The importance of ergonomics in schools – secondary technical school students’ opinion on the comfort of furniture in the classroom for computer aided design

B Gligorović 1, E Desnica12 and I Palinkaš1

1University of Novi Sad, Technical Faculty “Mihajlo Pupin”, Dure Đakovića bb, 23000 Zrenjanin, Serbia

E-mail: desnica@tfzr.uns.ac.rs

Abstract. Considering the amount of time school children spend in school, primarily sitting, classroom furniture has a crucial role in the maintenance of good sitting posture and should be designed to promote it. However, there are numerous studies that have reported unsuitability of school furniture and its mismatch with students’ needs and anthropometric characteristics. This paper presents the results of research conducted among 100 students from a secondary technical school who were asked to answer to the questionnaire related to the comfort of furniture they use in the classroom for computer aided design, sitting posture they take as well as how it affects their psychophysical state and learning activities. Also, T-test analysis was conducted in order to determine whether there was statistically significant difference in opinion on the comfort of the furniture between first and fourth grade students. The results indicate that students do not feel totally comfortable when sitting at a computer in the classroom for computer aided design but that the discomfort does not have huge consequences on their mental and physical state (tiredness, pain, concentration and attention) during class.

1. Introduction

Derived from the Greek ergon (work) and nomos (laws) to denote the science of work, ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance and harmonize things that interact with people in terms of people’s needs, abilities and limitations [1]. The interdisciplinary nature of ergonomics makes it markedly applicable to various fields that involve human performance. Education is one field where ergonomics can make a significant contribution but the application of ergonomics to education has received only limited attention. Educational ergonomics is that branch of ergonomics/human factors concerned with the interaction of educational performance and educational design [2]. A systems analysis has identified 5 components for educational ergonomics: (1) learning ergonomics (2) instructional ergonomics (3) ergonomics of educational facilities (4) ergonomics of educational equipment (5) the ergonomics of educational environment [3].

According to [4], the ‘system’ within schools contains many different ‘elements’, ranging from micro to macro ergonomic in nature such as school equipment (desks, chairs, computers, laptops, books, schoolbags, pens, uniforms, and equipment used for sport and in the gymnasium and playground), work – (learning, teaching and playing) – spaces (desk/chair/workspace arrangements, lockers), school
facilities/environments (classrooms, laboratories, libraries, corridors, playgrounds staffroom, physical factors such as heating, cooling, lighting, noise, building design and the internet) and school organisation (subjects/topics, curricula, learning/teaching methods and pedagogy, school-day length and timing, study durations, timetable, rest breaks, physical activities, departmental structures, governance, school rules, personal security, human rights, school and national policies, educational priorities, internationalization, globalization).

The aim of this paper is to highlight the significance of educational ergonomics, especially ergonomics of educational equipment (desks and chairs) whose non-ergonomic design may cause severe problems, from health to those connected to school children’s learning and performance. Also, this paper presents the results of research conducted among secondary technical school students on their opinion about the comfort of furniture they use in the classroom for computer aided design, sitting posture they take as well as how it affects their psychophysical state and learning activities.

2. School furniture and school children’s sitting posture

School children spend most of their waking hours at school (approximately a quarter of the day) mostly in the sitting position doing their school work activities such as reading and writing [5,6]. Besides activities performed in the classroom, school children’s sitting posture is influenced by their anthropometric measures such as Stature (S), Popliteal Height (PH), Buttock-Popliteal Length (BPL), Elbow Height Sitting (EHS), Hip Width (HW), Thigh Thickness (TT) and Subscapular Height (SUH) as well as by design features and measures of school furniture including Seat Height (SH), Seat Depth (SD), Seat Width (SW), Upper Edge of Backrest (UEB), S Point (SP), Lower Edge of Backrest (LEB), Desk Height (DH) and Seat to Desk Clearance (SDC) (Figure 1).

Figure 1. Students’ anthropometric measures and furniture dimensions [5,7].

Considering the amount of time spent by children in the sitting posture, school furniture has a significant role in the maintenance of good sitting posture and should be designed to promote it. Use of the furniture that promotes correct posture is more important to children than to adults, because young age is the period when sitting habits are developed. Non-ergonomically dimensioned furniture, unsuited to body dimensions may lead to bad posture habits which may have a direct impact on the growth process because they are likely to remain unchanged into adolescence or adulthood [8-10]. Poor posture in school students using school furniture is considered as one of the factors that may increase the risk of developing musculoskeletal disorders [11], back, leg, arm, neck, shoulder and feet pain [10,12], loss of concentration and restlessness in the attempt to find a better position.

The design of school furniture is guided by national and regularity standards. Unfortunately, these standards do not always comply with the anthropometric reality of the users. The countries in the European Union follow the Normative EN 1729-1. This Normative is in Serbia applied as SRPS EN 1729–1:2016 which specifies functional dimensions and markings for chairs and tables for general educational purposes in educational institutions and SRPS EN 1729-2:2016 which specifies safety requirements and test methods for chairs and tables for general educational purposes in educational
institutions. There is also ‘The rulebook on norms of school space, equipment and teaching tools for elementary school’ which says that school furniture, especially furniture for students, must fulfil the hygiene, pedagogical and technical requirements. It should also be economically justifiable, allow proper development of young people and correspond to the needs of teaching and other educational activities in elementary school. It is especially important that school furniture is simple in design and stable, allowing students to sit comfortably and concentrate. It should be easily movable, and should not create noise damage the floor when moving (The rulebook on norms of school space, equipment and teaching tools for elementary school).

3. Mismatch between student body sizes and their desks and chairs

Mismatches between sizes of school furniture and students’ anthropometric dimensions have been reported in many countries. In reference [5], authors compared furniture sizes within three different schools with the anthropometric characteristics of Chilean students of the 8th grade, in order to evaluate the potential mismatch between them, and concluded that classroom’s furniture (especially seat height and seat to desk height) was, in almost all the analysed cases and subjects, not adequate for the student population, resulting in pain on the posterior surface of the knee and shoulder region. The examination of match between school furniture dimensions and anthropometry of 6-18 years old children from Athens schools revealed a substantial frequency of mismatch especially for desk height, seat height and seat depth [8]. Mismatching between bodily dimensions and the classroom furniture were identified among pupils in Thessaloniki which had negative effects on their sitting posture especially when reading and writing [9]. The data of the study by [10], indicated a substantial degree of mismatch between sixth-through eighth-grade Michigan students’ bodily dimensions and the classroom furniture available to them. Most of targeted students were sitting in chairs with seats that were too high or too deep and at desks that were too high. In reference [13], authors evaluated the potential mismatch between classroom furniture dimensions and anthropometric characteristics of Iranian high school students aged 15-18 years and found out a considerable mismatch between their body dimensions and the existing classroom furniture, with seat height (60.9%), seat width (54.7%) and desktop height (51.7%) being the furniture dimensions with a higher level of mismatch. A mismatch was identified between school furniture and the anthropometrics of Finland schoolchildren who sit in disadvantaged postures for a substantial part of school lessons [14]. The results of a study aimed at determining the relationship of anthropometric dimensions of pupils from grades 1 to 8 in primary schools in Croatia with the dimensions of school chairs showed that furniture of appropriate dimensions was not available to a large number of students in that country [15]. In reference [16], authors found that almost two thirds of 138 twelve to fifteen-years old Portuguese students studied suffered from back pain and that large differences between desk height and elbow height was associated with a greater likelihood of the adolescents having this problem while [17] found that the probability of back pain in Portuguese schoolchildren aged 7–10 years increased 4.4 times when school furniture was uncomfortable. According to [18] study 96% of students in three New Zealand secondary schools (years 9 to 13) were seated in furniture that was unsuitable for their body size.

4. Method

4.1. Participants and data collection

The research was carried out in one secondary technical school in Zrenjanin, Serbia, with 100 students aged 16-19 (first to fourth grade) who have classes in the classroom for computer aided design. The subjects were selected randomly from every class from first to fourth. The questionnaires, containing twelve questions, were distributed personally to the students in the sampled secondary school who expressed their opinion about the comfort of furniture (chairs and desks) they use in the classroom for computer aided design, sitting posture they take as well as how it affects their psychophysical state and learning activities through rating each question from 1 – ‘Never’ to 6 – ‘Always’. Furniture used in the classroom for computer aided design is presented in Figure 2.
4.2. Results

4.2.1. Descriptive statistics

The descriptive statistics for the questions about the comfort of classroom furniture and students’ sitting posture are shown in Table 1. In the table, among other things, the questions, their short names (which are used hereafter), mean size and standard deviation are given.

| Questions                                                                                       | Short name | Min. | Max. | Mean   | Std. Deviation |
|-----------------------------------------------------------------------------------------------|------------|------|------|--------|----------------|
| Do you feel comfortable when sitting at a computer in classroom for computer aided design?        | Q1         | 1    | 6    | 3.54   | 1.337          |
| Do you feel tired when sitting at a computer in classroom for computer aided design?             | Q2         | 1    | 6    | 2.70   | 1.267          |
| Do you feel any pain (in back, neck, arms, legs, knees) when sitting at a computer in classroom for computer aided design? | Q3         | 1    | 6    | 2.40   | 1.421          |
| Does your sitting position when working at a computer in classroom for computer aided design disrupt your concentration and attention in class? | Q4         | 1    | 6    | 1.78   | 1.106          |
| Do you find it difficult to sit during all class because your sitting position when working at a computer in classroom for computer aided design is not suitable for you? | Q5         | 1    | 6    | 2.44   | 1.351          |
| Are your feet fully supported by the floor and at a 90-degree angle when sitting at a computer in classroom for computer aided design? | Q6         | 1    | 6    | 2.80   | 1.400          |
| Are your knees bent at approximately a 90-degree angle when sitting at a computer in classroom for computer aided design? | Q7         | 1    | 6    | 2.87   | 1.261          |
| Is your back straight and supported by the chair when sitting at a computer in classroom for computer aided design? | Q8         | 1    | 6    | 3.12   | 1.320          |
| Are your elbows bent at a 90-degree angle and at desk height when sitting at a computer in classroom for computer aided design? | Q9         | 1    | 6    | 2.79   | 1.387          |
| Are your shoulders relaxed when sitting at a computer in classroom for computer aided design?    | Q10        | 1    | 6    | 3.92   | 1.161          |
| Have you ever complained to the teacher about the discomfort of the furniture (chairs, desks) you use in classroom for computer aided design? | Q11        | 1    | 6    | 1.53   | 1.193          |
| Have you ever complained to the classmate about the discomfort of the furniture (chairs, desks) you use in classroom for computer aided design? | Q12        | 1    | 6    | 1.87   | 1.468          |

Valid N (listwise) 100

4.2.2. T-test analysis (independent samples test)

The comparative results of the mean values of all twelve questions related to students’ opinion on the comfort of classroom furniture are presented in Table 2. T-test (independent samples test) was used for the comparison of two sets of data (first grade students’ opinion on the comfort of the furniture in
classroom for computer aided design and fourth grade students’ opinion on the comfort of the furniture in classroom for computer aided design). The main results of statistical analysis are also given in Table 2. It can be noted that in two questions (Q1 and Q11) there is a statistically significant difference between observed groups of data. The results of these two questions are marked in Table 2.

Table 2. The comparative results of the mean values of all twelve questions related to students’ opinion on the comfort of classroom furniture (t-test).

| Group Statistics | Independent Samples Test |
|------------------|--------------------------|
| Grade   | N  | Mean | Std. Dev. | Std. Error Mean | F  | Sig.  | t   | df  | Sig. (2-tailed) | Mean Diff. | Std. Error Diff. |
| Q1 First | 27 | 3.11 | 1.396     | 0.269         | 0.523 | 0.473 | -2.051 | 45  | 0.046           | -0.789     | 0.385          |
| Fourth  | 20 | 3.90 | 1.165     | 0.261         | 0.056 | 0.814 | 0.261  | 45  | 0.795           | 0.100      | 0.383          |
| Q2 First | 27 | 3.00 | 1.271     | 0.245         | 0.134 | 0.717 | -1.033 | 45  | 0.307           | -0.456     | 0.441          |
| Fourth  | 20 | 2.90 | 1.334     | 0.298         | 0.172 | 0.265 | 0.317  | 45  | 0.753           | 0.137      | 0.433          |
| Q3 First | 27 | 2.44 | 1.528     | 0.294         | 2.438 | 0.125 | 1.093  | 45  | 0.280           | 0.361      | 0.330          |
| Fourth  | 20 | 2.90 | 1.447     | 0.324         | 2.56  | 1.182 | 0.264  | 45  | 0.206           | 0.399      | 0.399          |
| Q4 First | 27 | 2.11 | 0.974     | 0.187         | 4.803 | 0.034 | 0.515  | 44.949 | 0.609       | 0.206      | 0.399          |
| Fourth  | 20 | 2.15 | 1.293     | 0.289         | 0.250 | 0.747 | 0.050  | 45  | 0.300           | -0.420     | 0.401          |
| Q5 First | 27 | 2.56 | 1.553     | 0.299         | 0.060 | 0.807 | 0.587  | 45  | 0.560           | 0.235      | 0.401          |
| Fourth  | 20 | 2.35 | 1.182     | 0.264         | 0.233 | 0.632 | -1.048 | 45  | 0.300           | -0.420     | 0.401          |
| Q6 First | 27 | 3.04 | 1.400     | 0.269         | 1.660 | 0.204 | -0.562 | 45  | 0.577           | -0.185     | 0.329          |
| Fourth  | 20 | 2.90 | 1.553     | 0.347         | 2.322 | 0.000 | -2.046 | 27.868 | 0.050       | -0.867     | 0.424          |
| Q7 First | 27 | 2.56 | 1.188     | 0.229         | 7.151 | 0.010 | -0.866 | 35.026 | 0.392       | -0.439     | 0.507          |
| Fourth  | 20 | 2.55 | 1.877     | 0.420         | 7.151 | 0.010 | -0.866 | 35.026 | 0.392       | -0.439     | 0.507          |

5. Discussion

According to the results of descriptive statistics presented in Table 1, students do not feel totally comfortable when sitting at a computer in the classroom for computer aided design. It can be seen that the mean value for Q1 is 3.54 which means that students sometimes feel comfortable.

When it comes to the questions related to students’ psychophysical state while sitting at a computer in the classroom for computer aided design (Q2, Q3, Q4, Q5), the results indicate that students rarely feel tired (mean value – 2.70) or experience pain in back, neck, arms, legs or knees (mean value – 2.40) and that their concentration during class is rarely disrupted by sitting position they take while working at a computer (1.78). Also, they almost never find it difficult to sit during all class because the sitting position they take while working at a computer in classroom for computer aided design is not suitable for them (2.44).

Mean value for questions about students sitting posture (Q6, Q7, Q8, Q9, Q10) is 3.10, which indicate that students sometimes take a proper sitting posture while working at a computer in the classroom for computer aided design. The lowest mean values have questions related to elbows, knees and feet position during sitting indicating that the chair seat height and desk height are inappropriate, so students’ feet are not fully supported by the floor and at a 90-degree angle, their knees are not bent at approximately a 90-degree angle, and elbows are not bent at a 90-degree angle at desk height.
According to the mean values of questions Q11 and Q12 it can be seen that students almost never complain neither to the teachers nor to the classmates about the discomfort of the furniture (chairs, desks) they use in the classroom for computer aided design.

T-test (independent samples test), presented in Table 2, was used for the comparison of two sets of data (first grade students’ opinion on the comfort of the furniture in classroom for computer aided design and fourth grade students’ opinion on the conformity of the classroom for computer aided design). Based on the results obtained by t-test, we can see that in two (of twelve) questions, there are significant statistical gaps between opinion on classroom furniture among first grade students and opinion on classroom furniture of fourth grade students. Differences exist in the following questions: Q1 – ’Do you feel comfortable when sitting at a computer in classroom for computer aided design?’ and Q11 – ‘Have you ever complained to the teacher about the discomfort of the furniture (chairs, desks) you use in classroom for computer aided design?’

According to the results, first grade students feel less comfortable when sitting at a computer in the classroom for computer aided design. It is not surprising considering the fact that they are new in school; it is their first year in the particular classroom so they are more sensitive to discomfort of the classroom furniture, inappropriate sitting posture they take and everything that disrupt their comfort. On the other hand, fourth grade students have been using the classroom for four years, they have adapted to the classroom conditions and have already got used to their sitting posture to extent that they sometimes do not notice the classroom furniture discomfort.

Based on the results obtained by t-test, first grade students less complain to the teachers about the discomfort of the furniture (chairs, desks) that is used in classroom for computer aided design. The reason is that they are less confident and just beginning to learn how to interact with teachers which can take some time before they feel comfortable with their new surroundings and feel free to express their opinion.

6. Conclusion

From all mentioned above, it can be concluded that correctly designed classroom furniture is, among others, one of the most important key factors in regular development of all abilities of school children. Being the workplace of future workers, classrooms must be equipped with furniture that safeguards the physical wellbeing of pupils through appropriate ergonomics and the ability to adjust to their individual physical needs.

However, numerous studies in many countries have shown that, in practice, situation is totally different. School children around the world spend their school life sitting on ergonomically inappropriate furniture that severely affects their health.

The results of the research presented in this paper indicate that students do not feel totally comfortable when sitting at a computer in the classroom for computer aided design but that the unconformity does not have huge consequences on their mental and physical state (tiredness, pain, concentration and attention) during class. Also, students sometimes take appropriate sitting posture, but they very rarely complain about the nonconformity of the classroom furniture either to the teachers or to the classmates.

One of the possible solutions that do not require excessive costs are adjustable chairs and desks, which would make students even more comfortable while sitting at a computer in the classroom for computer aided design. Also, raising awareness of the importance of ergonomics in Serbian schools by training all stakeholders (students, teachers, parents, and administrators) is essential for creating such school environment that will support students’ social, emotional and psychological welfare, and help them to make the most of their school day.

References
[1] International Ergonomics Association (IEA) 2000, Agenda Item 2.1.1, IEA Definitions: The Discipline of Ergonomics, Council Meeting Minutes, July 29-30
[2] Smith T 2001 Educational ergonomics: Educational Design and Educational Performance, 15th Triennial Congress of the International Ergonomics Association and the 7th Joint Conference of Ergonomics Society of Korea/Japan Ergonomics Society, Seoul, South Korea, August 24-29, pp. 1-13

[3] Kao H S 1976 On Educational Ergonomics, Ergonomics 19(6) 667-681

[4] Legg S 2007 Ergonomics in Schools, Ergonomics 50(10) 1523-1529

[5] Castellucci H I, Arezes P M and Viviani C A 2010 Mismatch Between Classroom Furniture and Anthropometric Measures in Chilean Schools, Applied Ergonomics 41(2010) 563-568

[6] Troussier B, Tesniere C, Fauconnier J, Grisons J, Juvin R and Philip X 1999 Comparative Study of two Different Kinds of School Furniture Among Children, Ergonomics 42(3) 516-526

[7] Cameiro V, Gomes A and Rangel B 2017 Proposal for a Universal Measurement System for School Chairs and Desks for Children from 6 to 10 Years Old, Applied Ergonomics 58 372-385

[8] Gouvali M K and Boudolos K 2006 Match Between School Furniture Dimensions and Children’s Anthropometry, Applied Ergonomics 37(2006) 765-773

[9] Panagiotopoulou G, Christoulas K, Papanikolaou A and Mandroukas K 2004 Classroom furniture dimensions and anthropometric measures in primary school, Applied Ergonomics 35(2) 121-128

[10] Parcells C, Stommel M and Hubbard R P 1999 Mismatch of Classroom Furniture and Student Body Dimensions: Empirical Findings and Health Implications, Journal of Adolescent Health 24(4) 265-273

[11] Hedge A and Lueder R 2008 Ergonomics for Children: Designing Products and Places for Toddlers and Teens, In: Lueder R and Rice V (Eds.) Classroom Furniture, pp. 721-751, CRC Press

[12] Molenbroek J F M, Kroon-Ramaekers Y M T and Snijders C J 2003 Revision of the Design of a Standard for the Dimensions of School Furniture, Ergonomics 46 681-694

[13] Diana I, Ali Karimi M A, Asl Hashemi A and Bahrampour S 2013 Classroom Furniture and Anthropometric Characteristics of Iranian High School Students: Proposed Dimensions Based on Anthropometric Data, Applied Ergonomics 44(1) 101-108

[14] Saarni L, Nygard CH, Kaukiainen A and Rimpelä A 2007 Are the Desks and Chairs at School Appropriate?, Ergonomics 50(10) 1561-1570

[15] Domljan D, Grbac I and Hadina J 2008 Classroom Furniture Design – Correlation of Pupil and Chair Dimensions, Collegium Antropologicum 32(1) 257-265

[16] Assunção A, Carnide F, Vieira F, Silva S and Araújo J 2013 Mismatch of School Furniture and Back Pain in Adolescents with Different Maturation Levels, International Journal of Human Factors and Ergonomics 2(1) 66-81

[17] Trigueiro M J, Massada L and Garganta R 2013 Back Pain in Portuguese Schoolchildren: Prevalence and Risk Factors, European Journal of Public Health 23(3) 499-503

[18] Legg S J, Pajo K, Sullman M and Marfell-Jones M 2003 Mismatch Between Classroom Furniture Dimensions and Student Anthropometric Characteristics in Three New Zealand Secondary Schools, 15th Congress of the International Ergonomics Association, Ergonomics for Children in Educational Environments Symposium, Seoul, South Korea, August 24-29, pp. 395-402