Łukasz J. Orman, Janusz Wojtkowiak
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# CASE STUDY OF THERMAL COMFORT, LIGHTING CONDITIONS AND PRODUCTIVITY AT TWO CLASSROOMS OF POZNAŃ UNIVERSITY OF TECHNOLOGY

# STUDIUM PRZYPADKU KOMFORTU CIEPLNEGO, OŚWIETLENIA I PRODUKTYWNOŚCI W DWÓCH SALACH DYDAKTYCZNYCH POLITECHNIKI POZNAŃSKIEJ

Łukasz J. Orman*
Kielce University of Technology, Poland
Janusz Wojtkowiak
Poznań University of Technology, Poland

**Abstract**

*The paper analyses subjective sensations of thermal comfort, lighting conditions and self-reported productivity of 51 students of Poznań Univeristy of Technology (Poland). The study took place in the spring and was based on the use of anonymous questionnaires with questions on thermal sensations, acceptability and preferences as well as the students' assessment of their current productivity and lighting conditions. The test results indicate that the overwhelming majority was satisfied with thermal environment and lighting conditions in the rooms. Their general sensations were also largely positive, while self – reported productivity was generally assessed to be normal.*

**Keywords:** thermal comfort, lighting conditions, productivity

**Streszczenie**

*Artykuł analizuje subiektywne odczucia komfortu cieplnego, warunków oświetleniowych oraz produktywności 51 studentów Politechniki Poznańskiej. Badanie odbyło się wiosną i opierało się na wykorzystaniu anonimowych kwestionariuszy z pytaniami o odczucia cieplne, akceptowalność i preferencje oraz ocenę przez studentów aktualnej produktywności i warunków oświetleniowych. Wyniki badań wskazują, że zdecydowana większość była zadowolona z warunków termicznych i oświetlenia w pomieszczeniach. Ich ogólne odczucia były również w dużej mierze pozytywne, podczas gdy produktywność została ogólnie oceniona jako normalna.*

**Słowa kluczowe:** komfort cieplny, warunki oświetleniowe, produktywność

## 1. INTRODUCTION

Indoor environment plays an important role in ensuring high level of comfort for living, working and studying. People's expectations regarding air quality and proper thermal sensations at homes, offices and public utility buildings are growing and building managers need be aware of the fact that the human's subjective feelings need to be addressed in terms of providing adequate indoor environment.

Thermal comfort has attracted a lot of attention in recent decades and it now an important element of civil and environmental engineering. Aghniaey et

*Kielce University of Technology, Poland, e-mail: orman@tu.kielce.pl

al. [1] studied thermal comfort in eleven classrooms at the University of Georgia campus in the United States. There were 18 to 54 students in each room. The operative temperature ranged from 21°C to 27°C. The authors claimed that the thermal environment in the considered classrooms proved to be overwhelmingly acceptable. Operative temperature of about 23.5°C was taken as optimal at the considered location. Dębska and Krakowiak [2] conducted tests of thermal comfort using the questionaires as well as a microclimate meter. Eighty three people participated in the study. The optimal air temperature was determined to be ca. 22.5°C. The number of the dissatisfied for one room was quite significant (exceeding 50%) due to high air temperature of 27.6°C. The respondents generally considered humidity as fine or quite dry. The value of relative humidity in all the rooms was measured to be about 52%. Thermal comfort tests in the smart laboratory building located in Slovakia were presented by Kolkova et al. [3]. The authors considered the impact of two positions of the window blinds on employees' sensations. It was stated that the optimum temperature was not exceeded during the measurements. Kuchen and Fisch [4] conducted tests in twenty five office buildings in Germany in winter conditions. The total number of measurements amounted to 345. The value of the most preferred operative temperature varied from 21°C to 22°C.

The analysis of subjective productivity of Polish students was presented by Krawczyk [5]. The tests were done in the intelligent building of Kielce University of Technology (Poland). Over 80% of the respondents assessed their productivity as normal, while over 10% as weak. The study performed in the same building by Dębska and Białek [6] indicate that about 80% of the respondents considered lighting conditions there as suitable (followed by a "too weak" response from 15% of the people). The authors claimed that the actual satisfaction with lighting in the subjective opinion of the students started from the illuminance value of 430 lx.

It needs to be added that one of the problems related to the indoor environment is the occurrence of the sick building syndrome (SBS). Lis [7] presented an extensive study on the SBS symptoms observed in pre-school, school and flats of multi-family buildings. The volunteers complained mainly about the poor air quality ($CO_2$ concentration was over 1000 ppm in educational buildings) together with eyes irritation, headaches, respiratory tract as well as fatigue. It shows how important proper indoor environment is for human health and well – being. Moreover, Basińska et al. [8] analysed the use of portable devices in the Polish primary school building with the aim to assess the effectiveness of air purification device used in the experiments. The authors also considered indoor air quality taking into account microbiological contaminantion and particulate matter concentration.

The paper focuses on the subjective assessments of over fifty students regarding the indoor environment at two selected classrooms of Poznań University of Technology. The tests have been conducted with anonymous questionaires, so that the subjective sensations of each person could be collected and analysed.

## 2. MATERIAL AND METHOD

The study was aimed at determining the subjective sensations of 51 students expressed in the anonymous questionnaires during the classes. The measurements were performed in two separate buildings of the campus. One is a modern, recently developed building located in the Western side of the campus, while the other is a traditional building, a few decades old. Both are situated about three hundred meters from each other. Two rooms (each in a different building) were selected for the analysis: "room 1" with 30 students and "room 2" with 21 students. An example classroom/lecture room of Poznań University of Technology has been shown in Figure 1.

*Fig. 1. Example classroom/lecture room of Poznań University of Technology*

In total 27 women (53%) and 24 men (47%) took part in the study. Their age ranged from 19 to 24 y.o. The assessment was conducted on the same day. There were six questions in the questionnaire with a set of answers for each of them to choose from. The students ticked the appropriate box, if they felt that the answer, which they chose, properly described their sensations. The tests lasted about 5 minutes and the volunteers found the questions easy to answer. The first survey took place in the morning (about 9.15), while the second in the afternoon (about 13.40) during the regular classes. The students' clothes were "typical summer" with the clothing thermal insulation of ca. 0.6 clo. The room temperature in both the classrooms was comparable. The students were seated in about 2/3 of the classroom 1 and quite evenly in room 2.

## 3. RESULTS AND DISCUSSION

The first question aimed to determine the student's opinion on their thermal sensations at that moment. They expressed their opinions of the indoor thermal environment ranging from "too hot" (+3), through "hot" (+2), "warm" (+1) and neutral (0) to the negative values down to (–3), which meant "too cold". Figure 2 presents the results of the study as a frequency count of the answers for both rooms.

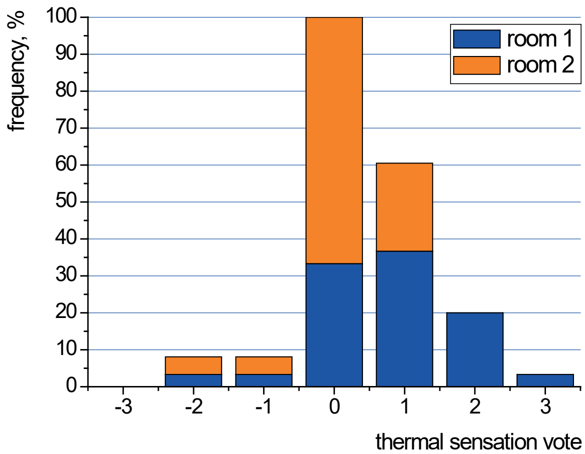


*Fig. 2. Thermal sensation vote for two rooms*

As can be seen the largest share of the answers was in the range 0 – 1, which indicates an overall positive assessment of the thermal environment. In room 1 twenty percent of the respondents considered the conditions as hot and 3.3% (one person) as too hot. It shows how subjective thermal environment might be (the conditions for all the students in each room were comparable e.g. none of them was subject to some excessive sources of heat and etc.). It needs to be added that the next question – on acceptability of the indoor conditions – proved that the respondents were almost completely (98%) in favour of the air temperature values in the rooms with 49% of the students considering it to be "comfortable" and 49% as "acceptable".

The next Figure 3 presents the students' willingness to change the state in the rooms regarding temperature. They might have opted for "much warmer" (+2) through "no change" (0) to much cooler (–2) environments.

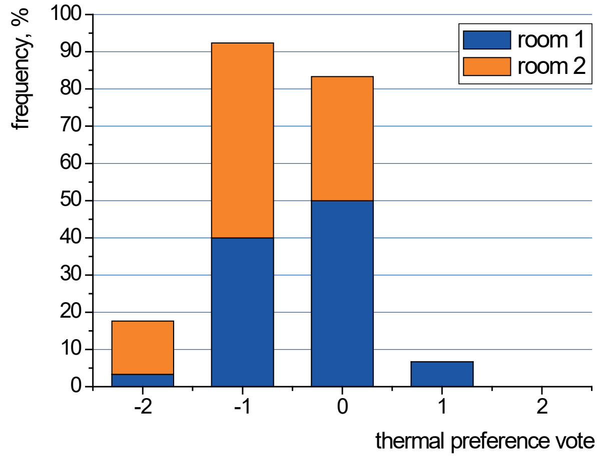


*Fig. 3. Thermal preference vote for two rooms*

Half of the students in room 1 did not want any change to their thermal environment, while quite many (40%) wanted to reduce the air temperature. A temperature reduction vote was very strong in room 2 (although the majority of the respondents felt fine there as shown in Fig. 2). It might be related to individual preferences of the students or the influence of other factors, not considered in this study (such as health, past activities before entering the class e.g. running). Typically the respondents would like to see a temperature reduction in the warm environment and the opposite would be true for cold environments. The relation of the mean values of random five answer pairs on thermal sensation and preference has been presented below in Figure 4 and it supports the above mentioned statement.

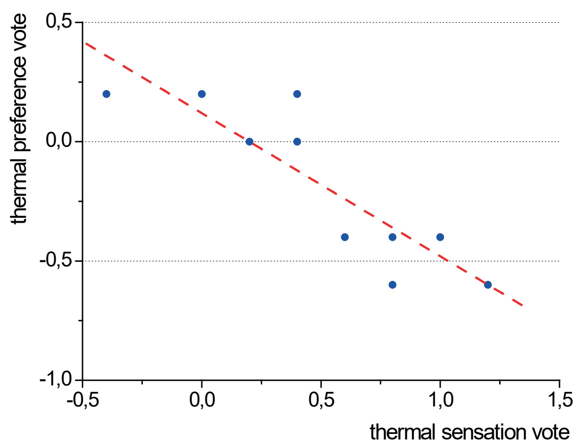


*Fig. 4. Thermal preference vote (TPV) vs. thermal sensation vote (TSV) for both rooms*

The obtained correlation takes the form of TPV = -0.6TSV+0.12 with the $R^2$ value of 0.76.

The students were also asked to assess the lighting conditions in the classrooms. Naturally, the level of illuminance is easily regulated and for classrooms should meet the requirements of adequate standards. However, in this study only a subjective assessment has been conducted. The results have been presented in Figure 5. The largest majority of the respondents considered the conditions as acceptable (0), only some thought the it was too strong (+1) or too weak (–1) – this answer was provided by almost 24% of the students in room 2. This might be related to both individual preferences as well as the location of the students in the room.

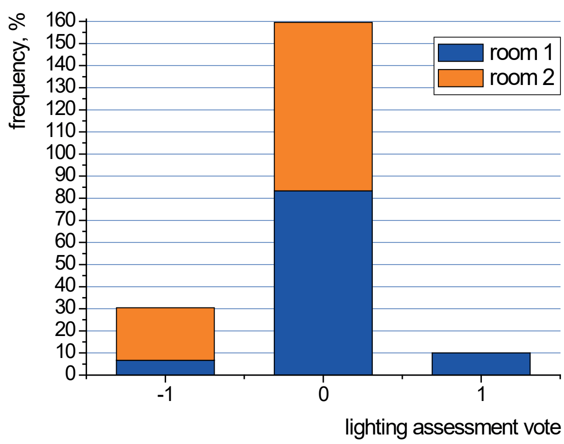


*Fig. 5. Assessment of lighting conditions for two rooms*

The students who participated in the study were also asked about their learning potential due to the fact that the indoor environment might have a significant impact on productivity (apart from other factors such as health, outside noise and etc.). The possible answers on self – reported productivity were: normal (0), high (+1) and weak (–1). The results of the investigation has been shown in Figure 6 for both the rooms separately.

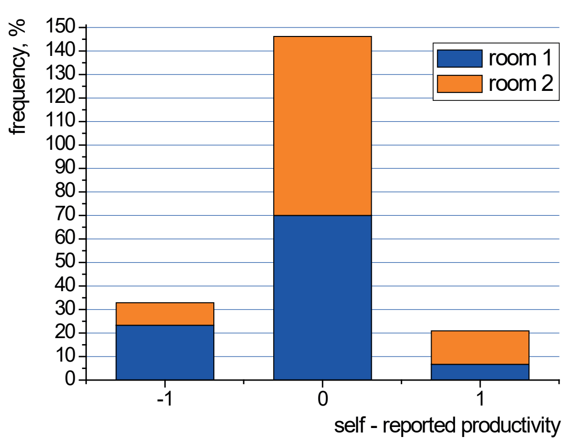


*Fig. 6. Self – reported productivity for two rooms*

The largest group of students in both rooms considered their productivity (learning potential) as normal. Some (especially in room 2) thought that it was higher than normal, while some (especially in room 1) regarded it to be weak. Obviously, there might be many reasons influencing the result, for example the timing of the measurements (morning/afternoon), personal issues (e.g. hunger, tiredness, illness) and others not necessarily related to the surrounding environment.

The last question in the questionnaire dealt with a general feeling of the respondents, namely how they felt in the rooms. The possible answers ranged from "very well" (+2), through "neutral" (0) to "very bad" (–2). Again, this subjective assessment is only partly related to the indoor conditions and other factors might play a decisive role (such as the state of health, personal problems and etc.). The results of the study have been presented in Figure 7.

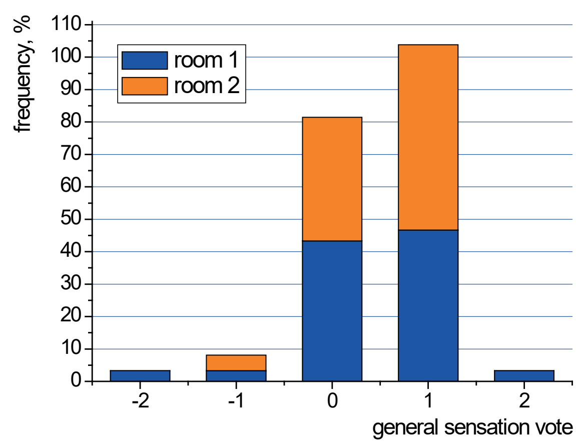


*Fig. 7. General sensations of the students in two rooms*

Data presented in Figure 7 reveals that the overwhelming majority of the students considered their state to be either well or neutral. It is worth noting that in room 1 one person felt "very well" and also one felt "very bad". Such "extreme" cases can occur especially in a large group and might not be linked with the indoor conditions prevailing in the closed space.

The general sensations experienced by a person might influence his/her productivity. When people feel well, their learning potential can be improved. Figure 8 presents the data of self – reported productivity vs. general sensation vote for 51 students (the largest dot on the graph represents 19 identical responses, while the smallest dots – one response) together with the linear fitting.

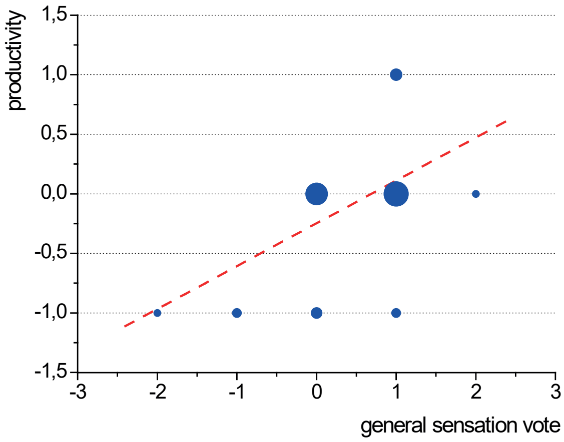


*Fig. 8. Self – reported productivity (P) vs. general sensation vote (GSV) for both rooms*

The analysis of the figure leads to a conclusion that a relation might exist between the person's self – reported productivity and subjective general sensation vote. The number of people participating in the study was limited to only 51 people. Consequently, drawing more general conclusions on this issue might be difficult. The resulting correlation took the formula of P = 0.36GSV-0.25 with the $R^2$ value of only 0.23.

## 4. SUMMARY AND CONCLUSIONS

The conditions of indoor environment considerable influence people's sensations and their well – being. One of the most important aspects is providing and maintaining thermal comfort. The study analysed the subjective assessment of fifty one students. It was found that the overwhelming majority was satisfied with their thermal environment as well as lighting conditions in the considered two classrooms. Their general sensations were also largely positive, while self – reported productivity was generally assessed to be "normal" (ca. 70% of such a response in each group). Broadening the experimental database might provide more insight into the nature of subjective human sensations in various indoor environments.

## REFERENCES

[1] Aghniaey S., Lawrence T.W., Sharpton T.N., Douglass S.P., Oliver T., Sutter M., *Thermal comfort evaluation in campus classrooms during room temperature adjustment corresponding to demand response*. Building and Environment, 148, 488-497, 2019.

[2] Dębska L., Krakowiak J., *Thermal environment assessment in selected Polish educational buildings*, E3S Web of Conferences, 246, 15004, 2021.

[3] Kolková Z., Hrabovský P., Florková Z., Lenhard R., *Analysis of ensuring thermal comfort using an intelligent control system*, MATEC Web of Conferences 328, 03017, 2020.

[4] Kuchen E., Fisch M.N., Spot Monitoring: *Thermal comfort evaluation in 25 office buildings in winter*, Building and Environment, 44, 839-847, 2009.

[5] Krawczyk N., *Assessment of productivity in different thermal working environments*, Proc. of Int. Symp. on Occupational Health and Safety SESAM 2021, Matec Web of Conferences, vol. 354, 2021.

[6] Dębska L., Białek A., *Lighting conditions as the occupational health related issue – case study*, Proc. of Int. Symp. on Occupational Health and Safety SESAM 2021, Matec Web of Conferences, vol. 354, 2021.

[7] Lis A., *Sick building syndrome as a result of poor indoor air quality in educational and residential buildings*, Zeszyty Naukowe Politechniki Częstochowskiej, 27, 2021, pp. 141-151.

[8] Basińska M., Ratajczak K., Michałkiewicz M., *Effect of air purifier use in the classrooms on indoor air quality – case study*, Atmosphere, 12(12), 1606, 2021.

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