

## Lighting as an Important Factor of Students' Work Environment

<https://doi.org/10.3991/ijep.v9i1.9319>

Ivana Tureková (✉), Danka Lukáčová and Gabriel Bánesz  
Constantine the Philosopher University, Nitra, Slovakia  
i.turekova@ukf.sk

**Abstract**—Good work conditions for students at the university are important for education quality and that is the reason why we should pay adequate attention to the factors of work environment in those particular places where students spend most of their learning time. Monitoring of the current state of illumination within school facilities can be performed by two principally different approaches. The first one deals with the exact measurements of illumination and their evaluation in regard to laws, acts, regulations and norms. The second approach is based on subjective perception of lighting in particular work place that can be confirmed via qualitative research methods. In this contribution we combine both approaches. Authors evaluate the actual lighting state in a computer classroom by means of exact measurement of sunlight and compound lighting. The article also offers subjective reactions of students regarding possible improvements of views through the window as one of some factors that influence the state of well-being of students and it also serves as prevention against eye strain, especially when working on computer. The measurement outcomes have confirmed that the overall amount of daylight illumination is insufficient, what leads to the deployment of compound lighting, especially in winter months.

**Keywords**—Illumination, student, visual comfort, computer class, practical measurement

### 1 Introduction

Ergonomic demands for workplace, work tools, machines including factors of work environment are crucial demands regarding the workplace, hand in hand with technical, economic and safety requirements [1].

From the point of view of relations in the system man-machine-environment, modern workplaces can be divided into these four groups [2, 3]:

- **Manual workplace (R)**, it is based on relation man-tool. Here, the demands are orientated on dynamic stereotype of employees, ergonomics of work tools etc.
- **Mechanized workplace (M)**, it is based on relation man-machine. The work environment influences both the man and machines and the machine influences the workplace in return.

- **Automated workplace (A)**, it is based on relation man-computer, or the work in central control stations (CCS). The work environment plays an important role, it must provide the well-being of employees, since such environment places extreme psychic demands on them.

Sophisticated workplace (S), the man is not directly included in the relation with production technologies, he just uses modern communication technologies (annunciator panels, detectors, mobiles, sensors and others) and he intervenes only in case of emergency [4].

In every workplace, the man is influenced by the factors of work environment that are not of the same importance for particular workplace (Table 1) [5, 6].

**Table 1.** Relations between the importance of work environment factors and the type of workplaces

Type of workplace	Lighting	Noise	Vibrations & tremors	Micro-climate	Dustiness	Colour design
Manual	A	A	I	A	A	E
Mechanized	E	E	E	E	I	I
Automated	E	E	E	UI	UD	I
Sophisticated	UI	UI	UI	UD	UI	UI

Note to table 1: A – Absolute, E – Eminent, I – Important, UI – Unimportant, UD–Undesirable

The type of environment where students are being taught at universities can be considered to be an automated workplace, especially when talking about classrooms orientated on the school subjects of Computer Science and Informatics. Students usually spend there more than 10 hours a day, which is more than a standard time of employees at work and this is one of the key reasons why we must pay attention to the arrangement, organization of work and factors of work environment so that they comply with the type of performed actions[7, 8]. All of this in order to make sure technology is properly leveraged so as to enable student-centered learning [9]. Eminently important factors in computer classrooms are: lighting, noise, vibrations and tremors and the other important factor is the colour design (Table 1). Dustiness belongs among undesirable factors both from the point of view of students and the expected faultless operation of computers [8, 10, 11].

### 1.1 Lighting as a factor of work environment

You may also simply delete all the text in this document, paste yours and format it with the styles. Importance of sunlight illumination should be taken into consideration already in the initial phases of projecting and designing the new buildings. Number of transparent constructions, their size, geometry and also optic attributes influence the overall amount of sunlight illumination in a workplace [12] and this assumption logically applies to all school buildings and facilities [13].

The lighting system should be designed in a way so that it can provide adequate visual conditions which help realize particular visual tasks in effective, safe and comfortable way [14]. Luminous conditions in the workplace influence the overall performance of employees and the workforce productivity by means of mutually inter-linked chains of mechanisms [15].

Also students within the school environment are influenced by luminous conditions, which leads us to the conclusion that they can be efficient enough in their work, when the luminous conditions are at adequate level during the whole learning process in school [16]. Visual comfort at different levels of illumination generally influences the state of physical wellness and any physical discomfort influences our behaviour and work efficiency in negative way [17].

Suitable and sufficient lighting leads to the visual health, which is defined as “optimal psycho-physiological states of an organism stimulated by an optic situation in external environment that is needed for both effective work and relax” [18].

On the contrary, visual discomfort can cause the eye strain, visual impairment and consequently other health problems that weaken the workforce productivity [19].

Places that are intended for educational purposes must provide adequate sunlight illumination and if this natural source is not sufficient, it should be supplemented by suitable artificial sources of light [20]. In many school buildings we can find light bulbs, fluorescent lamps or LED diodes.

Generally, the quality of the sunlight illumination depends on its intensity, angle of incidence, position, size and cleanness of windows, the size and distance from neighbouring buildings and the colour of walls and ceiling [21, 22]. Soiled and dirty windows can block up to 40-50 % of the overall amount of sunlight.

To assess the influence of lighting systems on students we decided to measure the luminous intensity  $E$ , that is derived photometric quantity belonging to the international system of units (SI). It is defined by the quotient of equally divided luminous flux that falls on the surface of an object and the area of this surface. Relation between the area  $S$  and luminous flux  $\Phi$  that falls on the area  $S$  lead us to:

$$E = \frac{\Delta\Phi}{\Delta S} \quad (1)$$

- $E$  = illuminous intensity;
- $\Delta\Phi$  = luminous flux;
- $\Delta S$  = the area of fallen luminous flux.

A lux (lx) is the unit of illuminance and luminous emittance, measuring luminous flux per unit area. It is equal to one lumen per square meter [23]. Luminous-technical requirements are defined by STN EN 12464-1 norm [24]. The minimal demand regarding illumination in school computer classrooms equals to 300 lx.

## 1.2 Variability of views through the window

When working on computers, the students' attention is orientated on the projecting units—computer monitors or projecting screens. The possibility to change the focused

look at monitor to any bigger distance (ideally in external environment) is an important form of prevention against the eye strain which can be realized thanks to the transparent constructions. The quality of view itself depends on size of transparent constructions, their position, number, type of venetian blinds or other shadowing equipment and maintenance. Unfortunately, it can be limited by some factors that are e.g. furniture, various classroom equipment or other persons in the room, external built-up area and the height of construction above terrain. According to Flimel [25], the views can be divided into these three specific layers:

- Layer of sky
- Layer of town or countryside (green vegetation, houses)
- Layer of ground (soil).

The view through the window enables not only mental wellness and relaxes, but the orientation in time or weather changes, what has the positive effect against suffering from fatigue when performing monotonous activities.

The aim of this research is to find out whether both particular luminous conditions and the possibilities of views through windows are adequate and satisfactory for our students. We decided to execute measurements regarding sunlight and compound illumination in the computer classroom and those students who were present in the classroom that day were asked some questions via questionnaire.

## 2 Methodology and Measurement

To fulfill our research goal we decided to measure the level of illumination in one of our computer classrooms and to devise a questionnaire for the students (see Figure 1).



**Fig. 1.** A view to the computer classroom

A relatively small classroom at UKF in Nitra was chosen for our experiment. It is situated in the building of Faculty of Education, on the fourth floor at the department of Technology and Information Technologies. This classroom is regularly used for

educational purposes with 24 seats for students and 1 for a teacher. There are no blocking buildings in the exterior; the room is of rectangular shape (7.62 m x 6.25 m). It has two glass transparent constructions (23800 mm x 1320 mm) that are orientated to the northeast. The students' tables are arranged in two parallel rows to the wall with windows. The students sit facing each other, what means that one half of them can see the exterior directly (without turning around), while the students who sit back to windows do not have this possibility. There are computers and monitors positioned on the tables for students. The floor and walls are of suitable colors and they do not reflect the sunlight. Thanks to this, there is no decrease in quality of lighting in this classroom.

Particular measurement was performed by a light meter Testo 545. It was extremely accurate measurement since the permissible deviation defined by producer was  $\pm 2\%$  (according to DIN 5032, part 6).

The conditions were met during the measurement of sunlight level according STN 73 0580-1. All sources of artificial illumination were turned off, shadowing equipment was in a position that simulated standard daylight conditions without access of direct sunlight.

The lighting measurements were executed within the net of check points that were in mutual distance of 1 meter and 85 cm above the floor. This happened on March 2018 between 9:00 – 13:00 in one hour intervals. Average (mean) values of illumination

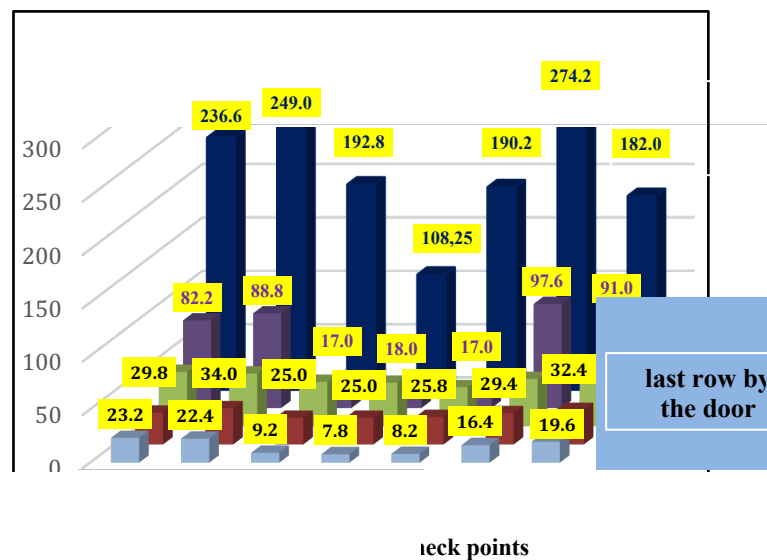


Fig. 2. Average daylight illumination (lx)

The overall mean value of daylight illumination reaches 70.37 lx. Additional characteristics of measured values are shown in Table 2.

**Table 2.** Obtained measurement values of daylight illumination

<b>Mean</b>	70.37
<b>Standard Error</b>	5.74
<b>Mode</b>	22 1
<b>Standard Deviation</b>	75.99
<b>Sample Variance</b>	5774.12
<b>Minimum</b>	7
<b>Maximum</b>	334

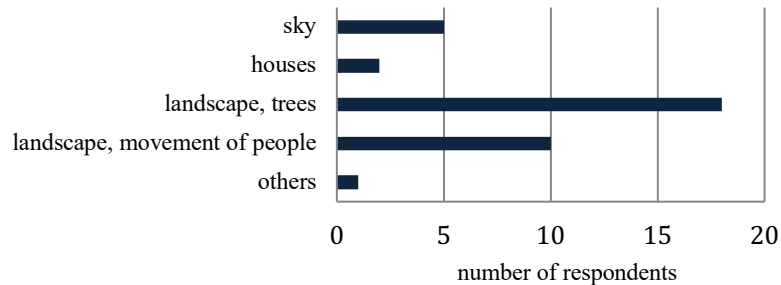
The mean value of daylight illumination does not reach defined standard for this type of environment (computer classroom), so we executed new measurements of compound lighting. We measured the level of illumination in the same check points and times. Now, all the artificial sources of light were on (active) during the measurements. The room is equipped by 15 pieces of Philips MASTER TL5 HE (actual output 35/830 W). In this case, the mean value of compound illumination equals to 730 lx. This value complies with defined standards and it is considered to be adequate for educational purposes.

The survey was used a questionnaire according Flimel [25]. It related to the view from the interior of the classroom to the exterior in relation to the mental needs of the users. He pointed to the following facts. There were 36 respondents (35 women and 1 man) participating. Students responded to questions, three of which were written and solved with the possibility of answering questions. The questions involved perceiving views through the window during lesson, how to sit in the classroom at entrance, and which views they prefer from the window during real lesson (they are most likely to look at the layer).

Only 3 % of respondents said that they never looked through the window. 63 % said they were using view very often and 33 % occasionally. In the next question we wanted to find out whether our students prefer sitting by the window. 69 % stated they preferred sitting by the window, on the other side, 31 % preferred sitting in a further position from the window. In the last part of our questionnaire we wanted to find out what type of view was preferred by the respondents. Majority of them would prefer a view at countryside, nature or trees (53 %), followed by a view at terrain or moving people (28 %) see Fig. 3.

### 3 Discussion

Research is focused on verifying on the suitability and sufficiency of one computer classroom. We used a mixture of exact lighting measurements and subjective evaluation of students regarding possible views into the exterior.



**Fig. 3.** Preferred types of views through the window

When we compare our measurement outcomes with the limit values defined by the norm, we dare say that the level of sunlight in the classroom is not sufficient. Fortunately, there are some sources of artificial illumination in the classroom and thanks to this fact (when all the sources are on), the level of illumination complies with norm STN EN 12464-1: Internal workplaces [26]. Required outcomes regarding compound illumination (300 lx and more) were obtained in all our measurements.

There are two transparent constructions in the classroom and our respondents confirmed that they preferred sitting next to the windows and looking through them. The views at countryside, trees (53 %) or at terrain and moving people (24 %) belong to the most favorite ones. These results also correspond to the results of Flimel [24], where respondents preferred views of the sky, greenery (45%), and secondly the view of people and terrain (28 %).

Objective view through the window can be seen in Fig. 4.



**Fig. 4.** A view through the window

Evaluation of experimental measurements of daylight illumination showed that it does not reach the sufficient level. It is needed to use the compound lighting in the classroom, especially in winter months. The level of overall illumination is also influenced by the arrangement of tables and computer equipment which, due to its unsuitable position on the tables, blocks and decreases the level of sunlight.

When working on computer, it is recommended to change the distance of visual perspective from the close (monitor) to the more distant one (exterior) and this is provided via transparent constructions in a huge majority of school classrooms and workplaces. Thanks to a simple questionnaire we have found out that our respondents (students) frequently look through the window and therefore prefer sitting by the windows. These facts should be implemented in the process of redesigning the classroom in a way, so that the students have a chance to sit by the windows and at the same time not to be glared by the sunlight reflecting from monitors. In this particular case, the situation can be easily solved by turning the tables perpendicularly to the wall with windows, which would enable the sunlight shining from the right side of students.

From the point of view of health, the sunlight illumination is extremely important, since its lack can lead to fatigue, sleeplessness and changes in metabolism or even depression.

It is clear incorrect arrangement of seats. The chairs must be placed in such a way that the light comes from the left or right. This can be done simply by reorganizing the room. To improve the overall level of illumination in the abovementioned classroom, the following measures can be taken:

- To remove the desktops from the tables and arrange them in a way, so that they do not block the sunlight,
- To rearrange positions of the tables, so that majority of students has a chance to enjoy the view through the window,
- To clean the windows more frequently, since the near frequent construction causes high level of dustiness,
- To use compound lighting, especially in winter season,
- To clean the lighting sources according to the plan of maintenance,
- To check and change lighting bodies regularly,
- To use the shadowing equipment in a correct way.

## **4 Conclusion**

The paper studies qualitative and quantitative parameters of lighting in a university computer classroom. Lighting is one of the factors of learning environment that may indirectly influence the results of teaching and learning. Its influence may increase as the learning process is becoming more and more intensive and students spend a lot of time in computer classrooms. The paper discusses the experimental data and the results of the survey. These claims confirmed experimental measurements (insufficient illumination) and a questionnaire that were conducted in a real classroom and in real learning conditions.



This is the reason why architects should pay attention to adequate supply of sunlight into the indoor space already in process of designing the buildings. If this is not technically possible, there should be appropriate artificial lighting, so that the level of illumination complies with defined standards. From the point of view of general well-being of students, the ongoing monitoring of the current state of illumination in particular workplaces is needed (objective – in the form of exact measurements, and subjective – considering students' opinions).

Only this combination of the two different approaches can help assess conditions in the real workplace in computer classrooms and consequently to create the ideal conditions for learning.

The procedures and outputs of our research are applicable in the education of technical subjects, because every practical activity, including computer work, also requires visual comfort that influences the quality of the work done and the psychological well-being. Acknowledgment

This article was supported by the Grant Agency Ministry of Education SR KEGA - project no. 014UKF-4/2016.

## 5 References

- [1] G. C. David, "Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders," *Occupational medicine*, vol. 55, no. 3, pp.190-199, 2005. <https://doi.org/10.1093/occmed/kqi082>
- [2] R. Lin, J. G. Kreifeldt, "Ergonomics in wearable computer design," *International Journal of Industrial Ergonomics*, vol. 27, no. 4, pp. 259-269, 2001. [https://doi.org/10.1016/S0169-8141\(00\)00055-X](https://doi.org/10.1016/S0169-8141(00)00055-X)
- [3] D. Spath, M. Braun, W. Bauer, *Integrated human and automation systems. In Springer Handbook of Automation*. Berlin: Springer, 2009. [https://doi.org/10.1007/978-3-540-78831-7\\_34](https://doi.org/10.1007/978-3-540-78831-7_34)
- [4] E. Szombathyová, "Telework and Work Environment," *Human Resources Management & Ergonomics*, issues 3, p. 23, 2007.
- [5] D. Šebo, E. Szombathyová, E, "New Insights into Ergonomics of Workplaces," *The 6th International Scientific Conference New Trends in Operation*, Prešov: UPJŠ, p. 404. 2003.
- [6] J. A. M. Bell, "Development and practice in the daylighting of buildings," *Lighting Research & Technology*, vol. 5, no.4, pp. 173-185, 1973. <https://doi.org/10.1177/096032717300500401>
- [7] M. Dado, R. Hnilica, M. Schwarz, E. Sujová, "Design and evaluation of virtual lab for measurement and control of occupational risk factors," *ICERI 2013*, pp. 3211-3215. 2013.
- [8] J. Záhorec, A. Hašková, M. Munk, "Particular Results of a Research Aimed at Curricula Design of Teacher Training in the Area of Didactic Technological Competences," *iJEP*, vol. 8, no. 4, 2018. <http://online-journals.org/index.php/i-jep/article/view/8184>
- [9] M. Cornejo, B. O'Hara, F. Tarazona -Vasquez, F. Barrios, M. Power, "Moray: Bridging an Ancient Culture of Innovation with Emerging Pedagogies in Engineering," *iJEP*, vol. 8, no. 4, 2018. <http://online-journals.org/index.php/i-jep/article/view/8139>

- [10] S. C. Horii, H. N. Horii, S. K. Mun, H. R. Benson, R. K. Zeman, "Environmental designs for reading from imaging work stations: ergonomic and architectural features," *Journal of digital imaging*, vol. 2, no. 3, p. 156, 1989. <https://doi.org/10.1007/BF03168035>
- [11] Š. Svetský, O. Moravčík, P. Tanuška, I. Markechová, "The Personalized Computer Support of Teaching," *iJEP*, vol. 8, no. 4, 2018.
- [12] A. McNicholl, J. O. Lewis, "Energy efficiency and solar energy in European office buildings: a mid-career education initiative," *Energy and Buildings*, vol. 33, no. 3, pp. 213-217, 2001. [https://doi.org/10.1016/S0378-7788\(00\)00084-0](https://doi.org/10.1016/S0378-7788(00)00084-0)
- [13] E. Mačurová, A. Pavúk, *School Hygiene and Primary Prevention of Drug Addiction*. Prešov: UPJŠ, 191 p., 2007.
- [14] P. R. Boyce., *Human Factors in Lighting*. 3rd ed. London and New York: Taylor & Francis, 703 p. 2014. <https://doi.org/10.1201/b16707>
- [15] V. Gligor, *Luminous environment and productivity at workplaces*. Thesis (Licentiate), Helsinki: University of Technology, 2004.
- [16] M. M. Hossain, K. S. Ahmed, "Illumination condition and work efficiency in the tropics: study on production spaces of ready-made garments factories in Dhaka," *Proc. 28th International PLEA Conference Opportunities, Limits & Needs Towards an Environmentally Responsible Architecture*, pp. 223-236, 2012.
- [17] O. D. Lara, M. A. Labrador, "A survey on human activity recognition using wearable sensors," *IEEE Communications Surveys and Tutorials*, vol. 15, no. 3, pp. 1192-1209, 2013. <http://romisatriawahono.net/lecture/rm/survey/computer%20vision/Lara%20-%20Human%20Activity%20Recognition%20-%202013.pdf> <https://doi.org/10.1109/SURV.2012.110112.00192>
- [18] S. Gilbertová, O. Matoušek, "Optimization of Human Activity," *Ergonomie*, Praha: Grada Publishing, pp. 29-37, 2002.
- [19] M. Winterbottom, A. Wilkins, "Lighting and discomfort in the classroom," *Journal of environmental psychology*, vol. 29, no. 1, pp. 63-75, 2009. <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.527.8058&rep=rep1&type=pdf> <https://doi.org/10.1016/j.jenvp.2008.11.007>
- [20] R. C. Aldworth, D. J. Bridgers, "Design for variety in lighting," *Lighting Research & Technology*, vol. 3, no. 1, pp. 8-24, 1971. <https://doi.org/10.1177/147715357100300110>
- [21] S. A. Samani, S. A. Samani, "The impact of indoor lighting on students' learning performance in learning environments: A knowledge internalization perspective," *International Journal of Business and Social Science*, vol. 3, no. 24, 2012.
- [22] J. Škvařil, "Design and Measurement of Indoor Spaces," *Electrotechnical magazine*, no. 3, pp. 70-73, 2004.
- [23] D. Pelech, A. Kecskés, *General Physics: Task Collection*. Banská Bystrica: UMB, 1989.
- [24] STN EN 12464-1: 2012. Light and lighting. Lighting of workplaces. Part: Indoor workplaces
- [25] M. Flimel, *Managing Daylighting in the Work Environment*. Prešov: UPJŠ, 2015.
- [26] STN 73 0580-1:1986. Daylighting in buildings.

## 6 Authors

**Ivana Tureková** is an Associate professor at the Faculty of Education of the University of Constantine the Philosopher in Nitra, Slovakia. She guarantees the bachelor degree of Safety and Health at Work. At present, she is engaged in technical education aimed at the safety of both students and adults.

**Danka Lukáčová** is an Associate professor at the Faculty of Education of the University of Constantine the Philosopher in Nitra, Slovakia. She deals with technical education at elementary and secondary schools, the use of ICT in practice - as in teacher training as well as teaching itself. She guarantees study programs for technical education.

**Gabriel Bánesz** is an Associate professor at the Faculty of Education of the University of Constantine the Philosopher in Nitra, Slovakia. He guarantees study programs for technical education and he is co-graduate doctoral studies in the field of didactics of technical education too. The research focuses on the use of multimedia technologies and preparation of training programs for technical education.

Article submitted 07 August 2018. Resubmitted 28 October 2018. Final acceptance 30 October 2018. Final version published as submitted by the authors.