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Perception of air quality in the selected classroom

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Abstract: This work is focused on monitoring the perception of indoor environment quality in the classroom. The research was carried out within the framework of the authors' internship at the Lviv Polytechnic in Ukraine in March 2019. The experimental measurements were carried out in the selected teaching class. In this article, there are presented the results of measurements, that were carried over three teaching hours with varying numbers of students. The measurements recorded by the means of measurement devices were: the air temperature, the relative humidity and the concentration of carbon dioxide in the interior of the classroom. At the same time as the objective measurements, a subjective evaluation was conducted. At the beginning and at the end of the lesson, the students and teacher completed the questionnaires about their perception of the internal environment. The results of the subjective assessment were compared with the measured values of the objective evaluation. Completion of the research is oriented on the perception of temperature and smell in the classroom, as well as overall satisfaction with the internal environment of the selected room.

Keywords: carbon dioxide, temperature, ventilation, questionnaire

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Introduction

Schools are a category of buildings in which a high level of environmental quality can considerably improve the occupants' attention, concentration, learning,

hearing and performances. In work (Corgnati et al., 2007) thermal, acoustic, visual and air quality aspects were analyzed in classrooms at different high schools within the Provincia di Torino and four typical medium-sized university classrooms of the Politecnico di Torino, Italy. In research (Almeida et al., 2016) data was collected regarding educational spaces. A mixed-methods thermal comfort study in a classroom of Eindhoven University of Technology (Mishra et al., 2017) was conducted to provide a better understanding of the thermal perception of students as they move into and adapt to their classroom environment. The paper (Puteh et al., 2012) exposes some aspects of the debate in the field of thermal comfort in naturally ventilated buildings located in warm and humid climates. A field study (Katafygiotou & Serghides, 2014) was conducted in a secondary school building in Cyprus, to assess the indoor thermal conditions during the students' lesson hours. An overview of thermal comfort field surveys (Zomorodian et al., 2016) in educational buildings over the last five decades are reviewed in two sections; the first covering the field study methodologies including the objective and subjective surveys, and the second reviewing study results based on the climate zone, educational stage, and the applied thermal comfort approach. Kapalo et al. (2019) carried out measurements of indoor air temperature, relative humidity and CO_2 concentrations as well as determined CO_2 production by students and teacher during various physical activities. Results of objective measurements confirmed a strong correlation between CO_2 concentration occupancy for all measurements. The results of this study showed insufficient ventilation intensity in classrooms as well as an obvious rise of CO_2 concentration during exams. The highest increase of CO_2 was recorded during harder physical activity (running on the spot, squats, right and left side lunges, and rotating of the hips). Regarding CO_2 production by the respondents, it can be seen that it visibly increased with increasing physical activity.

The work (Adamski, 2014) contains an overview of the results of indoor air quality tests in Poland. Teleszewski and Gładyszewska-Fiedoruk (2018) present a simplified model of CO_2 concentration in classrooms equipped with stack ventilation systems, based on experimental research. The test was conducted in six classrooms in the building of the Faculty of Civil and Environmental Engineering of the Białystok University of Technology in north-east Poland. In all classrooms, a linear increase in the CO_2 concentration during the classes was observed. According to Krawczyk et al. (2016) in the school buildings located in two different climates: Białystok (Poland) and Belmez/Córdoba (Spain) the CO_2 concentration in first 45 minutes met require-ments of regulations, but with medium occupation of places in classrooms.

Kapalo et al. (2020) probably first presented the results of CO_2 concentration measurements in a classroom in Ukraine. This work shows some of the results of a field study about the perception of air quality in the selected classroom in a high school in Ukraine.

1. Materials and methods

The research was carried out within the framework of the authors' internship at the Lvov Polytechnic in Ukraine in March 2019. For the experimental measurements, a north-facing classroom was selected so as the sun would not influence measurements during the day. The measurements were realized in three stages - over the following lessons, among which there were breaks. For every measurement, there was another group of students in the classroom. The classroom was ventilated during the break. The measurements that were recorded, by means of measurement devices, were the air temperature, the relative humidity and the concentration of carbon dioxide in the interior of the classroom. At the same time, during the objective measurements, the subjective evaluation was carried out. At the beginning and at the end of the lesson, every student and teacher who were in the room completed a questionnaire about their perception of the internal environment. The results of the subjective assessment were compared with the measured values of objective evaluation. Completion of the research was oriented on the perception of temperature and smell in the classroom as well as overall satisfaction with the internal environment of the selected classroom.

2. Characteristics of the experimental room

The experimental room was located on the fourth floor of the Lviv Polytechnic building. The photo from the interior of the classroom is shown in Figure 1. The size of the room is length: 5.90 m, width: 6.30 m and height: 3.30 m. The volume of the room is 122.7 m^3 and the floor area is 37.2 m^2. In the classroom were 5 persons during the first lesson, 16 persons during the second lesson and 10 persons during the third lesson.

Fig. 1. The interior of classroom (*own study*)

3. The measuring devices

A temperature and relative humidity sensor S3541 and carbon dioxide concentration sensor C-AQ-0001R were used for the measurement of indoor air temperature, indoor relative humidity, and concentration of carbon dioxide.

The technical parameters of the sensors are given in Table 1.

Table 1. Technical parameters of sensors (*own study*)

Parameter	Range of measurements	Unit
CO_2 concentration	0-5000	[ppm]
Accuracy of CO_2 concentration measurement	±75	[ppm]
Effect of temperature	±0.5	% ppm to 1°C
Temperature measuring range operating temperature range	0-+50	[°C]
Temperature measurement accuracy	±0.8	[°C]
Permitted transport temperature	–25-+70	[°C]
Relative humidity	10-95; non-condensing	[%]

4. Results and discussions

The measured indoor air temperature, relative air humidity, and carbon dioxide concentration are documented in Figure 2.

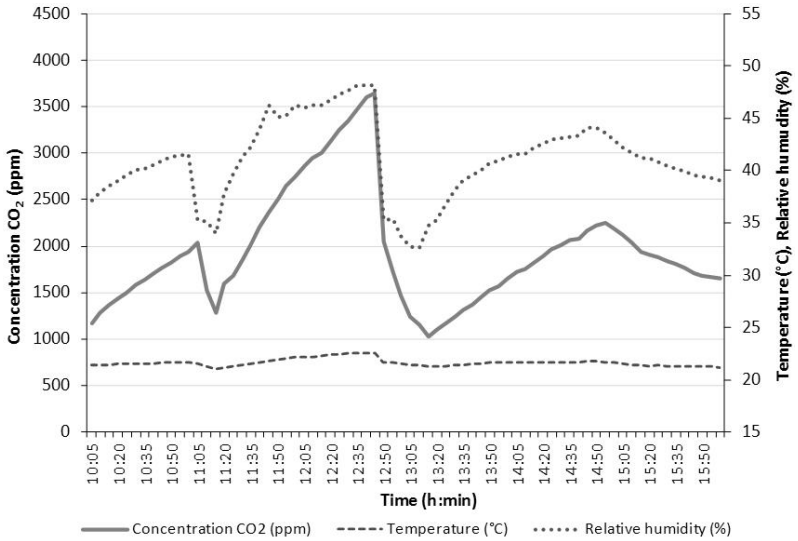

Fig. 2. Measured data of indoor air in the classroom (*own study*)

Based on the measured parameters of the indoor air, it can be seen that the carbon dioxide concentration was in the range of 1,024 ppm to 3,649 ppm, which is too large a value. The relative humidity was in the range of 32.6 to 48.1%.

To better illustrate the course of the air temperatures, Figure 3 was created, where it can be seen that the course of the air temperature is similar to that of the CO_2 concentration.

The indoor air temperature was in the range of 21.0 to 22.6°C.

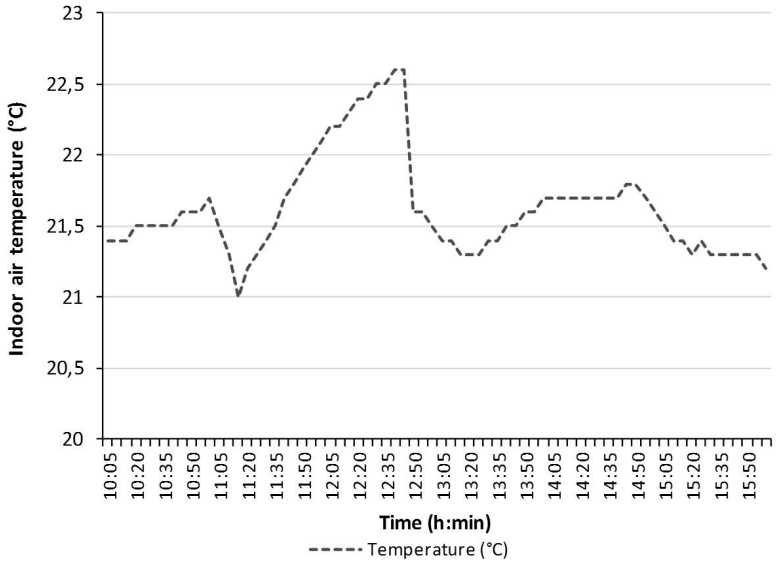

Fig. 3. The measured indoor air temperature in the classroom (*own study*)

At the beginning of each lesson and at the end of the lesson, all persons present in the classroom completed a questionnaire, in which they commented on their perception of the temperature and odor in the room. In the second lesson 16 people filled in the questionnaire after being present in the room during the experimental measurement. The evaluation results from the second lesson are documented in Figures 4-6.

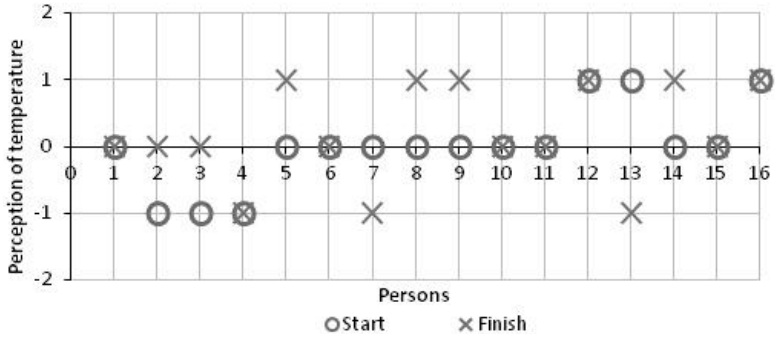

Fig. 4. Perception of the indoor temperature of the air in the classroom (*own study*)

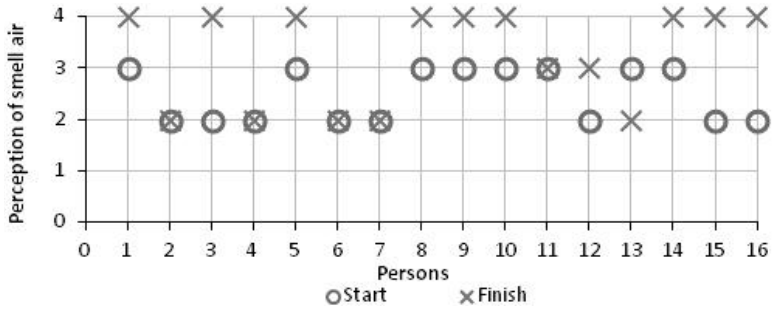

Fig. 5. Perception of the smell of the air in the classroom (*own study*)

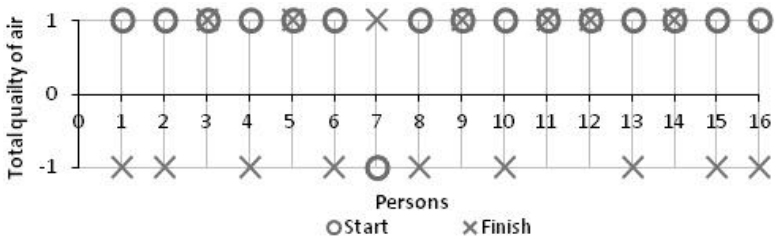

Fig. 6. Perception of the total quality of the indoor air in the classroom (*own study*)

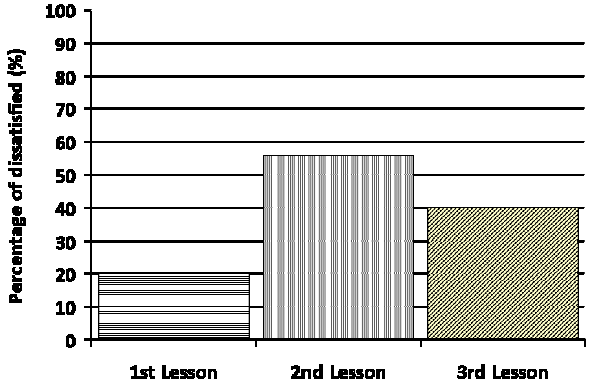

Fig. 7. Percentage of dissatisfaction with the total quality of indoor air in the classroom (*own study*)

Figure 4 shows the perception the people had of the air temperature in the room at the beginning and end of the second lesson. Levels of indoor air temperature in Figure 4 are: –2 is cool; –1 is moderate cool; 0 is acceptable; +1 is moderately hot and 2 is hot. Figure 5 shows the perception the people had about the odor in the air at the beginning and the end of the second lesson. Levels of indoor air odor in Figure 5 are: 1 is fresh air; 2 is acceptable; 3 is a moderate smell and 4 is an unfresh smell. Figure 6 shows the people's perception of total air quality in the room at the start and end of the second lesson. Levels of total indoor air quality in Figure 5 are: –1 is unsuitable and +1 is suitable. From Figure 3 it can be stated, that during the second lesson the indoor air temperature increased from 21.0 to 22.6°C; a tempera-

ture increase of approximately 8%. Figure 4 shows that 37% of people perceived the temperature increase. Figure 2 shows that the CO_2 concentration increased from 1.024 ppm to 3.649 ppm, an increase of approximately 184%. Figure 5 shows that 62% of people perceived the increase in odor. It can be seen from Figure 6 that 56% of people perceived the overall worsening of air quality in the classroom.

The people during the other lessons also reacted similarly. The overall room air quality rating for all three lessons are documented in Figure 7.

Conclusions

Based on the objective evaluation documented in Figures 2 and 3 and on the subjective evaluation documented in Figures 4 to 7, it can be stated, that the people in the classroom responded appropriately to the total air quality in accordance with the measured parameters of the indoor air during the lessons.

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Bibliography

Adamski, M. (2014) *Pomiary stężenia CO_2 w pomieszczeniu mieszkalnym w zabudowie jednorodzinnej*. Rynek Energii, 4, 70-74.

Almeida, R.M.S.F., Ramos, N.M.M. & de Freitas, V.P. (2016) *Thermal comfort models and pupils' perception in free-runningschool buildings of a mild climate country*. Energy and Buildings 111, 64-75.

Corgnati, P.S., Filippi, M. & Viazzo, S. (2007) *Perception of the thermal environment in high school and university classrooms: Subjective preferences and thermal comfort*. Building and Environment 42, 951-959.

Kapalo, P., Klymenko, H., Zhelykh, V. & Adamski, M. (2020) *Investigation of Indoor Air Quality in the Selected Ukraine Classroom - Case Study*. https://doi.org/10.1007/978-3-030-27011-7_21 (19.09.2019).

Kapalo, P., Meciarova, L., Vilcekova, S., Burdova, E.K., Domnita, F., Bacotiu, C. & Peterfi, K.E. (2019) *Investigation of CO_2 production depending on physical activity of students*. Int. J. Environ. Health Res. 29(1), 31-44, https://doi.org/10.1080/09603123.2018.1506570.

Katafygiotou, M.C. & Serghides, D.K. (2014) *Thermal comfort of a typical secondary school building in Cyprus*. Sustainable Cities and Society 13, 303-312.

Krawczyk, D.A., Rodero, A., Gładyszewska-Fiedoruk, K. & Gajewski, A. (2016) *CO_2 concentration in naturally ventilated classrooms located in different climates - measurements and simulations*. Energy Build. 129, 491-498.

Mishra, A.K., Derks, M.T.H., Kooi, L., Loomans, M.G.L.C. & Kort, H.S.M. (2017) *Analysing thermal comfort perception of students through the class hour, during heating season, in a university classroom*. Building and Environment, 125, 464-474.

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

Teleszewski, T. & Gładyszewska-Fiedoruk, K. (2018) *Changes of carbon dioxide concentration in classrooms - simplified model and experimental verification*. Pol. J. Environ. Stud. 27(5), 2397-2403. https://doi.org/10.15244/pjoes/77074.

Zomorodian, Z.S., Tahsildoost, M. & Hafezi, M. (2016) *Thermal comfort in educational buildings: A review article*. Renewable and Sustainable Energy Reviews 59, 895-906.

Postrzeganie jakości powietrza w wybranej klasie

Streszczenie: Praca dotyczy monitorowania postrzegania jakości środowiska wewnętrznego w sali dydaktycznej. Badania przeprowadzono w ramach stażu na Politechnice Lwowskiej na Ukrainie w marcu 2019 r. Pomiary eksperymentalne przeprowadzono w wybranej sali dydaktycznej Politechniki Lwowskiej. W artykule przedstawiono wyniki pomiarów, które zostały przeprowadzone w ciągu trzech godzin dydaktycznych z różną liczbą studentów. Rejestrowane za pomocą urządzeń parametry to: temperatura powietrza, wilgotność względna i stężenie dwutlenku węgla we wnętrzu sali. Równolegle z pomiarami przeprowadzono subiektywną ocenę środowiska. Na początku i na końcu zajęć studenci i nauczyciele wypełnili kwestionariusze dotyczące postrzegania otaczającego środowiska. Wyniki subiektywnej oceny środowiska dokonanej przez studentów porównano ze zmierzonymi wartościami parametrów. Wnioski dotyczą odczuwania temperatury i zapachu w klasie, a także ogólnej satysfakcji z wewnętrznego środowiska wybranego pomieszczenia.

Słowa kluczowe: dwutlenek węgla, temperatura, wentylacja, kwestionariusz