

Ergonomics of Organizational and Technical Space in the Educational Process of Children in Kindergarten

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Keywords: Ergonomics, Ergonomic Design, Kindergarten, Occupational Health and Safety, Occupational Safety Management, Technical and Organizational Factors

Abstract. Ergonomics is an interdisciplinary science that applies to various aspects of our lives, extending beyond the workplace. Ergonomics enhances work, education, and leisure activities for lifelong well-being. This article presents the ergonomic principles of the preschool child's world that influence the correct psychophysical development of the child. A quantitative study was conducted in seven non-public kindergartens in the Silesian voivodeship, using direct interviews and elements of overt observation. The study aimed to identify strengths and weaknesses in the ergonomics of kindergartens' organizational and technical spaces, specifically focusing on legal requirements for safe and ergonomic working conditions for children up to the age of 6. The results highlight the challenges faced by designers and kindergarten directors in creating an ergonomic environment for children, revealing numerous difficulties in this area. There is increasing recognition of the importance of ergonomic and safe organizational and technical conditions in early childhood education. The obtained research results are a valuable contribution to a larger study on ergonomics and safety in Polish pre-schools, scheduled for the coming years.

Introduction

Ergonomics is an applied science that is present throughout our lives. Of course, its beginnings, which date back to 1857, concerned primarily work. The name is taken from the Greek: ergon - work, nomos - natural laws. According to the then view, ergonomics as an applied science should define the interdependence between the operation of tools, devices and machines and the protection of the environment in the optimal scope to the possibilities and psychophysical needs of a human being. The goal formulated in this way and the possibilities in relation to humans should be based primarily on the latest achievements in science and technology. Today, after more than 160 years, ergonomics applies to every human activity. We distinguish the ergonomics of work, product and production, but also the ergonomics of living, leisure, the ergonomics of the elderly and the disabled. One of the youngest ergonomics, both at the level of concept and correction, is the ergonomics of the children's world [1-3].

The first stage of a child's education is usually the pre-school period. The architecture and space of the kindergarten building affect the organization of work, as well as aspects related to behavioral needs, including the child's sense of security. Therefore, a well-designed building should also contribute to reducing the sense of stress in children. Equally important is the architecture of the kindergarten building itself - the body, facade solutions, entrance area, development of the facility's surroundings. Particularly important design criteria are the shape of the building and the facade solution, including facade divisions, colors, materials used, and possible graphics emphasizing the character of the building's function. By using appropriate denotative elements, the function of the kindergarten facility is properly recognized and associated in the urban space. The architecture of the building should take into account the aesthetic needs of the main users, i.e. children, i.e. evoke good associations, reactions, evoke positive feelings, and thus encourage attending kindergarten and contacts with peers. Moderation and restraint in the use of colors,

graphic forms or details are important in designing the "enclosure" of the kindergarten building, because it is important that the architecture is not infantile, too literally imitating phenomena from the world of nature or fairy tales. The context of the place, the character of the street, housing estate or district in which the kindergarten is located are also important. In any case, however, the function of the kindergarten facility will be characterized by: form, formal and aesthetic features - colors, details, possible graphic elements of the façade, as well as the development of the surroundings, in which the playground and greenery play the dominant role. However, taking into account the needs, possibilities and psychophysical limitations of a preschool child, attention should be paid primarily to the equipment of the kindergarten and the organization of activities. They create an organizational and technical space that is very important in the educational and upbringing process of children in kindergarten. Ergonomics is a very important reference to the entire environment, which consists of e.g. volume of rooms, access to natural lighting, materials that make up floors, walls, equipment, tables, chairs, as well as their adaptation to the anthropometric dimensions of a preschool child [3-12].

Methods

Ergonomics of the child's world is based on general principles of organizational and technical space design based on the selection of appropriate technical equipment and the adjustment of material parameters to the needs of ensuring full safety of use [4-7]. This paper analyzes the organizational and technical space in a kindergarten dedicated to children aged up to 6 years. Children at this age have special needs, because between 3 and 6 years of age is the first critical period of the child's development, in which, in the event of an oversight in the technical design of space, disturbances may occur. Poorly designed space and technical equipment may contribute to an anterior tilt of the pelvis, which results in an enlargement of the lumbar lordosis with simultaneous flattening of the abdomen. Therefore, this is a period in a child's life when the first symptoms of body posture and habits are formed, which very often mark the child's further activity and body positions in relation to sitting on a chair, sitting at a table or on other flat surfaces, e.g. on the floor, carpet, etc. In most European countries, there is a statutory obligation to equip educational institutions, including kindergartens, with ergonomic furniture.

About 20 kindergartens were subject to observation in terms of technical equipment and space as well as the selection of equipment. All kindergartens were located in Poland - 6 of them are private kindergartens, the rest are financed from the state budget (public funding). The qualitative study – a face-to-face interview with elements of open observation – were very similar in terms of the size of the building, the arrangement of individual rooms, the number of children, teachers and equipment.

The face-to-face interview was conducted using a checklist whose questions were based on checklists prepared by the Central Institute for Labor Protection - PIB and the California Childcare Health Program of the University of California San Francisco. The TOL classification was used to develop the checklist. This method assumes that an accident occurs as a result of a component of three types of indirect causes: technical, organizational and human. Consequently, in order to achieve the best results in building a safe and ergonomic environment for people, one should strive to maintain a balance between technical, organizational and human activities. The questions, in accordance with the assumptions of the method, were grouped into technical, organizational and human factors. The technical factors were divided into three areas that were subjected to the study: an educational and leisure room, communication routes and hygienic and sanitary rooms. Each question could be answered with a "yes" or "no" answer. Negative answers ("no") were aimed at identifying weak points that may contribute to the occurrence of accidents in the kindergarten. On the other hand, the answers to "yes" were to indicate the strengths of the surveyed kindergartens in relation to the level of ergonomics of the kindergarten and the safety of children.

Results and Discussion

It is very important to indicate the key aspects that have been observed, these include: selection of construction, selection of materials, lighting, ensuring the proper climate (temperature and ventilation in rooms), ergonomics of movement in space, technical protection (balustrades, covers, etc.), and many others.

All remarks and conclusions were formulated in relation to legal provisions and documents (or standards) which regulate the requirements for technical equipment in kindergartens.

One of the most important issues that should be taken into account when choosing school and kindergarten equipment are legal requirements (on the example of Poland). The main document regulating the selection conditions is § 9 sec. 3 of the Regulation of the Minister of National Education and Sport of December 31, 2002, which reads as follows: "Schools and institutions purchase equipment with appropriate attestations and certificates." The certification obligation covers skeletal products, such as benches, tables and chairs, and box items, i.e. wardrobes. In addition, the obligation also applies to display cases and hangers. Obtaining the certificate is aimed at ensuring the safety of children in kindergartens. In order to obtain the certificate, it is necessary to submit an application by the manufacturer who plans to introduce products to kindergartens. The certification is based on the PN-F-06010-01:1990, PN-EN 1729-1:2016 and PN-EN 1729-2+A1:2016 standards, which are assigned on the basis of the technical documentation of the furniture. Before issuing the certificate, it is also necessary to test all the previously mentioned items of equipment.

Due to the fact that kindergarten furniture is subjected to everyday use, it should be made of high-strength materials that will ensure full safety for users. Particular attention is also paid to the selection (if possible) of natural materials - eg wood, wooden veneers. . However, if there are plastics or materials of chemical origin, they must have an appropriate certificate. An important issue is also the selection of furniture that will be appropriate for the height of students. This has been described in the PN-EN 1729-1:2016-2 standard. It specifies the heights of seats and tables as well as color codes that should be used for individual groups of furniture. Another issue is the color of school furniture. Taking into account the hygiene of children's eyesight, countertops with a matte and smooth surface will work best in a kindergarten. It is also worth choosing products that will be resistant to abrasion, water, grease or impact.

In Polish preschool institutions, more and more attention is paid to safe and ergonomic equipment. All tables and chairs must be conducive to children's development. Ergonomic furniture has all the approvals that confirm that the product will be perfect for schools and kindergartens. It is worth noting that poorly selected equipment of rooms in a kindergarten can significantly reduce the efficiency and cognitive functions of children. Uncomfortable and badly shaped chairs and tables contribute to the development of spinal degeneration, which is difficult to cure. In the case of a young organism, susceptibility to diseases may be even greater. Certificates confirm compliance with all ergonomic principles. A very important role is played by the proper adjustment of the seat and backrest. First of all, in modern preschool institutions, hard wooden chairs are being replaced by soft seats. The aforementioned European Union standard EN 1729 precisely defines how to adjust furniture to the needs of preschool children. Chairs and armchairs must be adapted to the natural curvature of the human spine.

Ergonomics is not only about school furniture. It is equally important to ensure the safety of the youngest, i.e. children in kindergartens. During crazy games, various unforeseen accidents can happen. Frames, doors, free-standing shelves and all furniture with sharp corners are a great danger. Therefore, it is worth planning the entire space in the kindergarten correctly so that children do not hurt themselves. It is a good idea to use special covers, e.g. for door frames. One could be tempted to assess the "occupational" risk for children in the space of such a room. In spaces for children, it is better to limit the amount of glass or mirrors. On the floor there should be

a good quality soft carpet that prevents the wards from getting cold. All these elements will create a space ideal for the development of the youngest. There are several more factors influencing good conditions for development.

Good lighting must be installed in kindergartens. In each classroom there should be several lamps with a neutral color of light - 3000 Kelvin. Of course, no lamp must blink as this can be distracting and even cause vision problems. In addition, in rooms intended for small children, it is not recommended to use open luminaires with easy access to bulbs that can break while playing, and instead of popular discharge fluorescent lamps full of heavy metals, it is recommended to choose much safer LED bulbs, which, if broken, do not will emit harmful substances into the environment.

Teachers and babysitters in kindergartens must remember to regularly ventilate the rooms. Crowded kindergartens or classrooms do not give freedom of movement and can lead to numerous stressful situations. Therefore, each student must have their own personal space.

A big problem both in homes and institutions is the failure to adjust the dimensions of furniture to its users. This is due to the financial situation and the lack of awareness of both parents and institutions. In Polish homes, children's furniture is often bought "over the top" and the choice of equipment is determined by the price, not ergonomics. Assigning furniture - tables and chairs to a specific child may be the cheapest and easiest solution, although it is still not a routine activity in many institutions. Ill-fitting furniture worsens the working conditions of internal organs, may result in the emergence or development of posture defects and vision defects.

According to the regulation on technical conditions, if children are expected to stay in buildings without constant supervision, railings should be secured against climbing up and sliding down the railing. In rooms where children may be present, all sources of heat emitting should be shielded - e.g. radiators to prevent them from having direct contact with the hot surface and to prevent burns. According to statistical data, more than 1% of children under the care of educational institutions (hereinafter: "facilities") are involved in accidents in Poland. In 2020/2021, 139 accidents of children in kindergartens were recorded in the Śląskie Voivodeship, including one serious accident. The most common causes of injuries were the child's inattention, other causes, unintentional actions of the child and other people. There have also been intentional actions by others and unintentional strikes. Only 1% of the causes of injuries were deliberate actions of children and poor technical condition of the equipment.

Pursuant to the Education Law, the kindergarten implements the core curriculum for pre-school education. Not all children develop in the same way, therefore the kindergarten should take into account and respect the individual needs of each pupil. The content of education should be selected adequately to the child's level of development, taking into account their interests and way of reasoning. The kindergartens that voluntarily took part in the qualitative study – a face-to-face interview with elements of open observation – were very similar in terms of the size of the building, the arrangement of individual rooms, the number of children, teachers and equipment. Starting the study, the author of this article assumed the fact that no kindergarten is able to guarantee a completely risk-free environment. However, it should strive to minimize the risk by removing causes that may threaten the life or health of children and appropriate planning in order to effectively respond to these threats. By analyzing the entire research process, the weaknesses most frequently indicated by the surveyed teachers were grouped, consisting of various elements of the organizational and technical area. These are primarily:

- tables and chairs of the same size for all children, regardless of their height, without the possibility of adjustment,
- hard tables and chairs, made of wood, not very comfortable to sit for a long time,
- no rounded edges of chests of drawers, tables and window sills,

- no carpet/carpet attached to the floor over the entire surface,
- lack of radiator covers protecting against direct contact with the heating surface and the possibility of moving the knob regulating the radiator heat,
- too poorly lit corridor leading to the toilets for children,
- lack of appropriate, average height of washbasins for children - too low for older children,
- inadequate organization of the "working" space for artistic and technical tasks - lack of appropriate protection of the remaining elements of the equipment against damage and soiling.

The strengths of the organizational and technical space, on the other hand, include the following elements - indicated by the surveyed teachers and observed by the author of this article:

- very ergonomically friendly changing rooms with colorful furniture, individualized both for the characteristics of healthy children and those with various disabilities (e.g. for a child with poor eyesight, the locker was marked with bright colors and the name was written in bold);
- benches in the dressing rooms are stable, have the appropriate width of the seat part, with a suitable place for changeable shoes;
- changing rooms have adequate ventilation and access to natural light.
- passageways and communication routes are sufficiently wide.

Of course, ergonomics is not only the elements included in the organizational and technical area. Ergonomics are also those elements that determine the appropriate psychophysical well-being, i.e. physical and psychosocial factors and environmental conditions in which they spend most of their time during the day. This article, however, focuses primarily on the organizational and technical area of kindergartens, which are the basis for the proper formation of both the body and the soul of a small person. It should be remembered that there are elements of ergonomic space that are the basis for further, appropriate psychophysical development of a child at preschool age.

It is obvious that each child has different perceptual abilities, imagination and perceives the world differently. It also has other anthropometric dimensions. Therefore, both furniture, chairs, tables, as well as devices, toys and equipment that he uses throughout his preschool life, should be adapted to his - already mentioned - anthropometric dimensions, as well as possibilities, needs and psychophysical limitations. It is very important to ensure the freedom to play, develop and rest, provide support to children who develop in a dissonant, slower or accelerated way, support children's independent discovery of the world, including the world of nature, create a variety of natural situations that build the child's sensitivity, support in building a system of values and familiarizing with social norms, supporting body activity through e.g. physical, environmental and music classes, learning about safety, including road safety, learning independence and creating healthy habits, preparing to start learning at school by supporting mechanisms of learning.

Summary

The basis of safety and ergonomics in the kindergarten environment, which should be provided to the child obligatorily, because it has reference to legal provisions, regulations and standards, is the most important. The key aspects in that have been indicated: selection of construction, selection of materials, lighting, ensuring the proper climate (temperature and ventilation in rooms), ergonomics of movement in space, technical protection (balustrades, covers, etc.), and many others. The most common poorly prepared space elements include: tables and chairs of the same size for all children (lack of personal adjustment), heavy tables and chairs, no rounded edges of chests of drawers, lack of radiator covers protecting against direct contact with the heating surface, too poorly lit corridor, lack of appropriate, average height of washbasins for children – too low for older children, inadequate organization of the "working" space for artistic and technical tasks – lack of appropriate protection of the remaining elements of the equipment against damage and soiling. The safety of children in kindergarten is an absolute priority. However, organizational

measures alone will not ensure their safety. Technical measures must be employed, including proper materials [13], shaping of surfaces [14] in conjunction with appropriate protective coatings [15, 16], and for highly critical components, special coatings [17, 18]. Reliable and strong welds [19], appropriately processed and secured, are essential elements. The proper location and securing of windows [20] also significantly impact safety. All these elements are numerous and mutually influential, thus requiring an appropriate analysis of their interactions [21]. In this regard, suitable statistical methods [22-24] come to the aid, including non-classical approaches that do not require a priori assumptions about the model's form [25-27].

References

- [1] R. Michnik et al. Research on the Stability of the Users of Chair with a Spherical Base. *Adv. Intell. Syst. Comput.* 623 (2017) 299-307. https://doi.org/10.1007/978-3-319-70063-2_32
- [2] A.K. Mańka et al. Ergonomics of the Early Schoolchildren's Position in Terms of the teaching and Learning Process Effectiveness, *Edukacja-Technika-Informatyka* 3 (2022) 133-140.
- [3] K. Goniewicz et al. Management of child injuries in traffic and other accidents: the WHO policy guidelines, *Health Problems of Civilization* 12(3) (2018)157-162.
- [4] J.S. Antonenko et al. Design Features of Furniture and Equipment for Entrance Areas of Kindergartens. *IOP Conf. Ser. Mater. Sci. Eng.* 463 (2018) art. 042013. <https://doi.org/10.1088/1757-899X/463/4/042013>
- [5] M. Grozdanovic et al. Methodological framework for the ergonomic design of children's playground equipment: A Serbian experience. *Work* 48 (2014) 273-288. <https://doi.org/10.3233/WOR-131661>
- [6] B. Iliev et al. Comparison of anthropometric dimensions of preschool children and chairs in kindergartens in North Macedonia, Bulgaria and Croatia. *Heliyon* 9 (2023) art. e14483. <https://doi.org/10.1016/j.heliyon.2023.e14483>
- [7] D. Domljan et al. Equipping building for upbringing and education. Volume I. University of Zagreb, Zagreb, 2015. ISBN 978-9532920314
- [8] G.T. Jones, G.J. Macfarlane. Epidemiology of low back pain in children and adolescents, *Arch. Dis. Child.* 90 (2005) 312-316. <https://doi.org/10.1136/adc.2004.056812>
- [9] L. Liu et al. Ergonomics Design Research on Writing Tools for Children, *Procedia Manuf.* 3 (2015) 5859-5866. <https://doi.org/10.1016/j.promfg.2015.07.890>
- [10] C.L. Bennett, D. Tien. Ergonomics for Children and Educational Environments - Around the World. In: *Proc. the XVth Triennial Congress of the Int. Ergon. Assoc. and the 7th Joint Conf. of Ergon. Soc. of Korea*, Seoul, Korea, 2003. ISBN 978.8990838001
- [11] J. Charytonowicz, A. Jaglarz. Ergonomic Formation of Hygienic-Sanitary Spaces in Consideration of Health, Safety and Well-Being of Children. *Adv. Intell. Syst. Comput.* 600 (2018) 64-76. https://doi.org/10.1007/978-3-319-60450-3_7
- [12] P.A. Farahani et al. Design of an Ergonomics Assessment Tool for Playroom of Preschool Children. *Physical Treatments* 6 (2017) 217-226. <https://doi.org/10.18869/nrip.ptj.6.4.217>
- [13] P. Jonšta et al. The effect of rare earth metals alloying on the internal quality of industrially produced heavy steel forgings, *Materials* 14 (2021) art.5160. <https://doi.org/10.3390/ma14185160>

- [14] N. Radek et al. The influence of plasma cutting parameters on the geometric structure of cut surfaces, *Mater. Res. Proc.* 17 (2020) 132-137. <https://doi.org/10.21741/9781644901038-20>
- [15] N. Radek et al. Technology and application of anti-graffiti coating systems for rolling stock, *METAL 2019 28th Int. Conf. Metall. Mater.* (2019) 1127-1132. ISBN 978-8087294925
- [16] N. Radek et al. Formation of coatings with technologies using concentrated energy stream, *Prod. Eng. Arch.* 28 (2022) 117-122. <https://doi.org/10.30657/pea.2022.28.13>
- [17] N. Radek et al. Microstructure and tribological properties of DLC coatings, *Mater. Res. Proc.* 17 (2020) 171-176. <https://doi.org/10.21741/9781644901038-26>
- [18] N. Radek et al. Influence of laser texturing on tribological properties of DLC coatings, *Prod. Eng. Arch.* 27 (2021) 119-123. <https://doi.org/10.30657/pea.2021.27.15>
- [19] N. Radek et al. The impact of laser welding parameters on the mechanical properties of the weld, *AIP Conf. Proc.* 2017 (2018) art.20025. <https://doi.org/10.1063/1.5056288>
- [20] J.M. Djoković et al. Selection of the Optimal Window Type and Orientation for the Two Cities in Serbia and One in Slovakia, *Energies* 15 (2022) art.323. <https://doi.org/10.3390/en15010323>
- [21] B. Jasiewicz et al. Inter-observer and intra-observer reliability in the radiographic measurements of paediatric forefoot alignment, *Foot Ankle Surg.* 27 (2021) 371-376. <https://doi.org/10.1016/j.fas.2020.04.015>
- [22] J. Pietraszek et al. The fixed-effects analysis of the relation between SDAS and carbides for the airfoil blade traces. *Arch. Metall. Mater.* 62 (2017) 235-239. <https://doi.org/10.1515/amm-2017-0035>
- [23] R. Dwornicka, J. Pietraszek. The outline of the expert system for the design of experiment, *Prod. Eng. Arch.* 20 (2018) 43-48. <https://doi.org/10.30657/pea.2018.20.09>
- [24] J. Pietraszek et al. Challenges for the DOE methodology related to the introduction of Industry 4.0. *Prod. Eng. Arch.* 26 (2020) 190-194. <https://doi.org/10.30657/pea.2020.26.33>
- [25] J. Pietraszek. The modified sequential-binary approach for fuzzy operations on correlated assessments, *LNAI 7894* (2013) 353-364. https://doi.org/10.1007/978-3-642-38658-9_32
- [26] J. Pietraszek et al. The fuzzy approach to assessment of ANOVA results, *LNAI 9875* (2016) 260-268. https://doi.org/10.1007/978-3-319-45243-2_24
- [27] J. Pietraszek et al. The non-parametric approach to the quantification of the uncertainty in the design of experiments modelling, *UNCECOMP 2017 Proc. 2nd Int. Conf. Uncert. Quant. Comput. Sci. Eng.* (2017) 598-604. <https://doi.org/10.7712/120217.5395.17225>