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THE INFLUENCES OF FURNITURE ON CHILDREN'S HEALTH AND WELL-BEING AT PRIMARY SCHOOOL

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Graphical abstract

Abstract

Pre-schools and primary schools play a prominent role in the lives of children. In this phase of their life, reading and writing would begin. There are studies which explored the relationships between writing and reading performance and furniture in the classroom. A considerable body of research addresses the role of school furniture on children's health. Nevertheless, the impact of furniture on behaviour received fairly insufficient attention in design and furniture industries. Since children have no choice in selecting their furniture, they ended becoming passive users in the design process. In this paper, we aim to understand the impacts that school furniture have on children's health and performance. This paper reviews previous studies about children's furniture at educational centers in order to introduce a new prototype of school furniture. This study could inform designers and those involved in children related educational systems to develop better furniture designs in schools.

Keywords: Anthropometry dimension, Back pain, Ergonomic, School children, School furniture, Sustainable design informatics

Abstrak

Pra-sekolah dan sekolah rendah adalah bahagian berpengaruh dalam memainkan peranan penting dalam kehidupan kanak-kanak. Selain itu, pada fasa permulaan kehidupan mereka, membaca dan menulis bermula. Kajian mendapati terdapat hubungan antara menulis dan prestasi bacaan dan perabot di dalam kelas. Kajian kami mendapati sebahagian besar penyelidikan menangani peranan perabot sekolah ke atas kesihatan kanak-kanak. Sebaliknya, kami dapati impak perlakuan turut tidak mendapat perhatian sewajarny di dalam reka bentuk dan industry perabot. Memandangkan kanak-kanak tiada kuasa memilih perabot mereka, mereka merupakan penaggung pasif sebuah proses reka bentuk. Dalam kertas ini, kami berhasrat memahami impak perabot sekolah ke atas kesihatan dan prestasi murid-murid. Kami telah mengkaji literature mengenai perabot kanak-kanak di pusat-pusat pendidikan. Kertas ini membentangkan kajian literature untuk memperkenalkan prototaip baru perabot sekolah. dalah kertas kajian yang cuba untuk memperkenalkan prototaip baru perabot sekolah. Penerokaan ini mampu memanfaat para pereka dan mereka yang terlibat dalam sistem pendidikan kanak-kanak.

Kata kunci: Ukuran antropometri, Sakit belakang, Ergonomik, Murid sekolah, Perabot sekolah, Informatiks Reka Bentuk Mampan

1.0 INTRODUCTION:

The schooling phase is a dominant force in the life of children. Being alone in an environment which is different from home is the first experience for children when they start schooling. This experience can affect children's psychological well-being either positively or negatively. Hence, providing legible spaces for children has been proposed to contribute to their psychological well-being by Helvacıog˘lu & Olguntürk [20]. Study by Linton, Heilsing and Halme in 1994 [25] found that schoolchildren spend 30% of their waking hours at school, most of the time in sitting position [7]. According to Panagiotopoulou, Christoulas, Papanckolaou, and Mandroukas [41] a number of researchers dealt with the principles for the design of chairs and desks in the workplace, particularly for computer system users. However, little interest has been shown in the design of school furniture used by children for prolonged periods of time during school time. Furthermore, Bland & Sharma-Brymer in 2012 [2] claim that the situation is made worse when the children, the main stakeholders of education are rarely consulted on the issue of school design and end up without any say in the design process and become passive recipients of adults' decisions. The lack of concern on the impacts of school furniture on children motivates us to study how the school furniture fulfill the different demands, such as anthropometric and ergonomic, orthopedic, ophthalmologic, pedagogic, educational, technical, economical and other design parameters for children.

Large sums of money are invested in transforming traditional classrooms into technology-equipped learning environments with the assumption that both student engagement and learning outcomes will improve. This improvement seems sensible for anyone involved in education but to support this contention, it is still essential to do further studies. Such a study will also help to determine impacts of installing innovative physical spaces on student performance.

According to the definition by Mendell and Heath [29], student performance includes student results, attendance, learning and social development. There are some studies that confirmed a connection between student performance and physical equipment in the classroom. For instance, a study by Lyons [27] and Syakima M.Y, Sapri, & A.R Shahril [47] reveal that there are connections between the facility and utility of the classroom and students' attendance and learning performance. So with poor classroom facilities, we expect to see a downfall in students' performance. In addition, in another study by Earthman in 2002 [10] schools with low quality level and inadequate facilities can decrease teachers' efficiency and performance. Meanwhile, there is a direct relation between teachers' performance and student performance. Thus, directly and indirectly, poor school facilities have negative impacts on students learning.

To be familiar with the important role of seating equipment inside the classroom, we divided the studies in this field. First of all, we introduce the major problems about school furniture and also the problem about anthropometry dimensions through past research. Some researchers have tried to solve these problems by introducing a new criteria and framework to consider during the design process and also when buying school furniture. Others tried to design new model of furniture or define new function for chairs or desks to mitigate the associated problems which will be discussed in the following sections.

2.0 THE CHILDREN'S MAJOR PROBLEM ASSOCIATED WITH SCHOOL FURNITURE

Bourdeaudhuij, & Breithecker [4] in their study, mention that children in traditional school spend an average of 93% of their school time in static sitting. Another study by Goddared [16] states that children spend approximately 15,000 hours sitting down during school time (between age 5 to 16). Therefore, uncomfortable postures could be painful due to the long periods children spend at school. Aagaard & Storr-Paulsen [1] and Murphy, Buckle & Stubbs (38) report posture related syndromes in students. Moreover, in 2006 Gouvali & Boudolos [17] state that it is possible that children keep those postural behaviors for the rest of their lives.

Murphy & Buckle, [36] reveal that up to 60% of school pupils complain of back pain at one time or another. They added that good posture starts from a very early age and good posture is not just key to skeletal and muscular health but a stimulus to concentration and the way we approach our time in the classroom. Musculoskeletal disorders (MSDs) are injuries or pain in the body's joint, ligaments, muscles, nerves, tendons, and structures that support limbs, neck and back. These disorders can affect many different parts of the body including upper and lower back, neck, shoulders and extremities (arms, legs, feet, and hands) [39]. Motamedzade [33] believes that musculoskeletal disorders (MSD) such as neck and low back pain among pupils can be attributed from different factors and using inappropriate school furniture is one of the main associated factors. Grimes & Legg [18] introduce five elements which could influence the prevalence of MSD (Musculoskeletal disorders) among pupils and these are student posture, anthropometrics and furniture; computer use; pain reporting; vision. They suggest that any attempt to decrease MSD amongst school children could lead to identifying and improving micro and macro ergonomic factors such as classroom furniture design, posture education, backpack weight and load carriage, learning systems re-organization and general organization of school activities [18].

A number of researchers [24, 48, 51] explain that LBP (low back pain) is a phenomenon which

increases in prevalence with age. Moreover some other researchers [3, 19, 31, 48, 50] suggest that LBP is more common among females compared to males. In addition, it is a common belief that back pain is just for adults but Murphy, Buckle, & Stubbs [36] reveal that LBP is also a prevalent phenomenon among young people. They found in an epidemiological studies that school children are faced with high spread rates of back pain.

Geldhof, De Clercq, De Bourdeaudhuij, & Cardon in 2007 [15] divided pupils' sitting postural behavior to dynamic sitting, static sitting, trunk flexed forward and using back rest. They reveal that school furniture is one of the infuential components on postural behavior of young pupils. Among all behaviors, sitting statically was the most common posture among school children. On the other hand, dynamic sitting is very unusual in classroom environment. Children who spent more time sitting with a flexed trunk reported significantly more thoracolumbar pain (lower back pain category) compared to pain-free children and children with cervical pain. It was observed that children who report pain stand for more period of time than pain free children [15]. Murphy, Buckle, & Stubbs [35] state that twenty-seven percent of children in South-East England reported having neck pain, 18% reported having upper back pain, and 22% reported having low back pain. All of these pains were associated with several factors such as emotional problems, family history, previous injury or accident and school furniture. Surprisingly, in this study, unsuitable furniture was the same factor associated for all kinds of pains. Furthermore, in 2009, two researchers from Iran [13] claim that mismatch between school furniture height and the dimension of students' bodies caused uneven shoulder among primary school girls and forward head among primary school boy.

Briefly, previous research prove that unsuitable furniture has a variety of negative impacts on bodies of school children. Some of these impacts may cause serious physical problems which can have effects to their somatic health in future. Some of the common pains and problems that unsuitable furniture causes at schools are: prevalence of MSD, lower and upper back pain, neck pain, uneven shoulder and forward head. In addition, furniture has influenced postural behavior in sitting position and students may suffer from those behaviors for a life time. Therefore, school furniture plays a significant role in two aspects for young individuals. These two aspects are transformation of skeletal shape and formation of sitting postural behavior.

3.0 ANTHROPOMETRY AND ERGONOMICS

Nowadays children's size has changed and it is different from thirty years ago. Now they are bigger and taller than they were in the past and research shows that most of this growth has been in the arms and legs as stated in the research by Goddared [16] about children anthropometry dimension. Jung [21] believes that students' anthropometric measurements vary widely across different age groups, within the same age groups, and between genders and cultures.

A design process for school furniture contains several steps, including: Target group, Anthropometric model and Percentage exclusion [21]. Molenbroek et al., [32] define a new approach for an anthropometric design process. They point out that the prescription of a furniture size should be based on popliteal height rather than body height. They also demonstrate when a set size is based on popliteal height instead of body height, it can eliminate the problem of too high or too low chair [32].

Mismatch between body size and school furniture is an issue that many countries around the world are facing such as India, China, Greece, New Zealand, Iran, etc. During the last decade, several studies have been done which demonstrate a mismatch between current school furniture and body measurements. To prove this fact, Dhara, Khaspuri, & Sau in 2009 reveal that in India, considerable number of school children suffered from various discomforts during classwork because of the mismatch between school furniture and anthropometric dimensions [6]. Another study done in 2007 by Chung & Wong [5] examined current furniture in Hong Kong's schools to know whether it is suitable for children's dimension or not. They found that almost none of the pupils had a chair with an appropriate seat height. On the contrary, seat depth was appropriate for large group of children. Authors believe that comfortable chairs and desks with practical efficacy matching furniture design (ergonomic design) with suitable body measurements will provide a better learning environment [5]. A mismatch was also reported in Thessaloniki, Greece in 2004 by Panagiotopoulou et al [41]. The researchers worked on furniture dimension in primary school. They point out that the available chairs are too high and too deep and desks are also too high for the pupils. The authors argue that this situation would cause some negative changes in the sitting posture of the children especially when reading and writing [41].

In 2006 in New Zealand, Kane, Pilcher, & Legg, [22] reported up to 96% mismatch recognized between the dimensions of school furniture and student body size. The mismatch between pupils and educational furniture were also reported by two researchers from Iran [13]. Farahani & Shakib [13] found that the proportion of furniture height and students' dimension did not match. They discovered from comparison of three anthropometric features (stature, popliteal height and elbow height from the earth) among both genders that elbow height of students from all grades and popliteal height of the third, fourth and fifth grade students were not similar. In Finland it was reported by L Saarni, Nygård, Kaukiainen, & Rimpelä (2007) that because of mismatch between school furniture and the

anthropometrics dimension, school children sit in disadvantaged postures for a substantial part of school lessons [44]. They state that children at school, sat with their backs flexed >20^0 and/or rotated >45^0 56% of the time. 70% of the time they sat with their necks flexed >20^0 or rotated >45^0 [44].

According to a study by Troussier et al., [49] ergonomically designed furniture have significant effect on the writing position, in comparison between other subjective factors. Linton. *et al.* [25] claim that ergonomically designed furniture results to a reduction in musculoskeletal symptoms and increased comfort which can be used to motivate pupils to sit correctly. Sitting correctly is an important factor and since pupils do not automatically sit 'properly', proper instructions and adjustment is necessary for children [25]. Oyewole et al. in 2010 [40] provide a guideline for ergonomic classroom furniture and recommended dimension for children in United States. It was suggested that, in order to implement an ergonomic-oriented classroom, it would be easier to provide adjustable furniture within the design limits.

In summary, it is a fact that children's anthropometric measurement has changed not only from the time of our parent's childhood, but even in the last two decades. So, designers and industrial producers should be aware that conventional measurements will most likely not provide comfortable furniture for pupils at school. Moreover, these dimensions vary between genders, races and even age groups in primary school. There is a demand for a new framework in dimension. Besides the importance of anthropometry and measurement, it is an accepted fact that there is a link between the facility and utility of the classroom and students' attendance and learning performance [27, 47]. Thus, designing school furniture based on ergonomic parameters can improve the learning environment.

4.0 CRITERIA AND STANDARDS

According to the study by Meservey [30] before selecting furniture, there is a need to plan and research to ensure it is suitable for the environment and fulfill the specific requirements. Thus, we identify the characteristics necessary for a set of furniture to be considered suitable for use at primary school. Goddared [16] suggests that furniture for primary children educational center first of all should reflect the move from teacher-focused to learner-focused education and be flexible enough to respond to changing educational requirements. Stotz & Walker [46] introduced some characteristics that manufacturers should consider in furniture industry. Furniture must be aesthetically pleasing, durable, lightweight (in appearance and structure), comfortable and inexpensive.

Knight & Noyes [23] suggest that in case of designing or purchasing furniture for school, the first stage is identifying the major roles of school furniture and then considering the standards. They also introduced two major functions for chairs and desks at school which are to support the child when attending to the teacher and when writing or drawing on the working surface. Moreover, before purchasing school furniture it is important to ensure that the selections are safe, flexible, durable, age-appropriate, and affordable [30]. In 2001, Eckelman et al. indicate that ideally, furniture should conform to national performance, quality standards, ergonomically correct, aesthetically pleasing, modular (the fastening systems can be readily assembled from components), easily maintained and simply repaired [11]. Domljan et al. [8] also introduce some basic requirements which should be considered when buying furniture for primary school. These are mobility, portability, maintainability, functional adjustability, with satisfactory durability, strength and safety. In addition, they propose that for contemporary furniture, it is vital to provide for dynamic and active sitting during different lessons as well as ergonomic and anthropometric principles [8]. Motmans in 2006 evaluated three types of school furniture and points out that when designing or buying new school furniture, it is important to consider a slanted desk top, a forward sloping chair and different sizes of furniture conforming to the body dimensions of the students [34].

Another important factor about furniture is durability. Durability is one of the factors of quality. One chair at school should be used for at least 10 years. Besides design factors, a chair should be durable and easy to clean and repair [16]. Moreover, cost is always a controller in the provision of educational facilities. Furniture usually is the last purchase in the school constructing process or even in the school renovation. In this case the material is an important element which can minimize the cost as well as maximize the quality.

In summary, prior research introduced some criteria and framework for standard school furniture. They reveal that school furniture should be aesthetically pleasing (good looking), durable, comfortable, inexpensive, conforming to national performance quality standards, ergonomically correct, easily maintained and simply repaired, portable (light weight), adjustable, provide safety, provide dynamic and active sitting during lessons and provide more freedom of movements for the legs.

5.0 MATERIAL

For the material of children's furniture, Stotz & Walker [46] conducted a research about the damages in furniture of different materials. They found that wire steel mesh chairs in some cases split under heavy use. The back of the molded plywood chair

frequently rubbed against the table edge that sometimes the plywood split. The reinforced fiberglass, has the advantage of color and easy maintenance but has proven unsatisfactory because the backward slope of the seat makes it uncomfortable to use when writing on a table. This kind of furniture is common in small and medium size and is light weight so children can move it. However, it can also become uncomfortably warm for a great length of time. If buildings come with air condition, this is not much of a problem [46].

Wood is the oldest material for school furniture. It has been used widely as furniture's material since the first generation of primary school. According to Stotz & Walker [46], wooden chairs are low in maintenance and repair and it is a common belief that these chairs can be as durable as the new materials when welded over a glued joint. This is the main reason that wooden traditional furniture is still used extensively. Stotz & Walker proposed that furniture should fulfill a variety of perceptions and avoid monotony, sterility, and institutional look. Obviously, there is a need to have larger diversity of high-styled, well-designed, and well-constructed chairs in metal, wood, plastic or a mixture of these materials

Edwards in 2001 conducted a comprehensive review about the nature and role of aluminum in furniture industry [12]. In this research, it was stated that aluminum is a material which has been used mostly as outdoor furniture. But for indoor furniture, a combination of aluminum with fabric or wood is more preferable. The ESAvian school chair and desk, is an example of first usage of aluminum as a material for school furniture in 20th century. It became a standard for new school furniture from the late 1940s onward. The designer was James Leonard which became known internationally after World War II for this aluminium furniture [12].

Loepp & Weede [26] conducted a study about plastic technology in furniture industry. According to their research, plastic entered the furniture industry shortly after its discovery. Its advantages ensured its continuous growth. Among the benefits are it is low cost which is especially important for countries that lack wood. Plastic can be formulated to meet any desired colour; thus, scratches and marks can be hidden. Moreover, furniture designers have more freedom in designing any shape in any colour. Thus, with creation of plastic, designers can be hopeful for the realization of special forms in the furniture designing industry [26].

In general, selecting material depends on some factors. Cost is one of the important issues in this field. Available resources in each country play critical role in determining the finished cost for furniture. Another issue is the life cycle of material. Nowadays, presenting a creation that is manufactured in an environmentally friendly way is a fundamental factor especially for mass production. For this purpose, it is better to use materials with less negative impact on the environment.

Durability of material in furniture is another important issue. When the users are school children, demand for durable furniture is more because we are talking about immature population. It is expected to see more damage in furniture used by school children than the other population group.

6.0 FURNITURE TYPE

Knight & Noyes [23] reveal that in designing classroom furniture, it should be considered that it is unnatural to keep children in one position for long periods of time. Furniture should allow children to move around in their seats. Duan is one of the designers of adjustable furniture [9]. Duan defined an intelligent children furniture that can imitate human's intelligence activity. However the life cycle of these products is becoming shorter and shorter in comparison with non-intelligent furniture. Jung, S is another researcher who tried to develop a framework for adjustable table and chair for educational institutions [21]. These parameters are: decreasing the production cost, minimum adjustment controls for easy adjustability, providing a flexible adjustment interval, adequate space for feet and knees and reducing weight for easier mobility. In New Zealand three researchers conducted a study to design new furniture for primary schools [22]. Kane, Pilcher, & Legg, (2006) gathered information from 19,000 New Zealand school pupils. Eventually, they created simple three-step self-guide for the furniture which is now called The Bodyfurn® (Figure 1). The adjusting steps assist students to determine the size of furniture to best fit them. After the first 10 weeks of using new furniture pupils and teachers were surveyed and both indicated very high approval of the furniture, especially the chairs. There was a high success in the implementation system [22]. Knight & Noyes [23] compared children's sitting behavior using traditional classroom furniture with a designed chair known as Chair 2000 (Figure 2) and its table. They found that children showed a modest but significant improvement in on-task behavior and they also seated in a more attentive and orderly way in ergonomic designed chair. Saarni, L. *et al.,* [44] compared saddle chairs and desks (Figure 3) with conventional one. In this study the authors report that schoolchildren preferred the ergonomic workstations to the conventional workstations. However, they did not find any considrable effetct on spine position in the new designed furniture.Paschoarelli & da Silva [42] introduced a new model of preschool furniture "Mobipresc 3.6" (Figure 4). They defined a set of furniture composed of sixty-five parts, including ferules, interchangeable legs, a work surface which can be inclined for artistic activities, writing and reading, and a supporting table which permits a freedom of lay-out, and a receptacle where the child can keep his belongings.

The standardized furniture permits more freedom of movements for the legs, and there are numerous

differences in children's movement pattern with respect to sex, age, and type of furniture [45]. T.Mandal (2009) explains posture problems with conventional furniture and presents solutions using appropriate science-based ergonomic designed furniture by AC. Mandal, with assistance by T. Mandal (Figure 5). In the developed furniture, chairs and tables can slope and causes highly significant improvements in flexion, pains and comfort [28].

Figure 1 Bodyfurn

Figure 2 Chair 2000

Figure 3 Saddle furniture

Figure 4 Mobipresc 3.6

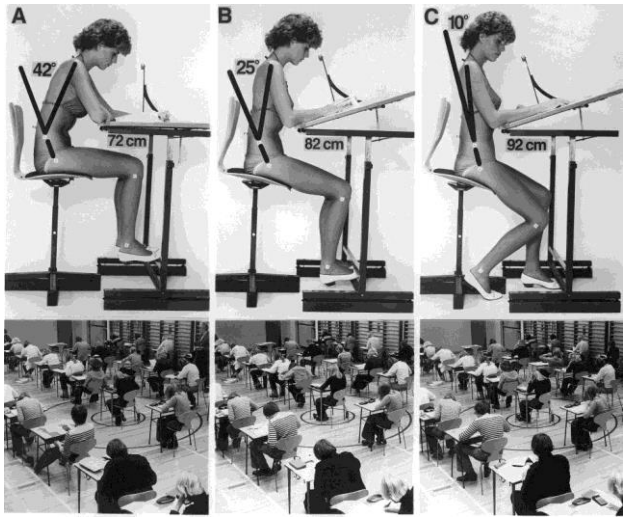

Figure 5 Mandal furniture

7.0 DISCUSSION

In summary, when we talk about children, we are talking about a sensitive stage of life. Therefore, we need to be aware of our thoughts, perceptions, attitude, etc. towards children. The basic features of every human personality are shaped in childhood. We are reflecting all the positive and negative experiences of childhood every day, unconsciously. These experiences (physically or mentally) have cosmic influences on everyone's life. Typically, children are passive in decisions and usually just receive and accept the decisions of adults. Researchers agreed that with precise design and

well developed educational centers, the level of mental and physical health can be improved.

Chairs and desks are basic facilities inside classrooms and therefore the most important element in this environment. Review of past literature reveals that suitable furniture has critical impacts on learning environment. Besides health and safety, it is clear that studying using comfortable furniture grounds better learning. Moreover, in a convenient environment, people would be more willing to stay.

In conclusion, there are some features which are expected to be improved by using suitable furniture. These features are writing position, sitting position and on-task behavior. Moreover, back pain and MSD (Musculoskeletal disorders) were reported to be decreased by using ergonomic furniture at primary school. Nevertheless, any improvement in actual sitting behavior can't be expected just by purchasing new furniture. Pupils will still need to be trained and encouraged about ergonomics and seating correctly.

Identifying the major roles of school furniture is the first stage of designing or purchasing furniture for school. For example, chairs and desks at school have two major functions, supporting children while attending to teacher and holding them when writing or drawing on the working surface. After the identification, one should consider the standards. Prior researchers introduced some criteria and framework for standard school furniture. They reveal that school furniture should be aesthetically pleasing (good looking), durable, comfortable, inexpensive, conform to national performance quality standards, ergonomically correct, easily maintained and simply repaired, mobile and portable (light weight), functionally adjustable, provide safety, provide dynamic and active sitting during different lessons and provide more freedom of movements for the legs.

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