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Conference Paper

Design of Ergonomic Tables and Chair for Special Needs Students (Case Study: Elia Junior High School Surabaya)

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ABSTRACT

Elia Junior High School is one of the private middle schools in Surabaya. The school has special needs students. Elia Junior High School uses normal sized school chairs and tables for students in general, when using it they often complaints of pain in the neck, and shoulders to the size of the table is too high and the table is not flexible, pain in the spine caused the back of the chair too upright, also the table does not have a drawer and a place to put a drink and hang shoes. The purpose of this study to design school tables and chairs for special needs students with ergonomic at Elia Junior High School Surabaya with the Anthropometry approach to reduce the grievances felt by these junior high school students. Finally, on the results of the study, the size of ergonomic school tables and chair of the seat high is 40.31 cm, the seat length is 45 cm, the seat width is 35 cm, the high back of the chair is 50 cm, the seatback width is 45.44 cm, the high t of the bottom table is 54 cm, the high of the top table is 70 cm, the length, and width of the table is 54.24 cm and the high of the drawer is 10 cm. These school tables and chairs are flexible because height and inclination can be adjusted to the dimensions of the student's body and have a drawer for storing drinks, and a place to hang shoes.

Keywords: *Anthropometry*, design, ergonomic, flexible

Introduction

Tables and chairs are school facilities that influence students' sitting attitudes while studying, besides from being a means and infrastructure in teaching and learning activities, these tables and chairs also have other functions and roles outside of learning activities. The relationship of school tables and chairs to students is very close, namely almost as much as 80% of the time students at school almost always involve school tables and chairs in activities in the classroom. Closely the role of school tables and chairs for student activities in the classroom will indirectly relate to the design of ergonomic school tables and chairs which, due to learning activities that are more than six hours, can cause students to experience physical and mental stress due to mismatches in size school tables and chair.

The literature studies used in this study are: A Review of the Methodology and Applications of Anthropometry in Ergonomics and Product Design (Dianat *et al*., 2018), Design of Ergonomic Tables and Chairs that Can Support Activities and Needs in Playing Games with the Thinking Design Process (Aprillina *et al*., 2019), Anthropometric measurement for the ergonomic design of students' furniture in India (Taifa & Desai, 2017), Hand Anthropometry of Indonesia Young Adult Females (Nidiaputri, & Ardiyanto, 2017), Design a Spring Iron Product Using the Kano Method (Nurjannah & Purnomo, 2018),

Ergonomic Computer Workstation Design for University Teachers in Bangladesh. Finally, an ergonomic computer workstation was proposed by considering anthropometric measurements and

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guidelines to reduce the musculoskeletal disorders among the teachers (Kibria & Rafiquzzaman, 2019), Designing a New Ergonomic Student Backpack. The results showed that the new backpack using a medical belt based on ergonomic features with appropriate features provides a greater sense of comfort for users and it is improved compared to the existing backpack which is available in the Iranian market and design based on previous studies (Mansoorian et al., 2019), Determination Application of Ergonomics Chair Design in Batik Activities to Increase Productivity (Sugiharto, & Sokhibi, 2019) and Design of Tables as a Tool for Welding Process Based on Ergonomic Principles (Sutrisno et al., 2020)

Elia Junior High School is one of the Private Middle Schools in Surabaya, the school has students whose physical development difference of students in general. it uses normal sized school tables and chairs for students in general, where complaints often appear in the neck and shoulder pain because the size of the table is too high and not flexible, back pain is caused the back of the chair is too upright, and the table doesn't have a drawer and a place to put drinks following government policy that suggest bringing a drink holder to school. The purpose of this study to design ergonomic school tables and chairs in Elia Junior High School Surabaya with the Anthropometry approach with the hope of reducing the complaints felt by the Junior school students.

Research Method

Steps of the research method :

Anthropometric data collection

Human Body Dimensions used :
- Knee Fold High (KFH)
- Knee Fold to Buttocks (KFB)
- Hip Width (HW)
- Sitting Shoulder High (SSH)
- Shoulder Width (SW)
- Knee-High (KH)
- Seated Elbow High (SEH)
- Hand Range (HR)

Data Uniformity Test

Data uniformity test to find out uniform data or not (extreme data or not) using map control. Extreme data is data that exceeds the control limit and then the data is discarded (Wignjosoebroto, 2016). The data uniformity test steps are as follows:

a. The average value of observation.

$$\bar{x} = \frac{\sum x_1}{n} \quad (1)$$

Where :

$\bar{x}$ = Average observations

x = Measurement data

b. Deviation Standard

$$\sigma = \sqrt{\frac{\sum(xi-\bar{x^2}}{n-i}} \quad (2)$$

Where :

σ = Deviation standard of the sample

n = the number of observations

c. Upper Control Limit (UCL) and Lower Control Limit(LCL).

$$UCL = \overline{X} + k\sigma \quad (3)$$
$$LCL = \overline{X} - k\sigma$$

Where :

k = confidence level index:

The confidence level of 0%-68%, k is 1

The confidence level of 69%-95%, k is 2

The confidence level of 96%-100%, k is 3

Data adequacy test

Test the adequacy of the data to find out whether the amount of data taken is sufficient or not, if (N'≤ N) then the data is sufficient, and if (N> N) then the data is insufficient and must be re-measured until the data is sufficient (Wignjosoebroto, 2016).

Data adequacy test:

$$N' = \left(\frac{\frac{k}{s}\sqrt{N\left(\sum Xi^2\right) - \left(\sum Xi\right)^2}}{\sum Xi} \right)^2 \quad (4)$$

Where :

N'= The number of observations that should have been made

s = level of accuracy

Determine Percentiles

Percentile values were used to determine the size of the school table and chair design. Percentile values are calculated based on Table 1.

Table 1. Percentile and calculation in normal distribution (Wignjosoebroto, 2016)

Percentile	Calculation
1-st	$\bar{X} - 2325\ \sigma_{\bar{x}}$
2.5-th	$\bar{X} - 1960\ \sigma_{\bar{x}}$
5-th	$\bar{X} - 1645\ \sigma_{\bar{x}}$
10-th	$\bar{X} - 1280\ \sigma_{\bar{x}}$
50-th	$\bar{X}$
90-th	$\bar{X} + 1280\ \sigma_{\bar{x}}$
95-th	$\bar{X} + 1645\ \sigma_{\bar{x}}$
97.5-th	$\bar{X} + 1960\ \sigma_{\bar{x}}$
99-th	$\bar{X} + 2325\ \sigma_{\bar{x}}$

Table 1, shows the formula that will be used in calculating the size of the product design by using percentile values suitable for product design. The design of the school table and chair in this study uses 5-th, 50-th, and 95-th percentiles.

Designing a school table and chair design

Designing a school table and chair concerning the results of the calculation of percentiles and other existing data.

Proposed use of school table and chair

Proposed school tables and chairs are subjected to a trial run process until an ergonomic design is obtained.

Result and Discussion

Data uniformity test

Knee Fold high (KFH)

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{\sum n} = \frac{43 + 44 + \cdots + 40}{35} = 40.31$$

$$\sigma x = \sqrt{\frac{\left(x_1 - \overline{X}\right)^2 + \left(x_2 - \overline{X}\right)^2 + \cdots + (x_n - \overline{X})^2}{n - 1}}$$

$$\sigma x = \sqrt{\frac{(43 - 40.31)^2 + (44 - 40.31)^2 + \cdots + (40 - 40.31)^2}{35 - 1}} = 2.097 = 2.1$$

Data Uniformity test of Knee Fold high (KFH) with a confidence level of 95% and k = 2 :

UCL = $\overline{X}$ + k. σx ; UCL = 40.31 + (2) 2.1 = 44.51

LCL = $\overline{X}$ - k. σx ; LCL = 40.31 - (2) 2.1 = 36.11

The data is made by the UCL and LCL control maps as shown in Figure 2.

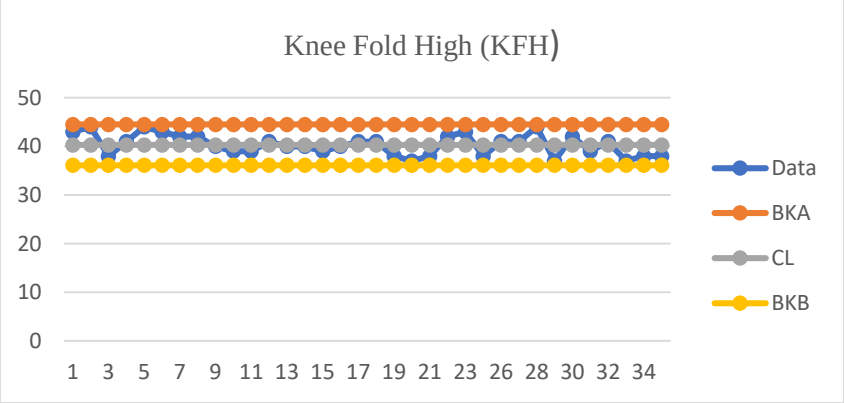

Figure 1. Data uniformity test of Knee Fold High (KFH)

Figure 1, shows the measurement of the dimensions of the knee folf high (KFH) is uniform. The recapitulation results of the measurement data uniformity test for other body dimensions can be seen in Table 2.

Table 2. Data uniformity test results

Body Dimension	UCL (cm)	LCL (cm)	$\overline{X}$ (cm)	∑x (cm)	Min Data (cm)	Max Data (cm)	Information
KFH	44.51	36.11	40.31	1411	37	44	Uniform Data
KFB	48.54	40.52	44.62	1562	42	48	Uniform Data
HW	37.28	24.36	31.82	1114	28	37	Uniform Data

SSH	53.91	46.43	50.17	1756	47	53	Uniform Data
SW	43.00	36.47	39.74	1.391	42	37	Uniform Data
KH	50.71	41.07	45.89	1606	41	50	Uniform Data
SEH	23.97	16.25	20.11	704	17	23	Uniform Data
HR	64.12	53.28	58.70	2055	54	63	Uniform Data

Table 2, shows the results of the data uniformity of all body dimensions are uniform so that all measurement data can be used for further data processing.

Data adequacy test

The data adequacy test uses a level of accuracy of 5% and a confidence level of 95%. Knee Fold High (KFH) data adequacy test:

$$N' = \left(\frac{\frac{k}{s}\sqrt{N\left(\sum Xi^2\right) - \left(\sum Xi\right)^2}}{\sum Xi} \right)^2$$

$$N' = \left(\frac{\frac{2}{0.05}\sqrt{35(57033) - (1990921)}}{1411} \right)^2 = 4.20$$

Value of N' (4.20) ≤ N (35), then the data from the measurements taken are sufficient to represent Junior High School special needs students. The results of data adequacy tests for other body dimensions can be seen in Table 3.

Table 3. Data adequacy test results

No	Body Dimensions	N	N'	Information
1	Knee Fold High (KFH)	35	4.20	Enough Data
2	Knee Fold to Buttocks (KFB)	35	2.75	Enough Data
3	Hip Width (HW)	35	11.50	Enough Data
4	Sitting Shoulder High (SSH)	35	2.16	Enough Data
5	Shoulder Width (SW)	35	2.62	Enough Data
6	Knee High (KH)	35	4.29	Enough Data
7	Seated Elbow High (SEH)	35	1.61	Enough Data
8	Hand Range (HR)	35	3.33	Enough Data

Table 3 shows the results of the adequacy test of all body dimensions where there is enough data, so no additional measurements are needed.

Size of proposed school tables and chairs based on percentile value

- The high of the chair seat uses 50 percentile
  The hight of the chair seat = $\overline{X}$
  = 40.31 cm
- The length of the chair seat uses 50 percentile

The length of the chair seat = $\overline{X}$
= 44.97 cm = 45 cm

- The width of the chair seat uses 95 percentile
  The width of the chair seat = $\overline{X}$ + P95 (SD)
  = 31.82 cm + 1,645 (1,87)
  = 34,89 cm = 35 cm
- The high back of the chair uses 50 percentile
  The high back of the chair = $\overline{X}$
  = 50,17 cm = 50 cm

- The width back of the chair uses 95 percentile
  The width back of the chair = $\overline{X}$ + P95 (SD)
  = 39,74 cm + 1,645 (3,47)
  = 45,44 cm
- The high of the bottom table uses 95 percentile
  The high of the bottom table = $\overline{X}$ + P95 (SD) + *Allowance*
  = 45,88 cm + 1,645 (1,633) + 5 cm
  = 54 cm
- The high of the top table
  The high of the top table = $\overline{X}$ + 10 cm
  = 60,11 cm + 10 cm
  = 70,11 cm = 70 cm
- The length and width of the table uses 5 percentile
  The length and width of the table = $\overline{X}$ - P5 (SD)
  = 58,7 cm - 1,645 (2,71)
  = 54,24 cm
- The high of the drawer
  The high of the drawer = (The high of the top table – the high of the bottom table) - *Allowance*
  = (70,11 cm – 53,56 cm) - 6,5 cm = 16,5 cm - 6,5 cm = 10 cm

School table and chair design

Figure 2. Table and chair design

Figure 2, shows the design of an ergonomic table and chair proposal because it is following the body dimensions of special needs students and flexible where the table and chair can be tilted so that when using, it does not cause pain in the neck, shoulders, and back. In terms of function, the proposed school table and chair have a place to put drinks and a place to hang shoes.

Conclusion

Based on the body dimensions of the special needs student's, obtained an ergonomic school table and chair-size has the hight of the chair seat is 40.31 cm, the length of the chair seat is 45 cm, The width of the chair seat is 35 cm, the high back of the chair is 50 cm, the width back of the chair is 45.44 cm, the high of the bottom table is 54 cm, the high of the top table is 70 cm, the length and width of the table is 54.24 cm and the high of the drawer is 10 cm. The table and chair are flexible, where the high and slope of the table and the slope of the back of the chair can be adjusted to the dimensions of the junior high school student's body. The proposed school table and chair also have a drawer for put drinks and a place to hang shoes.

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