and CO₂ levels assessment in academic buildings with different heating, ventilation and air-conditioning systems. *Building and Environment* 133, 83–90. <https://doi.org/10.1016/j.buildenv.2018.01.042>
- Au-Yong, C. P., Ali, A. S., & Ahmad, F. (2014). Improving occupants' satisfaction with effective maintenance management of HVAC system in office buildings. *Automation in Construction*, 43, 31–37. <https://doi.org/10.1016/j.autcon.2014.03.013>.
- Baird, G., & Thompson, J. (2012). Lighting conditions in sustainable buildings: results of a survey of users' perceptions. *Architectural Science Review*, 55(2), 102-109. <https://doi.org/10.1080/00038628.2012.667941>
- Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis. *Building and Environment*, 89, 118-133. <https://doi.org/10.1016/j.buildenv.2015.02.013>
- Beckers, R., Van der Voordt, T., & Dewulf, G. (2016). Learning space preferences of higher education students. *Building and Environment*, 104, 243-252. <https://doi.org/10.1016/j.buildenv.2016.05.013>
- Beshir, M. Y., & Ramsey, J. D. (1981). Comparison between male and female subjective estimates of thermal effects and sensations. *Applied Ergonomics*, 12(1), 29-33. [https://doi.org/10.1016/0003-6870\(81\)90091-0](https://doi.org/10.1016/0003-6870(81)90091-0)
- Blyth, C. R. (1970). On the inference and decision models of statistics. *The Annals of Mathematical Statistics*, Vol. 41, No. 3, p. 1034-1058.
- Bortolini, R., Forcada, N. (2018). Facility managers' perceptions on building performance assessment. *Frontiers of Engineering Management* 5, 324–333. <https://doi.org/10.15302/J-FEM-2018010>
- Bortolini, R., Forcada, N. (2019). A probabilistic-based approach to support the comfort performance assessment of existing buildings. *Journal of Cleaner Production*. 237, 117720. <https://doi.org/10.1016/j.jclepro.2019.117720>
- Choi, J., Aziz, A., & Loftness, V. (2010). Investigation on the impacts of different genders and ages on satisfaction with thermal environments in office buildings. *Building and Environment*, 45(6), 1529-1535. <https://doi.org/10.1016/j.buildenv.2010.01.004>
- Commission for Architecture and the Built Environment. (2005). *Design with distinction: The value of good building design in higher education*. London: CABE.
- Cui, W., Cao, G., Park, J. H., Ouyang, Q., & Zhu, Y. (2013). Influence of indoor air temperature on human thermal comfort, motivation and performance. *Building and environment*, 68, 114-122. <https://doi.org/10.1016/j.buildenv.2013.06.012>
- Dear, R., & Fountain, M. (1994). *Field experiments on occupant comfort and office thermal environments in a hot-humid climate*. UC Berkeley: Center for the Built Environment. Retrieved from <https://escholarship.org/uc/item/97n1d8hd>
- Erlandson, T., Cena, K., De Dear, R., & Havenith, G. (2003). *Environmental and human factors*

- influencing thermal comfort of office occupants in hot-humid and hot-arid climates. *Ergonomics*, 46(6), 616-628. <https://doi.org/10.1080/0014013031000085707>
- Fanger, P. O. (1970). *Thermal Comfort: Analysis and Applications in Environmental Engineering* McGraw-Hill Medical, New York.
- Ferguson, D. A., Major, G., & Keldoulis, T. (1974). Vision at work visual defect and the visual demand of tasks. *Applied Ergonomics*, 5(2), 84-93. [https://doi.org/10.1016/0003-6870\(74\)90084-2](https://doi.org/10.1016/0003-6870(74)90084-2)
- Fountain, M., Brager, G., Arens, E., Bauman, F., & Benton, C. (1994). Comfort control for short-term occupancy. *Energy and Buildings*, 21(1), 1-13. [https://doi.org/10.1016/0378-7788\(94\)90011-6](https://doi.org/10.1016/0378-7788(94)90011-6)
- Frontczak, M., Schiavon, S., Goins, J., Arens, E., Zhang, H., & Wargocki, P. (2012). Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. *Indoor Air*, 22(2), 119-131. <https://doi.org/10.1111/j.1600-0668.2011.00745.x>
- Gravetter, F. J., Wallnau, L. B., Forzano, L. A. B., & Witnauer, J. E. (2020). (5th ed.). Belmont, MA: Wadsworth Thompson Learning.
- Griffiths, M., Eftekhari, M. (2008). Control of CO₂ in a naturally ventilated classroom. *Energy and Buildings*, 40(4), 556-560. <https://doi.org/10.1016/j.enbuild.2007.04.013>
- Heydarian, A., Pantazis, E., Wang, A., Gerber, D., & Becerik-Gerber, B. (2017). Towards user centered building design: Identifying end-user lighting preferences via immersive virtual environments. *Automation in Construction*, 81, 56-66. <https://doi.org/10.1016/j.autcon.2017.05.003>
- Jensen, P.A., Maslesa, E. (2015). Value based building renovation - A tool for decision-making and evaluation. *Building and Environment* 92, 1-9. <https://doi.org/10.1016/j.buildenv.2015.04.008>
- Karjalainen, S. (2012). Thermal comfort and gender: a literature review. *Indoor air*, 22(2), 96-109. <https://doi.org/10.1111/j.1600-0668.2011.00747.x>
- Kim, J., de Dear, R., Candido, C., Zhang, H., & Arens, E. (2013). Gender differences in office occupant perception of indoor environmental quality (IEQ). *Building and environment*, 70, 245-256. <https://doi.org/10.1016/j.buildenv.2013.08.022>
- Kwon, M., Remøy, H., & van den Bogaard, M. (2019). Influential design factors on occupant satisfaction with indoor environment in workplaces. *Building and Environment*, 157, 356-365. <https://doi.org/10.1016/j.buildenv.2019.05.002>
- Lai, J. H., & Man, C. S. (2017). Developing a performance evaluation scheme for engineering facilities in commercial buildings: state-of-the-art review. *International Journal of Strategic Property Management*, 21(1), 41-57. <https://doi.org/10.3846/1648715X.2016.1247304>
- Leaman, A., & Bordass, B. (2007). Are users more tolerant of 'green' buildings? *Building Research & Information*, 35(6), 662-673. <https://doi.org/10.1080/09613210701529518>
- Li, P., Froese, T. M., & Brager, G. (2018). Post-occupancy evaluation: State-of-the-art analysis and state-of-the-practice review. *Building and Environment*, 133, 187-202. <https://doi.org/10.1016/j.buildenv.2018.02.024>
- Mahmoud, A.S., Sanni-anibire, M.O. (2018). Key performance indicators for the evaluation of academic and research laboratory facilities. <https://doi.org/10.1108/IJBPA-08-2018-0066>
- Maykot, JK, Rupp, RF and Ghisi, E. (2018) A field study about gender and thermal comfort

- temperatures in office buildings. *Energy and Buildings*, v 178, p 254-264. <https://doi.org/10.1016/j.enbuild.2018.08.033>
- Messing, K., & Stellman, J. M. (2006). Sex, gender and women's occupational health: the importance of considering mechanism. *Environmental research*, 101(2), 149-162. <https://doi.org/10.1016/j.envres.2005.03.015>
- Muhammad, S., Sapri, M. (2014). Academic Buildings and Their Influence on Students' Wellbeing in Higher Education Institutions. *Social Indicators Research*. <https://doi.org/10.1007/s11205-013-0262-6>
- Nico, M. A., Liuzzi, S., & Stefanizzi, P. (2015). Evaluation of thermal comfort in university classrooms through objective approach and subjective preference analysis. *Applied ergonomics*, 48, 111-120. <https://doi.org/10.1016/j.apergo.2014.11.013>
- Preiser, W.F.E. (1995), Post-occupancy evaluation: how to make buildings work better, *Facilities*, Vol. 13 No. 11, pp. 19-28. <https://doi.org/10.1108/02632779510097787>
- Preiser, W.F.E., Vischer, J. (2005) *Assessing Building Performance*. Elsevier-Butterworth-Heinemann, Oxford.
- Ricciardi, P., Buratti, C. (2018). Environmental quality of university classrooms: Subjective and objective evaluation of the thermal, acoustic, and lighting comfort conditions. *Building and Environment* 127, 23–36. <https://doi.org/10.1016/j.buildenv.2017.10.030>
- Riley, M., Kokkarinen, N., & Pitt, M. (2010). Assessing post occupancy evaluation in higher education facilities. *Journal of Facilities Management*. <https://doi.org/10.1108/14725961011058839>
- Sadick, A., Issa, M.H. (2018). Assessing Physical Conditions of Indoor Space Enclosing Elements in Schools in Relation to their Indoor Environmental Quality, *Journal of Building Engineering*. <https://doi.org/10.1016/j.jobee.2018.08.018>
- Sarbu, I., Pacurar, C. (2015). Experimental and numerical research to assess indoor environment quality and schoolwork performance in university classrooms. *Building and Environment* 93, 141–154. <https://doi.org/10.1016/j.buildenv.2015.06.022>
- Schellen, L., Loomans, M. G., de Wit, M. H., Olesen, B. W., & van Marken Lichtenbelt, W. D. (2012). The influence of local effects on thermal sensation under non-uniform environmental conditions—Gender differences in thermophysiology, thermal comfort and productivity during convective and radiant cooling. *Physiology & behavior*, 107(2), 252-261. <https://doi.org/10.1016/j.physbeh.2012.07.008>
- UPC, Universitat Politècnica de Catalunya. (2020a). Aerial image from Campus 1 (photography). (Accessed: 16 June 2020). Available at: <https://electronicengineering.phd.upc.edu/en/images/campus-nord-retall.jpg/view?>
- UPC, Universitat Politècnica de Catalunya. (2020b). Aerial image from Campus 1 (photography). (Accessed: 16 June 2020). Available at: <https://eseiaat.upc.edu/en/shared/imatges-recurs/imatgeaereacampusupcterrassa.png/view>
- Vimalanathan, K., & Babu, T. R. (2014). The effect of indoor office environment on the work performance, health and well-being of office workers. *Journal of environmental health science and engineering*, 12(1), 113. <https://doi.org/10.1186/s40201-014-0113-7>
- WELL Building Standard. (2014). International WELL Building Institute. Available at: <https://www.wellcertified.com/> (Accessed on 18 October 2020).
- Yang, Z., Becerik-Gerber, B., Mino, L. A study on student perceptions of higher education classrooms: Impact of classroom attributes on student satisfaction and performance,

APPENDIX A

Section 1. Interviewee details

1. Sex:
 - ☐ Male
 - ☐ Female
 - ☐ Other:
2. Age:

Section 2. Workplace details

- ☐ Please select the campus you have been working on:
 - ☐ Campus Terrassa
 - ☐ Campus Nord
3. Please select the name of the building you have been working in.
4. On which floor of the building is your workspace located?
 - ☐ 1st floor
 - ☐ 2nd floor
 - ☐ 3rd floor
 - ☐ 4th floor
 - ☐ 5th floor
 - ☐ Other:
5. Please write the name of the room you have been working in:
6. How long have you worked in this building?
 - ☐ Less than 1 year
 - ☐ Between 1 and 5 years
 - ☐ Over 5 years
7. Which of the following do you personally adjust or control in your workspace (tick all the points that apply)?
 - ☐ Windows blinds or shades
 - ☐ Room air-conditioning unit
 - ☐ Portable heater
 - ☐ Permanent heater
 - ☐ Adjustable air vent in wall or ceiling
 - ☐ Ceiling fan
 - ☐ Portable fan
 - ☐ Thermostat
 - ☐ Operable window
 - ☐ None of these
 - ☐ Other:

Section 3. Satisfaction with the workplace.

8. Indicate your degree of satisfaction with the following aspects of your **workplace**:

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Thermal sensation in summer	☐	☐	☐	☐	☐
Thermal sensation in winter	☐	☐	☐	☐	☐
Air quality in summer	☐	☐	☐	☐	☐
Air quality in winter	☐	☐	☐	☐	☐
Light quality	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐
Space adequacy	☐	☐	☐	☐	☐
Acoustic quality	☐	☐	☐	☐	☐

If you are dissatisfied, which of the following contribute to your dissatisfaction:

9. Thermal quality:

- ☐ Always too hot
- ☐ Often too hot
- ☐ Occasionally too hot
- ☐ Occasionally too cold
- ☐ Often too cold
- ☐ Always too cold

10. Air quality:

- ☐ The air is stuffy
- ☐ The air is dry
- ☐ The air is humid
- ☐ There are disturbing odours
- ☐ Other:

11. Light quality:

- ☐ Glare of sunlight
- ☐ Lack of daylight
- ☐ Dark
- ☐ Impossibility of controlling lighting
- ☐ Low level of artificial lighting
- ☐ High level of artificial lighting
- ☐ Other:

12. Adequacy of space:

- ☐ Quantity of space (m²)
- ☐ Circulation space
- ☐ Privacy
- ☐ Ergonomics of chairs and tables
- ☐ Availability of equipment (furniture, printer, etc.)
- ☐ Lack of flexibility
- ☐ Other:

13. Acoustic quality

- ☐ Noise from air conditioning unit
- ☐ Noise from lights
- ☐ Noise from exterior machines
- ☐ People talking loudly in the corridor
- ☐ Noise from the elevator

- ☐ No insulation between rooms
- ☐ Other:

Section 4. Satisfaction with common spaces.

For the following questions, if you do not use some common areas, please select “not applicable”.

14. Indicate the degree of your satisfaction in relation to aspects of the **classrooms**:

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Thermal sensation in summer	☐	☐	☐	☐	☐	☐
Thermal sensation in winter	☐	☐	☐	☐	☐	☐
Air quality in summer	☐	☐	☐	☐	☐	☐
Air quality in winter	☐	☐	☐	☐	☐	☐
Light quality	☐	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐	☐
Adequacy of the space	☐	☐	☐	☐	☐	☐
Acoustic quality	☐	☐	☐	☐	☐	☐

If you are dissatisfied, which of the following contribute to your dissatisfaction:
(Repeat questions 9 to 13)

15. Indicate the degree of your satisfaction in relation to aspects of the **hall, corridors and stairways**:

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Thermal sensation in summer	☐	☐	☐	☐	☐	☐
Thermal sensation in winter	☐	☐	☐	☐	☐	☐
Air quality in summer	☐	☐	☐	☐	☐	☐
Air quality in winter	☐	☐	☐	☐	☐	☐
Light quality	☐	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐	☐
Adequacy of the space	☐	☐	☐	☐	☐	☐
Acoustic quality	☐	☐	☐	☐	☐	☐

16. Indicate the degree of your satisfaction in relation to aspects of the **laboratories**:

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Thermal sensation in summer	☐	☐	☐	☐	☐	☐
Thermal sensation in winter	☐	☐	☐	☐	☐	☐
Air quality in summer	☐	☐	☐	☐	☐	☐
Air quality in winter	☐	☐	☐	☐	☐	☐
Light quality	☐	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐	☐
Adequacy of the space	☐	☐	☐	☐	☐	☐
Acoustic quality	☐	☐	☐	☐	☐	☐

17. Indicate the degree of your satisfaction in relation to aspects of the **conference rooms**:

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Thermal sensation in summer	☐	☐	☐	☐	☐	☐
Thermal sensation in winter	☐	☐	☐	☐	☐	☐
Air quality in summer	☐	☐	☐	☐	☐	☐
Air quality in winter	☐	☐	☐	☐	☐	☐
Light quality	☐	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐	☐
Adequacy of the space	☐	☐	☐	☐	☐	☐
Acoustic quality	☐	☐	☐	☐	☐	☐

18. Indicate the degree of your satisfaction in relation to aspects of the **restrooms**:

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Thermal sensation in summer	☐	☐	☐	☐	☐	☐
Thermal sensation in winter	☐	☐	☐	☐	☐	☐
Air quality in summer	☐	☐	☐	☐	☐	☐
Air quality in winter	☐	☐	☐	☐	☐	☐
Light quality	☐	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐	☐
Adequacy of the space	☐	☐	☐	☐	☐	☐
Acoustic quality	☐	☐	☐	☐	☐	☐

19. Indicate the degree of your satisfaction in relation to aspects of the **lunchrooms**:

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Thermal sensation in summer	☐	☐	☐	☐	☐	☐
Thermal sensation in winter	☐	☐	☐	☐	☐	☐
Air quality in summer	☐	☐	☐	☐	☐	☐
Air quality in winter	☐	☐	☐	☐	☐	☐
Light quality	☐	☐	☐	☐	☐	☐
Cleanliness	☐	☐	☐	☐	☐	☐
Adequacy of the space	☐	☐	☐	☐	☐	☐
Acoustic quality	☐	☐	☐	☐	☐	☐

Section 5. Satisfaction with other aspects of the building.

20. How satisfied are you with the accessibility of the building?

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neutral
- ☐ Satisfied
- ☐ Very satisfied

21. How satisfied are you with the state of preservation of the building and its service systems?

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neutral
- ☐ Satisfied
- ☐ Very satisfied

22. If you are dissatisfied with the state of preservation of the building, which of the following contribute to your dissatisfaction:

- ☐ Structure vibrating
- ☐ Façade covering may fall down
- ☐ Aesthetic problems (wall needs to be painted)
- ☐ Doors/windows do not work properly
- ☐ Lights burnt out
- ☐ Elevator not working
- ☐ Equipment not working (air-conditioner, projectors, computers, etc.)
- ☐ Other:

23. Indicate your overall satisfaction with the building that you work in:

- ☐ Very dissatisfied
- ☐ Dissatisfied
- ☐ Neutral
- ☐ Satisfied
- ☐ Very satisfied

24. Additional comments: