ERGONOMIC BASED DESIGN AND SURVEY OF ELEMENTARY SCHOOL FURNITURE

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ABSTRACT

This paper presents the ergonomic aspects in designing and prototyping of desks cum chairs used in elementary schools. The procedures adopted for the assessment included- the study of existing school furniture, design analysis and development of prototypes. The design approach proposed a series of adjustable desks and chairs developed in terms of ergonomic concepts. In the development stage, the production cost, ease of management, installation and storage were the important factors undertaken. A questionnaire based subjective comfort evaluation survey was carried out on the developed prototypes and the results showed good response and satisfaction levels upto an overall 94 %. The details on the ergonomically designed prototype, its development process and customer satisfaction survey have been elaborated in this paper.

Key words: Ergonomic Design, Desk Cum Chair, Anthropometric Data

INTRODUCTION

The schools have a variety of students and traditional desk and chairs which are not suitable to fit all of them having varied body figures; therefore, individual needs, physical constraints and ergonomic aspects need to be considered in developing the user friendly designs. Prototype need to be made tested and evaluated. In an attempt to gain sufficient understanding on the issue, some earlier researches and designs were studied and are being presented herein. Georgia et al. [2004] have carried out an exhaustive survey in the primary schools in Thessaloniki, Greece for the students aged between 7-12 years, they measured the human body dimensions, mainly the stature, elbow height, shoulder height, upper arm length, knee height, popliteal height and buttock–popliteal length. The Anthropometric measures of the students and the furniture dimensions were compared in order to identify any incompatibility between them and based on their findings the utilities were designed. In another study conducted by Hwa Jung [2005]; prototypes were developed for an adjustable table and an adjustable chair for educational institutions and they were evaluated for adoptability in accordance with the international standards. The development process began with the identification of problems in the existing tables and chairs available in the market. The main criterions used in developing the prototypes were: minimizing the production cost to lower the market retail price, designing a stable and solid structure with minimum adjustment controls for easy adjustability, providing a flexible adjustment interval and adequate spacing for the feet and knees.

In another study carried out by Saarni et al. [2009], it was reported that children have been known to spend over 30% of their time at school. The study proposed a methodology and guideline for the design of ergonomic-oriented furniture as first grade in the elementary school. Based on the need to accommodate at least 90% of the population of first graders in the United States, the furniture design dimensions were finalized as seat height (25.83–32.23 cm); seat depth (27.41–33.86 cm); seat width (17.91–23.29 cm); back rest (35.64–44.37 cm); arm rest (16.28–20.68 cm); and desk height (30.12–37.85 cm). The anthropometric analysis could be used to design ergonomic-oriented classroom furniture which would not only incorporate adjustability, but also improve the level of comfort for the intended users.

In another study reported by Gouvali & Boudolos [2005], it was examined whether school furniture dimensions matched the children's anthropometry. Children aged

6–18 years (n= 274), divided into 3 groups on the basis of the used furniture size, were subjected into anthropometric measurements (shoulder, elbow, knee and popliteal height, buttock-popliteal length and hip breadth). Desk and seat height were bigger than the accepted limits for most children (81.8% and 71.5%, respectively), while seat depth was appropriate for only 38.7% of children. In conclusion, the assumption that children could use the most appropriate yet available size significantly improved the match, indicating that the limited provision of one size per cluster of grades does not accommodate the variability of anthropometry even among children of the same age.

In the study reported by Samuel et al. [2010]; the workstations at school were among several factors contributing to Musco Skeletal symptoms among the school children. In the first 14 month phase of the study, 42 from the intervention and 46 from the control school have participated. Anthropometrics and musco-skeletal symptoms were measured.

Anthropometric study of Mexican primary school children

An anthropometric survey was conducted on male and female primary school children aged 6–11 years in the metropolitan area of the city of Guadalajara, Mexico and reported by Lilia et al. [2004]. The anthropometric measurements were compared to those of American, Cuban and Mexican children. The results indicate that the body dimensions of Mexican children from this study are different from those of American, Cuban, and other Mexican children, probably due to ethnic differences and the time lapse between the different studies. It is considered more than 50 parameters are necessary for the design of school furniture.

Evans et al. [1998] have studied on the anthropometric data of Hong Kong school children and analyzed it in order to develop recommendations for the design of chairs and tables for use in Hong Kong Government coeducational schools. The anthropometric data for Hong Kong have been compared with data from a Western population (United Kingdom) and another Asian population (Japan).

Manufacturers of kids furniture do not take into consideration the establishment of elementary school students anthropometric database; such consideration of comfort for the small children needs to be incorporated in the design. In most of the cases, commercial aspects of the products are addressed rather than focus on variety and versatility of the designs.

Objective and methodology for the development of design

The objective of this study project was to access the ground situation in the elementary school levels regarding the issues in seating and comfort and to develop an ergonomic based better seating design, which could be suitable from multiple angles (comfort along with ease of storage and economy). The design project simulates a class into the normal distribution situation. A school desk and chair will undertake a student's physical and psychological needs. A class including students of different body figures is considered wherein students require different type of desks and chairs to fit their body figures. In the growing age, students are filled with tremendous energy levels, hence there is a need to apply more storage space for students' and staff and more efforts should be made to simplify the production procedure and reduce its cost. The schools should find it easy to organize its desks and chair in each classrooms. The most suitable material (good quality wood) needs to be considered and the wood consumption should be reduced through proper design. The organization of such chairs in each classroom is done as per the proposed optimum layout. Figure 1 describes the design parameters of interest for ensuring adequate comfort and Table 1 gives the values for the

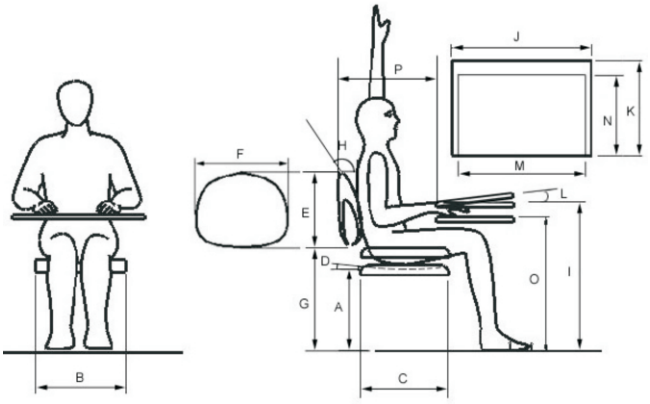

Figure 1. Ergonomic design development

parameters mentioned in Figure 1.

Table 1 suggests the ideal parameters that have to be conformed to while designing an ideal desk cum chair for students. These parameters vary according to various factors involved, age, height, etc. of the subject (student in this case).

Current Primary school students' desk and chair

Considering the human factors as discussed in Figure 1 and Table 1, ten different desks with variable surface heights along with five types of different school desks and chairs were manufactured. These were being considered to completely fit students in the different body figure ranges; however, with the manufacturing and capitalization point of view, for those fifteen types of different desks and chairs, it required equal number of production processes. According, to school management point of view, storing such different types of desks and chairs in order to cater to the variety of physical dimensions of the students was difficult; also it would require organizing them to suit such different body figures in the subsequent years. Therefore, in order to undertake ergonomic requirements, saving production costs, desk and chair management in school and students needed the most attention, which was taken up in the current study. Table 2 describes ideal school chairs' parameters for different physical dimensions of students.

Code	Item	Measurement	Design
A	Seat surface height	28.8 cm	
	Adjustable range	27-33 cm	Adjustable design
B	Seat surface width	38cm	Extremely design
C	Seat surface depth	37cm	Adjustable design
D	Seat surface angle (degrees)	3- 5	Adjustable design
E	Back support length	30cm	Adjustable design
F	Back support width	40cm	Extremely design
G	Back support angle (degrees)	100 – 105	Adjustable design
H	Desk surface height	58cm	
	Adjustable range	56-62cm	Adjustable design
I	Desk width	65cm	Adjustable design
J	Desk angle (degrees)	0~10	Adjustable design

Table 1. Ergonomic suggestion for ideal desk cum chair design

	School –I	School-II
No. of students	50	50
Range of student height	106-120.9cm	121-135.9cm
Seat surface width	30cm	34cm

Table 2. Ideal school chairs for different physical dimension of school students

In Table 2, the data is taken into consideration for 50 students each from two schools (without naming), ranging from the age group of 4-7 years. In addition to it, the height too which was taken into consideration which is mentioned as above (different for the two schools) is different for different age group of the students. For the better comprehension there are two cases projected here, both having different parameters and both being the ideal.

Material consideration

In terms of economic consideration, the frame was made of hard wooden board which helped in achieving strong and durable character; these desks cum chairs can also be manufactured by plastic boards, which are strong and durable, easy to maintain, clean, light weight and reduces the iron import burden to the nation. The prototype is indicated in Figure 2.

The opinion results described these new designs as acceptable, economic, multi featured and serving to the ergonomic requirements of kids in the age group of 4-10 years. The collected response from the survey yielded an average rating of 4.69 out of maximum 5, thereby yielding a satisfaction level of 93.76%, amongst the thirty samples collected from teachers and student reactions through opinion surveys. The painting of such furniture with attractive colors, cartoons and pictures would further make the design fascinating and admirable amongst the target population.

Conclusion

This study involved the usage of industrial tools such as Questionnaire (physical surveys), whole body assessment tools (Semi-Quantitative), Rapid Upper Body Assessment (RUBA) to cater to the ergonomic design requirements as per demands from the end consumer. It has been an earnest endeavour to undertake these issues (comfortable

Figure 2. The ergonomically designed compact desk cum chairs

S. No.	Question (Answer in 5 point scale, with one being least and five being highly appreciated and best)	Response (tick the relevant) 1(Poor)	2(Fairly)	3(Average)	4(Definitely)	5(Outstanding)	Average result (overall obtained response)
1	Whether the new design of desk cum chairs attracted the children?						4.52
2	Whether all essential amenities of the children were accommodated in the prototype?						4.82
3	Were the chairs comfortable and provided ambiance?						4.46
4	Whether the design fitted in the available space and eased storage requirements?						4.56
5	Whether the overall economics fitted in the school budgets?						4.32
6	After the prototype test on actual usage for the trial period of 5 hours, did the children report physical discomfort?						4.8
7	Any stress condition reported or noticed on the child, after its usage?						4.78
8	Was the design safe and comfortable?						4.92
9	Whether any injury was reported during its usage?						4.98
10	What was the overall response from the concerned teachers monitoring the practical test conditions?						4.72

Appendix : Optimum Survey questionnaire

and compact seating) and come up with a revolutionary product, most appropriate for the usage of the primary school students. At the same time, due attention was given to conformity to the design regulations suitable for different body figures of the primary school students. Considerable research has been put into, while including various physical surveys, ergonomic analysis tools, physical proto type modelling, and then sketching, and finally a product prototype was developed. The main achievement of this study was in getting the good customer satisfaction, through achievement of ergonomically derived comforts through the use of Product Design Methodology. The recommendations of the study were that such designs could be used in schools and can be further made attractive with aesthetic modifications in terms of painting with motivational pictures and colours.

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