The educational organizations buildings and infrastructure health indicators’ monitoring by means of information systems

N I Basina, E N Pozharskaya, S L Popova1 and Yu A Rybalka*  
Don State Technical University, 1, Gagarin sq., Rostov-on-Don, 344010, Russia

E-mail: rybalka-yuliya@mail.ru

Abstract. The development of computerized monitoring systems for the educational environment health-saving indicators is currently one of the most urgent tasks of pedagogical research. The article presents the experience of using the information system developed by the Don State Technical University and used to conduct the monitoring studies in 1210 educational institutions of the Rostov region. The information system for monitoring the education sector includes monitoring the indicators of the educational organizations’ property complex, the technical condition of the school building and the institutions’ visual environment design. The information system used in the Rostov Region is the first computerized system for monitoring the environment of educational institutions in the Russian Federation, which allows automatic control of the environmental factors for students and institutions’ property complex technical re-equipment optimization to ensure the health activities of schools throughout the region.

Introduction

The social order of the society to protect the health of citizens is oriented to the modern education system, to the consistent formation in schools of a health-saving educational environment that ensures the creation of the conditions that guarantee the preservation and development of the student’s physical, mental and social health, and the promotion of a health culture as an important component of human culture. A rational approach to the students’ health requires regular diagnosis of the factors in the school environment that can adversely affect the health indicators of students, as well as the use of corrective actions in relation to the educational environment conditions to improve these indicators. These environmental factors primarily include the state of the school property complex, the rational architectural solution of the school building and the correct school grounds’ zoning, the design of the school’s visible environment, which have a significant impact on the psychophysiological state of students and teachers. The tasks of preserving and developing the health of the educational activities’ subjects necessarily include an analysis of the relationship between the degree to which the health protection requirements for the infrastructure and property complex of schools are met and the schoolchildren’s health indicators as an indicator of assessing the work effectiveness is performed. All of these activity areas in modern conditions are implemented on a regional educational space scale using monitoring and expert information systems. The literature widely discusses the use of information technology in education, including those applied to monitoring procedures [1-9].

Monitoring the technical buildings’ condition, the property complex and the infrastructure of educational organizations is of great importance due to the fact that students spend a significant part of
the daily time budget in schools, colleges, universities, which imposes the strict health requirements on the environmental indicators of educational institutions. In relation to educational organizations, all requirements for the safety of students’ health are regulated by the sanitary and epidemiological rules (SER), approved by the chief sanitary doctor of the Russian Federation. The current sanitary - epidemiological rules and standards “Hygienic requirements for the conditions of training in educational institutions: Sanitary and epidemiological rules: SER 2.4.2.2821 – 10” approved by the decree № 189 from 29.12.2010.

Among the factors and conditions of the educational organizations’ property complex that can affect the human health state (and pose a potential threat to the health of schoolchildren), traditionally include:

- ecological state of the adjacent territory;
- level of the school site gardening and zoning;
- remoteness of buildings from main transmission lines (power lines - PL), protection from the magnetic fields action;
- remoteness of the educational organization building from the main roads, railways, etc.;
- sound insulation level, not exceeding threshold noise values in rooms;
- sanitary and hygienic requirements for used building materials, paint, etc.;
- quality of architectural decisions, design, color of walls (video-ecological factors);
- sanitary and hygienic requirements for the size of the premises, the cubic capacity of classrooms;
- sanitary and hygienic requirements for air, lighting in classrooms;
- air ventilation system quality;
- condition and degree of electrical wiring insulation, requirements for the video-screen means - computers, multi-projector systems placement;
- condition and equipment of the school’s sports complex;
- condition of plumbing equipment, water supply, heating;
- quality of drinking water used in the educational institution;
- sanitary and hygienic requirements for the catering unit - the size of the premises, cubic capacity and technical equipment of the catering unit, meeting the requirements for the area of the dining room and technical premises of the catering unit; and so on.

As the parameters’ detail of the property fund and technical support of the institution, related to the class of sanitary and hygienic factors affecting the health indicators of students, we can consider a hygienic assessment of the air-thermal regime, lighting and noise level in the classroom. All these parameters are regulated by the applicable norms of SER 2.4.2.2821-10.

So, maintaining the optimal air conditions in the classroom is ensured by the following hygiene requirements:

1. **Compliance with the number of students in classes hygienic norm of capacity.** Norms are set by SER taking into account the area required per student and the height of the room:
   - at height 3.5 m per student requires at least 1.43 m²;
   - at height 3 m – 1.7 m²;
   - at height 2.5 m – 2.2 m².

2. **Mandatory daily wet cleaning of classrooms after class and during a big break.** Daily wet cleaning with the use of disinfectants provides not only dust control, but also prevents the possible spread of chronic infection foci (typical for children’s groups: inflammation of the tonsils, sinuses, etc.).

3. **Compliance with the ventilation of classrooms with effective ventilation systems.** Two ventilation systems are used in educational organizations: natural air flow through the air vents and a duct exhaust system (exhaust ventilation and organized fresh air flow in two versions - decentralized with unheated air and centralized with heated air).

To ensure the efficiency of air flow through transoms (vents), a certain ratio of transom and floor areas should be observed. This ratio is called the aeration coefficient (Ca) and is calculated as the ratio
of the area of all transoms in this class to the floor area. According to the SER standards, the aeration coefficient should be at least 1:50, the optimal ratio is 1:30.

4. **Temperature mode** It is one of the important environmental factors affecting the performance and health status of students. Various optimal air temperatures in the rooms of the educational organization are recommended, depending on the purpose of the room:
   - maximum temperature - in classrooms (18-20 °C);
   - below - in recreation (corridors);
   - the lowest - in workshops and gyms (15-17 °C).

   The students’ thermal comfort is located in the air temperature zone in the auditoriums and laboratory rooms +18-20°C. According to physiological and hygienic studies, at a temperature 16-18°C and relative humidity of 30-60% in the classroom for students for a long time, high performance is maintained. In the rooms where students are in motion (for example, in the gym), the air temperature should be lower, since the level of heat transfer is directly proportional to the work performed.

5. **Room humidity** It is also one of the important environmental factors affecting the performance and health status of students. The optimal moisture parameters, determined by the equipment in the breathing zone, are 40-60% (permissible limits are 35–65%).

   The state of the air-thermal regime of the auditoriums and laboratory rooms affects both the functionality of the child’s body and the assimilation of learning material by students. Particular attention in this regard is required by students, often suffering from respiratory diseases. For the students who are often ill with upper respiratory tract diseases, when hygiene requirements are not met for the indoor air, oxygen deficiency, and the absence of ultraviolet radiation, the risk of viral infections is particularly acute, and the number of complaints of headache and fatigue is growing.

   The main indicators of natural lighting are defined in the requirements of SER and include the following items:
   - The natural illumination coefficient (NIC) shows the illumination ratio in the classroom in the suites to the illumination at the same time in the open air. NIC is expressed as a percentage. In accordance with the requirements of SER, the minimum value of NIC in the classrooms should be 1.5%, in drawing and drawing rooms - 2.0%.
   - The light coefficient (LC) shows the ratio of the glazed area of the windows to the floor area. In classrooms, involving a significant visual load of students, the SC should be 1: 4, in recreation - 1: 6.
   - The screening coefficient shows the ratio of the height of the opposite building or trees to the distance to the school building; normal 1: 3.
   - The coefficient of the apparent horizon is a subjective-objective indicator. Its definition consists in assessing the percentage of the sky in the window opening: if at least 2/3 of the sky is visible from the class wall opposite the windows, the illumination is satisfactory; if 1/3 - unsatisfactory; if all the windows are filled with sky - the light is good.

   Among the health-damaging factors of the school environment is noise level in an educational institution. This factor belongs to the number of psycho-hygienic factors, in a weak degree of severity (insignificant sub-threshold sound background) necessary for a person. The silent environment (sound deprivation) negatively affects the psyche, since absolute silence is an isolation evidence and subconsciously perceived by a person as a survival danger.

   However, loud noise reduces attention concentration, increases fatigue, reduces performance. With prolonged work in conditions of noise exposure, the risk of developing asthenic-neurotic conditions, chronic fatigue, depression, etc. increases. The body’s reactions to noise exposure are diverse and largely depend on the individual sensitivity, mental and physical condition of a person. The noise effect has a greater effect on intellectual productivity than on physical performance.

   In educational organizations, special acoustic measures should be provided that impede the distribution and amplification of sound. In accordance with the requirements of SER, educational institutions are located far from highways, use soundproof building materials, green spaces around the building.
Monitoring the implementation of all the above-mentioned parameters of the property complex in educational institutions of the Rostov Region is a priority in the framework of the region performing pilot activities to save students (the order of the Ministry of General and Professional Education of the Rostov Region dated 01.03.2012 No. 155 “On the implementation of the pilot project on health saving”). Pilot health-saving activities on the scale of the Rostov region have been implemented since 2012, in 2019 all 1210 educational institutions, boarding schools and colleges in the Rostov Region were connected to the computerized monitoring and testing procedures. Information on the pilot project’s implementation for the health conservation of the educational system in the Rostov region is published in the literature [10-11].

Monitoring programs are implemented in the Rostov region by means of an information system (IS) “Information Technologies in Education” (copyright holder - FSBEI HPE DSTU), the system is developed by the educational and scientific laboratory “Computer Methods of Psychological and Pedagogical Diagnostics” of the Don State Technical University (the head of the laboratory is Associate Professor E.N. Pozharskaya). The laboratory was created for the purpose of developing the new monitoring programs and diagnostic techniques for the problems relevant to the education system and their implementation in the form of the information systems and interactive Internet applications. Information on the methodological content, computerized programs of psychological and pedagogical diagnostics integrated into the information system “Information Technologies in Education”, published in the literature [12-13].

Monitoring the health environment of schools using IS DSTU “Information Technologies in Education” provides a comprehensive approach to monitoring and analyzing various areas of the school environment affecting the state and preservation of students’ health. During the pilot phase of the project activity (2012-2017), schools in the Rostov region annually monitored the indicators of the property complex for all the above-mentioned assessment parameters. The indicators’ monitoring was aimed at identifying the current state of schools by the analyzed parameters and providing the targeted assistance to the educational organizations in case of identifying the problem areas. Targeted assistance included a wide range of funds - from the overhaul of the property complex of schools to the re-equipment of classrooms and methodological assistance to the teaching staff. At the same time, an important aspect was the economic calculation of the financing amount, while observing the support measures’ effectiveness requirements is provided. So, relying on the annual monitoring data collected by IS tools is most effective in analyzing such costs as: overhaul of school buildings, purchase and installation of sports and sports facilities - sports grounds at schools, purchase of equipment for school canteens, reconstruction and re-equipment of school medical rooms, etc.

Among the positions that showed a significant increase in indicators when conducting the innovations in the field of education during the pilot period of the project implementation, it is necessary to highlight the following areas of monitoring control, which relate in large part to the health-saving requirements’ implementation for the educational organizations’ infrastructure (the names of the directions are given in accordance with the names of the monitoring sectors IS programs):

- fulfillment of health-saving requirements for the placement of an educational organization (EO), a land plot and a building of an (EO);
- compliance with health-saving requirements for air-thermal conditions EO;
- compliance with health-saving requirements for natural and artificial lighting;
- fulfillment of health-saving requirements for the condition and equipment of classrooms and the use of technical training tools in the educational process;
- student catering;
- state of the sports complex EO;
- organizing a secure supportive educational environment;
- organization of medical services for students, the state of the medical office.

Monitoring data obtained on a pilot sample of more than 200 educational organizations in the Rostov Region showed a significant improvement in the above-mentioned parameters of the school environment.
environment (the growth of indicators in the region averaged about 10-15%). Calculation of school environment indicators was carried out in relative percentage points - the approximation degree of educational institutions in the region to the ideal functioning model that meets all the sanitary and hygienic requirements stipulated by SER 2.4.2.2821-10 was taken into account. The indicator for the section on the implementation of health-saving requirements for the infrastructure of an educational organization averaged 58.4158% of the ideal functioning model in the region, then in 2017, at the end of the pilot period, this indicator grew to 69.8020%. In comprehensive surveys of educational institutions in the Russian Federation conducted by the Institute of Age Physiology of the Russian Academy of Education [14], 13% of the schools revealed deviations from the norm in noise, in 34% in electromagnetic fields, in 31% in illumination, and in 21% microclimate, 25% - furniture. Monitoring compliance with the sanitary SER factors, bringing them in line with hygienic standards is entrusted to the medical workers supervising an educational institution, a school doctor, an average medical worker at a public health institution, and bodies of Rospotrebnadzor. The school administration is obliged to comply with the requirements of the Rospotrebnadzor bodies for monitoring hygiene factors in the educational institution. Information on the monitoring studies’ results carried out by means of the information system “Information Technologies in Education”, published in the literature [15].

Summary
In addition to the technical condition of the building, the important hygiene factors in the educational institution are architectural decisions and the visible environment design of the school from the point of view of the visual perception. Psychophysiology. The studies of psych physiologists have proved that a monolithic, with repeatedly repeated elements interior of a room has a negative, depressing effect on a person. Straight lines, clearly drawn corners are an aggressive video environment. Patterns with respect to the color scheme were also found: a white-gray-black environment with rhythmically repeating lines increases human fatigue, worsens the emotional state. A variety of colors, rounded shapes, a combination of various geometric shapes in the interior contribute to higher workability, improves mood. In this regard, when organizing the visual environment of a health-saving educational institution, the color and light design of visible fields, the surfaces’ quality and their mobility should be taken into account. In the interior of the class should not be homogeneous and aggressive fields. The preferred warm light colors in pastel colors. The visual environment is improved by indoor plants, the presence of decorative details. The choice of colors for painting walls and school equipment has not only aesthetic value, but also affects the emotional state of schoolchildren, their well-being and performance.

Environmental requirements for the location of the school, its surrounding green spaces, etc., are regulated by SER. Taking into account the ecological disadvantage of a significant part in the territory of Russia, it is impossible to completely exclude the environmental group of factors from among potentially pathogenic factors for students. Therefore, efforts to create a health-saving educational environment in educational organizations should be aimed at creating the conditions in and around the institution that are more favorable for the students and teachers to stay in it.

References
[1] Usacheva N V and Pomazan V A 2016 Development of computer psychodiagnostics tests using the environment of object-oriented design DELPHI Materials of the III All-Russian scientific-practical conference "The formation of human capital by the resources of the educational system" (Krasnoyarsk April 21-22) 163-165.
[2] Shmelev A G and Lisitsa I A 2016 Computer testing and gamification: prospects for monitoring the functional state of workers in the era of computerization of psychodiagnostics Bulletin of Moscow University Series 14: Psychology 4 98-109.
[3] Kozyreva O A, Kozyrev N A and Mitkina E V 2016 Innovative pedagogy in the model of modern education Internet science 10 178-92.
[4] Konovalov S V and Kozyreva O A 2017 Pedagogical modeling in the constructs of modern education *Bulletin of TSPU* 1 (178) 58-63.

[5] Selivanov V V and Selivanova L N 2016 Influence of virtual reality tools on personality formation *Continuing Education: XXI Century* 2 (14).

[6] Kostrigina A A 2017 Digital history of psychology: problems and prospects *History of Russian Psychology in Persons: Digest* 4 17-24.

[7] Efremova G I, Aysina R M, Maksimenko Z A, Kolotilova I V and Shagurova A A 2015 Virtual Computer Technologies in Practice of Socio-Psychological Assistance toward the Unemployed People: Current State and Prospects of Researches *Asian Social Science* 11 (2) 262-69.

[8] Piaw C Y 2012 Effects of computer-based testing on test performance and testing motivation *Computers in Human Behavior* V (28) 1580-6.

[9] Piaw C Y 2012 Replacing paper-based testing with computer-based testing in assessment: Are we doing wrong? *Procedia - Social and Behavioral Sciences* V (64) 655-64.

[10] Guskov I A, Balina L V, Vygonskaya T V, Pozharskaya E N and Chausova L K 2015 Unified information space of the Rostov region: innovative direction for the development of health-saving activities in the regional education system *News SFU Pedagogical sciences* 9 21-8.

[11] Khlebunova S F and Pozharskaya E N 2017 Health-saving technologies in education: content, application, effectiveness *News SFU Pedagogical sciences* 1 57-66.

[12] Pozharskaya E N 2018 Psychological and socio-pedagogical testing of students by means of information technology: a teaching aid (LLC DGTU-Print, Rostov-on-Don) 245.

[13] Pozharskaya E N, Dolgov V V and Platonov D A 2018 Computer program "Psychological and pedagogical monitoring program" Information technologies in education ”, Certificate of state registration of computer programs № 2018619414. Registered in the Computer Software Registry on August 6, 2018.

[14] Bezrukikh M M 2004 Health Saving School (Moscow Psychological and Social Institute, Moscow) 240.

[15] Balina L V, Bezrukikh M M and Pozharskaya E N 2016 The Unified Information Educational Space of the Rostov Region - Modern Approaches to the Development of a Regional System of Health Care in Education *Bulletin of Education (Collection of orders and instructions of the Ministry of Education and Science of the Russian Federation)* 11 22-32.