The use of microcontrollers to improve the quality perception of the education environment

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DOI: https://doi.org/10.53349/re-source.2025.is1.a1380

Abstract

Many domestic and international studies confirm that a high-quality environment enhances human performance, including performance influenced by the quality of the educational setting. The educational process involves activities that require critical thinking, creativity, and sustained concentration.

To effectively improve the learning process, targeted measures can be implemented to create optimal conditions for student performance. Our proposed methods aim to enhance the perception of the educational environment, thereby improving well-being during education.

Optimizing the well-being of teachers and students requires assessing and evaluating key indicators that influence well-being, followed by the development of strategies for their optimization. We designed and constructed microcontroller-based instruments to measure these indicators. The measured values (objective indicators) were then compared with students' perceptions of comfortable learning conditions (subjective indicators) to assess the overall quality of the educational environment.

Keywords: Microcontrollers, Calibration, Information and Communication Technologies

1 Introduction

The article describes the research carried out on optimizing the quality of the educational environment and its impact on the performance of participants in the educational process. The importance of the quality of the environment in which the educational process takes place is undeniable. Current research, both domestically and internationally, clearly demonstrates that environmental quality directly influences individual performance. This applies not only to

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workplaces but also to schools, universities, and other educational institutions. Since the educational process involves activities that enhance cognitive engagement, creativity, concentration, and motivation, it is essential that the learning environment meets specific qualitative criteria.

This article focuses on evaluating the quality of the educational environment in terms of its impact on the well-being of education participants—teachers and students—and on optimizing these conditions through targeted measures. Additionally, it presents methods for measuring and evaluating factors that influence environmental quality, with an emphasis on both objective and subjective indicators.

2 Environmental Quality and Its Impact on Performance in the Educational Process

The educational process is complex and dynamic, including various activities that require the active involvement of thinking, cognitive abilities, creativity and concentration. The ability of pupils and students to learn and achieve optimal results depends not only on their individual abilities, but also on the factors that affect their well-being and comfort during class. These factors include the quality of the physical and psychological environment into which education and learning are integrated. A quality environment can promote learning efficiency, creativity, and productivity, while a low-quality environment can inhibit these processes.

Recent studies show that an optimal environment contributes to better focus, reduced stress, and improved overall well-being. The importance of these factors is particularly important in educational settings, as students are subjected to long-term mental and emotional strain that affects their ability to absorb new information, solve problems, and engage in creative activities.

Given that the well-being of participants in the educational process is key to achieving performance, it is necessary to carry out a systematic assessment of the factors that influence this well-being. These factors include, in addition to physical aspects (such as temperature, humidity, lighting, acoustics), psychological factors such as teacher-pupil interactions, the organisational structure of teaching, as well as the subjective perception of the environment by pupils and teachers (Marchand, J.-M. 2007, p. 756), (Wargocki, P. et al. 2007, p. 63).

2.1 Measurement of objective and subjective indicators of environmental quality

Measuring the quality of the educational environment can be carried out using various tools that provide both objective and subjective indicators. In our research, we focused on

combining these two approaches to get a comprehensive picture of the impact of the environment on student performance.

Objective indicators: These indicators are based on the measurement of physical and technical parameters of the environment, such as:

- Temperature and humidity: Air quality and temperature can directly affect students' concentration and comfort. Temperatures that are too high or low can cause discomfort that leads to a decrease in productivity.
- Lighting: High-quality lighting is essential for proper visual perception, reducing eye fatigue and promoting concentration.
- Acoustic conditions: Disturbing sounds and high noise levels can significantly.

As part of the research, we used measuring instruments based on microcontrollers, which enabled continuous monitoring of these parameters in real time. These instruments provided accurate and reliable data on temperature, humidity, lighting and noise in classrooms, giving us an objective basis for comparison with students' subjective assessments.

Subjective indicators: The subjective assessment of the comfort of the environment by students and teachers is equally important, as it reflects their personal perception of the conditions during the lesson. To find out the monitored indicators, we used the Marchand questionnaire, which focuses on the evaluation of various aspects of the school environment from the point of view of comfort and satisfaction of participants in the process. This questionnaire allows you to identify the factors that have the greatest impact on subjective feelings of well-being, such as stress levels, emotional experiences during class, or perception of relationships with teachers (Depešová, 2019, p. 92).

2.2 Optimization of the conditions of the educational environment

The aim of our research was not only to obtain objective and subjective data on the quality of the environment, but also to propose measures for its optimization. Based on the analysis of the results of measurements and questionnaires, we have identified key areas in which the conditions for effective learning and teaching can be improved.

- *Temperature and humidity:* Maintaining an optimal temperature in classrooms (around 21°C) and adequate humidity can improve concentration and reduce fatigue. In this case, it is recommended to invest in a high-quality ventilation and air conditioning system.

- *Lighting:* Using natural daylight, along with artificial lighting that mimics natural conditions, can reduce eye strain and improve overall well-being. It is also important to place the light sources correctly to avoid glare or uneven lighting.

- *Acoustics:* Ensuring low noise levels and optimizing the acoustic properties of the classroom through appropriate materials and equipment (e.g. acoustic panels) can significantly increase comfort during lessons.

- *Electromagnetic smog:* Electrical and electromagnetic impulses cause various health problems – nervousness, depression, headache and eye pain, buzzing and whistling in the ears, sleep disorders, leukaemia, Alzheimer's, behavioural disorders. The most effective protective factor is the harmonization of the environment in which we live, work, or teaching is in progress. The basic means of protection against the effects of electromagnetic smog is sufficient shielding of the radiation source.

- *Psychological factors:* To improve the psychological conditions of the environment, it is essential to promote positive interaction between teachers and students, develop active learning methods and strengthen student engagement. Creating an environment that encourages creativity, open communication, and flexibility leads to improved well-being of participants in the educational process (Tureková et al. 2018, p. 86), (Tureková & Depešová, 2020, p. 250).

A student working indoors is primarily affected by the heat-humidity microclimate, which influences heat and moisture flows within the building. These flows can enter the interior through the building's envelopes. Additionally, the interior can be impacted by the odor microclimate, which generates gaseous components in the space. While these odors do not directly threaten human health, at higher concentrations they can reduce concentration, impair performance, and cause nausea (Heschong, L., 2002, p. 159).
Environmental well-being can be understood as the sum of chemical, biological and physical factors in the environment that affect building occupants as a whole. The well-being of the environment is influenced by air temperature, air flow velocity, air humidity, heat-insulating properties of clothing and physical activity of a person.

The well-being of the environment can be divided into several areas, such as:

- energy – heat, cold, noise, radiation,
- cloth – water vapour, gases and aerosols,
- thermal, thermal humidity,
- acoustic, light and others.

Factors influencing personal well-being include gender, age, and the ability to acclimatize. An optimal microclimate refers to a condition in which the body does not need to engage thermoregulatory mechanisms (Kachaňáková, 2007, p. 32).

3 Conducting a research survey

Monitoring of the quality of the environment was carried out in a selected classroom in such a way that the monitoring device was connected to a computer via the Fy Eaton PLC module, or it is also possible to connect to a mobile phone.
As a model space suitable for monitoring, we chose a lecture room designed for about 50 people, where it is a prerequisite to create suitable conditions for monitoring selected factors. The connection of the measuring instrument via the PLC device creates a connection that allows the measured factors to be recorded in short periods of time. The device for measuring parameters characterizing air quality is currently connected to the EATON PLC system, which sends the measured data in 30-second intervals directly to an Excel document within Google Apps with the currently measured values through a communication protocol implemented by us.
This creates a database of data suitable for subsequent analysis and evaluation. These output values are followed by a software tool designed by us to compare the measured values with the required parameters set by the valid documents pertaining to the given measured factor, evaluate these results with an emphasis on human health and propose effective measures to improve the workplace in accordance with legal regulations. The implementation of measurements and the subsequent proposal for optimization of working conditions is expected to achieve an improvement in the quality of the working climate and thus an increase in working comfort and performance.

3.1 Tools for verifying the quality of measured factors

To assess the quality of the educational environment, activities were carried out that led to the design and implementation, creation of a software tool for evaluating the results of the obtained measured values. The design of the method of evaluating the mutual relationships of the measured factors can be verified with the required values using a simple software tool designed by us.
Based on the assessment of the factors that have the greatest impact on the quality of the results of the educational process in the educational process, we have selected the factors for which the software tool was created.

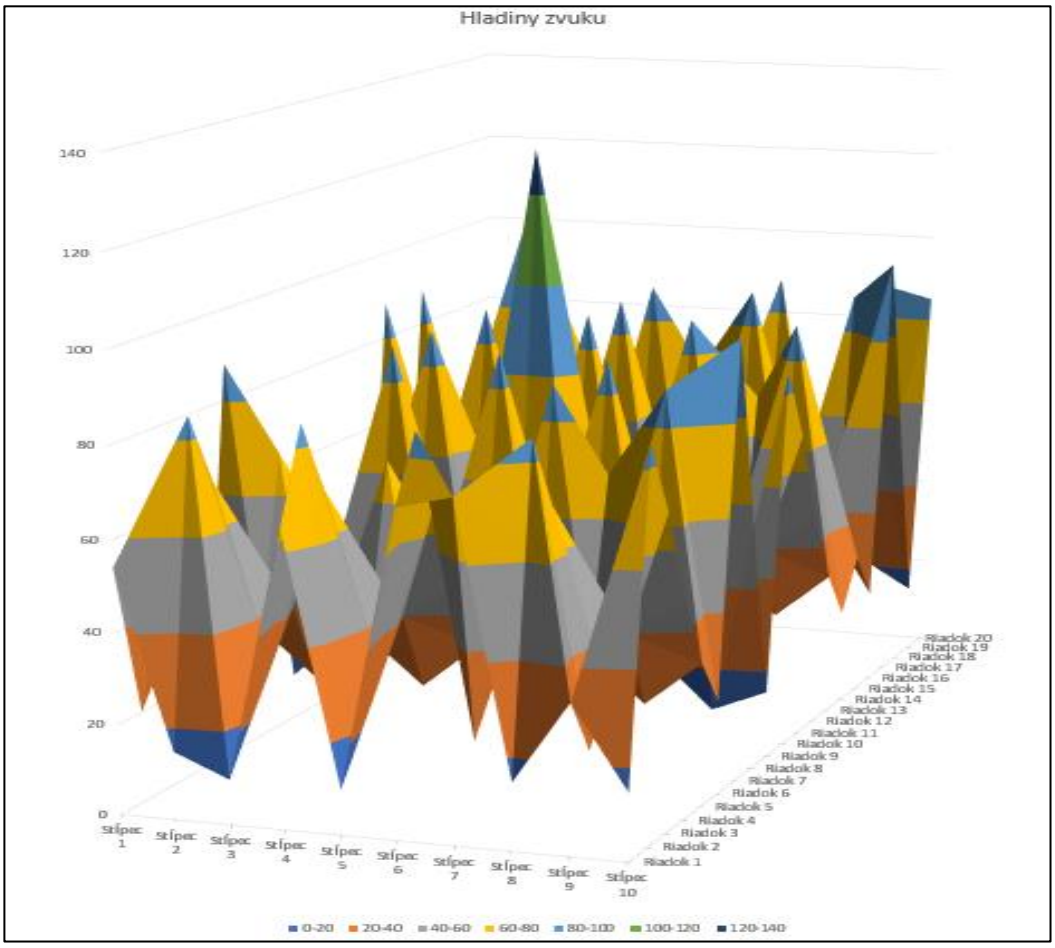
When creating it, we relied on valid documents:
Decree 99/2016 (temperature and humidity)
Decree 541/2007 (lighting)

Government Regulation 355/2006 (CO2)
Government Regulation 115/2006 (noise).

As an example of the created software tool, we present a table for recording measured noise values and the corresponding graph of measured values. With the help of a software tool, the measured value is compared in a graph with the permissible values specified in the relevant decree. Just as the measured values are recorded in a table, a specific level is recorded and evaluated in the corresponding graph.
Other selected factors of the educational environment are processed in a similar way and the measured parameters are evaluated.

Tabuľka	Stĺpec 1	Stĺpec 2	Stĺpec 3	Stĺpec 4	Stĺpec 5	Stĺpec 6	Stĺpec 7	Stĺpec 8	Stĺpec 9	Stĺpec 10
Riadok 1	54	15	10	65	10	71	74	15	33	15
Riadok 2	20	85	20	85	20	85	20	85	20	85
Riadok 3	30	69	30	69	30	69	30	69	30	69
Riadok 4	40	48	40	48	40	48	40	48	40	48
Riadok 5	22	32	22	32	22	32	22	32	22	32
Riadok 6	88	69	30	69	30	21	88	69	88	21
Riadok 7	36	48	40	48	40	48	40	48	36	98
Riadok 8	48	32	22	32	22	32	22	32	48	55
Riadok 9	10	21	88	21	88	21	88	21	10	15
Riadok 10	20	32	22	32	22	32	22	32	20	85
Riadok 11	30	21	88	21	130	69	30	69	30	69
Riadok 12	40	48	40	48	40	48	40	48	40	48
Riadok 13	22	32	22	32	22	32	22	32	22	32
Riadok 14	88	21	88	21	88	21	88	21	88	21
Riadok 15	22	32	22	32	22	32	30	69	30	32
Riadok 16	88	21	88	21	88	21	40	48	40	21
Riadok 17	36	32	22	32	22	32	22	32	22	98
Riadok 18	48	21	88	21	88	69	88	21	88	55
Riadok 19	10	98	36	48	40	48	22	32	22	15
Riadok 20	20	85	20	32	22	32	88	21	88	85

Table 1: Normalized Sound Level Action Values.



Graph 1: Sound level measurements.

4 Conclusion

The quality of the educational environment plays a crucial role in optimizing the effectiveness of the educational process. Measuring objective indicators such as temperature, humidity, lighting, and acoustics, alongside subjective assessments of comfort from students and teachers, provides valuable data for identifying and optimizing conditions that enhance well-being and learning efficiency.

Implementing appropriate measures to improve these conditions can significantly contribute to better overall educational outcomes while mitigating negative factors that affect student performance.

All activities conducted during the research aimed at optimizing the well-being of both teachers and students. The monitoring of research results focused on improving selected environmental factors, such as thermal comfort, lighting, noise levels, and the presence of pollutants, particularly carbon dioxide concentration in

classrooms. The emphasis on objective factors facilitates the implementation of effective measures. Ultimately, improving these factors enhances students' health and increases their productivity.

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