Assessment of the Indoor Environment Quality in UM6P Classrooms

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Abstract. The present study is the result of a global study conducted by the students of the Master Program "*Green Building Engineering and Energy Efficiency*" at the School of Architecture Design and Planning (SAP+D) of Mohammed VI Polytechnic University (UM6P) in Benguerir, Morocco. The study is a hands-on experience that allows the master's students to learn by doing about the concepts of the indoor environment quality, in addition to the classroom training. The objective of the study is to assess the indoor environment quality of selected classrooms in different buildings of the UM6P campus. To this end, seven classrooms were monitored by means of sensors that measure all the IEQ parameters including thermal, acoustic, and lighting. In addition, the occupants of these classrooms were asked to fill out a survey based on a questionnaire. In this paper, we report a sample of the results of this study relative to one classroom. The analysis of these results reveals that students' thermal perceptions differed because they were divided into three vote categories: neutral, feeling slightly hot, and feeling slightly cold. Based on the survey analysis, the percentage of each category varied during each session. The obtained results were later compared with the thermal comfort model, and the two approaches showed a good match in terms of describing the overall satisfaction of the occupants.

Keywords. Learning, Education, University Classroom, IEQ, Survey, Monitoring.
DOI: https://doi.org/10.34641/clima.2022.272

1. Introduction

Observational studies of indoor climate in classrooms have generally been justified by highlighting the negative effects of conditions such as warm temperatures and poor ventilation on student comfort and academic performance [1-2]. According to adaptive comfort theory, occupants are considered to be an agent in creating "ideal" indoor thermal conditions by adjusting behavior or changing the surrounding environment [3]. A classroom occupied by students and a teacher represents a good environment for studying indoor comfort because the occupant's activities are known and their metabolic rate can be estimated and the schedules of occupancy allow us to determine the periods when occupants/indoor environment interaction is significant; the periods of non-occupancy were used only to get an idea of the initial state when the classroom is empty.

The most difficult challenge for architects and building engineers today is to maintain a comfortable indoor environment passively throughout the year. In a hot semi-arid climate similar to the one of the city of Benguerir, Morocco [4], occupants are exposed to relatively high temperatures with possible high fluctuations inside a naturally ventilated building, causing the occupant to perceive dissatisfaction with the surroundings. Other factors such as humidity and air velocity, lighting, etc. can contribute to this discomfort [5].

In this study, we report on a hands-on experience that allowed the master's students at UM6P university (Benguerir, Morocco) to learn by doing about the concepts of indoor environment quality. This hands-on experience was conducted in the frame of the course 'Indoor Comfort' of the Master Program "*Green Building Engineering and Energy Efficiency*" (G*reenBEEE*) at the School of Architecture Design and Planning (SAP+D) of UM6P. The objective is mainly to show how the students of G*reenBEEE*, conducted a survey and measurement campaigns to assess the IEQ in the university classrooms during the COVID-19 pandemic. This is education-oriented research for "learning by doing". The results presented in this paper are a sample of those obtained by the 21 students of *GreenBEEE* in the Spring 2021 semester. These students, gathered in 7 groups, monitored 7 classrooms and conducted a field survey of the occupants. Due to the pandemic situation and the time limitation of the study, it was not possible to extend the monitoring beyond 2.5 days per classroom.

2. Study methodology

This work is part of a larger study that includes various aspects of comfort, namely acoustic comfort, visual comfort, air quality, and thermal comfort. The primary focus of this paper will be on thermal comfort.

The study was conducted by means of monitoring several indoor parameters inside the selected classroom during a relatively long period which includes occupation (class hours) or no occupation (off course). In addition, the occupants of these classrooms were asked to fill out a survey based on a questionnaire. The monitoring system enables to calculate the mean PMV of the occupants based on the Fanger model considering the mean values of the clothes insulation (CLO parameter) as well as the metabolism rate (MET parameter) of the occupants. Moreover, the PMV of each occupant was calculated at the beginning and the end of each class, based on the survey. Due to COVID-19 pandemic restrictions, the classroom ventilation system was turned off during the period of this study.

2.1. Climate conditions of the case study

The study location is in the city of Benguerir, which is in southwest Morocco with a hot semi-arid climate, cold in winter, and hot in summer. The typical average temperature throughout the year is 19°C, and the average wind speed does not exceed 7m/s. The humidity level remains moderate throughout the year, with an average rate of 45% [4].

The study was conducted in May 2021, at the end of the spring season, given the rise in the outdoor air temperature as well as changes in the level of air humidity, which becomes almost dry during this period in mid-day, while it is still high at the beginning of the day due to the low outdoor air temperature. Figures 1 show the meteo data recorded during the period of the study which lasts from May 24 to May 26, 2021.

2.2. Indoor measurements

Measuring the building's physical conditions is often one of the most challenging tasks to achieve. In the case of a school classroom, it is advisable to use the smallest size and amount of equipment possible. The recording data loggers are suitable options, as they record time-based information and can measure different parameters simultaneously. Our study was carried out with a system called BAPPU-Evo which allows measuring air temperature, humidity, and air velocity as well as lighting, acoustic and CO2 levels, and globe temperature [6]. All these parameters were recorded every 5 minutes during the whole period of the study including the off-class period (24h monitoring per day). The sensors of the BAPPU-Evo system were placed on one of the classroom's tables in the middle of the classroom. The globe temperature sensor was at the mean level of the heads of the seated occupants. The technical characteristics of these sensors are given in Table 1.

In addition to monitoring the IEQ parameters of the classroom, the occupants were asked to fill out a questionnaire to indicate their sensations regarding thermal comfort, acoustics, and lighting. The occupants needed to fill out two questionnaires, one 30 min after the beginning of the class and the second one at the end. A specific questionnaire is dedicated to the teacher, who was also asked to report about the light operation and windows and doors opening. The questionnaires are given in Annex.

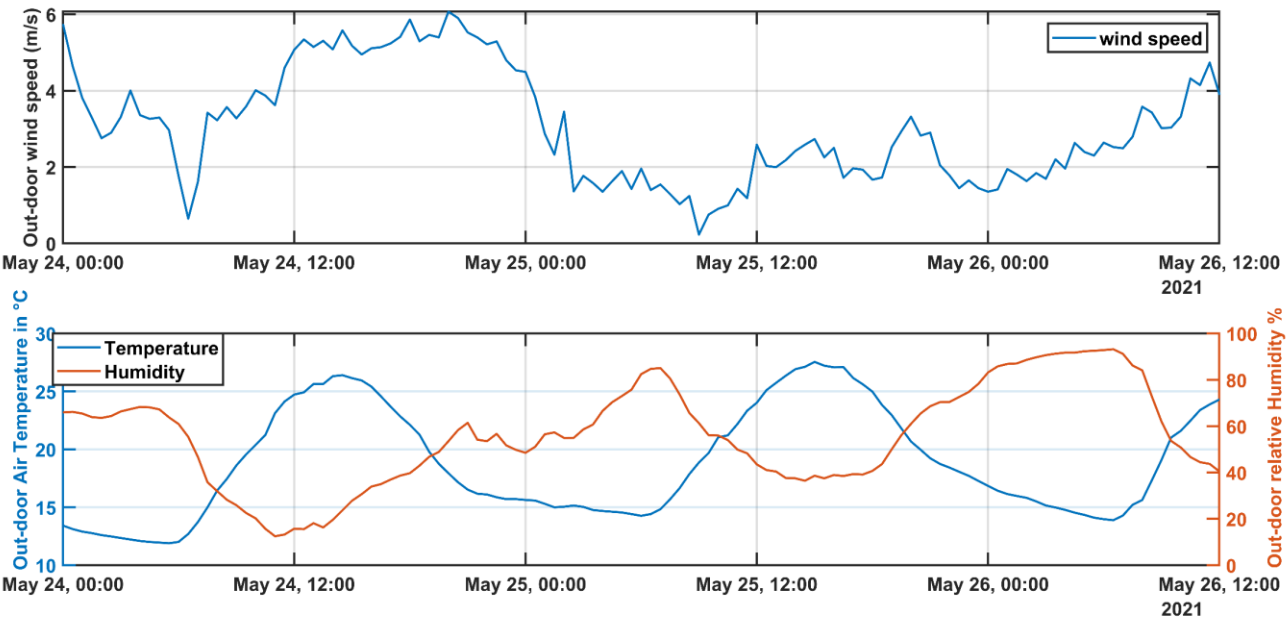


Fig.1 – Meteo data recorded by a local weather station

Table.1 – Technical details of the monitoring system

Technical Details BAPPU-evo			
measured physical characteristics	Measurement Range	Tolerance	Sensor
Air temperature	-20....50°C	+/-0.5°C	PT 1000 Sensor
Globe temperature	0...70°C	+/-0.5°C	Integrated temperature
Relative humidity	10...90%	+/-4% r.H	Capacitive humidity sensor
Air speed	0.0...5m/sec	+/-10%f.MV.+/-3 Digit	Thermo-anemometer
Noise level	30...100dB(A)	+/-1.0dB(A) (at 1 kHz)	Precision electret
Illuminance level	50...30000Lux	V-Lambda adjustment 7.5% Cos-accurate evaluation 4% linearity 3%	Silicon photo element with adapted spectral sensitivity
CO_2(Carbone dioxide)	0...10 000ppm	+/- 75ppm +/-5%f.MV. (at 0...2 000ppm)	Non-dispersive infrared

2.3. Classroom Characteristics

The monitored classroom is located on the main campus of UM6P. It was occupied by the 2nd year students at EMINES School of Industrial Management. Fig. 2 shows the architecture plan of this classroom and Tables 2-3 show additional information about the classroom. The electrical switches as well as the windows were identified to allow for easy identification of their on/off and open/close operation that has been reported to us by the teacher in a specific survey (see the Annex). During the monitoring period, the number of occupants varied each day the given results in the following section are representative of the group of students who attended the class.

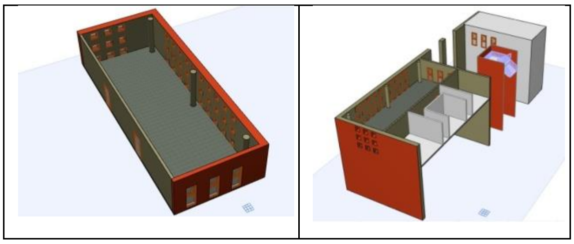


Fig.2 - The architecture of the studied classroom

Table.2 – Building specifications

Locatin	Oriontation	Surface	Occupancy
Ben Guerir	South-Eeast	107,6 m^2	50

Table.3 – Information about the monitored classroom

Occupants	Students and Professors
Number of occupants	50
Switches	4
Windows Glazing	3 (0,98m x 0,75m) 39 (0,6m x 0,6m)
Doors	2 (2m x 1m)
Ventilation Cooling system	Centralized system (Not activated)

3. Results of the surveys

Fieldwork and post-occupancy studies are generally complex. Therefore, it is vital to gather all the necessary information while on-site then the planning stage is often laborious due to the type and number of parameters that could be measured to study thermal comfort. Our state required a study of several factors that make the link between the studied entourage and the occupants. These parameters can vary according to the model chosen for the assessment process. The survey was constructed for the professor and students based on the model of ASHRAE 55. It is composed of three sections. The first section considers the physiological parameters the second section corresponds to the clothing insulation and the activity level. The clothing insulation and activity level are expressed in terms of Clo and Mets units, respectively, according to ISO 7730 and ASHRAE standard 55 [7]. In the third section, the questionnaire considers the climate control device in use. The fourth section included subjective information such as the thermal sensation vote TSV, the thermal preference or acceptability in the lighting, and the noise level [1][7].

To follow the thermal perception of the group of students and not disturb the teaching process the survey was distributed twice at the beginning and the end of the session and filled after 30 mins to ensure thermal equilibrium.

Table.4 – Duration and numbers of occupants per session

Date	Time	Total observation	Female	Male	Total
24/05/2021	08:30 10:30	2	8	17	25
25/05/2021	09:00 12:00 14:00 16:30	2 2	9 10	12 18	21 28
26/05/2021	11:00 12:30	2 2	2 2	5 5	7 7

Table.5 – Voting scale for indoor comfort

Scale	Thermal sensation	Lighting	Acoustic
-3	Too cold	-	-
-2	Cold	Very poor	-
-1	Slightly cold	poor	poor
0	Neutral	Neutral	Neutral
1	Slightly warm	Intense	Intense
2	warm	very intense	-
3	Hot	-	-

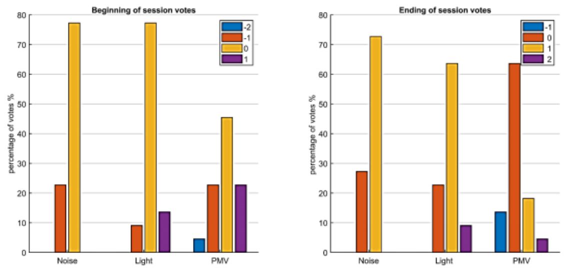
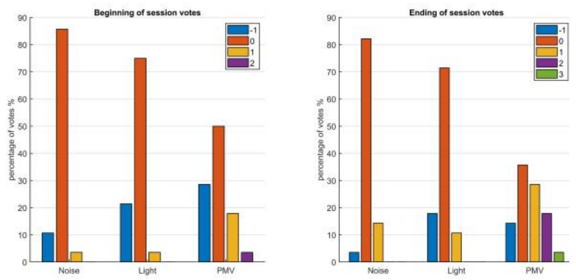
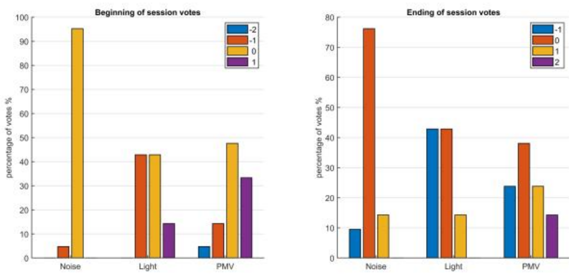


Fig.3 - Survey data first day of the assessment

At the beginning of the session, 45% of the students were showing satisfaction with the indoor environment the rest were unsatisfied, figure 3 shows that the votes were varying from a hot perception to cold and slightly cold. At the end of the sessions, the students' votes showed more tendency toward a neutral sensation as the percentage reaches 60% of satisfaction, but still, a group of students was voting hot and slightly hot, 12% also were feeling cold.



(a): Morning session



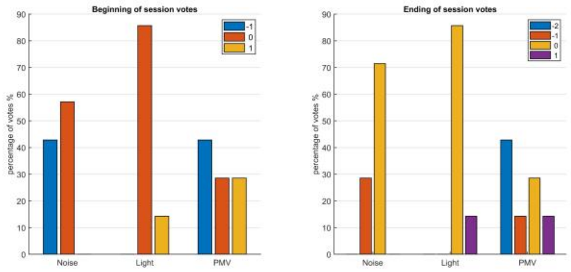
(b): Afternoon session

Fig.4 - Survey data second day of the assessment

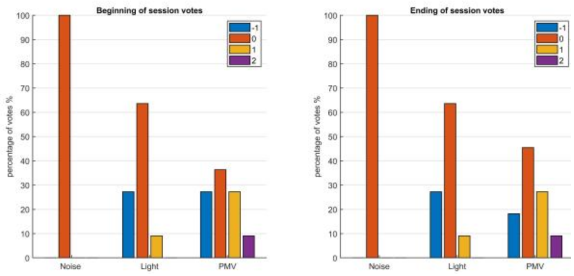
On the second day at the morning session (figure 4. a), 50% of the students were satisfied but the rest were voting that they were unsatisfied with indoor conditions, it goes for both the beginning and end of the session, also we remark that the percentage of satisfied people has dropped which cause an encasement in the dissatisfaction of the group of students. In the second session (figure 4. b) we observe that almost 50% of the students were voting neutral and the rest were voting slightly hot, with the same variation at the end of the session. Some variation in the votes might be caused by the clo of the students, sex, and metabolic rate.

The first session of the third day (figure (5. a) shows that the slightly cold sensation was dominated with a percentage of 43% and the rest vote were divided equally between neutral and slightly warm. But, at the end of the session, most of the students were feeling cold, approximately 43% of the votes had a cold sensation, and 15% of the votes had a sightly cold sensation. Unlike the percentage of neutral vote stay the same.

The last session of the monitoring (figure 5. b) shows an increase in the neutral sensation between the beginning and the end of the session, unlike the slightly cold sensation decrease, but the warm sensation stays the same.



(a): First session



(b): Second session

Fig.5 - Survey data third day of the assessment

After analyzing the survey's results during the three days of the monitoring, we can conclude that the classroom offers different categories of comfort to the occupants. In the next session, we will analyze the temperature variation during the period of occupancy, and it relates to the thermal sensation perceived by the students and professor.

4. IEQ Monitoring results

The results of the monitoring are presented in Fig. 6 for the considered parameters in this paper.

4.1. Indoor air temperature

The mean operative temperature recorded (figure6) for the 3 days is around the value of 23.7°C. This value causes the occupants to feel discomfort usually in the morning, the occupants were perceiving cold thermal sensation in the interval of 8:00 AM to 10:30 AM, where the temperature was ranging from 20°C to 24°C and this is caused by the average Clo of the

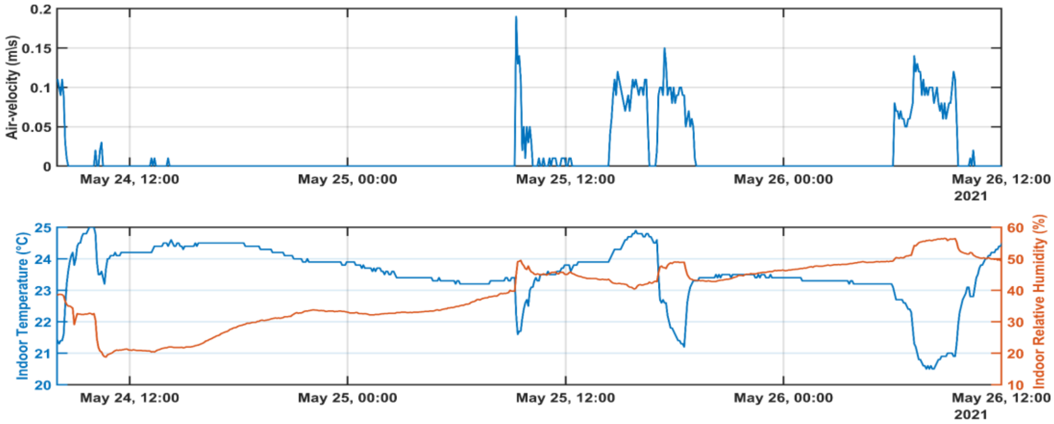


Fig.6 - Measured average indoor parameters

class was 0.58 clo which is close to the summer average Clo value. For the activity, only the professor who was in standing mode the rest of the class were all sitting.

For the interval of time 11:00 AM to 16:30 PM, the operative temperature was ranging from 23°C to 25.3°C, in this range, the occupant was feeling slightly hot even if the average clo value remains the same. Concluding that the students were feeling discomfort in this range would not be convening if we base our analyses only on temperature there is other parameters intervening in the thermal perception of the student that will be analyzed in the next session, these factors are humidity and air velocity.

4.2. Indoor air velocity

The average air velocity recording for the 3 days was ranging from 0.0009m/s to 0.076m/s. In some periods the air velocity peaks because of doors and windows opening, for 25th and 26th may the velocity was fluctuating around the value of 0.1m/s. According to Edward Arens et al [8] if the operative temperature is ranging from 22.9◦ C to 24.24◦ C and the airspeed is in the interval of 0 m/s to 0.2 m/s the occupant perceived a cold sensation. For the other periods where people were perceiving a slightly hot sensation, the temperature ranged from 23◦ C to 25◦ C and the air velocity was ranging from 0 to 0.2 m/s.

During the 3 days of the monitoring, the average value of humidity was ranging from 24.44% to 54.7%. The influence of relative humidity on physiology and thermal sensation has been conducted both under steady state [9,10] and under transient conditions [11]. In modest environments, the effect of humidity on thermal sensation could be ignored when the air temperature is in the comfort range. In warm environments, discomfort may be caused by too much moisture on the skin by high humidity levels [12].

4.3. Predicted Mean Vote (PMV) and Predicted Percentage of Dissatisfi ed (PPD)

Using the air temperature, the mean radiant temperature, the air velocity, the relative humidity, the average metabolic rate, and the average of the students' clothing, a representative instantaneous PMV is calculated for each time step of the data; this PMV progression over the three days, particularly during the occupation hours, assists us in evaluating comfort based on an analytic approach to be compared with the experimentation findings.

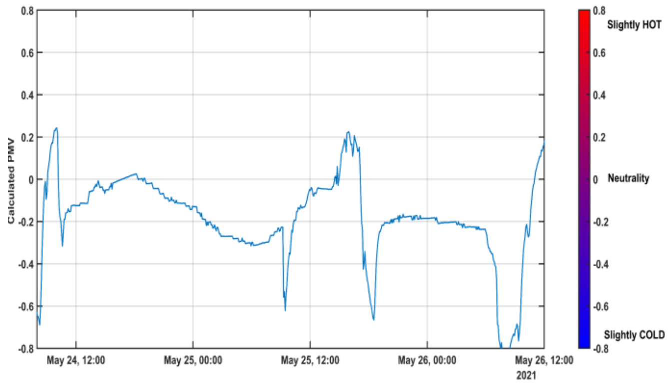


Fig.7 – Predicted Mean Mote calculated by the BAPPU system

Figure 7 shows that during the occupation hours, the PMV ranges between -0.2 and 0.2, as shown by the graph, thermal neutrality was obtained at specific points in small time intervals (the curve crosses the neutrality line PMV=0). The calculated PMV results agree with the experiment's findings. Because the obtained PMV values ranged from slightly hot to slightly cold, this demonstrates the neutral TSV's dominance, for the rest of the votes were always ranging from -1 to 1; however, in a few cases, a minority of students voted outside of this range.

The percentage of dissatisfaction based on the PMV can be used to determine the abundance of satisfaction among students; however, in this experiment, only the calculated PPD values associated with the occupancy hours were considered. Because the night periods are characterized by a negative PMV, including the entire data set in this process would result in misleading results because the number of samples with high PPD would increase.

Figure 8 depicts two plots. The first is a histogram of the calculated PPD, which shows the number of samples and the ranges of dissatisfaction. In this study, the PPD ranged from 5% to 18%. In this observation, we found approximately more than 140 samples with a PPD of less than 6.5 percent. This demonstrates why more than half of the students were pleased with the temperature of the indoor environment.

The second plot illustrates the average PPD of each session; as we can see, the calculated PPD on the first and second days was less than 7%, which explains why the satisfaction perception was more prominent. In contrast, the PPD increased to 8% on the last day, which explains why the number of satisfied students was less than 50% on this day.

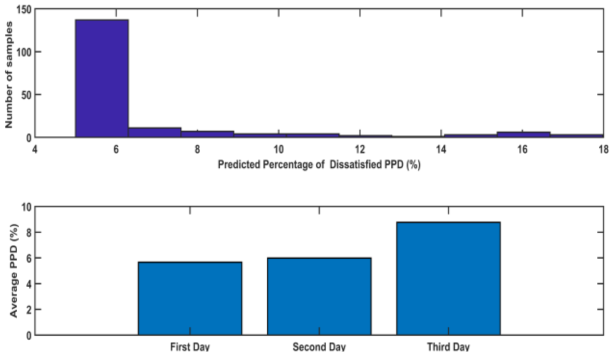


Fig.8 – The average Predicted percentage of dissatisfaction (PPD) each day

4.4. Operative temperature

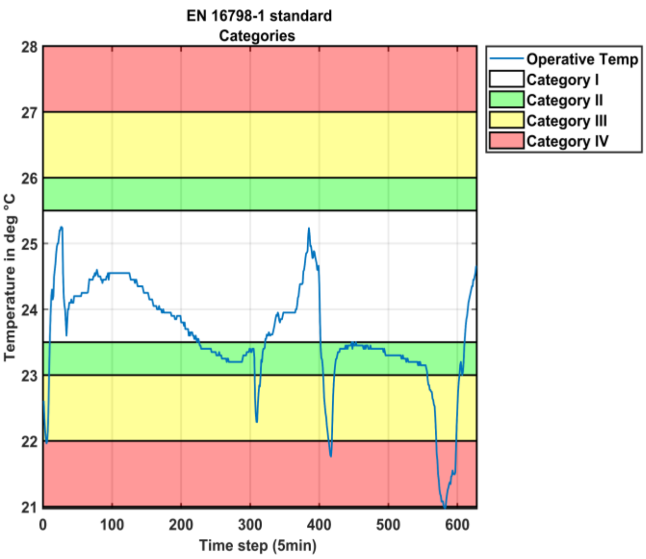


Fig.9 – Time evolution of operative temperature according to EN16798-1 comfort categories

According to a work done by professor Gameiro da silva [14], a similar methodology was adapted to evaluate the operative temperature according to the EN16798-1.

As we can see in our instance, the extreme values of the operating temperature reach down to 21°C, which was obtained in the early morning of the last day, for most of the time manly day one and two the operative temperature is in the category 1 during the occupancy.

4.5. Thermal neutrality temperature

The neutrality temperature is the operative temperature at which the occupant feels in equilibrium with the environment in other words the heat gains are equal to heat losses [13]. It is also the operative temperature value associated with TSV that is equal to zero. To determine the neutrality temperature, we had to calculate the average TSV for each session and associate it with the operative temperature perceived at the same time when students were voting. The results, presented in Table 5, show that the neutrality temperature is 24.2°C. After the elimination of some aberrant values of the mean TSV, the results enable to get a linear regression from Fig 10 according to equation 1

$$TSV = 0.143 \times T_{op} - 3.41 \qquad (1)$$

Table.5 – Average calculated temperature and average TSV base in the survey

TSV	0	0.13	0.28	0.09	0.60	-0.03	0.10	0.27	-0.14	-0.85
T_{op}	24.2	23.9	24.8	24.13	23.4	22.2	23.2	24.5	21.2	23.0

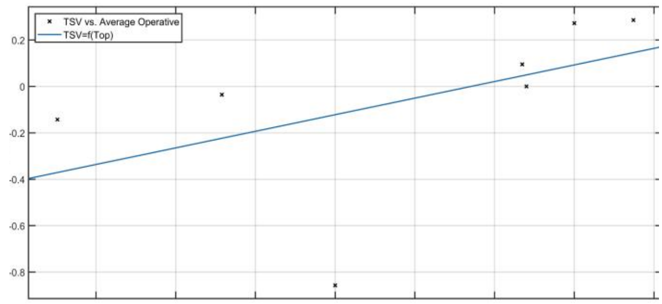


Fig.10 - Regression model plot of TSV as a function of operative temperature

Regression analysis is considered more appropriate for cooling mode's data. On the other hand, Griffith's method is more useful in estimating the comfort temperature with a small number of samples. We utilize the following expression (Eq. (2)) to calculate the comfort temperature of Griffiths [13]:

$$Tcmf = Top + \frac{(0 - TSV)}{\alpha} \qquad (2)$$

Using this model, we were able to calculate the comfort temperature for the entire session, and the average values were ranging from 23.98 to 24.11 which still confirms that the obtained comfort temperature is reflecting the real case, the chosen value of alpha is 0.5 according to Talukdar et al[13].

5. Conclusion

This study was conducted in the frame of the GreenBEEE Master students project for the purpose of learning by doing. Its objective was to assess the Indoor Environment Quality (IEQ) in selected university classrooms. The study was conducted either by means of IEQ parameters monitoring aspect and by surveying the occupants of the classroom. A sample of results, that corresponds to three days of monitoring in May 2021, are presented and analyzed in terms of thermal comfort. The meteo data was also recorded by means of a weather station located not far from the monitored classrooms. Due to COVID-19 pandemic restrictions, the air conditioning system of the classrooms was deactivated by the administration. This allowed assessing the IEQ in a free-running mode.

Overall, the results showed that the majority of students were satisfied by the indoor thermal comfort, due to the comfortable outdoor conditions. The mean calculated percentage of dissatisfaction based on the surveys was less than 6%. However, this percentage increased slightly to around 9%, during the last day due to low outdoor air and students' clothing which seemed not adapted to this situation.

This first experience which suffered from the pandemic situation is going to be repeated next April by the next cohort of the GreenBEEE Master students. The lessons learned from this first study at the UM6P level will be of good guidance to perform better monitoring and survey.

Acknowledgment

The authors would like to express their gratitude to all the UM6P students who contributed to the survey, as well as the administrative staff of UM6P for making the monitoring process easier. GreenBEEE master students of cohort 2 are thanked for their contribution to the monitoring and survey material preparation.

References

[1] Mishra, Asit Kumar, and Maddali Ramgopal. "A thermal comfort field study of naturally ventilated classrooms in Kharagpur, India." Building and Environment 92 (2015): 396-406.

[2] Puteh, M., Ibrahim, M. H., Adnan, M., Che'Ahmad, C. N., & Noh, N. M. (2012). Thermal comfort in classroom: constraints and issues. Procedia-Social and Behavioral Sciences, 46, 1834-1838.

[3] KIM, Jungsoo et DE DEAR, Richard. Thermal comfort expectations and adaptive behavioral characteristics of primary and secondary school students. Building and Environment, 2018, vol. 127, p. 13-22.

[4] BORN, Kai, CHRISTOPH, Michael, FINK, A. H., et al. Moroccan climate in the present and future: combined view from observational data and regional climate scenarios. In: Climatic changes and water resources in the Middle East and North Africa. Springer, Berlin, Heidelberg, 2008. p. 29-45.

[5] López-Pérez, L. A., Flores-Prieto, J. J., Et Ríos-Rojas, C. Adaptive thermal comfort model for educational buildings in a hot-humid climate. Building and Environment, 2019, vol. 150, p. 181-194.

[6] BAPPU-EVO, https://www.bappu.de/en/

[7] Olesen, Bjarne W. "Guidelines for comfort." Ashrae Journal 42.8 (2000): 41-47.

[8] ARENS, Edward, TURNER, Stephen, ZHANG, Hui, et al. Moving air for comfort. 2009.

[9] AlpinKöknelYener. (2011) "Daylight analysis in classrooms with solar control. "Architectural Science Review 45.4 (2011): 311-316.

[10] Eduardo L. Kruger and Adriano Lucio Dorigo. (2008) "Daylighting analysis in a public school in Curitiba, Brazil. "Renewable Energy33.7 (2008): 1695–1702.

[11] X. Yo and Y. Su. "Daylight availability assessment and its potential energy-saving estimation –A literature review." Renewable and Sustainable Energy Reviews 52 (2015): 494-503.

[12] Jing, Shenglan, et al. "Impact of relative humidity on thermal comfort in a warm environment." Indoor and Built Environment 22.4 (2013): 598-607.

[13] Talukdar, Md Sarwar Jahan, et al. "Status of thermal comfort in naturally ventilated university classrooms of Bangladesh in hot and humid summer season." Journal of Building Engineering 32 (2020): 101700.

[14] M. Gameiro da Silva, L. W. van Cappellen, and E. Sanjuanello, "Assessing and Communicating Indoor Environmental Quality," vol. Rehva Journal, Volume 56, pp. 14–18, Apr. 2019.

[15] Stefano Paolo Corgnati, Manuel Gameiro da Silva (Editors). Indoor Climate Quality Assessment. Finland, Forssa Print 2011: ISBN 978-2-930521-05-3

ANNEX: Questionnaires used in the survey

Questionnaire : Etudiant

Date(jr/m/an):
heure(hr:mn):

(reportez votre numéro de table svp) ☐

1. Quel est votre numéro de table ? ☐
2. Sexe

   Femme ☐ Homme ☐

3. Age ☐
4. Taille ☐
5. Poids ☐
6. A quel moment êtes-vous entré dans la classe ? ☐
7. Cochez la totalité de ce que vous portiez avant d'entrer en classe (Aller sur image 1)
8. Si vous avez enlevé un vêtement pendant le cours, veuillez indiquer lequel/lesquels ? (Aller sur image 2)
9. Quelle est votre activité à cet instant?

   Assis (e) ☐ Debout ☐

10. Quel est votre ressenti thermique à cet instant?

Trés froid	froid	frais	neutre	Légèrement chaud	chaud	très chaud
-3	-2	-1	0	1	2	3

11. Comment jugez-vous l'éclairage de la salle?

Très faible	faible	neutre	intense	très intense
-2	-1	0	1	2

12. Comment jugez-vous le son de la salle?

faible	neutre	forte
-1	0	1

Image 1 (question 7) :

Image 2 (question 8) :

Questionnaire : Professeur

Date(jr/m/an):
heure(hr:mn):

1. Sexe

   Femme ☐ Homme ☐

2. Age ☐
3. Taille ☐
4. Poids ☐
5. A quel moment êtes-vous entré dans la classe ? ☐
6. Cochez la totalité de ce que vous portiez avant d'entrer en classe (Aller sur image 1)
7. Si vous avez enlevé un vêtement pendant le cours, veuillez indiquer lequel/lesquels ? (Aller sur image 2)
8. Quelle est votre activité?

   Assis (e) ☐ Debout ☐

9. Quelle est la fenêtre ouverte à cet instant ?

   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ aucune ☐

10. Quelle est la Porte ouverte à cet instant ?

    1 ☐ 2 ☐ aucune ☐

11. Le système de chauffage ou de climatisation est t-il allumé ?

    Oui ☐ Non ☐

    Si oui à quelle valeur :

12. Le DATASHOW (vidéo projecteur) est t-il allumé ?

    Oui ☐ Non ☐

13. Quel (s) est l' interrupteur(s) allumé?

    1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ aucun ☐

14. Quel est votre ressenti thermique? (encercler la valeur)

Très froid	froid	frais	neutre	Légèrement chaud	chaud	très chaud
-3	-2	-1	0	1	2	3

15. Sinon que préfériez-vous ressentir? (encercler la valeur)

Très froid	froid	frais	neutre	Légèrement chaud	chaud	très chaud
-3	-2	-1	0	1	2	3

16. Quelle est votre niveau d'acceptation thermique?(encercler la valeur)

Très faible	faible	neutre	intense	très intense
-2	-1	0	1	2

17. Comment jugez vous l'éclairage de la salle?(encercler la valeur)

Très faible	faible	neutre	intense	très intense
-2	-1	0	1	2

18. Comment jugez vous le son de la salle?(encercler le numéro choisi)

faible	neutre	forte
-1	0	1

Image 1 (question 7) :

Image 2 (question 8) :