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Impact of the Climate Background of Students on Thermal Perception: Implications for Comfort and Energy Use in University Lecture Theatres

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Abstract: The thermal conditions in lecture theatres directly affect the well-being and overall learning experience of the users but also offer a testbed for understanding the degree to which people's thermal perceptions are affected by their climate background. This study included surveys completed online by users in situ and environmental measurements conducted on four different days in three different lecture theatres at the University of Liverpool. The 340 participants who took part in the study were divided into three groups—from climates warmer or cooler than that of the UK and similar to that of the UK. Based on statistical analysis, it was observed that the climatic backgrounds affected participants' thermal sensations and preferences. The results showed that the thermal sensation and preferences of people from warmer backgrounds and similar backgrounds were different and statistically significant. Most users from a warmer background preferred the environment to be warmer while most users with a similar background preferred it to be cooler. These findings have energy and comfort implications for how heating and cooling set-point temperatures in lecture theatres should be determined.

Keywords: thermal comfort; thermal perception; climate; climate background; indoor temperature; university buildings

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1. Introduction

In 2021–2022 there were 679,970 international students at UK universities, around 24% of the total student cohort [1]. It is therefore important to consider climate background when setting thermal comfort standards for university buildings in which students from different nationalities come together. As de Dear [2] has stated, buildings are expected to offer comfortable spaces without affecting the health and performance of users. Thermal comfort in education buildings is important because many studies have shown that indoor temperature affects productivity and mental acuity [3–8]. However, it is difficult to please all users simultaneously given that people's comfort levels may differ under the same conditions [9].

Thermal comfort is defined as "a condition of mind which expresses satisfaction with the thermal environment" in ASHRAE Standard 55 [10] and EN ISO 7730:2005 [11]. Several factors affect this mental state that can be gathered under three main headings: environmental (air temperature, mean radiant temperature, relative humidity and air movement) [12–14]; personal (metabolic rate and clothing insulation) [13,14] and contributing factors (age, gender and health condition) [14]. In addition, Parsons [15] mentioned that climate and cultural background can also affect thermal comfort. Knez et al. [16] and Wang et al. [17] demonstrated that long-term thermal memory affects people's thermal experiences and expectations.

A study of students from different climatic conditions living in university halls of residence in England revealed that the average indoor air temperature of those with a warm climate background was 2.3 °C higher than those from a cold climate when looking at room temperatures in the winter months [18]. A very similar result was obtained by Jowkar et al. [19] for students in UK higher education buildings. According to their results, among students who had been in the UK for less than three years, the ideal acceptable temperature was 24 °C for those from a warm climate background and 22 °C for those from a cold climate.

In CIBSE Guide A [20], the temperature comfort ranges for educational buildings are 19–21 °C in winter and 21–25 °C in summer. The clothing level is assumed to be 1.0 clo in winter and 0.6 clo in summer, with an activity level of 1.4 met in winter and 1.3 met in summer. These specified indoor comfort temperatures are used as a reference in educational buildings with heating and cooling systems. Although students cannot usually change the thermal conditions of their lecture theatres, the activity levels of the students and the insulation values of their clothes significantly affect their thermal comfort [21]. Although students try to adapt physically to the environmental conditions, they are mostly in a sitting position in lecture theatres with limited scope to adapt by changing their activity levels. Therefore, students often try to adapt to the ambient conditions by putting on and taking off layers of clothing [22]. On the other hand, it is thought that a user's adaptation to their current condition might be related not only to environmental conditions but also to their cultural background and expectations [23].

Studies show that thermal comfort depends on cultural heat expectations as well as climatic conditions [24]. Thermal comfort conditions in buildings affect energy consumption as well as people's well-being [25]. Considering that heating and cooling systems constitute 64% of the energy consumption in the UK's Further and Higher Education building stock [26], it is important to understand the expectations of the users and to try and meet these expectations whilst using less energy. For this reason, this study investigated how the climate backgrounds of the users of lecture theatres in university buildings in the UK affected their thermal perceptions and expectations.

The Climate Change Act 2008 in the UK aims to reduce greenhouse gas emissions and reach net zero emissions by 2050 [27]. Despite the efforts of UK universities, the 2020 target of 43% emissions reduction was not achieved due to increasing student populations [28]. The government is investing £500 million to improve energy efficiency and create better learning environments in schools and colleges [29]. The Carbon Trust [26] report underscores the detrimental impact of overheating on fuel consumption, with an estimated 8–10% rise in consumption for every 1 °C increase. Another study also showed that even a 1 degree decrease in indoor temperature provides a 10% energy saving [9]. In a systematic literature review, it was mentioned that occupant behaviour is one of the main factors affecting energy consumption [30] in higher education buildings [31]. Since there is a relationship between energy consumption and comfort in buildings, defining the building user profile and understanding their expectations and behaviour is important both in terms of comfort and energy saving.

When educational buildings are mentioned, buildings that contain many different spaces such as classrooms, laboratories and libraries come to mind. For this reason, factors such as the type and size of the educational building and the heating and cooling systems used also affect the comfort and performance of the users [21,32–34]. In a study conducted under the same outdoor temperature, learning performance showed the most variation in small classrooms, while large classrooms showed the least change [35]. They suggested that this was because smaller classrooms had higher indoor temperatures. Another study found that students performed significantly better in air-conditioned classrooms, which were considered thermally comfortable, compared to non-air-conditioned classrooms [36]. The study by Rodríguez et al. [34] also showed that the effect of the thermal environment on students' perceived cognitive performance increased with age, as older students reported increasing difficulties in concentrating when they felt thermally uncomfortable.

In a previous study on thermal perception in university buildings, the results of the research conducted at two different universities in the UK revealed that students' sensitivity to hot and cold was related to the temperature conditions of the city where their university is located [33]. In another study, it was observed that since the levels of freedom offered by different classroom types, such as lecture theatres, studios and computer laboratories, are different, this situation affects the behavioural adaptation of students [37]. For all these reasons, this study was conducted in a single city and in lecture theatres with similar conditions. In this way, other factors that could affect the participants' thermal perceptions were minimized and the main subject of the research, the effect of climate background, was the key focus.

The aim of this research is to investigate the effect of the climate backgrounds of users on thermal perception in university lecture theatres. To support this aim, two main objectives have been identified: first, to research and analyse the heating and cooling strategies of the university's lecture theatres, and second, to collect and analyse survey data to understand the effect of climate backgrounds on thermal perception.

2. Methods

A field study was undertaken at the University of Liverpool in the United Kingdom. In the Köppen–Geiger climate classification system, Liverpool's climate is classed as Cfb, which is a temperate oceanic climate with mild winters and cool summers. According to the UK's Meteorological Office [38], average air temperatures in Liverpool typically vary between 7.5 °C and 13.6 °C, the hottest months are July and August, and the coldest months are January and February [39].

Three different University of Liverpool buildings, with one lecture theatre from each, were chosen for the case study. These buildings were the Eleanor Rathbone Building (ERB), Rendall Building (RB) and Teaching Hub 502 (TH). The chosen lecture theatres are presented in Figure 1, which also shows the locations of the data loggers used to record temperatures and relative humidities at the locations.

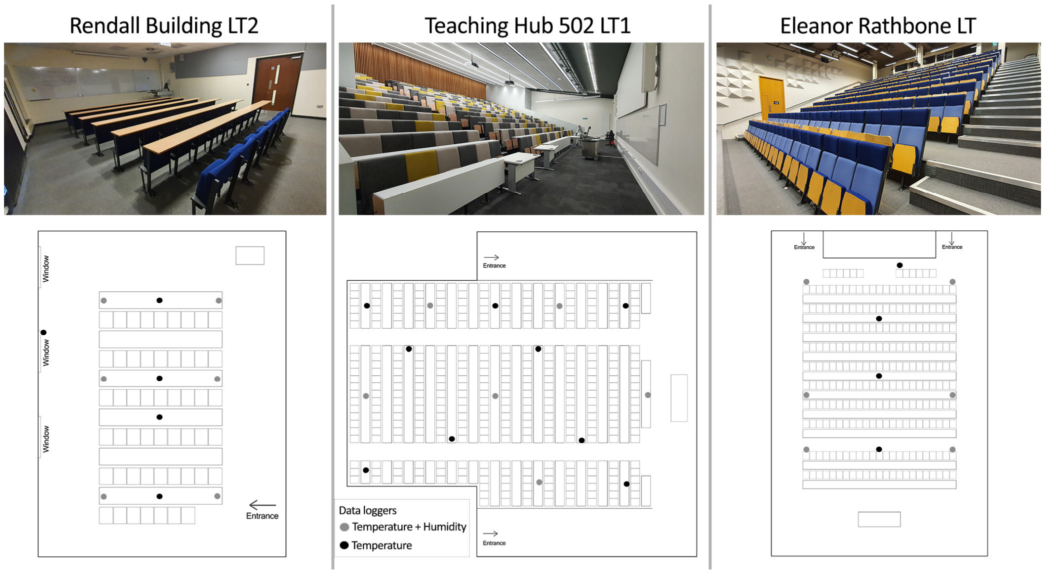

Figure 1. Selected lecture theatres and schematic plans showing the location of data loggers (●).

This study was carried out on four different days in October 2022 using surveys and environmental data collection methods, starting with RB Lecture Theatre 2 on the 11th of October, then TH Lecture Theatre 1 on the 14th of October and finally the ERB Lecture Theatre on the 19th of October and 25th of October.

During this study, nineteen iButton data loggers were used to measure indoor air temperature (Tin) and relative humidity (RH). Six of them measured relative humidity and temperature while the remaining thirteen measured temperature only. The number of these devices used in three different lecture theatres varied according to the size of the lecture theatres. While ten iButtons were used in the lecture theatre in the RB and ERB, fifteen iButtons were used in the TH. The loggers recorded at 10 min intervals and were placed to reflect the position of a sitting person before the start of the lecture (Figure 2). Lectures varied between one and a half and two hours. The loggers' specifications are given in Table 1.

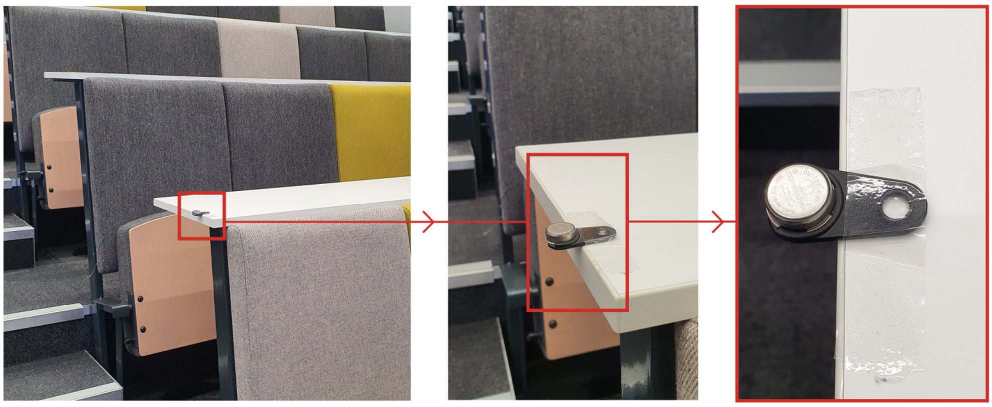

Figure 2. Photos showing how the data logger was placed during the measurement.

Table 1. List of equipment for the lecture theatre study.

Image	Name	Specification
	iButton DS1922L Thermochron Temperature Recording	Measurement Range: −40 to +85 °C Accuracy: correctible to ±0.5 °C Resolution: Selectable: 8-bit = 0.5 °C—11-bit = 0.0625 °C Thermal Response time: up to 130 s Sample Rate: 1 s to 273 h Memory Size: 512 bytes
	iButton DS1923 Hygrochron Temperature/Humidity Data Logger	Measurement Range—Temperature: −20 to +85 °C Measurement Range—Humidity: 0 to 100% RH Accuracy: correctible to ±0.5 °C Resolution: Selectable: 8-bit = 0.5 °C—11-bit = 0.0625 °C Sample Rate: 1 s to 273 h Memory Size: 512 bytes

The survey study used the JISC online survey program [40] and consisted of two parts: personal information and thermal evaluation. In the first part, users were asked for background biographical information, such as age, gender and nationality, as well as their city of birth, where they lived before coming to Liverpool and how long they had been in Liverpool. In the second part, the participants were asked to evaluate their environment in terms of temperature, relative humidity, air movement and comfort. In addition, the level of clothing and their location in the lecture theatre were also requested.

The ASHRAE scale and Bedford scale, as seven-point scales, are commonly used to evaluate thermal conditions in survey questions. In this study, the numbers from 1 to 7 were used to assess thermal conditions, as in the Bedford scale. However, it has been observed in previous studies that in cases where the native language of the participants in the study is different from English, the verbal expressions used in the thermal comfort scale may be perceived differently by the participants [41–44]. The result obtained with the graphical scale that Woolard [45] used showed that the use of different scales makes the result more meaningful in cases where there may be a language barrier. Therefore, the scale was simplified (textual descriptors removed from the scale) to avoid any confusion. The scales in Figure 3 were prepared, and the participants were asked to evaluate from 1 to 7.

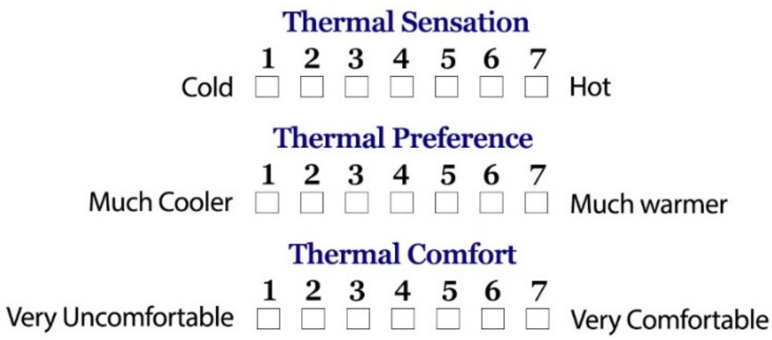

Figure 3. Scales for thermal evaluations.

As the study was conducted during a lecture, information was displayed on a screen during a lecture, and the participants were asked to scan a QR code using their phones to participate in the survey. The participants were given approximately 15 min to complete the questionnaire, and all participants completed the survey under the same conditions. In RB Lecture Theatre 2 and TH Lecture Theatre 1, the survey was conducted 15 min before the end of the lecture, while in ERB Lecture Theatre, it was conducted 30 min after the lecture started.

As people from 45 different nationalities participated in the study, an appropriate grouping method had to be chosen to analyse all the results. Since the effect of climate background on thermal perception was examined in the study, the participants were grouped according to their climate background. The Köppen–Geiger climate classification method, which is the most common grouping method used in climate studies, was chosen for this study [46–49]. The Köppen method was developed according to the most widely used temperature and precipitation parameters in the world [50].

Participants come from four main Köppen–Geiger classification climate groups, A, B, C and D, with fifteen sub-category climate regions. Three groups were formed, as seen in Table 2.

Table 2. Climate background groups determined according to the Köppen–Geiger climate classification.

Köppen–Geiger Climate Classification	Climate Group Classification
Af/Am/Aw	Warmer Climate Background
BWh/BWk/BSh/BSk	
Csa/Cwa/Cwb/Cfa	
Cfb (Liverpool's climate)	Similar Climate Background
Dwa/Dwb/Dfb	Cooler Climate Background

Statistical tests using the IBM® SPSS® program [51] investigated whether different climate backgrounds affected people's thermal perception. Since the data contained ordinal variables and three groups were to be compared, the Kruskal–Wallis test was used [52].

3. Results

3.1. Overview of Participants

A total of 340 people participated in the three building surveys. Approximately 97% of the participants were between the ages of 16 and 25; 59% identified as female, 39% as male and 2% as non-binary; 58% were British and 42% were international. According to Köppen–Geiger, 61% had a similar climate background to that of Liverpool, 34% had a warmer background and 5% had a cooler background (Figure 4). The survey results were compared according to this grouping method.

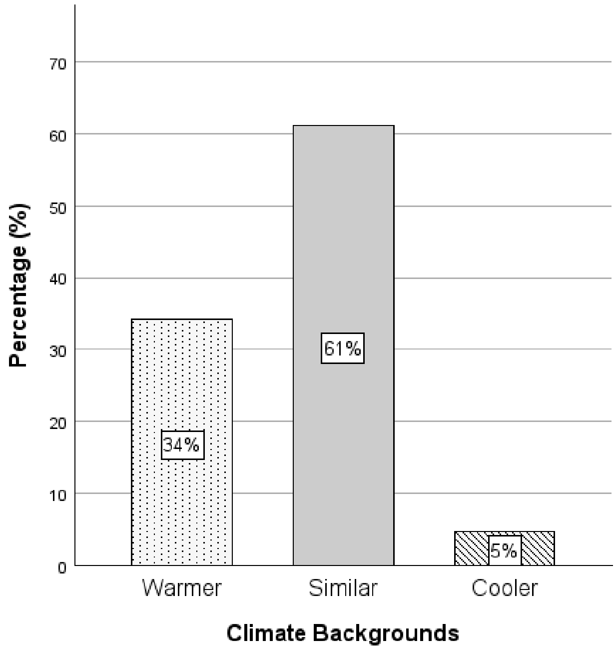

Figure 4. Percentage of climate backgrounds of respondents.

Figure 5 shows the global distribution of participants using Datawrapper [53]. The size of the symbols increases according to the number of participants from the same city, and the colour of the symbol indicates whether it is a warmer, cooler or similar climate zone. After the United Kingdom, most participants (69 people) were from China.

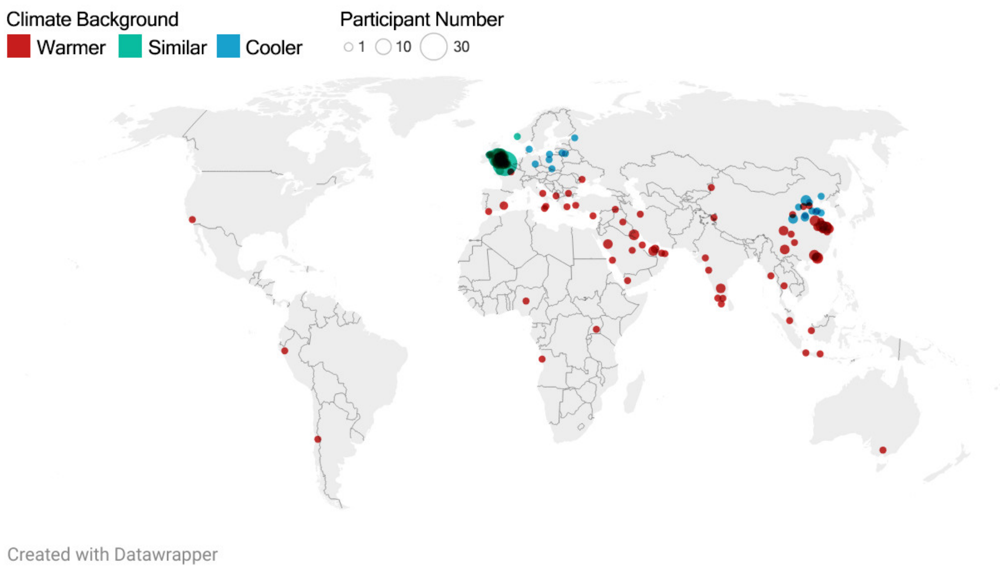

Figure 5. Distribution of the participants' countries of birth on the world map.

3.2. Outdoor and Indoor Environments

The outdoor air temperature and relative humidity values in Liverpool on the days of the study are shown in Figure 6. Additionally, the small circles in the figure show the outdoor temperature and relative humidity values at the time the study was carried out. The graphs were created using data from a local weather station located within 500 m of the lecture theatres [54]. The mean temperatures on the days when the study was conducted were 10.9 °C, 12.3 °C, 11.9 °C and 13.3 °C, while the temperature values at the time of the survey were 9 °C, 15 °C, 12 °C and 16 °C, respectively. The mean relative humidity values on the study days were 79%, 88%, 79% and 83%, while the relative humidity values during the survey were 87%, 77%, 82% and 72%, respectively.

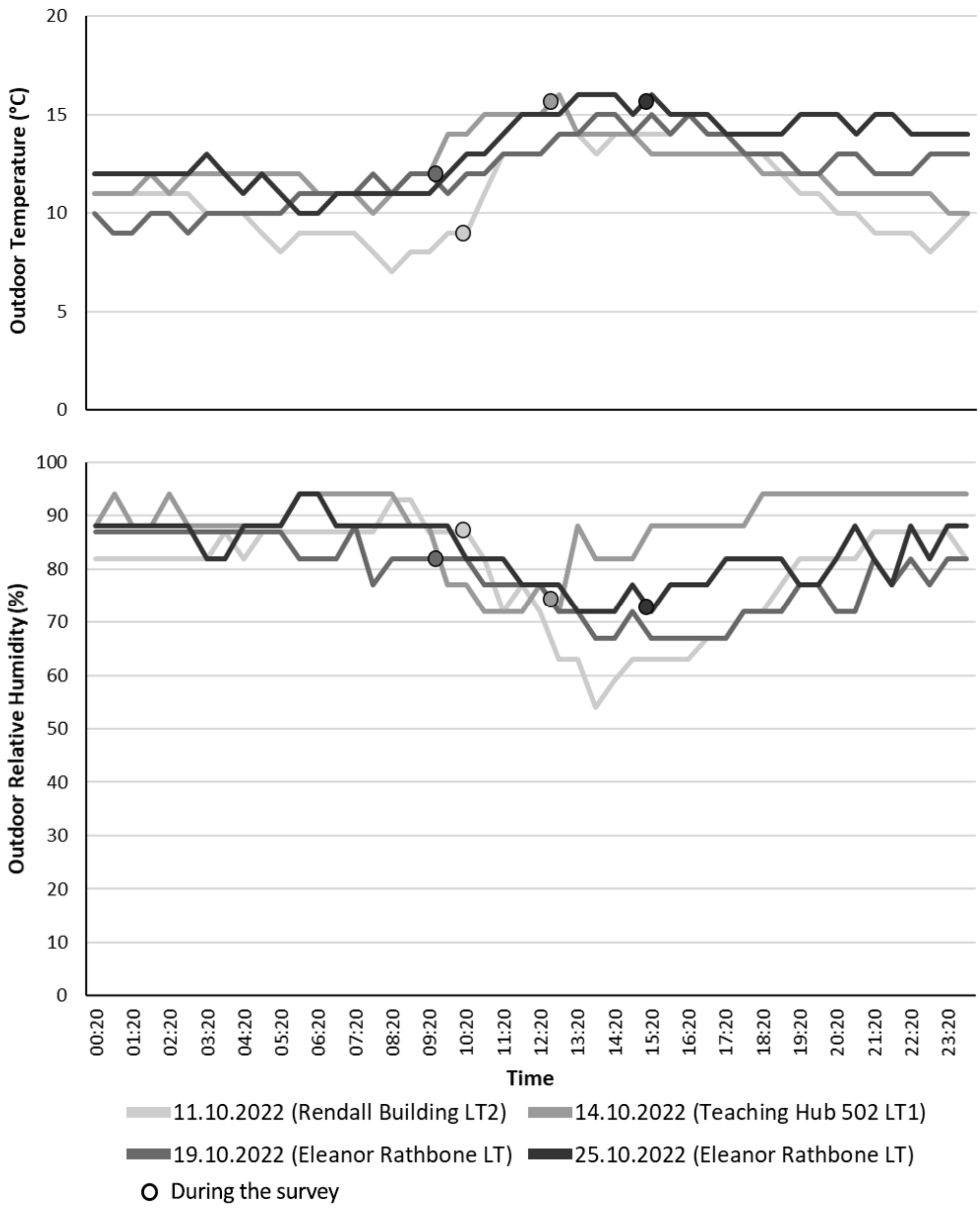

Figure 6. Outdoor temperature and relative humidity on the days of the study.

Measurements from data logger placed at different points were very similar, and the air temperatures in the front and back rows of the lecture theatres differed by less than 1 °C. Therefore, temperature and relative humidity values for the lecture theatres were calculated by taking the average of all data loggers results. In addition, air movement measurements were made around the lecture theatres, and the air velocities were low (<0.10 m/s).

Figure 7 shows the indoor air temperature and relative humidity results recorded by the iButton loggers recording at 10 min intervals during the lecture period of approximately 1.5–2 h in the survey lecture theatres. The temperature in RB LT2 increased by about 3 °C from the beginning to the end of the lecture, while the temperatures changed less in the other lecture theatres. The mean indoor air temperatures of the lecture theatres were 19.6 °C in RB LT2, 21.1 °C in TH 502 LT1 and 21.9 °C in ERB LT in the first record and 23.1 °C in the second record. The average relative humidity values were 49.7% in RB LT2, 51.9% in TH

502 LT1 and 46.1% in Eleanor Rathbone LT in the first record and 53% in the second record. As in the temperature graph, the most striking result was measured in the Rendall Building LT2. The relative humidity in this lecture theatre decreased by approximately 7% during the lecture. Given that CIBSE Guide A [20] recommends a comfort range for educational buildings of 19–21 °C in winter, Figure 7 suggests this range is not being consistently provided in the monitored lecture theatres.

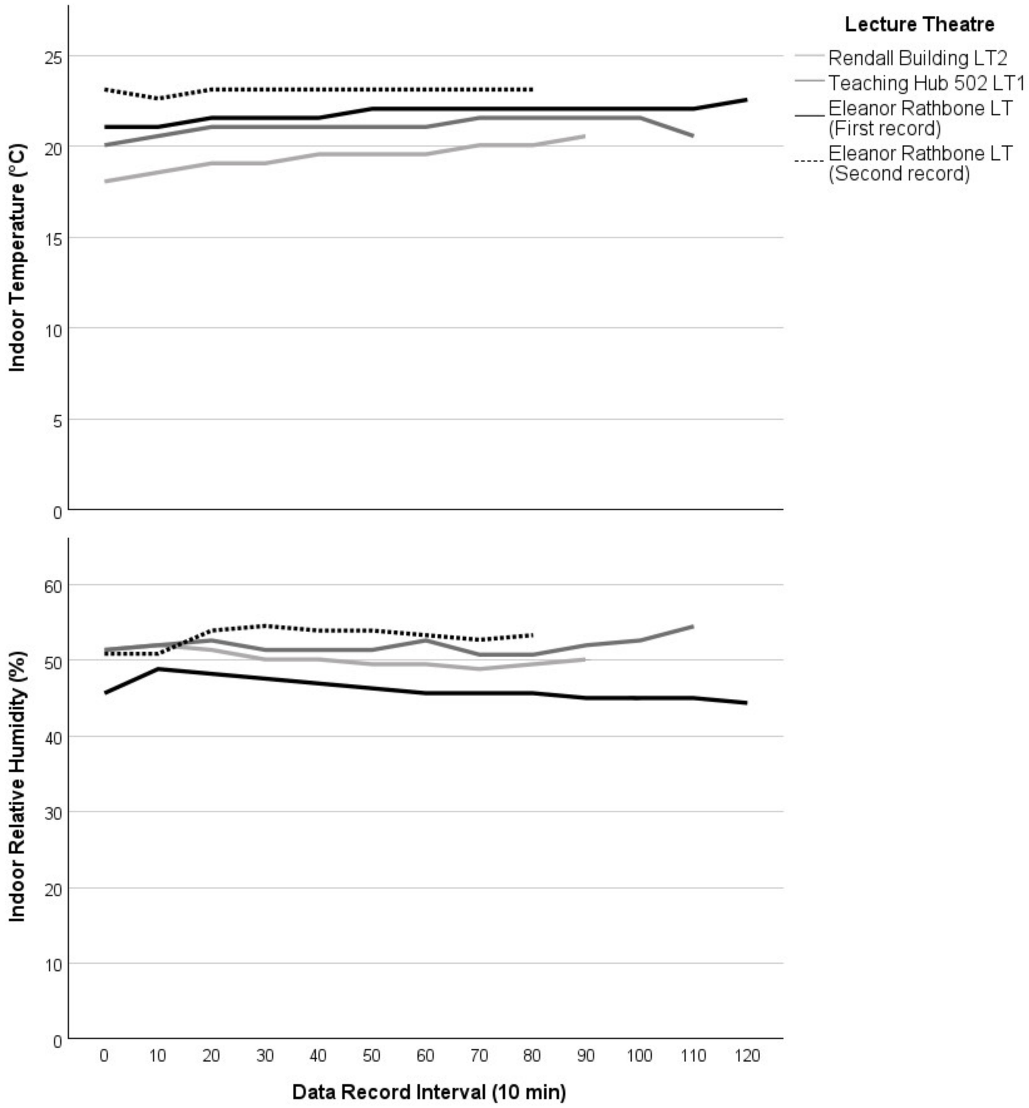

Figure 7. Indoor air temperatures and relative humidities during the survey periods.

3.3. Thermal Votes of Participants: The Influence of Climate Background

Figure 8 shows the percentage thermal sensation responses when evaluating the indoor temperatures. While most users with similar and cooler climate backgrounds rated the environment as 'slightly warm', most participants from warmer climate backgrounds rated the environment as 'neutral'. However, looking at the mean values of the responses for the thermal sensation of people from the three different climate backgrounds, the mean thermal sensation values of people from warmer, similar and cooler climate backgrounds were 3.96, 4.4 and 4.13, respectively. The mean thermal sensation of the participants in the three groups was 'neutral'. The percentage of those who felt hot and cold was low.

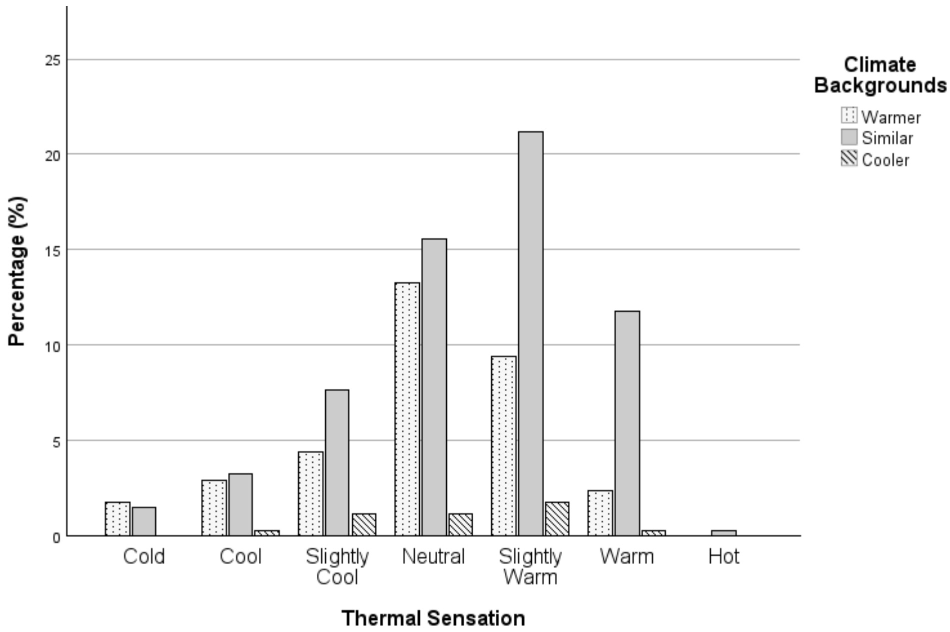

Figure 8. Percentage of thermal sensation votes by climate background.

Figure 9 compares thermal preference responses according to climate background. The majority of the participants preferred to keep the indoor temperature 'similar'. The mean thermal preference values of people with warmer, similar and cooler climate backgrounds were 4.16, 3.73 and 3.69, respectively. Figure 9 shows that, while the majority of warmer climate people wanted the environment to be 'similar' or 'slightly warmer', people from similar and cooler climate backgrounds wanted the environment to be 'similar' or 'slightly cooler'.

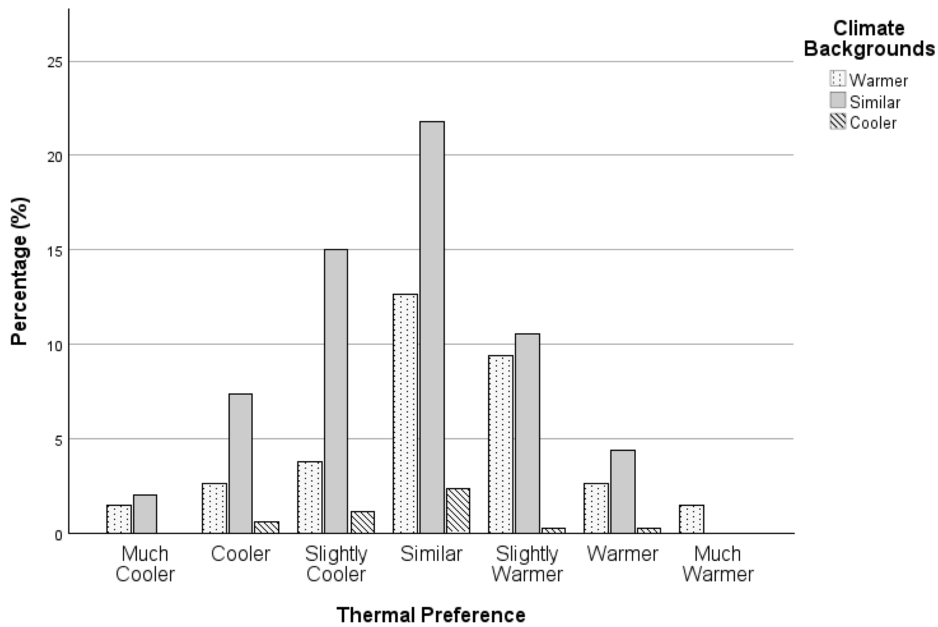

Figure 9. Percentage of thermal preference votes by climate backgrounds.

Figure 10 compares overall comfort responses. The mean comfort values of participants from a warmer and a similar climate background to that of Liverpool were 4.56 and 4.62, between 'neutral' and 'slightly comfortable'. For those from a cooler climate background, it was 5, i.e., 'slightly comfortable'. While the distribution of the responses differed in each of the three groups, the percentages of the comfort votes of the participants with a cooler climate background were closer to each other than the other two groups. Conversely, for participants from a climate similar to that of Liverpool, the percentage of those who felt comfortable was higher.

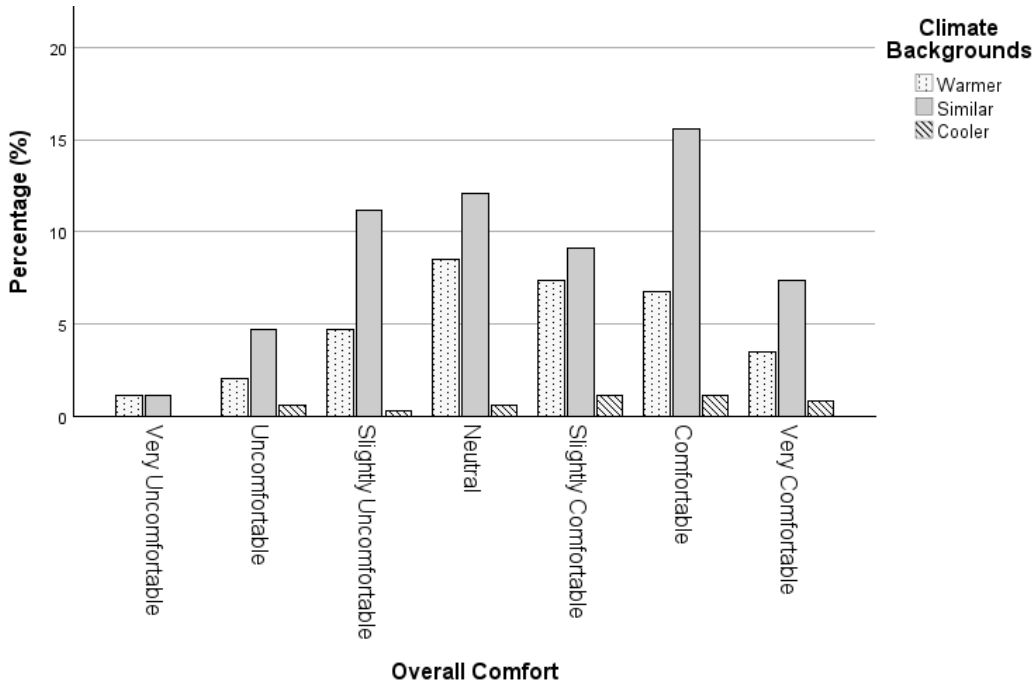

Figure 10. Percentage of overall comfort votes by climate backgrounds.

Figure 11 shows the participants' clothing insulation values (clo). The clothing insulation value of most of the participants in the three climate groups was 1.0 clo. It was determined that many of the participants wearing 0.6 clo were from a similar climate background. The mean values for participants were 1.02, 0.95 and 1.14 for warmer, similar and cooler backgrounds, respectively.

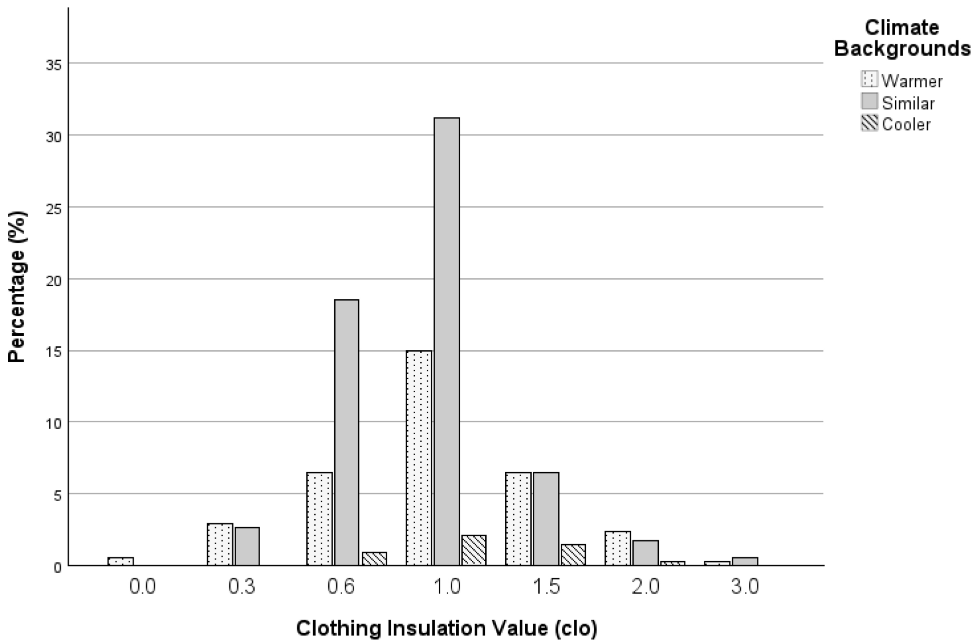

Figure 11. Percentage of clothing insulation value by climate background.

Statistical Tests

To see whether a participant's climate background affected thermal perception, the Kruskal–Wallis test and its post hoc test, pairwise comparison analysis, were performed using the IBM® SPSS® program [51]. In addition, regression analysis was performed to understand the relationship between indoor temperature and thermal perception according to climate background.

From the Kruskal–Wallis statistical test (Table 3), there was a strong relationship between the participants' climate backgrounds and their thermal sensations and preferences. Conversely, there was no significant relationship between the climate background of the participants and their thermal comfort and clothing level.

Table 3. Kruskal–Wallis nonparametric test summary.

Hypothesis Test Summary				
	Null Hypothesis	**Test**	**Sig.** [a,b]	**Decision**
1	The distribution of Thermal Sensation is the same across the Köppen Climate categories.	Independent-Samples Kruskal–Wallis Test	0.002	Reject the null hypothesis.
2	The distribution of Thermal Preference is the same across Köppen Climate categories.	Independent-Samples Kruskal–Wallis Test	0.004	Reject the null hypothesis.
3	The distribution of Overall Comfort is the same across Köppen Climate categories.	Independent-Samples Kruskal–Wallis Test	0.553	Retain the null hypothesis.
4	The distribution of Clothing is the same across Köppen Climate categories	Independent-Samples Kruskal–Wallis Test	0.053	Retain the null hypothesis.

[a] The significance level is 0.050. [b] Asymptotic significance is displayed.

Table 4 shows the results of the pairwise comparison analysis of climate backgrounds, conducted separately for thermal sensation, thermal preference, thermal comfort and the clothing insulation value. In this post-hoc test, which was performed to confirm the Kruskal–Wallis test result, only thermal sensation and thermal preference had a statistically significant relationship with climate background, as in the Kruskal–Wallis test. Thermal sensation and preference results revealed that the statistical difference was only between participants from warmer and similar climate backgrounds. It is not possible to identify a relationship between people from a cooler climate background and those in other climate groups as the number of people from cooler climate regions was significantly less.

To understand the relationship between temperature, thermal sensation and thermal preference, linear regression analysis was performed separately for each climate background group. Table 5 was created from this analysis. Since the 7-point scale system was used in the survey results, numbered from 1 to 7, the neutral value was 4. When the thermal sensation (TSV) and preference (TPV) value were 4 (neutral), the indoor temperature (Ti) was calculated and added to the last column in the table according to the equations in Table 5. The temperatures values calculated for the three climate groups were very similar. The indoor temperature required for participants to feel comfortable/neutral was calculated as between 21.2 °C and 21.6 °C.

Although the R-square value was low, the P value showed that there was a strong relationship between the variables. In similar studies showing the relationship between temperature and thermal preference, the R-square value was also found to be low [46,55]. This may be due to the inter-correlation between two variables [55].

Table 4. Pairwise Comparisons of Climate Backgrounds.

Thermal Sensation across Climate Backgrounds					
Sample 1–Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig. [a]**
Warmer–Cooler	−9.363	25.327	−0.370	0.712	1.000
Warmer–Similar	−38.644	11.005	−3.511	<0.001	0.001
Cooler–Similar	29.281	24.639	1.188	0.235	0.704
Thermal Preference across Climate Backgrounds					
Sample 1–Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig. [a]**
Cooler–Similar	7.483	24.623	0.304	0.761	1.000
Cooler–Warmer	42.638	25.311	1.685	0.092	0.276
Similar–Warmer	35.155	10.998	3.196	0.001	0.004
Overall Comfort across Climate Backgrounds					
Sample 1–Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig. [a]**
Warmer–Similar	−3.855	11.193	−0.344	0.731	1.000
Warmer–Cooler	−28.020	25.760	−1.088	0.277	0.830
Similar–Cooler	−24.166	25.060	−0.964	0.335	1.000
Clothing Insulation Value (clo) across Climate Backgrounds					
Sample 1–Sample 2	**Test Statistic**	**Std. Error**	**Std. Test Statistic**	**Sig.**	**Adj. Sig. [a]**
Similar–Warmer	17.627	10.607	1.662	0.097	0.290
Similar–Cooler	−47.565	23.747	−2.003	0.045	0.136
Warmer–Cooler	−29.938	24.411	−1.226	0.220	0.660

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. Asymptotic significances (2-sided tests) are displayed. The significance level is 0.050. [a] Significance values have been adjusted by the Bonferroni correction for multiple tests.

Table 5. Equations from regression analysis.

Climate Background	**Equations**	**R-Square**	**Sig. *p***	**Indoor Temperature Ti (°C) for TSV/TP = 4**
Warmer	TSV = −3.89 + 0.37 Ti	0.117	<0.001	21.32
	TP = 11.36 − 0.34 Ti	0.083	0.002	21.64
Similar	TSV = −6.39 + 0.49 Ti	0.139	<0.001	21.20
	TP = 15.65 − 0.54 Ti	0.179	<0.001	21.57
Cooler	TSV = −8.03 + 0.56 Ti	0.268	0.040	21.48
	TP = 18.51 − 0.68 Ti	0.457	0.004	21.33

4. Discussion

The environmental values recommended in the standards established for thermal comfort vary depending on building types. In these standards, the recommended values especially for educational buildings have been examined. While ASHRAE Standard 55 [10] does not specify specific values for building types, ISO 7730 [11], CEN Standard EN 15251 [56] and CIBSE Guide A [20] have separate values for educational buildings. However, these values are collected under the title of classrooms or lecture halls, and no level difference is included. In this case, the same comfort values are recommended for classrooms containing primary school students and university students of different ages and metabolic levels. Considering the length of time university students use classrooms, their adaptation methods, and the fact that they have more freedom, these recommended comfort values should be re-examined.

Although the main purpose of heating and cooling systems being controlled from a central university facility is to keep each educational building within the temperature range specified in standards such as CIBSE Guide A, this is not always possible. The measurements made in this study revealed some indoor temperatures in lecture theatres that were not within the CIBSE comfort limits. The average indoor temperatures during the lectures only met the comfort range specified in the CIBSE Guide A [20] in Rendall Building LT2. The indoor temperatures of the other lecture theatres were above the comfort range. However, the ambient temperature in Rendall Building LT2, which was 18 °C when students first came to the lecture, rose above 21 °C during the lecture, increasing by about 3 °C. In fact, this showed that the heating and ventilation systems did not keep the indoor temperature within the comfort range but, rather, it was the body heat generated by the students that warmed the environment, allowing the indoor temperature to reach the comfort range. Another example of this situation was the measurements made in the Eleanor Rathbone LT on two different days. In the first measurement, the lecture started at 9.00 am and it was the first lecture of the day, but the second measurement was made at 3.00 pm after there had been other lectures in the lecture theatre. Considering the results of the measurements in Figure 7, the indoor temperature had increased from 21 °C to about 22.5 °C in the first measurement, but in the second measurement, the indoor temperature did not change throughout the lecture and remained at 23 °C. This showed that the central heating and cooling system did not work as it should and could not keep the indoor temperature of the lecture theatres within the comfort range.

A study by Ji et al. [57] investigating how short-term thermal memory affects the thermal perception of students found that participants preferred to be at a lower temperature than the neutral temperature. However, together with previous studies, this study has revealed that students' long-term thermal memories affect their thermal preferences. While the indoor temperature was considered neutral by most of the participants from a warmer climate background, it was rated as warm by most participants from a similar or cooler climate background. However, when their thermal preferences were considered, it was seen that most participants from a warmer climate background wanted to feel warmer, most participants with a similar climate background wanted to feel cooler and the majority of those with a cooler climate background wanted the indoor temperature to remain similar. Previous studies found that people living in the UK from a warmer climate background wanted the indoor temperature to be higher [18,19]. The reason for the variation in people's ambient thermal preferences may be revealed by Jowkar et al. [19]. They found that the comfort temperature for people from a warmer climate background was 24 °C. Since the average temperature in lecture theatres in this study was found to be about 21 °C, this might explain why participants from a warmer climate background wanted to feel warmer. Although the regression analysis showed that the comfort temperature for most participants was between 21.2 °C and 21.6 °C, Humphreys and Hancock [58] noted that while the value chosen on the thermal sensation scale indicates thermal satisfaction for some participants, it may mean discomfort for others. The study by Singh et al. [59] showed that, while students whose thermal sensation was on the cold side of the scale felt more comfortable, it was observed that the conditions of the country where the study was conducted and the climatic background of the people where the study was conducted may affect this result. Since the word 'comfort' is subjective, it can be evaluated by students in a broader sense, not just in terms of thermal environment.

From the statistical tests, it was determined that there was a significant difference between the participants from a warmer climate background and the participants from a similar climate background. There were insignificant statistical differences between the participants from the cooler climate background and the other two groups. Jowkar et al. [19] observed that there was a statistically significant difference between people from a cooler climate background and people from a warmer climate background. Therefore, the main reason for the difference in the statistical results may be related to the fact that the number of participants from the cooler climate background was much lower than that of the other groups.

5. Conclusions

This study examined whether a student's climate background influences their thermal perceptions. Lecture theatres in three different buildings of Liverpool University were used, and the study ran on four different days in October 2022. The methodology involved environmental measurements and surveys, and 340 people participated in the study. The participants were divided into three main groups according to their climate background. As a result of the analysis, the following results were obtained:

- The comfort temperature in the winter months recommended for lecture theatres in the CIBSE Guide A [20] is 19–21 °C. However, the results of this study's measurements showed that only one of the lecture theatres, which had natural ventilation as well as the mechanical system, was in this temperature range, and that the mean temperatures of the other two lecture theatres without natural ventilation were above 21 °C. In this situation, it was seen that the users used natural ventilation systems to keep the indoor temperature at the comfort level.
- The percentage of users who evaluated the indoor temperature as neutral or slightly warm and who wanted the environment to remain the same or to be slightly warmer was high. Although most people with a cooler and similar climate background evaluated the environment as slightly warm, their thermal preferences indicated that the majority wanted the environment to remain the same.
- The clothing insulation value of the majority of the users was 1.0 clo, which is also the winter clothing insulation value used in CIBSE Guide A [20]. However, the clothing level of the users from the cooler climate background was higher than that of the other two groups.
- Based on non-parametric statistical analysis, the climate backgrounds of the participants affected their thermal sensations and preferences but did not affect their thermal comfort and clothing levels. While the results of this study showed that the thermal sensation and thermal preferences of people with a warmer climate background and those with similar climate backgrounds were different, no statistical significance was found between the people in these two groups and the people from a cooler climate background.

It was clear that the climate backgrounds of the participants influenced their perception of the environment. However, since lecture theatres are places where users have restricted freedom of movement, further studies may be required to examine whether users are able to adapt to environmental conditions in more free-running spaces where they have more freedom to change location or activity level.

Other factors that may affect thermal perception, such as smoking and drinking alcohol, and cultural differences other than clothing levels, as well as factors that may affect thermal comfort conditions, such as building materials and building orientation, were not considered in this study.

This study shows that it may be appropriate for lecture theatres with significant numbers of students from warmer climate backgrounds to be kept at a temperature range that is warmer than that recommended by CIBSE. Users from a similar climate background to the UK may be able to adapt to these conditions by adjusting their clothing levels. The findings also suggest that as average outdoor temperatures increase with climate change, it may be appropriate to adjust temperature set points and ultimately thermal comfort standards to match a warming climate. This will reduce energy use for cooling, especially in institutional settings such as universities with large associated heat gains.

The limitation of this study is that the number of participants from the cooler climate background was lower than that of the other two groups. This may have affected the finding of the statistically significant results between the students from the cooler climate background and the other two climate background groups.

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