Aleksandar Zunjic
Associate Professor
University of Belgrade
Faculty of Mechanical Engineering

Goran Papic
Ph.D. student
University of Belgrade
Faculty of Mechanical Engineering

Bozica Bojovic
Assistant Professor
University of Belgrade
Faculty of Mechanical Engineering

Lidija Matija
Associate Professor
University of Belgrade
Faculty of Mechanical Engineering

Goran Slavkovic
Teaching Assistant
University of Belgrade
Faculty of Mechanical Engineering

Petar Lukic
Associate Professor
University of Belgrade
Faculty of Mechanical Engineering

The Role of Ergonomics in the Improvement of Quality of Education

This paper considers the ways in which the ergonomics can contribute to the improvement of the quality of education. The global approach has been applied to this problem, which means that are discussed various aspects of application of ergonomics in improving the quality of education. Several basic segments have been identified, in which ergonomics can contribute to improve the quality of education of students. It is concluded that the results of ergonomic research in this area provide a good starting point that allows the creation of appropriate ergonomic designing solutions, aimed at solving the existing problems in this area.

Keywords: *ergonomics, education, quality.*

1. INTRODUCTION

Education is a complex process, which consists not only in the verbal presentation of material to be presented to pupils and students. The education process includes, among other things, providing of adequate conditions to be fulfilled, which allow the execution of assigned tasks, without violating the health of students. Additional aim is that the students should be able together with their educators to work in a safe, efficient and comfortable way as well as to friendly use software and devices. In these segments, the possibility of application of the ergonomic knowledge is perceived, which contribute that many problems of pupils and students in this field can be solved in an appropriate manner.

According to the above mentioned, it can be distinguished three main segments in which ergonomics can contribute to the quality of education. These are: preservation of the health of students, creation of a comfortable working environment and adjusting the process of education according to students' abilities. In the following, the results of some ergonomic research will be presented, related to these segments. These researches indicate the importance of application of studies in the field of ergonomics for detection of various problems that surround the education process.

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Correspondence to: Aleksandar Zunjic
Faculty of Mechanical Engineering,
Kraljice Marije 16, 11120 Belgrade 35, Serbia
E-mail: azunjic @mas.bg.ac.rs
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2. PRESERVATION OF THE HEALTH OF STUDENTS

Preserving health of pupils and students is one of the primary conditions that must be met during the process of education. However, for various reasons, this condition is often not satisfied in practice adequately.

Anthropometric measurements are an important aspect that should be taken into account in classroom furniture design. Specific measurements, such as popliteal height, knee height, buttock–popliteal length and elbow height are essential in order to determine school furniture dimensions that enable the proper sitting posture. Use of the furniture that promotes correct posture is more important to children than for adults, because in this young age starts the process of creation of habits related to sitting. Harmful sitting habits acquired in childhood are very difficult to change later in adolescence or adulthood.

Appropriate sitting posture is an important element in the prevention of musculoskeletal symptoms. According to Bendix and Brunswic, static posture and prolonged sitting in a forward bending position, as students often acquire, puts a considerable physiological strain on the muscles, ligaments and in particular, on discs [1].

An experimental study [2] compared the effects on children's behavior and sitting position of traditional classroom furniture with a chair that is known as "Chair 2000" and associated tables. It was found that children showed a moderate but significant improvement in "on-task" behavior, and a marked improvement in sitting positions on account of the introduction of the newly-designed furniture. However, these benefits need to be

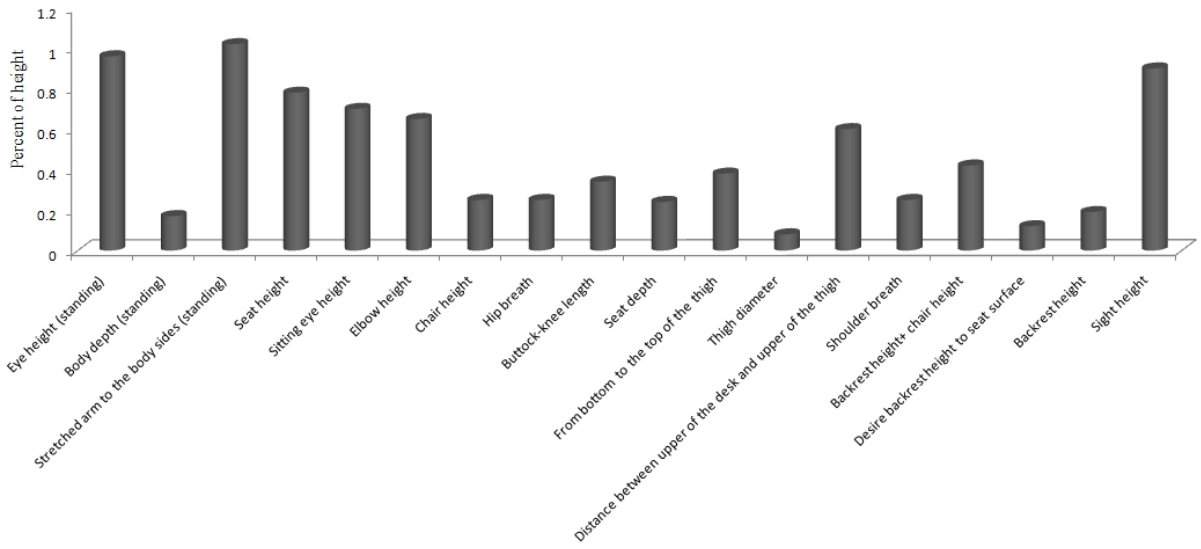

Figure 1. Dimensional relationships that need to be taken into account when forming the interaction between students and tables, benches and other furniture (adapted according to [1])

considered in the light of polarized opinion for and against the new furniture, having also in mind a high level of reported incidence of back pain that is associated with the frequency of non-standard sitting, which is connected with the application of the old furniture. In the absence of radically redesigned furniture, it is recommended that children should be given more choice in their seating, and better guidance should be given to individuals involved in education, in order to inform them about classroom furniture, proper sitting postures, anthropometric aspects of sitting and related ergonomic activities [2].

Additionally, symptoms resulting from continual inconvenient sitting on non-standard furniture in a classroom had been previously connected with the kidney and alimentary problems, as well as with the lumbar pain [1]. Changes in the passive flexion stiffness of the lumbar spine may increase the risk of the low back injury after prolonged sitting, and may lead to the low back pain in sitting [3]. Another conducted research indicates a mismatch between the students' physical dimensions and the classroom furniture that is available to them. Results of that research indicate that the chairs were too high and too deep, while the desks were also too high for the pupils. This situation has negative effects on the sitting posture of the children, particularly when reading and writing [4].

Results of another research have shown that desk and bench height, desk and bench slope, padding height and blackboard height were not in accordance with the anthropometric dimensions of users. This not only can cause the reduction in efficiency, early fatigue, cervical, backbone and lumbar pain, but also may cause postural disorders in long-term use, such are scoliosis and lordosis [1]. Additional modification in making of the desk and chair surface and back of the benches may contribute in creation of the appropriate slope.

A brief review of 19th century handwriting demonstrates the belief about the need to sit up with a straight back. This was reinforced in schools and elsewhere using backboards to maintain this posture. Typically, it was used chairs with vertical backs and horizontal seats, usually 46 cm off the floor [5]. The conviction in a validity of a straight back position when sitting on a horizontal seat is still implicit in descriptions of "correct" sitting. In the 20th century, the understanding about the consequences of the effects of sitting increased, probably guided by the expansion in seated workplaces and a recognition of the widespread presence of back pain in the population.

Ergonomics among other things seeks to establish the optimal interaction between people and products. In this regard, a number of researchers were focused on the establishment of functional dependencies between individual students' anthropometric dimensions and sizes of furniture that they should use. Figure 1 shows different anthropometric values and dimensions of the furniture, in the function of standing height. The first three dimensions in the figure are defined in the standing position, while the other parameters applicable to the students sitting position.

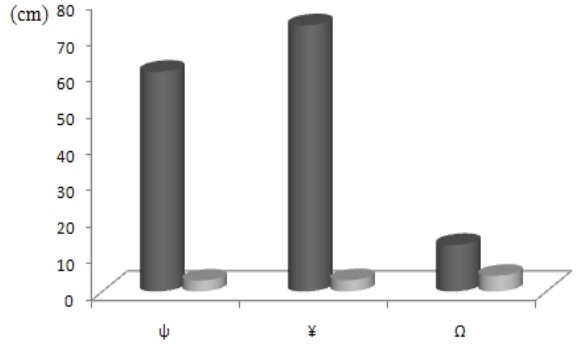

Figure 2. Mean and standard deviation for elbow–floor height (ψ), desk height (¥) and the difference between desk height and elbow–floor height (Ω), (adapted according to [6]).

Another ergonomic research [6] points to the importance of harmonization of certain furniture dimensions and anthropometric values of the students, in order to avoid certain consequences to their health. This research was performed in Finland, with 12 to 14 year old schoolchildren. The main outcome measures were the differences between desk height and elbow-floor height (figure 2), and chair height and popliteal height (figure 3).

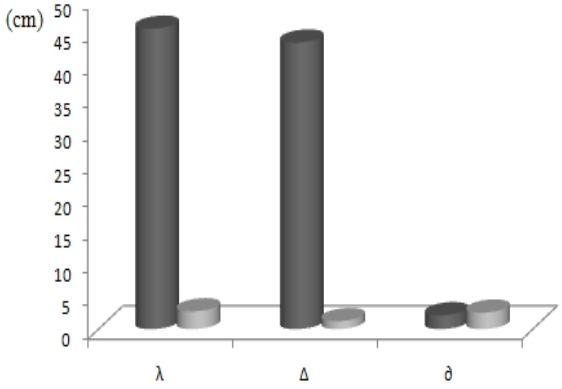

Figure 3. Mean and standard deviation for popliteal height (λ), chair height (Δ) and the difference between chair height and popliteal height (∂), (adapted according to [6]).

Although design of workplaces for students is important, the control of body positions of learners is perhaps more serious problem. Practically, school furniture is devastatingly inadequate in many cases. Reports by research groups in many countries, including Australia, New Zealand and the US, also have raised awareness about the large number of pupils with spinal cord problems. A committee working with a major charity in Britain has put forward to the government proposals for a change in school furniture shaping to link with the progression in school design and changes in teaching methods. The report is a direct response to repeated findings (quoted in the report) of an annual incidence of 20% or more of pupils aged 15-16 years reporting about frequent back pain [5].

3. CREATION OF A COMFORTABLE WORKING ENVIRONMENT

Creating a comfortable working environment contributes greatly to the creation of conditions that allow students to work in the absence of disturbing factors. Of the factors that can affect the teaching process, here can be mentioned noise, temperature, humidity and illumination.

The research evidence shows that noise does affect children's performance at school [7]. Older children within the age range that relates to the primary school appear as the most affected by noise. Moreover, children are annoyed by noise at schools. Measurement surveys of conditions in classrooms show that classroom noise levels can be high, particularly in rooms without proper acoustic treatment, and that this is often due to the noise of classroom activity. One example of the detrimental effect of noise is the degradation of speech intelligibility in the classroom. The precise mechanism of the effects of noise on the cognitive processes of children, however, is not yet fully understood.

It is generally accepted that noise has a detrimental effect on learning and performance of primary school children, and that the older children in this age group are more affected than the younger children [8]. Activities affected by noise include memory, reading, motivation and attention [9-12].

Sound pressure levels in school environments are often higher than prescribed or recommended values. One research that illustrates the previously mentioned statement is shown in [13]. The results shown in the table 1 refer to the calculated values of equivalent sound pressure levels.

Table 1. Measured school noise levels for selected classes in Assiut (adapted according to [13]).

Class	School noise level (db)
1	61.3
2	62.7
3	64
4	65.3
5	67.1
6	67.8
7	68.1
8	69
9	70.5
10	71.8
11	72.6
12	73.2

Many results show that both prolonged and acute exposure to classroom and environmental noise have a detrimental effect on children's learning and performance. Some characteristic additional effects of noise [13] on students are shown in figure 4. Background noise in the classroom also has a significant adverse effect. There are some indices that the children with special educational needs are more susceptible to the effects of classroom babble during verbal tasks than other children.

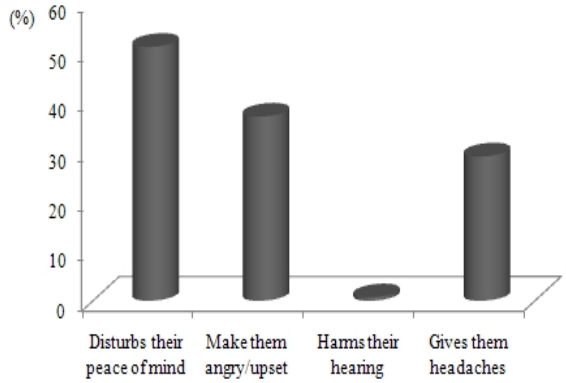

Figure 4. Percentage of respondents reporting specific types of disturbance from school noise (adapted according to [13]).

Noise from transport is an increasingly prominent feature of the urban environment. However, schools, especially in big cities, often are not isolated in terms of the location from the noise that originates from the transportation. Besides the well-known effects of noise on hearing, studies have demonstrated a moderate effect

of transport noise on hypertension, cardiovascular disease and catecholamine secretion. However, for children, there is ambiguous evidence of association with blood pressure. In relation to children, effects of road traffic and aircraft noise have been considered mostly in terms of impaired reading comprehension and memory skills. There is also evidence for an effect on some psychological manifestations. One way how the noise may affect the human health is through annoyance. The noise causes annoyance responses in both children and adults, and annoyance further may cause stress-responses and subsequent disease. Noise can be considered as a leading cause of environmental annoyance, and it negatively affects the quality of life of a large portion of the population, especially children at schools. Another possible mechanism of harmful effects of noise on children is sleep disturbance [14]. Studies have yet to examine how noise exposure interacts with other environmental stressors.

Illumination is an important factor affecting the perception of students, their performance and mood. Our pilot study shows that in some classrooms of a faculty measured illumination values are lower than 200 lx, which is below the recommended value for performing common activities of students. However, this fact points to the need for further measuring and monitoring of this parameter of lighting.

The effects of room temperature (58-60°, 67-68°, 72- 73°, and 78-80° F) on performance, comfort and arousal in different tasks (reading, mathematics and memorization) were examined in one research [15]. Participants arrived at one of four temperature conditions and completed three tasks, including a survey regarding subjective measures of physical comfort, task difficulty and arousal. Although participants' bodily comfort was dependent of the room temperature, no statistically significant performance differences based on temperature were found for any of the tasks. Interestingly, males outperformed females in both the reading and math tasks.

Although room temperature affected subjective physical comfort, it appears that had no impact on performance in some mathematics tasks, reading comprehension, or for the word recall. A part of findings from thermal comfort surveys of indoor environmental variables in naturally ventilated classrooms [16] is shown in figures 5 and 6.

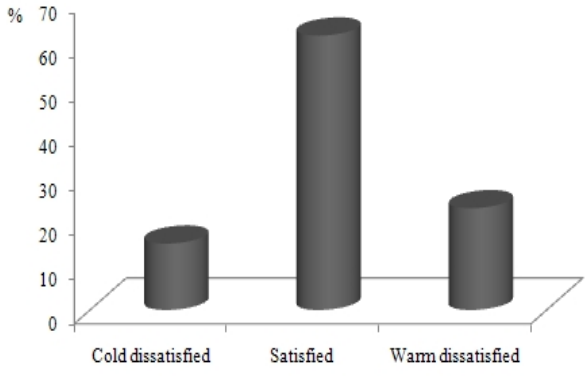

Figure 5. Thermal satisfaction of school children in Hampshire, based on the application of TSV (adapted according to [16]).

Figure 5 represents results that are based on the application of TSV scale. Figure 6 represents results that are based on the application of TPV scale. However, Wyon, Fanger, Oleson, and Pederson, in their research concluded that "While participants tend to prefer warmer temperatures (66-73.4°F) than cooler temperatures, warmer temperatures may not improve task performance" [15].

In many schools, thermal conditions are not controlled well, due to insufficient cooling or heating capacity, high internal or external loads, large areas that should be thermically regulated, improper design of the system for control, inadequate execution of operations, and other factors. Thermal conditions inside buildings may vary considerably, both with time (for example, example as outdoor conditions change), and spatially. Although the effects of temperature on comfort are broadly recognized, the effects on productivity have received much less attention.

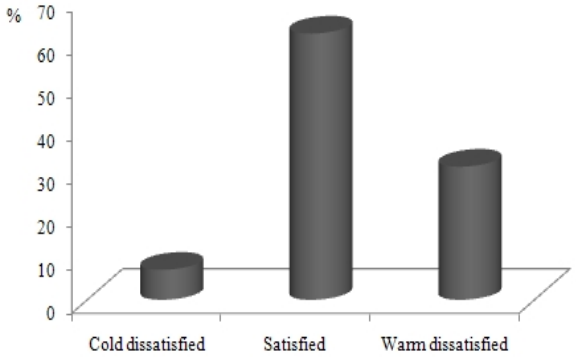

Figure 6. Thermal satisfaction of school children in Hampshire, based on the application of TPV (adapted according to [16]).

The indoor temperature affects several human responses, including thermal comfort, performance in certain kind of tasks, perceived air quality, and a phenomenon that is known as the sick building syndrome. In one study [17], authors concentrated on the effects of temperature on performance. They included those studies that have used objective indicators of performance, for which it is supposed to be relevant for intellectual performance, such as text processing and simple calculations (addition, multiplication). Authors calculated from all selected studies the percentage of performance change per degree of the increase in temperature, and statistically analyzed measured performance under the effect of temperature. The analysis showed that performance increases with temperature up to 21-22 ^{o}C, and decreases with temperature above 23-24 ^{o}C. The highest productivity is at temperature of about 22 ^{o}C. For example, at the temperature of 30 ^{o}C, the performance is only 91.1% of the maximum (i.e. the reduction in performance equals 8.9%). Data suggest that the effect of the temperature may be more prominent in actual work than in short-term laboratory experiments, where the motivation may weaken the effect of the temperature. Low ventilation in combination with high air temperature would most probably decrease the productivity further.

Using of the sophisticated laboratory equipment, such as equipment for the specific biotechnological, electromechanical and other measurements in mechanical engineering also requires ergonomic consideration, in terms of optimizing the interaction between the student and the measuring device. Some factors of the environment (such as lighting, for example), may affect the accuracy of readings from the measuring instruments. In connection with this aspect of measurement, students also need to be adequately informed.

4. ADJUSTING THE PROCESS OF EDUCATION ACCORDING TO STUDENTS' ABILITIES

It is of great importance that the education process be adapted to the possibilities and abilities of students. In this regard, the material that students need to learn should be consistent with the psychological and physical characteristics of students.

There are many theories about information processing, which focus on different aspects of perceiving of data, remembering and reasoning. One of the most important agreements is that elaboration is a key to permanent storing of information in a way that facilitates its quick retrieval when it is needed. Bloom et al and Anderson and Krathwohl provide suggestions as to how we can encourage increased elaboration among students. However, as suggested by Hummel and Huitt, if from students are not requested to demonstrate the results of elaboration on meaningful tasks (such as examinations or projects), it is not likely that they will adequately develop the skills that are required for higher-level thinking [18]. It is, therefore, important that educators promote the development and use of these skills, as a usual part of students' practice. If they do that, the amounts and types of student knowledge will increase, and students will be better prepared for life, as well as for professional demands and tasks.

5. CONCLUSION

Based on the research results presented that possess ergonomic properties, it can be noticed the importance and benefits of ergonomics application to improve the process of education and training. This benefit is not just at the level of detection of problems that are not easily visible or obvious. Ergonomic design solutions, based on the results presented in these and similar studies, may additionally contribute to the improvement of the education process in the registered segments.

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ФУНКЦИЈА ЕРГОНОМИЈЕ У УНАПРЕЂЕЊУ КВАЛИТЕТА ОБРАЗОВАЊА

Александар Жуњић, Горан Папић, Божица Бојовић, Лидија Матија, Горан Славковић, Петар Лукић

Овај рад разматра начине на које ергономија може да допринесе унапређењу квалитета едукације и образовања. Примењен је глобалан приступ овој проблематици, што значи да су разматрани различити аспекти примене ергономије у подизању квалитета едукације. Идентификовано је неколико основних сегмената, у којима ергономија може допринети унапређењу квалитета образовања, како код деце школског узраста, тако и код студената. Закључено је да резултати ергономских истраживања у овој области представљају добру полазну основу која омогућава креирање одговарајућих ергономских дизајнерских и других решења, усмерених на решавање постојећих проблема у овој области.