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LIGHTING CONDITIONS FOR PRACTICAL TEACHING IN A UNIVERSITY PRINTING LABORATORY

Research paper

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Abstract: University printing laboratories constitute a specific educational and working environment where practical teaching activities are carried out alongside the Faculty's printing and publishing activities. This study aimed to assess the lighting conditions in a university digital printing laboratory used for both purposes. Illuminance measurements were performed at nine representative student and employee workstations using a digital lux meter, and the measured values were compared with the recommended illuminance level of 300 lx for educational facilities. The results showed that illuminance was not uniformly distributed throughout the laboratory. While the employee workstations generally satisfied or closely approached the recommended illuminance level, illuminance at the student workstations ranged from approximately 142 to 236 lx, indicating insufficient lighting conditions for practical teaching activities.

Keywords: *illuminance; lighting assessment; printing laboratory; practical teaching; visual comfort.*

INTRODUCTION

The quality of the indoor environment has become an increasingly important aspect of modern educational facilities, particularly in university laboratories where theoretical instruction is complemented by practical training. Indoor Environmental Quality (IEQ) encompasses several physical factors, including thermal comfort, air quality, acoustics, and lighting, all of which contribute to occupants' comfort, health, and work efficiency (Brink et al., 2021). Among these factors, lighting is a key prerequisite for performing visual tasks safely and accurately, especially in laboratories where students work with technical equipment and printed materials.

Adequate lighting conditions directly affect visual comfort, concentration, learning performance, and task accuracy (Katabaro & Yan, 2019; Qu et al., 2024). Insufficient illuminance may increase visual fatigue, reduce productivity, and impair the recognition of fine details, while excessive brightness or glare can also negatively affect visual comfort and task performance. Consequently, international standards and national regulations prescribe recommended illuminance levels for educational facilities, including laboratories, to ensure safe, comfortable, and productive learning and working conditions (CEN, 2021).

Numerous studies have investigated different aspects of the indoor environment in schools, universities, offices, and industrial workplaces (Castillo-Martinez et al., 2018; Noor et al., 2021). However, considerably less attention has been devoted to specialised university laboratories equipped with printing machinery, where educational activities are carried out alongside printing and publishing. Such facilities offer a unique educational and working environment, as students and employees share the same space while performing tasks that require appropriate visual conditions.

Creating healthy learning environments has therefore become an important objective of universities, not only to ensure compliance with technical standards but also to support students' well-being, learning performance, and long-term occupational health (Heschong et al., 2013). Regular assessment of lighting conditions in educational laboratories provides an important basis for identifying lighting deficiencies, improving visual comfort, optimising workplace design, and supporting both teaching activities and occupational safety.

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The digital printing laboratory investigated in this study is used for practical teaching and for the Faculty's printing and publishing activities. Students attend laboratory teaching activities while employees operate digital printing and finishing equipment, making appropriate lighting conditions essential for both educational and professional tasks. In our previous study, the indoor environmental conditions of this laboratory were comprehensively evaluated through measurements of several physical factors and subjective assessment by laboratory users. The obtained results indicated that illuminance levels at several workstations did not fully comply with the recommended illuminance levels for educational facilities, suggesting the need for a more detailed evaluation of lighting conditions (Samardžić et al., 2023).
The present study focuses on assessing lighting conditions in the university printing laboratory. Illuminance measurements were performed at representative student and employee workstations and compared with the recommended lighting requirements for educational facilities. The study aimed to identify locations with insufficient illumination and to provide recommendations for improving visual conditions during practical teaching activities.

MATERIALS AND METHODS

Printing laboratory

The study was conducted in the Digital Printing Laboratory of the Department of Graphic Engineering and Design, Faculty of Technical Sciences, University of Novi Sad, Serbia. The laboratory is used for both practical teaching and the Faculty's printing and publishing activities. During laboratory classes, students participate in digital printing and finishing processes under the supervision of teaching staff and laboratory technicians who operate the equipment. The laboratory consists of two working areas equipped with digital printing and finishing machines, workstations, and student desks. A detailed description of the laboratory layout, equipment, and measurement locations has been presented in our previous publication (Samardžić et al., 2023) and is therefore not repeated in this paper.

Lighting measurements

Illuminance measurements were performed using a PeachTech 5025 Compact Digital Lux Meter with a measurement accuracy of ±(5% + 10 digits) and measurement ranges of 20, 200, 2000, and 20000 lx. The instrument incorporates an integrated spectral filter to ensure accurate measurements within the visible light spectrum.
Measurements were conducted at nine representative student and employee workstations within the laboratory. Each measurement location was divided into four equal sections. Illuminance was measured with the sensor placed horizontally over the centre of each section, and the average of the four measurements was used as the representative illuminance value for each workstation. Measurement locations were situated opposite the windows in both laboratory rooms, with a distance exceeding 4 m from the nearest windows, thus minimising the influence of daylight. The measurements were performed under normal operating conditions, using the laboratory's existing lighting system. The measured illuminance values were compared with the recommended maintained illuminance level of 300 lx in accordance with EN 12464-1:2021 (CEN, 2021). Since the evaluated laboratory is predominantly used for practical teaching activities, computer-based work, and routine printing tasks rather than high-precision visual inspection or colour matching, this value was adopted as the reference illuminance level for assessing the adequacy of lighting conditions.

Data analysis

The measured illuminance values were analysed using descriptive statistics and evaluated against the recommended illuminance level for educational facilities. The analysis focused on identifying workstations that did not satisfy the recommended requirements and assessing the adequacy of lighting conditions for practical teaching activities. The results were

subsequently interpreted to identify potential improvements that could enhance visual comfort and create a higher-quality learning environment in the university printing laboratory.

RESULTS AND DISCUSSION

The measured illuminance levels at the evaluated workstations are summarised in Tables 1 and 2, while Figure 1 provides an overview of deviations from the recommended illuminance level of 300 lx, allowing a direct assessment of lighting adequacy at all evaluated workstations. Measurements were performed at nine workstations, including three employee workstations in Room 1 and six student workstations in Room 2. Overall, the results indicate that the lighting conditions were not uniform throughout the laboratory, with larger deviations from the recommended illuminance level observed at most student workstations. For clarity, the results obtained for employee and student workstations are discussed separately below.
Among the three evaluated employee workstations, one (A2) met the recommended illuminance level, while workstation A1 was within the measurement uncertainty of the recommended value. In contrast, workstation A3 exhibited a considerably lower illuminance level, indicating that the available lighting was not uniformly distributed throughout the employee work area. Nevertheless, the overall lighting conditions in Room 1 were generally more favourable than those in the area intended for practical teaching activities, where substantially larger deviations from the recommended illuminance level were observed.

Table 1. *Illuminance levels at employee workstations (Room 1)*

Workstation	Natural illuminance (lx)	Combined illuminance (lx)	Compliance*
A1	37.6 ± 1.9	303.1 ± 15.2	Compliant
A2	29.7 ± 1.1	393.8 ± 19.7	Compliant
A3	31.5 ± 1.4	206.5 ± 10.3	Non-compliant

**Compliance with the recommended illuminance level of 300 lx for educational facilities (CEN, 2021)*

The lighting conditions at the student workstations in Room 2 were considerably less favourable than those observed at the employee workstations. Of the six evaluated workstations, only B1 was considered acceptable, as the measured illuminance differed from the recommended value by only 3.0 lx, which falls within the measurement uncertainty. The remaining five workstations exhibited illuminance levels below the recommended threshold, indicating that the existing lighting system did not provide adequate lighting throughout the area intended for practical teaching activities.

Table 2. *Illuminance levels at student workstations (Room 2)*

Workstation	Natural illuminance (lx)	Combined illuminance (lx)	Compliance*
B1	17.0 ± 0.9	297.0 ± 14.8	Compliant**
B2	12.9 ± 0.7	232.3 ± 11.6	Non-compliant
B3	14.9 ± 0.8	157.8 ± 7.9	Non-compliant
B4	11.0 ± 0.6	145.3 ± 7.3	Non-compliant
B5	7.9 ± 0.4	236.5 ± 11.8	Non-compliant
B6	14.3 ± 0.7	141.8 ± 7.1	Non-compliant

**Compliance with the recommended illuminance level of 300 lx for educational facilities (CEN, 2021)*

Since this part of the laboratory is primarily used for practical teaching activities, students spend considerable time performing visually demanding tasks, including reading, writing, examining printed materials, and following practical demonstrations. Under such conditions, insufficient illuminance may reduce visual comfort, increase visual fatigue, and adversely affect their performance during prolonged visual tasks (Qu et al., 2024). Workstations A1 and B1 were classified separately because their measured illuminance levels differed from the

recommended value by only +3.1 lx and −3.0 lx, respectively, which is within the measurement uncertainty.

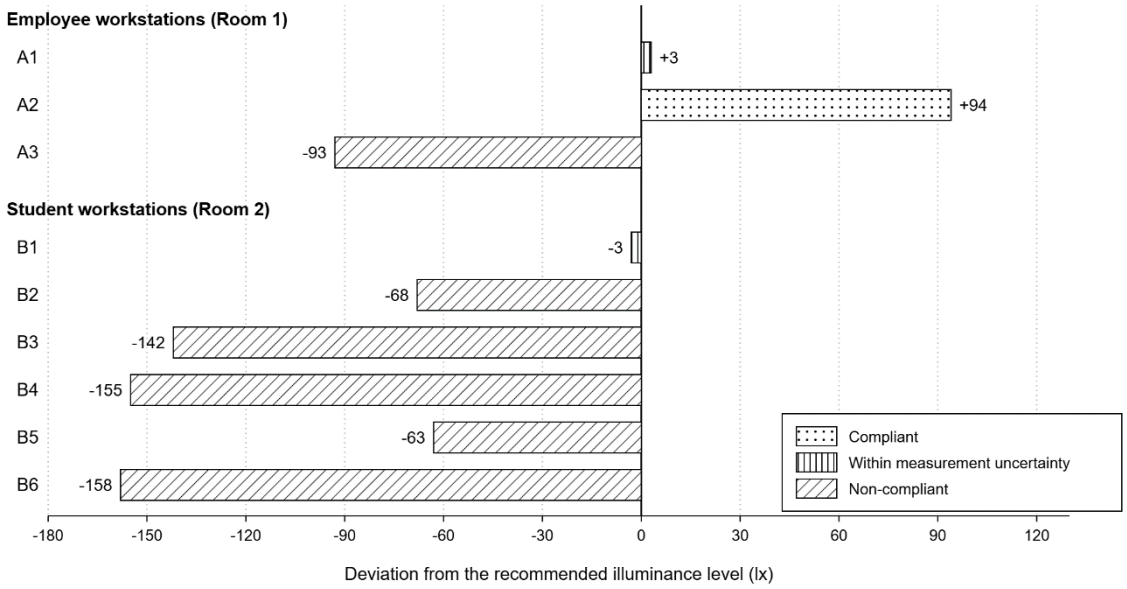


Fig. 1. *Deviation of illuminance levels at employee and student workstations from the recommended value of 300 lx.*

The overall distribution of deviations from the recommended illuminance level is presented in Figure 1. The figure clearly shows that the largest negative deviations were recorded at the student workstations, whereas employee workstations generally exhibited more favourable lighting conditions. These findings indicate that the existing lighting system provides uneven illuminance throughout the laboratory. Therefore, the identified lighting deficiencies should be taken into account when planning future improvements to the laboratory lighting system to provide more uniform illuminance and enhance the visual environment for practical teaching activities.

CONCLUSION

The present study demonstrated that lighting conditions in the investigated university digital printing laboratory were not uniform. While the employee workstations generally satisfied or closely approached the recommended illuminance level, most student workstations exhibited illuminance levels substantially below the recommended requirements for educational facilities. Since practical teaching activities involve prolonged, visually demanding tasks, improving lighting conditions at student workstations would enhance visual comfort, reduce visual fatigue, and create a more favourable visual environment for practical teaching. The findings of this study provide a useful basis for planning future improvements to the laboratory lighting system. The proposed approach may also serve as a practical framework for assessing and improving lighting conditions in similar university laboratories.

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