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Overheating in Schools: Factors Determining Children's Perceptions of Overall Comfort Indoors

Samuel Domínguez-Amarillo [1,*], Jesica Fernández-Agüera [1,*], Maella Minaksi González [2] and Teresa Cuerdo-Vilches [3]

1 Instituto Universitario de Arquitectura y Ciencias de la Construcción, Escuela Técnica Superior de Arquitectura, Universidad de Sevilla, 41015 Sevilla, Spain
2 Facultad de Arquitectura de la Universidad Autónoma de Yucatán, Merida 97000, Mexico; maella.gonzalez@correo.uady.mx
3 Instituto de ciencias de la construcción Eduardo Torroja (IETcc), Consejo Superior de Investigaciones Científicas (CSIC), 28033 Madrid, Spain; teresacuerdo@ietcc.csic.es
* Correspondence: sdomin@us.es (S.D.-A.); jfernandezaguera@us.es (J.F.-A.)

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Abstract: Climate change is raising the length and intensity of the warm season in the academic year, with a very significant impact on indoor classroom conditions. Increasingly frequent episodes of extreme heat are having an adverse effect on school activities, whose duration may have to be shortened or pace slackened. Fitting facilities with air conditioning does not always solve the problem and may even contribute to discomfort or worsen health conditions, often as a result of insufficient ventilation. Users have traditionally adopted measures to adapt to these situations, particularly in warm climates where mechanical refrigeration is absent or unavailable. Implementation of such measures or of natural ventilation is not always possible or their efficacy is limited in school environments, however. Such constraints, especially in a context where reasonable energy use and operating costs are a primary concern, inform the need to identify the factors that contribute to users' perceptions of comfort. This study deploys a post-occupancy strategy combined with participatory action to empower occupants as agents actively engaging in their own comfort. It addresses user-identified classroom comfort parameters potentially applicable in the design and layout of thermally suitable spaces meriting occupant acceptance.

Keywords: schools; heat perception; user's perception; thermal comfort; qualitative technique; POE

1. Introduction

Human beings depend on energy for almost all of their daily activities. Energy is not only required to cover basal needs, but also those which allow them to remain comfortable to face climate dynamic variations outdoors [1], even more for vulnerable populations, as children. These variations have been altered by anthropogenic activity, boosting extreme weather conditions related to climate change, or more complex effects, such as urban heat islands [2].

This effect also impacts on indoor air quality, resulting in discomfort and even affecting health [3–5], especially in risk groups, such as the elderly [6,7], children [8] and births [9], but also with a significant incidence in the active population [10,11].

Among the most studied buildings in the field of indoor comfort, schools represent a relevant group. One of the main reasons is the exposure of children to spending a long time under indoor environmental conditions. These children are considered a risk population, and there are also other considerations, such as social or vulnerability aspects, which can influence, so investigating in this regard has become a global priority, as a development objective sustainable by 2030 [12].

Comfort studies in schools have progressed in the last fifty years [13–16] and recently on indoor environments [17]. Recently, many of the studies in educational buildings include more innovative methods: student performance, cognitive processes or disruptive and engaging techniques, such as storytelling [18], gamification [19] or adaptation, and comparison among more traditional ones, as Post-Occupancy Evaluation (POE) [20–22]. Qualitative techniques are sometimes included as part of mixed methods, such as open-ended interviews [23]. Techniques to evaluate subjective aspects of users' perception on comfort have been developed [24], as well as on emotional state [25,26], but often are misnamed as "qualitative" [27–29].

According to the ASHRAE 55 standard [30] and the subsequent ISO 7730 [31], the thermal sensation experienced by human beings is mainly related to the global thermal balance in their body. It depends on physical activity, clothing and on environmental parameters, such as air temperature, average radiant temperature, air velocity and air relative humidity, whose values can be measured or estimated, to calculate the Predicted Mean Vote (PMV) comfort index. However, "nonthermal environmental parameters are not considered, such as air quality, acoustics and illumination or other physical, chemical or biological space contaminants that may affect comfort and health" [30]. Since thermal comfort is considered only a part of environmental comfort, and other environmental factors affect the thermal sensation, productivity, concentration and health of occupants indoors, this research proposes an overall comfort perception study, by a mixed method that allows to deepen the global satisfaction related to environmental comfort of users at class.

Questionnaires are a common practice either in internal environmental comfort research [32], or just in thermal comfort. These surveys are commonly based on ISO 7730 thermal comfort parameters and may include those related to potential local thermal discomfort (by unwanted air flows, temperature asymmetries, etc.). However, in recent years, research shows an increasing trend to complete the perception analysis also including nonthermal environmental factors that affect overall satisfaction and comfort perception, such as illumination, noises, odors, ventilation frequencies, spatial design elements of finishing and so on [33].

The inclusion of physiological indexes was not an objective of this study, due to several reasons: as considered in [32], physiological measurement (skin temperature, blood flow, core temperature, heart rate, etc.) can be correlated with thermal comfort/discomfort, but it consists of an invasive (contact) method that implies to have certain devices and a deep knowledge of the correct measuring method, for avoiding potential measuring mistakes, adding uncertainties to results. Since users' surveys are considered a traditional (contact) measure, the author did not want to interrupt the daily tasks at the classroom. Otherwise, the proposed technique, with its limitations, is understood as more effective and user-friendly, since it is not as invasive as physiological measures and is easier to carry out, with results more engaging and fun for kids, and it deals with behavior-change by debate sessions.

In the Mediterranean climate, thermal comfort studies in schools are scarce compared with tropical climates, however [34], there are many comfort studies in schools that develop research focused on the cold season, since it occupies most of the school period, sometimes also including midseason [15,35]. However, climate change is effectively lengthening the warm season, especially in areas of Southern Europe, where episodes of overheating affect the performance of daily tasks and health inside these buildings [36]. With the slow but constant rise in temperatures, the hot season extends over months that until a few years ago were months that were considered merely warm. This has forced the coincidence of the hot season with the start of classes in schools. In Seville, where "heat" implies exceeding 35 °C, the classrooms become spaces with an increasing lack of thermal comfort.

Despite some research, the literature has not taken into account children to express how they feel or perceive emotions when they interact with their built environment [37], or they are considered passive agents subject to the teacher's preferences [38]; recent studies have been demonstrated that the non-adult population is able to offer interesting insights to researchers, and they are in a position to express their thermal sensation and make adjustments to improve the thermal acceptability in the classroom [34]. Jindal's study carried out in India reported that students demonstrated adaptability to indoor temperature variations if they were able to adjust windows and switch off/on fans [39].

Fostering participative research with engaging techniques allows children motivation and broad-mindedness. The power of these techniques in sustainability, indoor environmental quality and users' global comfort in schools may not only make students aware, but also move their knowledge to homes and share it with their families [40].

These new approaches recently discussed in schools in the Netherlands [41–44] demonstrate that internal comfort in schools results in a wide-spread research topic. However, there are still some gaps that could be studied in greater depth and solved.

The main objective in this study consists of knowing the perception of overall satisfaction and environmental comfort perception in classrooms by secondary school children (12–16 years), using participatory techniques. It had been established a participatory, mixed method, where subjective and objective aspects can contribute to build a coherent discourse on the perception of comfort in the classroom, taking into account the active participation of the users.

We consider occupant perception to be a fundamental aspect of the process of architectural creation and engineering of environmental control. The purpose is therefore to provide mechanisms which can improve the response to the specific requirements of individuals. An improved adjustment to these needs can contribute to the design of more suitable (mechanical and constructive) systems, as well as to better energy use, improving both the practical energy efficiency of buildings and user experience.

2. Materials and Methods

This study presents a participative research on the overall environmental satisfaction and comfort perception at class, using the emotional design as a driver through a mixed approach to classroom users (students). The multifactorial character makes it necessary to collate and identify the (conscious or subconscious) information which users can provide as active "sensors" of their ambient environment to be able to feed predictive models for management of the indoor thermal environment.

The qualitative-exploratory and participatory part of the study is carried out using two techniques: emotional drawings, and group debate around them. Through the drawings, students visually express their understanding of indoor comfort in the school [43]. This technique also allows them to graphically communicate which elements provide comfort, and which contribute to a lack thereof.

Then, they develop their group discourse at the level of global environmental comfort perception inside the classroom. The drawings previously selected can act as triggers to elicit deliberation. Students build a consensus on what they understand by thermal and environmental comfort in the classroom, which aspects affect it positively and negatively and which solutions will be needed to achieve it. Finally, two questionnaires complete the whole students' evaluation, one based on the user perception of how they feel indoors (aligned with ISO 7730 [31]), and the second one about classroom features that may affect comfort and health in the classroom, under their point of view [44].

In parallel, indoor environment parameters (air temperature and relative humidity) were monitored with portable sensors during working sessions with children. Measurements of relative humidity and outdoor temperature conditions were continuously monitored during measurements. However, the humidity and the indoor temperature of the classrooms were only punctual measures during the development of the different sessions, to know the average temperature values during the different sessions for each class. During the research, the environmental conditions were obtained for both indoor and outdoor spaces to ensure similar boundary conditions for all users, and to be able to evaluate the different responses and contributions in these conditions.

Data monitoring allows assessing the adaptation degree of the method to the specific characteristics of the proposed study case.

2.1. Location and Climate

The city of Seville, in the south of Spain, has a typical Mediterranean climate with mild winters between December and March, very hot summers between June and September and short periods of variable temperatures between seasons in April–May and October–November, although each time with higher temperatures. Relative average humidity ranges from 44% to 80%, with variations inversely proportional to the daytime temperature due to air heating. The predominant wind direction is southwest with low speeds. There is a differentiation between the prevailing winds in winter, coming from the northeast, and those in summer, coming from the southwest. Seville also presents a large number of sunny days, with little cloudy or clear skies [45].

Figure 1 shows the school building, the study rooms are oriented south-southwest. Figure 2 shows the classroom typology.

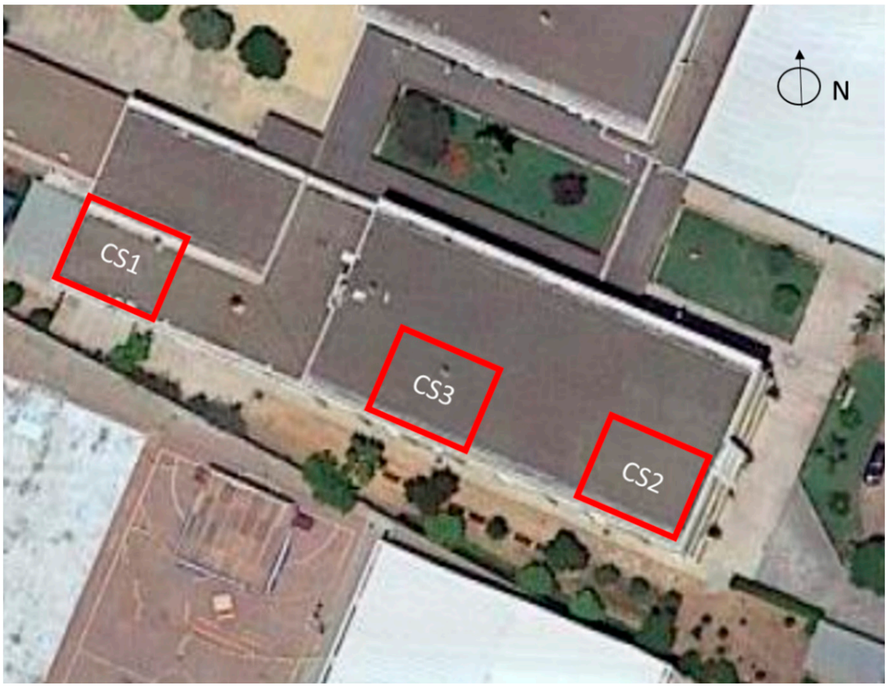


Figure 1. Location and orientation of the case studies.

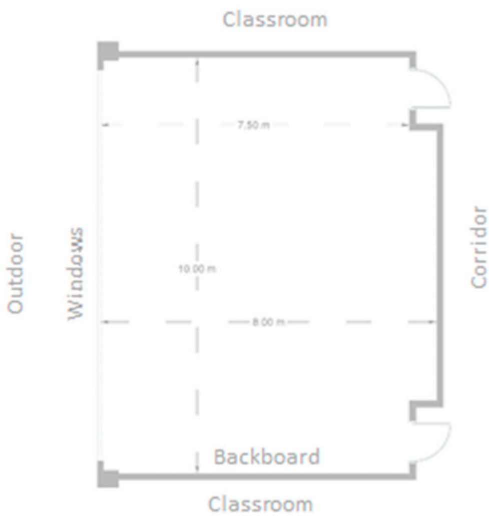


Figure 2. Classroom typology.

2.2. Case Study

The evaluation of this methodology was carried out in a secondary school in Seville (Spain). A total of 99 students were part of this study, aged between 12 and 14. According to the literature, this range of age is more appropriate to express descriptions and relationships between students and the built environment [37].

The study period was between 2 and 11 October 2019. The monitoring of indoor environmental parameters (temperature, relative humidity) was carried out simultaneously with the reflection-by-drawing exercise and the completion of questionnaires by the students. For the field measurements, a portable device was arranged in each class during the whole class time for every session and classroom. Despite the date, and as an evidence of the climate change ravages, the range of outdoor temperatures corresponds to the studied period, the temperature variation exceeds 15 °C, recording outdoor maximum temperature of 34.3 °C and minimum temperature of 19.4 °C. This difference has a great influence on the variation in the thermal sensation of the students throughout the day. The stablished schedule for students' evaluations was set between 08:00 and 14:30 hours, since children complete their activities during the class time. The indoor environmental conditions in classrooms in terms of support for heating, ventilation and air conditioning (HVAC) equipment were freely evolving.

To carry out the exercise in each classroom, four sessions were needed, taking three consecutive classes in the same week and lasting as much as 1 hour per session. The facilitator-researcher led these sessions. During this time, the tasks to complete were the following:

1. Shallow presentation of the activity, emotional drawing by the students, coding of the drawings;
2. First group debate after drawing selection by the facilitator;
3. Keywords categorization, jotted down by the facilitator from the students' consensus and questionnaires;
4. Thinking about possible solutions to settle what they considered negative for comfort.

2.3. Qualitative Technique: Drawings

Currently, drawing is a tool with unquestionable scientific rigor. It is used in medical tests, in pediatrics and psychology for instance, and its validation is based on evidence, recognized as an emotional driver to know and evaluate children behavior, even for the detection and monitoring of emotional, cognitive or behavioral disorders [46]. Despite that images in general are considered qualitative data [27], there are quantitative tests able to assess children drawings [47].

Drawings are also used as part of mixed methods, as well as triangulated with other evaluation techniques that support or refute the results, often applied in the child population. Well-known and validated drawing tests are Draw-a-man Test (DAMT), Family Drawing, linked to Attachment Theory [48], or Kinetic Family Drawing [49], validated with others, such as problem behavior tests, to predict and mediate internal childhood behavior problems [49]. Researchers often compare with questionnaires and objective visual indicators and given insights on familiar relationships, following the art-based phenomenological analytic approach [50]. Other research applies creative techniques as writing and storytelling to work out psychological disorders [51].

2.4. Questionnaires

Two questionnaires were given to students, with scaled answers for a better understanding and evaluation on their part, as well as to collect aggregated data.

Firstly, they were asked to fill in the questionnaire on user comfort perception, aligned with ISO 7730, with questions about comfort perception, which included environmental issues such as classroom location, lighting perception [52], indoor air quality and possible inconveniences linked to the pupil's position in the classroom. The survey was used to establish the boundary conditions of the classrooms, but its results are not discussed in this article in depth. However, the results of those surveys and the internal measurements of humidity and temperature and the quantitative indices such as PMV and

Predicted Percentage of Dissatisfied (PPD) in classrooms for the same typology have been discussed in [14]. The CO2 concentration and symptomatology of the students in [15] have also been analyzed for the same climate and typology. A version of this questionnaire adapted to schools has been adapted in [53].

Secondly, the facilitator distributed to the students the questionnaire on what conditions influence their comfort in the classroom. It also contained scaled-answers and included a wide variety of issues that potentially could affect to the environmental conditions of the classroom, as well as to their hypothetical improvement according to the students' own perspectives. In this questionnaire, the main questions use language aimed at obtaining an impulsive response, without prior reflection or necessary observation. The objective of this method is to extract the unconscious information that influences the state of thermal comfort. The surveys distributed to the students in their original version in Spanish are found in Appendix A.

2.5. Group Debate

The facilitator selected among all the drawings collected those that could represent most of the pupils, or which provoked more interesting questions, so that the debate flowed easily and effectively. The facilitator asked the creators to explain what they have drawn in order to better understand what they want to reflect, after a discussion started. The following questions were asked:

- What do you see here?
- What is really happening here?
- How does this relate to our lives?
- Why does this concern, situation or strength exist?
- How can we become empowered through our new understanding?
- What can we do?

One of the questions that was most affected during the debate was "empowerment", and it was interesting to obtain a group feedback through their answers, to know the perspective of how they understood it and what solutions could be put to such problems.

3. Results

In Seville, temperatures are highly variable between 8:00 and 14:30 hours. This implies that the adaptability of people must be able to assimilate all the conditions included in that hour range. When the temperature of a space deviates towards warmer or colder, it is altering the thermal comfort of individuals. In the short time of a morning, that adaptability is very difficult. Therefore, it is very likely that there will be situations in which one easily moves away from the comfort zone. To avoid extreme discomfort, people turn to conscious and unconscious systems of adaptability. The immediate system is the readjustment of clothing, putting on and taking off clothes throughout the morning.

Other factors of special interest are:

- The overcrowding of classrooms (there are 34 students in each class);
- The distribution of the students in the classrooms;
- The students' activity, it is not the same when coming from physical education or technology classes as coming from theoretical classes;
- Classrooms' orientation, three case studies have a south orientation.

3.1. Boundary Conditions

The school year begins in mid-September. This study was developed one month after the beginning of classes, with the autumn just begun. Autumn 2019 presented itself as a time of slightly higher temperatures than usual. The average temperature of this season tends to be around 20 °C, but in this case, it has been recorded at an average of 1 °C more. No rainfall was recorded in the days leading up to the survey.

On the day of the survey, the outdoor temperature variation exceeded 15 °C. In the morning at the beginning of classes, 18 °C was measured and at the exit, 34 °C was reached. This difference has a great influence on the variation in the thermal sensation of the students throughout the morning (Figure 3).

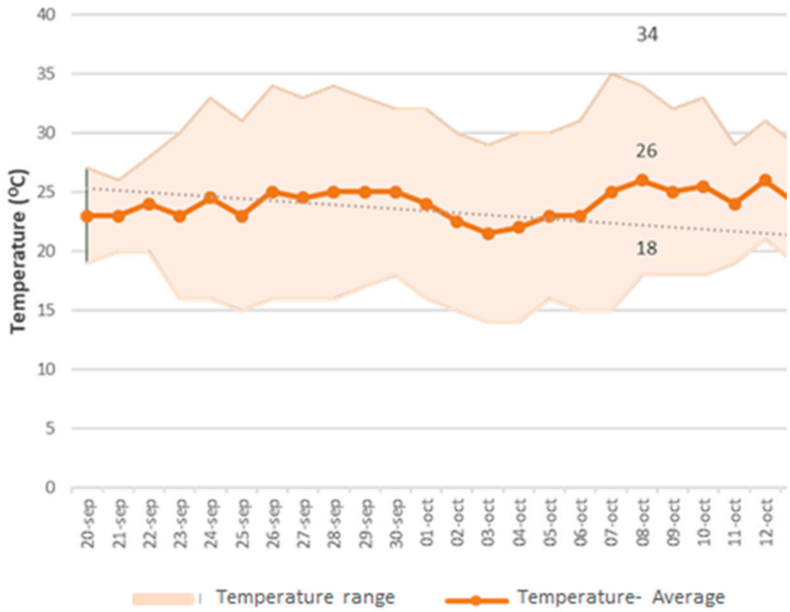


Figure 3. Outdoor temperature evolution in Seville during the study period.

Figure 4 shows a slight deviation from the CS1 and CS2 class towards heat sensations with respect to the CS3 class, who were more comfortable thermally because their class schedule was 10 to 11 hours and the average temperature measured was 26.2 °C. Meanwhile, for the CS1 and CS2 groups, the time frame in which they did the questionnaires and the discussion was 11:30–12:30 and 12:30–13:30, respectively, and the average temperature measured was 27.4 °C.

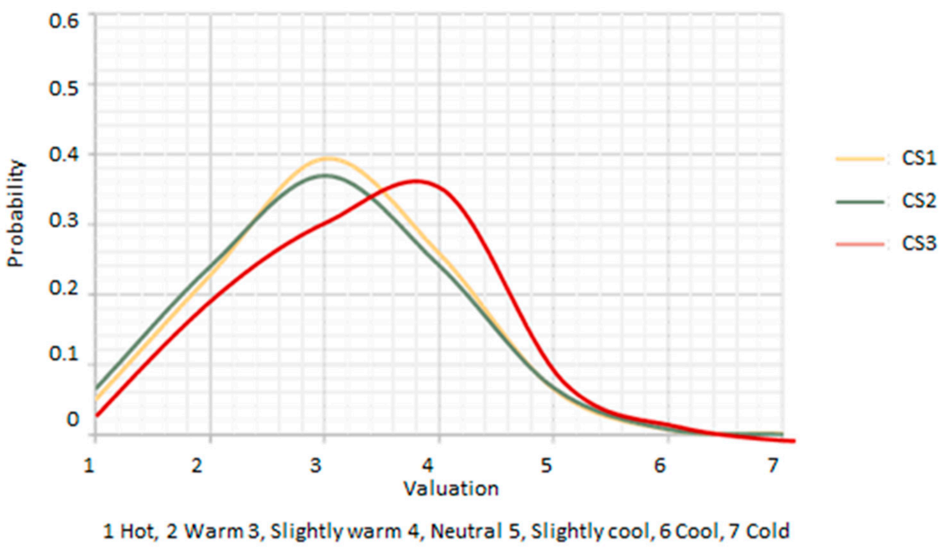


Figure 4. Thermal sensation reported by students.

Despite this, when assessing overall comfort (Figure 4), CS1 gets a rating somewhat worse than CS3. This is indicative that there are factors that are affecting comfort beyond temperature.

Figure 5 shows the comfort sensation reported by students. The valuations were affected by several overall comfort parameters, as well as the schedules and time-frames for the assessments, resulting in different distribution of rating among CS1, CS2 and CS3.

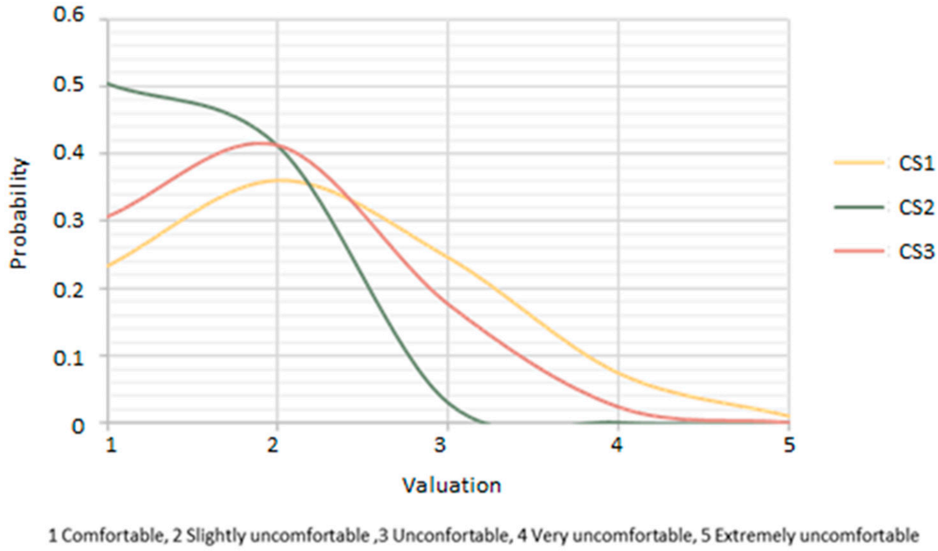


Figure 5. Comfort sensation reported by students.

Another value that can influence the results is the clothing of the occupants, as it has been evaluated and established that the conditions in this aspect are very similar, since the variation is minimal (Figure 6).

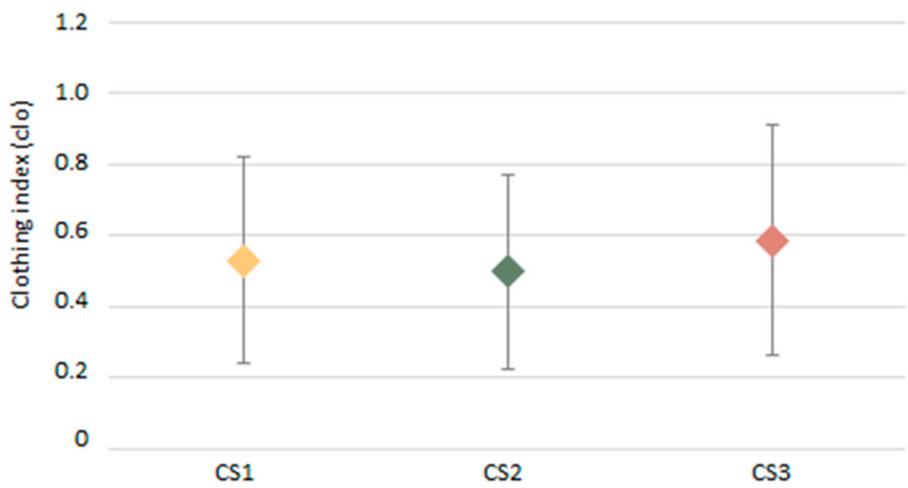


Figure 6. Clothing index (clo) in the classrooms.

3.2. Drawings

In the first session, students had to make a drawing that showed elements or factors that represented the discomfort in the classrooms (Figure 7). This explanation was just indicative, trying not to skew their own perceptions about the existing problems and their way of showing them with images. A code instead of the name was provided to each survey, in order so that they could be expressed more freely. For this study, spontaneous or freely expressed answers could give much more valuable data than pre-defined answers, even if it is harder to quantify.

Figure 7. Emotional drawings performed by students.

In this case study, 20% of the students did not know what to draw about the classroom, and 5% wrote a small opinion instead of drawing. A total of 50% of the drawings included an air conditioner and the student's position in the classroom. A total of 45% of the students drew windows, being one of the most significant elements because the sun's rays enter through them, and some even drew the views in front of the windows. Many of the drawings included the blackboard, although in the debate it was said that it was a component to be placed in the classroom. Other drawings included water, doors, airflow, clothes and hairstyles.

3.3. Questionnaires

The surveys distributed included three fundamental questions. Scale/rank questions (from 0 to 5) were used to ask respondents to rate items in order of importance or preference, where 0 meant that the element had no influence and 5 that it was very influential.

Figure 8 shows the mean values of factors that influence comfort in the classroom. A total of 50% of students voted that the most relevant elements influencing classroom comfort were noise, heat, smell and the number of students in the classroom. The elements voted as less important were wall color, roof color, floor material and table distribution. Regarding the trend in the different classes, there is a small divergence of less than 1 point in almost all the factors.

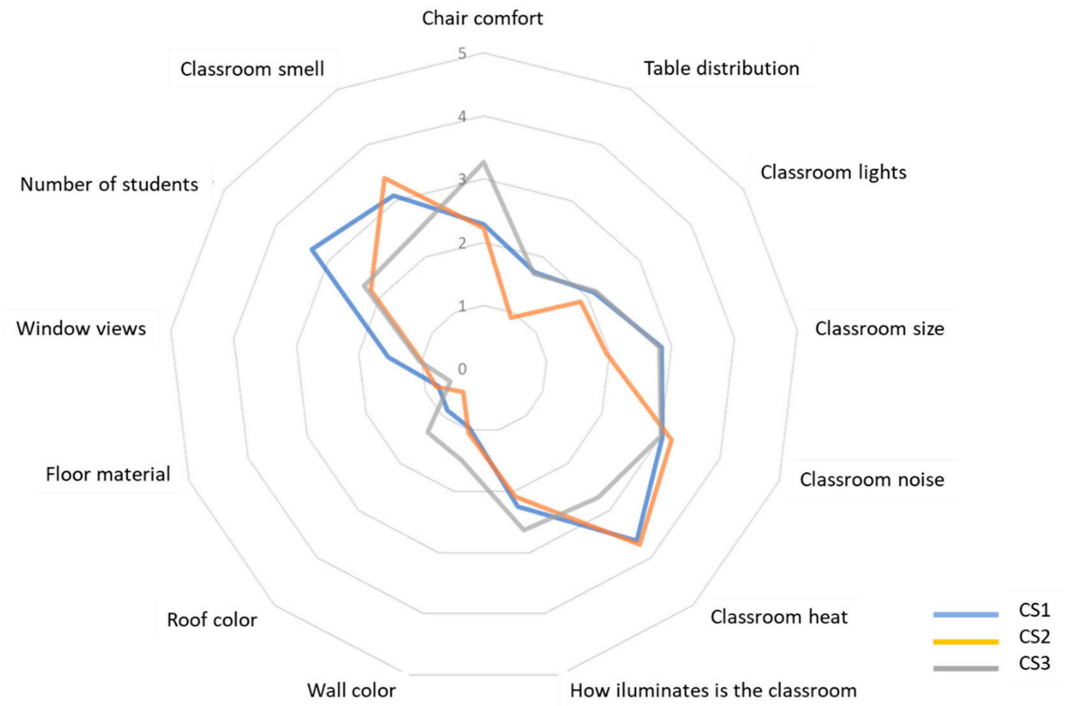


Figure 8. Response rates for factors that influence comfort in the classroom.

Figure 9 shows the mean values of factors that influence the temperature in the classroom. The most voted elements were to have air conditioning and that the air conditioning was on. Other factors voted as important were the number of students and the movement of the air in the classroom. Other elements were considered of medium importance, including elements that were of little importance in comfort such as wall color, roof color and the activity. Regarding the trend in the different classes, there is a small divergence in the importance of air conditioning, air movement and classroom size.

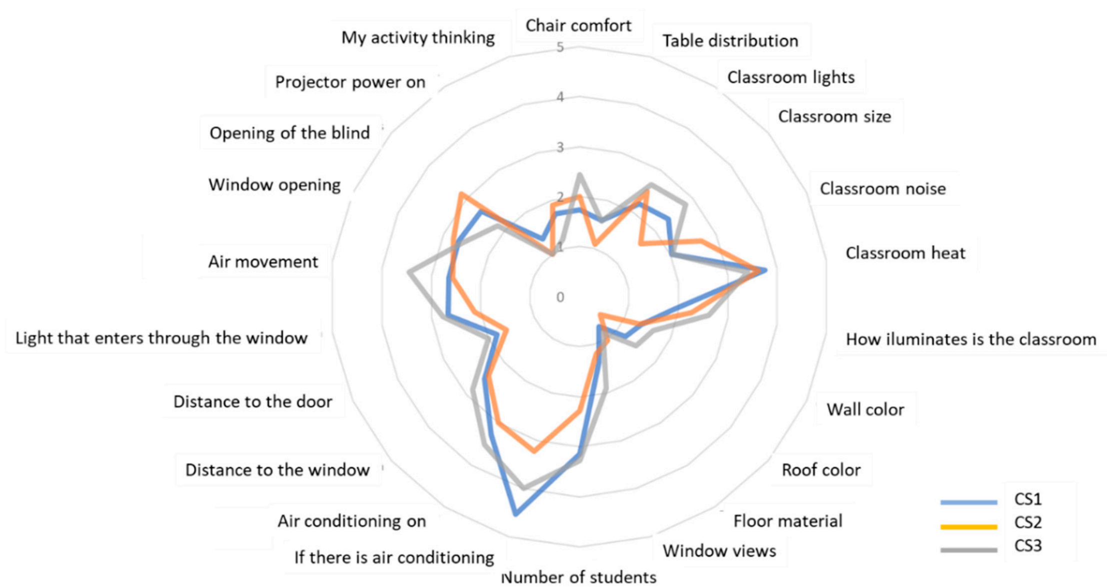


Figure 9. Response rates for factors that influence the temperature in the classroom.

Figure 10 shows the mean values for factors that should be changed to improve the temperature in the classroom. The answers were similar to question 2, given that the most important elements were related to air conditioning. Other additional factors were the distance to the window and the existence of air flow/breeze.

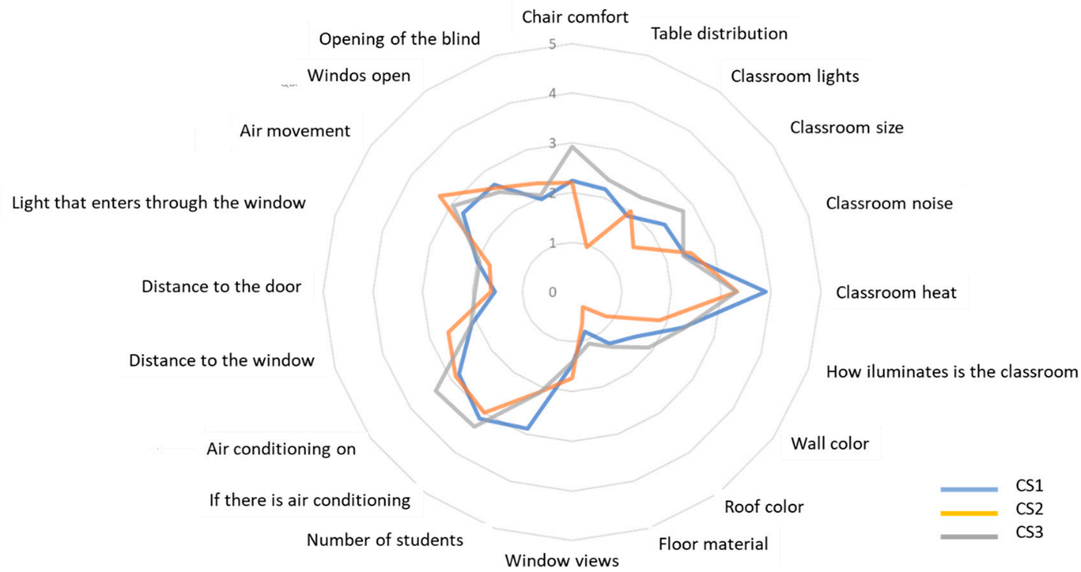


Figure 10. Response rates for factors that should be changed to improve the temperature in the classroom.

3.4. Group Debate

In session 2, the facilitator asked the creators to explain what they had drawn in order to better understand what they wanted to show, after other students expressed their opinions about those drawings. We conducted a thorough content analysis of conversation transcripts and other meaningful information collected, encompassing the researchers' notes, interviews and children's drawings. Table 1 describes the main themes identified.

Question "What do you see here?". The most repeated response was the entry of sun through the window. They also said that people, lights, walls and digital equipment were hot.

Question "What is really happening here?". It is very hot in the class, there are many students inside the class, the air does not move inside the class, the windows are broken and some reported bad odor and humidity.

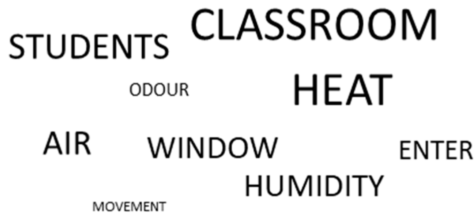
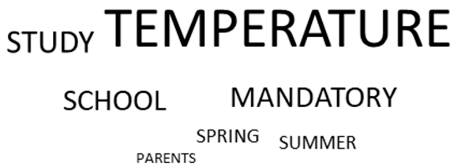
Question "How does it relates to our lives?". It is mandatory to study until the age of 16 in person, though in spring and summer, the temperatures are very high so it is more difficult to study, with some even saying that their parents force them to go to school when they do not want to.

Question "Why does this concern exist?". They believe the problem is that they do not put air conditioning on when the temperatures are very high in Seville in summer. Therefore, each year they pass, there is more heat and the heat is more durable, with some suggesting that this is due to climate change.

Question "How can we become empowered through our new understanding?". They think that to become empowered you have to put air conditioning on in all classrooms, allow them to drink water in class and adapt their clothes. They also think that if they create problems, do not go to class on hotter days and complain to the authorities, someone will listen to them and solve the problem. Further, they think that if someone measures the temperatures throughout the day it will be seen that they are not suitable for teaching.

In session 4, it was proposed to think about possible solutions to improve thermal comfort. The windows were proposed to be changed, using improvements such as corbels, sunshades or curtains. Larger trees could be planted in the playground to provide shade and a cooler environment. It was also necessary to include some element that moved the air, or open the windows when there were windy conditions outside to obtain ventilation.

Table 1. Frequency of Words in the Group Debate.

Letter	Question	Concept More Repeated	Number
S	What do you **S**ee here? 	Sun	60
		Window	56
		Wall	38
		People	29
		Light	25
		Digital Blackboard	16
H	What is really **H**appening here? 	Classroom	40
		Heat	40
		Students	35
		Air	28
		Window	26
		Enter	24
		Humidity	8
		Odour	7
		Movement	6
O	How does it relate to **O**ur lives? 	Temperature	52
		Study	30
		Mandatory	25
		School	25
		Summer	18
		Spring	17
		Parents	12
W	**W**hy does this concern exist? 	No Cooling	35
		Temperature	30
		Sevilla	20
		Spain	10
		Summer	10
		Climate change	8
		Long	7
E	How can we become **E**mpowered through our new understanding? 	Air conditioning	28
		Trouble	25
		Water	20
		Clothes	20
		White	15
		Hairstyle	14
		Shutters	12
		Blind	10
		No assist	8
		Report authority	3
		Monitoring	2
D	What can we **D**o? 	Air conditioning	38
		Clothes	25
		Fan	25
		Drink	17
		White	16
		Ventilation	16
		Short	12
		Hand fan	10
		Improve	8
		Open Windows	7
		Water	8
		Hairstyle	7
		Timetable	5
		Trees	5
		Paint	5

Many students said that it was important the kind of clothes they wore, although sometimes this measure was insufficient to achieve well-being conditions indoors. Other measures were to turn off the lights, install fans or hand-fans, drink water or even change the hairstyle.

In addition, students performed claims such as "overheating due to excessive solar radiation through the windows" or that "with such heat cannot think", even that "they get very distracted during the day to try to find solutions to have less heat".

Having to engineer "homemade" mechanisms to acclimatize or seek comfort often resulted in wasted time, according to the testimonies of the participants, such as using the notebooks as fans, or they got wet in the playground so as not to pass heat when they entered the classroom.

Some of them even thought that small actions such as painting the classrooms white or better thinking about the hours in which the different subjects are carried out can help to improve comfort in the classroom.

4. Discussion

The students proposed diagnoses and possible solutions to the problems of the indoor environment of the classroom. The teaching–learning indoor environment must have a global environmental comfort assessment (including aspects of thermal comfort [54], but not exclusively), and students should be considered as a fundamental part in this assessment, as well as the costs for its operation and adequacy [55].

The factors that in this study were considered the most influential with 50% of the students' votes were noise, heat and odor. In the study carried out by Zhang et al., where students were divided into different and independent clusters, noise was considered the most annoying followed by odor [43], while in the Sense Lab's experience room, students reported that the problems that affected them most were noise (58%) followed by temperature (53%) [43].

In the content analysis of the debate group a clear tendency towards student discomfort was found caused by overheating. Zhang et al.'s study in the Netherlands coincides, due to more than 70% of teachers from different types of schools indicating that the most requested students' modification was the adjustment of windows, with the argument of thermal discomfort [41].

The modifications proposed by the students in this studio range from modifications to clothing, window adjustments, equipping the classroom with air conditioners and fans to planting trees around the classrooms. In the study carried out by Bluyssen et al., students proposed similar solutions [43]. The students of both studies agreed on the need to implement a device that regulates ventilation in the indoor environment, adapting to changes in the outdoor environment automatically.

The differences in the perception of aspects that cause discomfort in the classroom between this study and the contrasted studies [41–44] may be due to the fact that the variation in the thermal environment not only affects thermal comfort but also has an impact on the perception of other factors related to the indoor environment [56].

5. Conclusions

Currently, the perceptions of overall comfort in general, and at schools in particular, are incomplete or biased, often leading to failure when carrying out HVAC interventions, or in prior installed air-conditioned classrooms, where students still declare that they are not comfortable. In educational buildings, the approach that engages students in POE provides researchers with highly contextualized information about which elements are most influential in global (thermal and environmental) comfort, helping the analysis to be done more accurately and thinking about the factors that maximize the performance solutions.

The adapted POE methods motivated the students: feeling involved, they seemed excited to share their opinion and propose improvements. When feeling empowered, they create real opportunities for change, even discussing it with their families and close friends to explore new possibilities. Leveraging this motivation offers a real opportunity for change.

On the other hand, the application of techniques or methods that promote the active participation of users (belonging to the Participatory Action Research (PAR)) implies reflection on a certain topic or issue, common for a collective (pupils in class or school). This reflection leads to deepen the problems' roots, so environmental comfort misinformation, ignorance or lack of autonomy in comfort-related device control could be detected. Group debates contributed to build a common and aware discourse that tried to fix those gaps, that also may be communicated to decision-makers (teachers, school managers and directors, etc.) as part of a potential intervention strategy.

On the other hand, using the qualitative participatory technique based on drawings and group debates, insights independent of this kind of research are unveiled, not before considered from researchers, that could result in solutions that not only conduct possibly energy-saving but also cheaper and faster environmental comfort-related interventions, since real needs and lacks are soon-detected, revealed and analyzed from the users' experiences, to the researchers and intervenors.

The solutions that students gave, which covered a wide range of issues, also served to address the heat adaptation concern and even to raise awareness about energy savings.

Taking into account starting points that do not cost money, such as the position of the tables in the classroom or the study of the hours in which the different subjects must be taught, including access to the operation of the windows, blinds and lights can contribute to improving comfort in spaces. In addition, there are other adaptive solutions like changing your hairstyle or clothes. There are even improvement proposals that cost less and can greatly influence the microclimate, such as planting trees. Classroom ventilation was determined as an important element of indoor air quality and thermal comfort.

This research has provided information to the design community that is not generally obtained through Post-Occupational Evaluation (POE) but is essential in addressing design quality, since the approach gives importance to the people who really use the school buildings.

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Appendix A

ALIAS:	CLASE:

¿Eres?	Chica ☐	Chico ☐	Edad:	
Estoy sentada/o	Cerca de la ventana ☐	En mitad ☐	Lejos de la ventana ☐	Cerca de la pizarra ☐	Lejos de la pizarra ☐

En términos generales me parece un ***Aula CONFORTABLE***

☐ Totalmente en desacuerdo	☐ En desacuerdo	☐ Indiferente	☐ De acuerdo	☐ Totalmente de Acuerdo

De la siguiente tabla, ¿Qué elementos te han influido para establecer dicha valoración?

	Elemento	**influye**		**En caso afirmativo, ¿Cuánto te influye?**				
		SI	**NO**	Muy poco	poco	regular	bastante	mucho
1	Comodidad de las sillas			1	2	3	4	5
2	Distribución de las mesas			1	2	3	4	5
3	Luces del aula			1	2	3	4	5
4	Tamaño del aula			1	2	3	4	5
5	Ruido del aula			1	2	3	4	5
6	Calor en el aula			1	2	3	4	5
7	Como de iluminada está el aula			1	2	3	4	5
8	Color de la pared			1	2	3	4	5
9	Color del techo			1	2	3	4	5
10	El tipo de suelo			1	2	3	4	5
11	Las vistas de la ventana			1	2	3	4	5
12	El número de compañeros en el aula			1	2	3	4	5
13	Olor en el aula			1	2	3	4	5

Figure A1. Original Questionnaire.

ALIAS: **CLASE:**

¿Eres? Chica ☐ Chico ☐ **Edad:**

Estoy sentada/o Cerca de la ventana ☐ En mitad ☐ Lejos de la ventana ☐ Cerca de la pizarra ☐ Lejos de la pizarra ☐

En términos generales me parece un ***Aula CON BUENA TEMPERATURA***

☐ Totalmente en desacuerdo	☐ En desacuerdo	☐ Indiferente	☐ De acuerdo	☐ Totalmente de Acuerdo

De la siguiente tabla, ¿Qué elementos te han influido para establecer dicha valoración?

	Elemento	**influye**		**En caso afirmativo, ¿Cuánto te influye?**				
		SI	**NO**	Muy poco	poco	regular	bastant e	mucho
1	Comodidad de las sillas			1	2	3	4	5
2	Distribución de las mesas			1	2	3	4	5
3	Luces del aula			1	2	3	4	5
4	Tamaño del aula			1	2	3	4	5
5	Ruido del aula			1	2	3	4	5
6	Calor en el aula			1	2	3	4	5
7	Como de iluminada está el aula			1	2	3	4	5
8	Color de la pared			1	2	3	4	5
9	Color del techo			1	2	3	4	5
10	El tipo de suelo			1	2	3	4	5
11	Las vistas de la ventana			1	2	3	4	5
12	El número de compañeros en el aula			1	2	3	4	5
13	Que haya aire acondicionado			1	2	3	4	5
14	Que el aire acondicionado esté encendido			1	2	3	4	5
15	La distancia a la ventana			1	2	3	4	5
16	La distancia a la puerta			1	2	3	4	5
17	La luz que entra por la ventana			1	2	3	4	5
18	La corriente de aire que me llega			1	2	3	4	5
19	La apertura de la ventana			1	2	3	4	5
20	La apertura de la persiana			1	2	3	4	5
21	El encendido del proyector			1	2	3	4	5
22	Mi actividad: pensando			1	2	3	4	5

Figure A2. Original Questionnaire.

ALIAS: CLASE:

¿Eres? Chica ☐ Chico ☐ Edad:

Estoy sentada/o — Cerca de la ventana ☐ — En mitad ☐ — Lejos de la ventana ☐ — Cerca de la pizarra ☐ — Lejos de la pizarra ☐

De la siguiente tabla, ¿Qué querrías cambiar para que la sensación de la temperatura fuera más acorde a tus necesidades?

	Elemento	influye		En caso afirmativo, ¿Cuánto te influye?				
		SI	NO	Muy poco	poco	regular	bastante	mucho
1	Comodidad de las sillas			1	2	3	4	5
2	Distribución de las mesas			1	2	3	4	5
3	Luces del aula			1	2	3	4	5
4	Tamaño del aula			1	2	3	4	5
5	Ruido del aula			1	2	3	4	5
6	Calor en el aula			1	2	3	4	5
7	Como de iluminada está el aula			1	2	3	4	5
8	Color de la pared			1	2	3	4	5
9	Color del techo			1	2	3	4	5
10	El tipo de suelo			1	2	3	4	5
11	Las vistas de la ventana			1	2	3	4	5
12	El número de compañeros en el aula			1	2	3	4	5
13	Que haya aire acondicionado			1	2	3	4	5
14	Que el aire acondicionado esté encendido			1	2	3	4	5
15	La distancia a la ventana			1	2	3	4	5
16	La distancia a la puerta			1	2	3	4	5
17	La luz que entra por la ventana			1	2	3	4	5
18	La corriente de aire que me llega			1	2	3	4	5
19	Que la ventana esté abierta			1	2	3	4	5
20	Que la persiana esté bajada			1	2	3	4	5

Figure A3. Original Questionnaire.

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