Ergonomics in Design, Vol. 129, 2024, 14–22
https://doi.org/10.54941/ahfe1004806

Comparison of Ergonomic Principles for School Furniture Design Between Europe, USA, and Asia: An Overview

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ABSTRACT

The present research provides a comprehensive overview of the comparison of school furniture design and its utilization across various regions, specifically Europe, the USA, and Asia. In particular, the study emphasises the ergonomics aspects of furniture design and its influence on students' health and learning outcomes. Secondary data was employed for comparative analysis of school furniture design, which includes surveys and ergonomics assessments or appraisals. This research aims to comprehensively analyse the intricate interaction of design features suitable for their intended function, explicitly focusing on the impact on students' well-being and academic performance. This will be achieved by employing an established methodological framework that uses an ergonomic sitting evaluation form and observational techniques based on ergonomic principles. Based on the current research, there are noticeable variations in ergonomics standards and practices across different regions. Specifically, Europe places a higher importance on ergonomics and customisation when designing school furniture. On the other hand, the USA values flexibility and adaptability in their school furniture design. In contrast, Asia combines conventional and modern design elements to create innovative solutions. These regional disparities offer valuable insights into how cultural factors, education systems, and economic conditions influence ergonomic principles in the context of school furniture. The study compared ergonomic principles in the design of school furniture from the 1800s years until 2000 years onward. This study underscores the critical role of ergonomics in design to promote optimal learning conditions in educational settings. Moreover, given available resources and policies, it highlights the need for customised and localised strategies to enhance student welfare and academic achievement. Additionally, it stresses the importance of recognising and addressing regional disparities when optimising learning spaces for maximum effectiveness. In conclusion, this comparative analysis of school furniture design between Europe, the USA and Asia demonstrated significant differences in the evolution of school furniture design, specifically in Asia. These analyses offer an initial insight into applying ergonomic principles in school furniture design, emphasising its importance in raising awareness and advocacy among stakeholders and industry players.

Keywords: School furniture, Ergonomic, Design, Education, Musculoskeletal disorder, Ergonomic in design

INTRODUCTION

A school is an organized educational establishment that facilitates the systematic delivery of knowledge, skills, and values to students. It typically includes a physical infrastructure with classrooms, educational resources, and administrative facilities. Schools are responsible for providing a structured curriculum, fostering a conducive learning environment, and promoting the holistic development of students through academic, extracurricular, and social activities. Ergonomics is the scientific discipline that studies the interactions between humans and the elements of a system, aiming to optimize the well-being and performance of individuals within that system. It involves the design and arrangement of products, systems, and environments to ensure they align with human capabilities and limitations. The primary goal of ergonomics is to enhance efficiency, comfort, and safety in various contexts, including workspaces, products, and daily activities (Applied Ergonomic, 2023).

Study Justification

Europe, the USA, and Asia are chosen for a comparative analysis of ergonomic principles in school furniture design due to their cultural diversity, different educational systems, economic factors, design trends and innovation, regulatory frameworks, demographic variances, global influence, and efforts towards accessibility and inclusivity. This analysis provides insights into how these factors influence the approach to creating comfortable and functional learning environments in each region.

Learning is an activity undertaken with the aim of acquiring knowledge, mastering certain competencies, and forming student attitudes. The success of learning can be seen from the changes in behaviour and student learning outcomes (Puspitarini & Hanif, 2019). Thus, raising the level of society's intelligence in Europe, the US, and Asia has always been facilitated by the educational system. Regarding student age, Europe, the US, and Asia differ in a few ways, and the paper's focus was on primary school students. According to Office of the Secretary-General of the European. Schools, Gezer, et al. (2023) the primary cycle consisted of five years of primary education, starting at age six and ending at age ten. Additionally, in Europe, there can be significant regional differences in school hours. While some nations may have longer school days, others might have shorter ones with an emphasis on independent study.

Meanwhile, in the United States, the primary school students were at the age of six until eleven which is at five years (Leeb et al., 2020). In this matter, the typical school day in the United States ranges from six to eight hours, depending on the grade level and individual school policies. However, compared to Europe and the US, systems in Asia, and particularly China, differ greatly. According to Liu et al., (2016), Zhao, (2016) and Jia et al. (2020), in 1986, China promulgated and implemented the Compulsory Education Law of the People's Republic of China, which emphasized the compulsory and universal benefits of nine-year compulsory education. School-age children have benefited from substantially higher rates of return on education,

greater educational opportunities, and higher academic achievements since the law's implementation in 1986. Other Asian nations, like Malaysia, also have their own educational systems, in which students begin primary school at age seven and finish it six years later at age twelve (MyGovernment, 2023). The education system in Europe, United States and Asia as shown in **Table 1** below:

Table 1. The education system in Europe, United States and Asia (Ministry Education of Malaysia, U.S. Department of Education).

Country	Age (Primary)	Hours/Day
Europe	3–11 years old	6–8 hours
United States	6–11 years old	6–8 hours
Asia	7–12 years old	6–8 hours

Based on an analysis of the age distribution and length of time spent in school in each of the three countries, it can be concluded that people spend half of their lives in education (Irwin et al., 2022). Given this, it is imperative that schools provide their students with high-quality facilities; therefore, administrators must follow basic ergonomic guidelines like compatibility (Strasser, 2022). In fact, Chim (2019) has raised several issues that have been on people's minds, such as (1) Why should workplace design incorporate ergonomics principles? (2) To whom should workplace design give due consideration and consultation? (3) When should workplace design incorporate ergonomics principles? (4) Where in workplace design should ergonomics be used? (5) How ought ergonomics to be incorporated into office design? (6) What are the design principles of ergonomics in the workplace? All user groups inclusive of students should be considered in workplace design (classroom), as they have varying physical and psychological requirements. Each of these queries ought to be considered when purchasing school supplies.

a. Wooden School Furniture in Malaysia, (2000's)

b. Adjustable School Furniture in Europe (1900's)

c. Vintage Wooden School Furniture in USA (1940's)

Figure 1: School furniture variants (Ministry of Education Malaysia, North of England School Furnishing).

Ergonomic furniture holds significant importance in primary schools, especially in Europe, the US, and Asia. The workload for students in these regions varies due to differences in their education systems. In Europe, the US, and Asia, the responsibility of providing quality formal education lies with the respective governments. In some countries, extracurricular activities are highly valued, leading to more flexible student schedules. Despite differences in formal school day lengths, extracurricular activities such as sports, clubs, and homework contribute to students' overall time commitment to education. Nevertheless, there is a need for change, as children spend a considerable amount of their school time in classrooms, predominantly in sitting positions. The use of ill-fitted classroom furniture can result in discomfort, irritation, and an increased risk of musculoskeletal disorders, as highlighted by Obinna et al. (2020). Therefore, addressing the ergonomic aspects of school furniture becomes crucial for ensuring the well-being and optimal learning conditions for students.

Children in schools need ergonomic furniture for both their health and academic success. Using chairs, desks, and other furniture with ergonomic designs encourages good posture, lowers the chance of musculoskeletal problems, and improves overall comfort. Considering that students spend a large amount of their times in classrooms, this is especially important. By giving ergonomics top priority when designing school furniture, educational establishments help to foster a welcoming and encouraging environment that benefits students' physical and mental well-being.

COMPARISON

The comparison of ergonomic principles for school furniture design across Europe, the United States, and Asia unveils a diverse landscape shaped by cultural, educational, and societal factors. As educational spaces continue to evolve globally, understanding how these regions approach and prioritize ergonomic considerations in school furniture is crucial. This study aims to explore and analyse the distinctive approaches, standards, and design philosophies employed in Europe, the United States, and Asia. By delving into the unique cultural nuances and educational practices of each region, this research seeks to provide valuable insights into the shaping of ergonomic principles in school furniture, ultimately contributing to the creation of more inclusive and effective learning environments.

CONCLUSION

Ergonomics is crucial for school furniture design as it directly impacts the well-being, comfort, and productivity of students. The design and arrangement of school furniture significantly influence the physical health and posture of students during extended periods of learning. According to the American Academy of Paediatrics in 2021, ergonomic considerations in school furniture contribute to creating an environment that promotes proper body alignment, reduces the risk of musculoskeletal issues, and supports overall student health.

Table 2. Comparison of ergonomic principles for school furniture between Europe, United State, and Asia.

Ergonomic Principle	Europe	USA	Asia
Legalisation and School Furniture Standards	• Emphasizes adherence to BS EN 1729 standard for ergonomic standards (BSI, 2012). • Includes specifications for chair and table dimensions, lumbar support, and adjustability. • Features promote dynamic sitting for enhanced concentration.	• Guided by ANSI/BIFMA X6.1-Educational seating standards. (ANSI, 2015) • Prioritizes flexibility and user-centred design principles. • Focuses on overall student well-being and the interconnectedness of physical comfort and academic performance.	• References BS EN 1729 for school furniture design. (BSI, 2012) • Reflects cultural perceptions of learning spaces. • Incorporates elements catering to group activities and community. • Emphasizes creating environments that support interactive and cooperative learning.
Aesthetic Preferences	• Balances functionality and aesthetic appeal with clean lines, minimalistic designs, and use of sustainable materials. • Aims to create visually pleasing and focused study spaces. (Imrie & Street, 2011).	• Reflects diverse and multicultural society with modern, technology-integrated designs and traditional layouts. • Aesthetic choices align with broader societal trends and reflect the dynamic nature of American educational spaces. (Chiu et al., 2019)	• Incorporates cultural motifs and symbols, characterized by vibrant colours, symbolic patterns, and a blend of traditional and modern elements. (Imrie & Street, 2011).
Functional Requirements	• Prioritizes durability, ease of maintenance, and adaptability. • Considers integration of technology in classrooms. • Emphasizes multifunctionality to meet modern educational needs. • (Miller, 2017)	• Focuses on versatility and modular designs. • Incorporates technology to cater to dynamic learning environments. • Incorporates interactive technologies. (Buckley, 2020).	• Focuses on collaborative learning spaces. • Features flexible furniture arrangements and easily reconfigurable setups. • Emphasizes community-driven functional choices. (Kim & Wong, 2019).
Implications for Designers	• Prioritize ergonomic considerations in EN 1729 while integrating innovative solutions. • Balancing functionality and aesthetics are crucial. • Collaboration with educators can provide insights into classroom needs.	• Adapt to the dynamic nature of American educational spaces. • Embrace user-centred design principles and technology-friendly furniture. • Collaborate with educators for ergonomic and adaptable designs.	• Integrate cultural symbols and preferences into furniture designs. • Prioritize flexibility and adaptability to diverse teaching methods.

(Continued)

Table 2. Continued

Ergonomic Principle	Europe	USA	Asia
Regulatory Frameworks	• European Standard EN 1729 provides guidelines on dimensions and functional requirements of school furniture. • EN 1729 promotes ergonomic principles by ensuring furniture designs adhere to standardized dimensions. • Compliance with this standard foster's consistent ergonomic considerations and design innovation.	• ANSI/BIFMA guides the regulatory framework for school furniture design. • ANSI/BIFMA X6.1-2018 Educational seating standards focus on performance and safety requirements for educational seating. • These standards emphasize safety and durability, promoting ergonomic designs prioritizing student well-being.	• Regulatory frameworks for school furniture design vary across countries, reflecting the diversity of educational systems. • In China, the National Standard GB/T 3324–2018 sets guidelines for classroom furniture dimensions, emphasizing ergonomic considerations for students. (GB Standard, 2018) • In Malaysia, all school furniture uses the BS EN 1729–2 standard as a nationwide reference standard. • Compliance with specific guidelines ensures basic ergonomic consideration, but variations may lead to differing design innovation approaches.
Ergonomic Features	Beginning in the late 1800s, the design of school furniture had special features such as adjustable chairs, sloping table surfaces and footrests.	Just like in the European country the design of school furniture in the United States already has ergonomic features such as sloping table surfaces, adjustable chairs, and sloping backrests to ensure the comfort of school students during that time.	In Asia, school furniture design only has a basic design without having a sloping table surface, adjustable chairs, and other ergonomic features.
Anthropometric Data	In European countries anthropometric data plays an important role in designing an equipment including furniture. This is to ensure that the size of the furniture and the size of the user can be adjusted and appropriate for use. (Yu Cheng et al., 2004)	In the United State anthropometric data is used in the production of clothing, furniture and fittings that correspond to the size of Americans. (AnthroKids, USA, 1977)	Based on previous studies produced in Asia, there are only 4 countries with national anthropometric data, namely China, Japanese, Korean and Taiwanese. Some other countries in Asia only adapt anthropometric data from foreign countries in the production of furniture. (Applied Ergonomic, 2004)

Incorporating ergonomic principles in school furniture design also enhances the learning experience by providing a comfortable and conducive environment. Comfortable seating, appropriate desk height, and well-designed furniture contribute to reduced distractions, allowing students to focus better on their studies. This aligns with research findings that link ergonomically designed classrooms to improved academic performance and student engagement (Dul, 2016).

Moreover, as technology becomes increasingly integrated into education, ergonomic considerations in furniture design play a crucial role in accommodating devices such as laptops and tablets. Properly designed furniture helps create a supportive infrastructure for technology-enhanced learning, ensuring that students can interact with digital tools comfortably and without adverse physical effects.

In summary, prioritizing ergonomics in school furniture design is essential for promoting the health, comfort, and concentration of students, ultimately contributing to an optimal learning environment.

RECOMMENDATION

To enhance the overall well-being of students, it is imperative to prioritize ergonomic considerations in school furniture design. A comprehensive approach involves utilizing anthropometric data specific to the diverse population of Asia, ensuring that ergonomic features are incorporated into the design of all school furniture. This goes beyond a mere aesthetic upgrade, as the implementation of ergonomic principles directly impacts the physical comfort and health of students. Furthermore, it is crucial to engage stakeholders in the enforcement of ergonomic standards for school furniture, fostering collaboration between educators, designers, and administrators. By recognizing the significance of ergonomic furniture in improving student well-being, we pave the way for a learning environment that not only meets educational needs but also prioritizes the health and comfort of the students who use it.

ACKNOWLEGMENT

The author would like to extend the sincere appreciation to the following individuals for their invaluable cooperation and unwavering support throughout the course of this study. Thank you to Dr. Irwan Syah Md Yusof, Dr. Norhafifah Samsudin, Associate Professor Dr. Ng Yee Guan, Dr. Velu A/L Perumal, Dr. Mohd Nor Zamri Mat Amin, Madam Nor Liza Mat Yasok and Madam Nik Zuraihah Nik Mohammad, on the cooperation and support throughout the study. Their collaborative efforts and support significantly enriched the quality and depth of this research. The authors are profoundly grateful for their dedication to the advancement of this study.

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