IMPACT OF WORKING ENVIRONMENT ON STUDENT LEARNING

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Abstract: Optimal working environment conditions contribute to people's well-being, whether at home or at work. The article deals with the determination of the objective values of selected factors of the working environment of students at the university during the lessons and their subjective evaluation of these factors before and during the lessons. Objective data on five factors of the working environment (temperature, relative humidity, noise, lighting, CO_2 content) were measured by measuring instruments. The results of the measurements were compared with the results of questionnaires 1 and 2. The survey showed that students are able to identify unsatisfactory classroom environments that have a negative impact on learners' learning and attention.

Keywords: working environment, objective values, subjective evaluation, questionnaire.

1 Introduction

The bioecological model of human development suggests that individual learning and the psychological functioning of students are influenced by several factors. Although not typical, the work environment can also be considered a context of human development (Evans, 2003, Hanuláková et al, 2019).

Poor organization of teaching or sub-optimal conditions in the work environment can impair the ability of individuals in the school, work or home environment to adequately process new information in a way that allows it to be retrieved and stored (Maxwell, 2010). The effects of working environment factors have been studied in relation to a wide range of human functions, including cognitive processes (e.g. Hygge, Knez, 2001) and mental health (Evans, 2003). The authors of these works mostly examine the influence of one factor on cognitive and psychological effects on students. Several factors of the working environment (e.g. temperature, lighting and noise) are rarely studied in the same study. Scientists focus only on one factor in the work environment, or on a combination of two environmental factors in an effort to isolate the impact of each component, and also develop and test the theory of processes that underlie the mechanism by which each element affects cognitive and psychological factors. (e.g. Sőrqvist, Stenfelt and Rőnnberg, 2012). Several of these studies have shown that, in listening-oriented tasks, a non-standard classroom environment may have an adverse effect on the education and performance of students, even in the test population with developed learning abilities (G. C. Marchand et al., 2014).

For this reason, we have decided to carry out a survey that will examine the impact of several factors of the working environment on students in their working environment - in the classroom.

2 Research objectives and methodology of the research

The survey was designed to address the following objectives:

1. To find out the objective state of factors of working environment of students.
2. To find out the students' subjective opinions on the monitored factors of the working environment.
3. To compare objective results of measurements with subjective statements of students.

In order to meet the objectives, an experiment was carried out, in which the students were trained in the information and communications technology classroom in the subject of Information and communication technologies and the monitored factors of the working environment of the students were measured during the lessons.

Based on previous research (Hygge, Knez, 2001) that individuals are able to detect negative factors of the working environment, we expected students to evaluate each of the monitored factors of the working environment more negatively than the objective values of individual factors.

Participants of the survey were university students of teaching study programs at the University of Constantine the Philosopher in Nitra. A total of 53 respondents participated in the survey. The survey was carried out in a classroom for information and communication technologies. The classroom made it possible to accurately measure and control several environmental factors (room temperature, outdoor temperature, air velocity, CO_2, lighting and noise). Room size was 7.5 meters and 5 meters. Students were taught from 8.00. to 14.30. continuously, with one lunch break at 11.30. 20 students took part in the lessons for the whole time which corresponds to the capacity of the classroom.

The measurement took place in a room located in the building of UKF in Nitra on the street Dražovská 4. The room is located on the second floor. The building is oriented in the north-south direction, with all the windows facing west. The room is designed for teaching subjects using computer technology. For this reason, it is equipped with 20 notebook computers and one Tower PC with a separate display unit. In addition, a projector is located on the ceiling and a box with the ads is located in the corner of the room. On each table there are two computers that students work with.

Objective data on five factors of the working environment (temperature, relative humidity, noise, lighting, CO_2 content) were measured by measuring instruments. Indoor temperature, CO_2 and noise sensors were placed in the middle of the room. The ambient temperature was controlled by a standard mercury thermometer. Illumination was measured at a network of selected checkpoints. The height of the reference plane was 0.85 m above the floor, the spacing between the measuring points was 0.5 to 2 m, and the distance of the edge points of the net was 1 m from the wall. The other checkpoints were spaced at regular distances at a density to provide a sufficient mapping of spatial progression, changes in illumination, and locations with the highest and least illumination intensity (Škvařil J., 2004, STN EN 12464-1: 2012).

The lighting in the classroom was measured with the Testo 545. The EXTECH® Anemometer AN 340 was used to objectify temperature and relative humidity. The concentration of carbon dioxide in the classroom was objectified by the TESTO 315-3 CO/CO_2 instrument. Sound intensity was measured using a Testo 8016-1 sound level meter. The main sources of noise were rivers, a data projector, computers and student and teacher talk. The course was focused on students' independent work with the Microsoft Office.

The survey focused on the perception of students in the test room, the conditions and the extent to which they felt the working environment and how it affected their attention and wellbeing in the classroom.

Before the beginning of experimental teaching, we examined the significance of individual factors of the working environment on a sample of 53 students. They expressed opinions in questionnaire 1 on five factors: air humidity, air temperature, CO_2 content in the air, room lighting, room noise. They could choose the answer on the Likert scale from 1 (very insignificant factor) to 5 (very significant factor). On October 18, 2019, we did experimental lessons in the classroom, where the monitored factors of the working environment were measured.

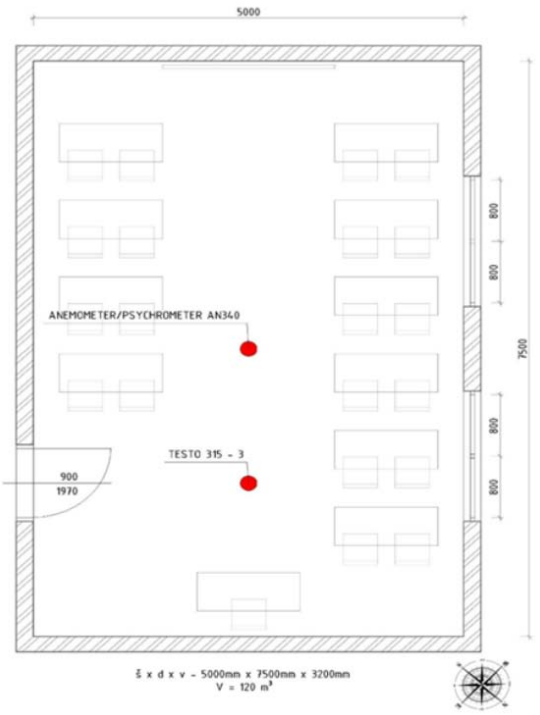

Figure 1: A plan view of the classroom indicating the location of the measuring instruments

After completing the lessons, the students completed the second questionnaire. The questionnaire consisted of 10 items on which the participants put forward their positions through a five-point Likert scale from 1 strongly agree to 5 strongly disagree.

3 Results of objective measurements of working environment factors

According to the Slovak Hydrometeorological Institute, the daily temperature on 18 October 2019 ranged from 8 to 20 °C measured in the meteorological station Nitra - center. Measurement of outdoor temperature in the school area showed values in the interval from 15 to 21 °C, in the time interval from 8:00 to 14:30. The process of temperature and relative humidity changes at the measured workplace is shown on the figure 2.

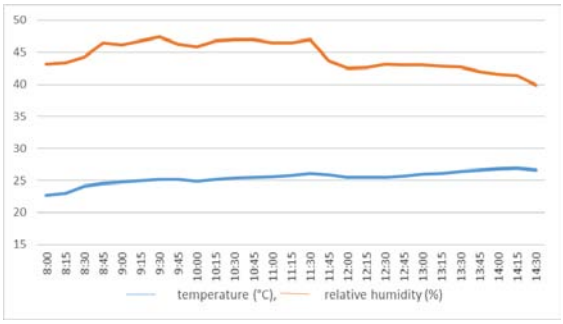

Figure 2 Temperature and relative humidity

As can be seen from the picture above, the temperature at the workplace ranged from 22.6 °C to 26.9 °C. The highest temperature was measured at 14:15. The arithmetic mean of the temperature was 25.4 °C with a mode of 25.5 °C.

The relative humidity in the room varied between 39.9 % and 47.4 %. The highest relative humidity was recorded at 9:30. The arithmetic mean of relative air humidity was 44.4 % with a mode of 46.5 %. The greatest change in humidity occurred in the time interval from 11:30 to 12:00, where the air humidity dropped from 47.0 % to 42.5 %.

The process of the carbon dioxide content, expressed in ppm over time, is shown in the figure 3.

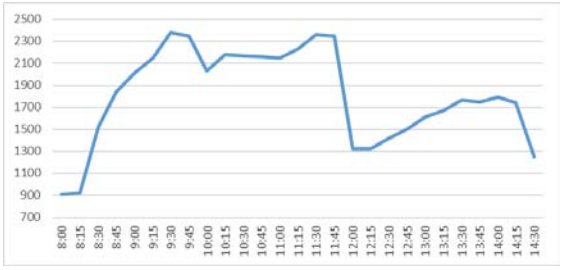

Figure 3 The process of the carbon dioxide content, expressed in ppm

The amount of carbon dioxide in the classroom ranged from 910 ppm to 2.380 ppm. The highest oxide concentration was recorded at 9:30. The arithmetic mean of the measured values was 1 809.2 ppm, with a mode of 2150 ppm. The biggest decrease in the amount of carbon dioxide occurred between 11:45 and 12:00, where the amount of carbon dioxide decreased from 2,350 ppm to 1,320 ppm.

This is probably related to a lunch break when the classroom was more intensely ventilated.

The process of maximum, medium and minimum noise is shown in the figure 4.

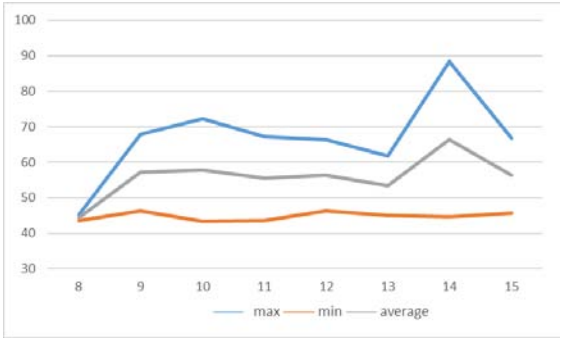

Figure 4 Sound waveform in dB

Using a noise meter, the maximum and minimum noise levels were recorded in the classroom. The noise level ranged from 43.4 dB to 883 dB. The highest noise level was at 14:00. At that time, there was a discussion between the students and the teacher on the subject matter that had been taken over and on the assignments they were dealing with during the day.

As the measured values show, the temperature gradually increased from the beginning to the end of the measurement. The relative humidity increased gradually from the beginning of the measurement until it reached extreme values at 9:30, where the highest concentration of carbon dioxide was also present. At 11:30, when there was a break in the classroom, the relative humidity of the air dropped and it did not increase anymore and tended to decrease. When measuring the amount of carbon dioxide, the biggest change occurred during the lunch break, after which the concentration no longer increased significantly. The highest noise level was recorded at 14:00. The average daylight value was 176.81 lx.

4 Results of respondents' subjective statements

53 respondents answered the first questionnaire. Table 1 summarizes the responses of respondents to which factors in the working environment they attribute most importance. For each questionnaire item, we calculated the average value of the respondents' answers.

Table 1: The average value of the respondents' answers

average value	factor
3.17	humidity
3.89	temperature
3.81	CO_2
4.02	lighting
3.72	noise

The highest average value was achieved by lighting as a factor to which respondents attribute the greatest importance.

A more detailed analysis showed that up to 40 respondents rated this factor with 4 - a significant factor, 5 - a very significant factor (Figure 5).

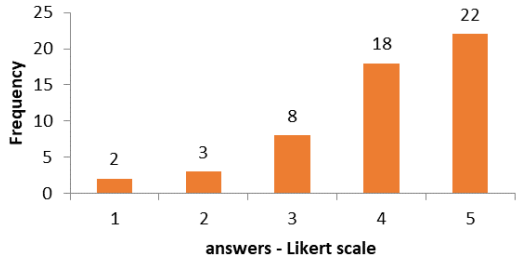

Figure 5: Frequency of respondents' answers in the first questionnaire

The second questionnaire was filled in only by those respondents who attended the lesson at the time of the measurement. The questionnaire commented on how the factors of the working environment influenced their performance in curriculum interpretation and independent work and identified the factors that caused them difficulties in focusing on curriculum interpretation and independent work. The respondents' answers are given in Table 2.

Table 2: Frequencies of respondents' answers to questionnaire items

	answer				
item	**1**	**2**	**3**	**4**	**5**
1. The humidity of the room negatively influenced my performance in the interpretation of the curriculum and independent work.	1	8	5	2	4
2. I had difficulty focusing on the interpretation of the curriculum and working independently because of the humidity in the room.	3	4	5	3	5
3. The temperature of the room has negatively affected my performance in the interpretation of the curriculum and independent work.	4	8	2	5	1
4. I had difficulty focusing on the interpretation of the curriculum and working independently because of the room air temperature.	3	7	2	5	3
5. Stale air in the room has negatively affected my performance focused on the interpretation of the curriculum and independent work.	7	4	2	4	3
6. I had difficulty focusing my attention on reading and testing tasks due to poor air in the room.	4	8	3	3	2
7. The illumination of the room negatively influenced my performance in the interpretation of the curriculum and the independent work.	4	5	5	4	2
8. I had difficulty focusing on the interpretation of the curriculum and working independently because of the illumination in the room.	4	6	4	4	2
9. The noise level in the room has negatively affected my performance in the interpretation of the curriculum and independent work.	1	7	2	5	5
10. I had difficulty focusing on the interpretation of the curriculum and working independently because of the noise levels in the room.	1	6	4	6	3

Individual items of the questionnaire were characterized by arithmetic mean. 1 point was given to the answers “I strongly agree”, to the answers “I agree” 2 points, “I cannot comment” 3 points, “I disagree” 4 points and “I strongly disagree” 5 points. We identified the ambient temperature in the room as the factor that influenced the respondents most during the teaching and individual work of students. Respondents identified as the second most important factor the amount of CO_2 in the air, i.e. the quality of the air they breathed during the class. As we can see, there was no consensus between the preference of the work environment factor from the 1st questionnaire and the determination of the factor that had the greatest impact on the teaching (Table 3).

Table 3: Arithmetic mean of respondents' answers for individual factors influencing attention

average value	factor	objective values
3	humidity	39.9 % - 47.4 %
2.5	temperature	22.6 °C - 26.9 °C
2.55	CO_2	910 ppm - 2 380 ppm
2.75	lighting	78 lx – 379 lx
3.3	noise	43.4 dB - 883 dB

According to the results of the questionnaire, the most significant factor that caused difficulties for students to focus their attention on the explanation of the curriculum or during their own work is the content of CO_2 in the air (Table 4).

Table 4: Arithmetic mean of respondents' responses for each factor causing difficulty

average value	factor	objective values
3.15	humidity	39.9 % - 47.4 %
3	temperature	22.6 °C - 26.9 °C
2.55	CO_2	910 ppm - 2 380 ppm
2.7	lighting	78 lx – 379 lx
3.2	noise	43.4 dB - 883 dB

Another important factor identified by students as a factor causing difficulty in focusing on teaching was lighting (average 2.55 points). In this case, there was a partial agreement between the assumed factor of the working environment, which the students identified as significant in the 1st questionnaire and the outcome of their opinions after teaching in a particular environment.

5 Discussion and conclusion

It is also apparent from objective measurements that the illumination in the room was not sufficient, although it must be kept in mind that teaching at the university is supposed to work with a data projector which requires at least a partial dimming of the illumination for better visibility. However, as can be seen in the comparison of respondents' statements in Table 4 and objectively obtained values for factors of the working environment, lighting was one of the factors that seriously impaired the well-being of students and made it difficult to work independently. Similarly, the amount of carbon dioxide that reached up to 2380 ppm in objective measurements was perceived by students as a factor that caused them difficulty concentrating on teaching. Ventilation that took place at lunch time is not considered sufficient and it would be necessary to include intensive ventilation earlier, e.g. around 9:30 am, especially if the classroom is fully occupied. Of course, the most effective way to avoid the negative impact of the work environment on student learning is to install equipment in the classroom to create a controlled work environment. However, it is currently very economically demanding for universities, not

only in Slovakia but also abroad, as several experts have stated (Kaiser, Davis, 1996; U.S. Department of Education, 2000, U.S. General Accounting Office, 1995).

The survey showed that students are able to identify unsatisfactory classroom environments that can have a measurable negative impact on their learning and attention. The results of the survey contribute to a better understanding of how the integrated effects of several factors in the work environment affect learners' learning and activity.

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