Journal of Industrial Technology 6 (1), 1997, 13-27

FUNCTIONAL DIMENSIONS OF CHAIRS AND TABLES FOR PRIMARY SCHOOLS IN MALAYSIA

Hamdan Husain, Tom Sickinger and Abd. Hamid Salleh

Forest Research Institute Malaysia (FRIM)
Kepong, 52109 Kuala Lumpur
Malaysia

RINGKASAN: *Kerusi dan meja di sekolah-sekolah rendah sekarang telah direkabentuk mengikut kumpulan umur dan bukannya kepada ketinggian murid yang mempunyai hubungkait dengan ukuran bahagian-bahagian lain tubuh badan. Bancian data antropometrik telah diambil dari murid-murid di sepuluh (10) buah sekolah rendah di lima (5) buah negeri di Semenanjung Malaysia dalam tahun 1992. Sebanyak lapan belas (18) punca ukuran badan telah diambil walaupun hanya sebahagian sahaja digunakan di dalam kajian ini. Tumpuan hanyalah kepada ukuran kerusi dan meja murid kerana ia merupakan dua aset penting untuk kegunaan pelajar di semua sekolah. Hasil kajian melalui analisis statistik menunjukkan terdapat perbezaan di antara ukuran yang digunakan sekarang dengan yang dicadangkan.*

ABSTRACT: Existing chairs and tables for primary school students were designed according to the age-group but not according to body-height measurements which is directly related to other part-body dimensions. Anthropometric data were collected from ten (10) primary schools in five (5) states in Peninsular Malaysia in 1992. A total of eighteen part-body were measured although only several were used in this study. Efforts were made only on determining the suitable measurements of student's chair and table because it is required by all schools. The study showed that the dimensions used in the present school furniture varied significantly from the proposed measurements.

KEYWORDS: Anthropometric data - part-body measurements - body heights - chairs - tables - primary schools - proposed measurements.

INTRODUCTION

There were about 2,655,700 primary one to primary six students registered in Malaysia for the 1992/1993 session, with an estimated increase of about two per cent annually (personal communication, 1997). The most essential items required by any school are the chairs and tables due to the increased number of intake and frequent damage due to various reasons. They are also difficult to design because it involves the basic physical requirements of the human anatomy, ultimately resulting in bringing comfort to the user.

Being active and at an age where growth is very crucial, it is rather strenuous for the students to spend every day studying on a rigid set of furniture. Although no formal study has been conducted locally, many cases of back pains which originate during schooling age have been reported (Anon, 1979 & 1987). Chairs and tables are often associated with this problem. Students sit on chairs that are of the wrong height and inclination, causing them to hunch over their work. This posture causes pinching of the intervertebral discs in the spine, which results in other related physical discomfort. As such, furniture should not be viewed simply as "pieces of furniture" but need to be thought of in a much broader context. The range of furniture provided should fit the body sizes of the children.

No study on the designing of primary school furniture in Malaysia has been recorded so far. Sheath and Vickery (1971), who conducted a study on utilization, design and cost of secondary schools in West Malaysia, however, commented that the single size of chair and table used in secondary schools (by students between 13-18 years old) is inadequate for a mean height variation of 175 mm and they suggested a range of sizes be used.

Two sets of working drawings for school furniture were analysed, the SIRIM/KPM/KM/88 and GF 90/KPM/0010 & 0011. These designs maintained a single size grouping for the secondary schools, but two sets of dimensions were provided for the primary schools; one for the 7-9 years old and the other for the 10-12 years old students (Table 1 and Appendix 1). How the measurements of the existing dimensions were derived could not be clearly ascertained.

Table 1: Existing Dimensions of Primary and Secondary School Furniture (Source: Ministry of Education)

a) Chairs (mm)

Year	C1	C2	C3	C4	C5
7 - 9	340	290	340	360	680
10 - 12	370	320	370	410	770
13 - 18	380	330	380	460	860

Note: C1 = exterior width of chair
C2 = interior width of chair
C3 = depth of chair
C4 = height of seat
C5 = height of chair back

b) Tables (mm)

Year	T1	T2	T3
7-9	610	457	637
10-12	610	457	686
13-18	660	508	737

Note: T1 = width of table
T2 = depth of table
T3 = height of table

This paper compares the primary school chairs and tables using the existing dimensions based on age-group and proposes a new set of dimensions based on standing heights (SH). They are derived from the ranges and means of anthropometric data collected by the Forest Research Institute Malaysia (FRIM) through a survey conducted in 1992 covering ten primary schools in five states of Peninsular Malaysia namely Kedah, Perak, Kelantan, Terengganu and Johore. Standing heights were chosen instead of age-groups (as conventionally practiced) because of the efficiency in satisfying the basic comfort requirements and conform to other part-body measurements, which refer to the measurements, of the human body at different points of reference (Anon, 1979).

Since human dimensions vary and only few individuals are at either extremes, the values of ranges (in percentiles) and means were used to determine the appropriate dimensions. In Malaysia, which have compulsory primary education, most of the children in each class will be of the same age. Therefore, the acceptable ranges should correspond well to that of the majority. It is also important to note that many influencing factors such as food, daily diet or general environmental and social factors may also contribute to the anthropometric variations. While standard dimensions are important to ensure comfort to the students ergonomics, other factors such as cost, design and aesthetic features should also be taken into consideration.

The Chair

A good chair should be comfortable for a child to sit with the feet flat on the floor, the underside of the lower thigh free from pressure near the knee, and sufficient support at the back below the shoulder blade. It is better for the seat to be low rather than too high, as seats that are too high increases discomfort (Vickery, 1964 & Anon, 1987).

The Table

The table height should be such that the upper part of the thigh of the sitting child is clear of the underside of the table. The working surface of the table should be of an appropriate height to allow the sitting child to write comfortably. In addition, the area of working surface

should be large enough to support the arms of the child while writing (Vickery, 1964). Generally, pupils adopt many sitting and writing postures but the assessment of a good fit situation should conform to the seven criteria mentioned in Figure 1 below.

Figure 1: *Fit of Pupil to Chair and Table (Source: ISO-DIN 1980)*

A: Shod feet flat on floor

B: Clearance between back of legs and front edge of seat

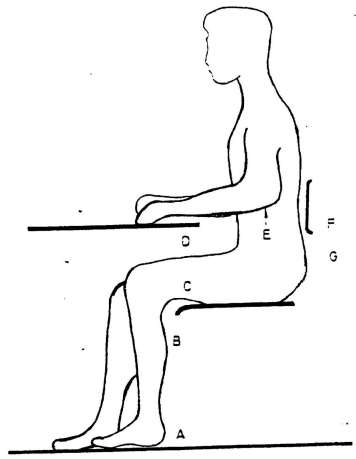
C: No pressure at front of seat between seating surface and thighs

D: Clearance between thigh and underside of table for freedom of movement

E: Elbows approximately level with table top when upper arm vertical

F: Firm support for back in lumbar region and below shoulder blades

G: Adequate clearance between backrest and seat to ensure free movement of buttocks



MATERIALS AND METHODS

Design Experiment

The anthropometric data were collected from students of both sexes from the age of 7 to 12 years old. A total of three thousand students from ten primary schools in five states in Peninsular Malaysia were involved in the survey. The schools are located in urban and sub-urban areas with the students coming from various social and educational background. The sampling of students were taken randomly from a class of 25 males and 25 females in each age group. Efforts to collect data from rural and remote areas were however not pursued due to unavoidable circumstances and constraints. The method for data collection was adopted from several methodologies including that of Damon *et. al.* (1966), with modification made according to the need of this study.

Eighteen different measurements were taken from the body of each student and recorded in a prepared standard form (Appendix 2). Anthropometric equipment such as large calipers, set squares and measuring tapes were also used with a reading tolerance of ± 5 mm. This

figure was taken to simplify computation and assist in data analysis. For all measurements taken at standing position, the students had to lean flat against a large piece of paper that had vertical and horizontal grid lines marked at 1 cm square, pasted onto the wall. As for sitting position measurements, they were required to sit on a table with their back straight against the wall. While taking these measurements, the students were in school uniforms but minus their shoes.

RESULTS AND DISCUSSION

The data were analysed using the Statistical Package for the Social Sciences (SPSS) and the Analysis of Variance (ANOVA) procedure to compare the effect of age of students from 7 to 12 years old on standing height (SH). The result indicates that the differences between the six age groups based on standing height are highly significant. Further analysis using Duncan's Multiple Range Test (DMRT) as shown in Table 2 indicates that students in the 12 years old group have the highest mean body height and the six age groups differ significantly from each other.

Table 2: Duncan's Multiple Range Test (DMRT) for Comparing Means* of Standing Height (SH in cm) of Male and Female Students in each Age-Group

Age	7	8	9	10	11	12
Male	113.78[a]	120.27[a]	124.45[a]	130.56[a]	135.12[a]	140.51[a]
Female	114.47[a]	118.80[a]	124.33[a]	129.80[a]	136.00[a]	143.52[b]

*Average of 500 students in each age group

Any two means in each age group having a common alphabet show no significant difference between Male and Female students at the 5% level of significance.

Within the same age group, however, the standing heights are generally insignificant between male and female students except for the 12 years old age group where the females are significantly taller than the males (Table 2). Due to the compulsory education system in Malaysia, the majority of students are generally of the same age in each class taken and thus irregularity pertaining to the mixture of age group does not arise here. With reference to Evelyn (1984) and Vickery (1964) and also other acceptable practice, the students were then divided into two different groups based on their standing heights (SH) i.e. Group 1 ranges between 1080 - 1230 mm and Group 2 between 1235 - 1400 mm. These SH-range are representative of the 90 per cent majority while the extreme measurements (below 5th percentile and above 95th percentile) recorded in the analysis were not taken into consideration. This is because the number of students recorded in the extremes are relatively small.

Table 3 also shows that the mean for low leg length (LLL) increases significantly with age body height. This is important as it will later determine the suitable height for the proposed chair. Table 4 compares the means of SH, LLL, EWB, ULT, SW and BKL between the two SH-groups. These means are important as it will determine the appropriate dimensions for the proposed measurements.

Table 3: Duncan's Multiple Range Test (DMRT) for Comparing Means* of Standing Height (SH) and Low Leg Length (LLL) in six Age Groups

Age		SH (cm)			LLL (cm)			
	Male	Female	Mean	SD	Male	Female	Mean	SD
7	113.78	114.48	114.13[a]	5.30	30.98	31.58	31.28[a]	2.41
8	120.27	118.81	119.54[b]	5.72	32.67	33.08	32.87[b]	2.31
9	124.45	124.33	124.39[c]	6.26	34.17	34.62	34.39[c]	2.59
10	130.56	129.80	130.18[d]	6.03	36.04	36.53	36.29[d]	2.49
11	135.12	136.00	135.56[e]	6.58	37.48	38.32	37.90[e]	2.79
12	140.51	143.22	141.87[f]	7.52	39.11	40.36	39.74[f]	3.29

*Average of 500 students in each age group.
Any two means having a common alphabet are not significantly different at the 5% level of significance.

Table 4: Comparing Means* of SH, LLL, EWB, ULT, SW and BKL for Male and Female in both SH-Group.

SH Group	1 (cm)				2 (cm)			
Part-body	Male	Female	Mean	Std. Dev.	Male	Female	Mean	Std. Dev.
SH	119.50	119.21	119.35	7.13	135.40	136.34	135.87	8.26
LLL	32.61	33.09	32.85	2.75	37.54	38.40	37.97	3.20
EWB	14.66	14.51	14.58	2.00	16.29	16.85	16.57	2.45
ULT	7.93	8.05	7.99	1.11	9.32	9.44	9.38	1.37
SW	22.19	22.22	22.20	2.31	25.36	26.17	25.76	3.08
BKL	39.59	40.55	40.07	3.11	45.83	46.91	46.37	3.56

*Average of 1500 students in each SH group.

Note: SH - Standing Height
LLL - Low Leg Length at Sitting Position
EWB - Elbow Height at Sitting Position
ULT - Upper Leg Thickness at Sitting Position
SW - Width of Bottom at Sitting Position
BKL - Bottom to Knee Length

Proposed Measurements

The information in Table 5 shows the Proposed Measurements (PM) for chair and table for the two SH groups. It will serve as an important guideline for the design of primary school furniture. The distribution of furniture sizes should be able to cater to the majority individual's range of measurements.

Table 5: Proposed Measurements (PM) of Chair and Table for Primary Schools

SH -GROUP **range (mm)**	**1** **1080-1230**	**2** **1235-1400**
LLL	320	370
EWB	140	160
Table Height (LLL + EWB)	460	520
Difference (tolerance)	200	220
Chair Height (Table Height - Difference)	**260**	**300**

The height of the table was obtained by adding the low leg length (LLL) and elbow height at sitting position (EWB). While Malaysia has not established her own standard, the chair height was obtained by deducting the table height and the difference (tolerance) which was derived from the ISO-DIN standards. This was also confirmed from the data analysed that 90% of Group 1 and Group 2 has a mean thigh thickness of 100 mm and 120 mm respectively (Hamdan *et. al.*, unpublished). The allowable difference is critical as it also determines the comfort tolerance between the top of knee and bottom of the table. This is because if a shelf is required for the table, then the minimum opening should not be less than 60 mm (Anon, 1980).

The results also indicated that the proposed chair height for the respective Groups 1 and 2 are 100 mm and 110 mm lower than the existing furniture used by the Ministry of Education (ED) but similar to those of ISO-DIN and BS. As for the table, the PM is 177 mm and 166 mm lower in Groups 1 and 2, respectively, than the ED (Table 6). It also clearly shows that the ED has the highest dimensions among the five anthropometric data analysed. Based on visual observation and random interviews conducted during the survey, it was found that quite a number of students using the existing furniture have to stretch up, forcing themselves to sit at the edge of the chair while at the same time leaning on the table for support.

Table 6: Size mark Comparison Between ISO-DIN, BS, AC, ED and PM for Each SH-Group

SH-Group	Description	ISO-DIN	BS	AC	ED	PM
1	Th (mm) Sh (mm)	460 260	460 260	400 250	637 360	**460** **260**
	Difference	200	200	150	277	**200**
2	Th (mm) Sh (mm) Difference	520 300 220	520 300 220	430 330 100	686 410 230	**520** **300** **220**

Note: ISO-DIN - International Standards-Deutsche Industrie Norm
BS - British Standards
AC - Asian Children
ED - Existing Dimension
PM - Proposed Measurement
Th - Table Height
Sh - Seat Height

Comparatively, the range of Proposed Measurement (PM) in Group 1 is approximately equivalent to Group 2 of ISO-DIN, while the PM Group 2 is equivalent to Group 3 of ISO-DIN. However, the ISO-DIN were divided into seven SH-group ranges whereas the PM will maintain the two SH-groups for primary schools, but with the intention of having at least two SH-groups for the secondary school to give more flexibility in design.

Prototypes

Although the number of students involved in this study consist only a fraction of the total primary students, it will be able to give an indication due to the wide fragments in students background and location of samples collected. The Proposed Measurements was further assessed through the fabrication of prototypes for evaluation before it can be accepted. Several students from both SH-group were randomly asked to sit on the prototypes. Generally, the students indicated comfort and preference for the proposed prototypes. However, it is difficult to determine whether their preference were due to politeness, excitement over the new furniture or others.

A complete analysis on the testing of the prototype was also conducted by the Furniture Testing Laboratory at FRIM. Although the tests conducted are towards physical and strength determination and not for the level of comfort, it should however provide an indicator to the effectiveness of this study.

It is recommended that this study should be followed up by a pilot project in which prototypes will be distributed to several schools and its performance monitored. The area of interest here is to observe the sitting and writting posture of each student using the furniture. They will then be interviewed at certain intervals to determine their comfort and suitability. All comments will be recorded and compiled until a conclusion is achieved. This analysis however should not only involve the ministries concerned but also the commitment of the manufacturers themselves. And aside from satisfying the chair and table height requirements for the majority, good furniture should also be manufactured in accordance to the specifications as shown in Table 7.

Table 7: Specification for Functional Dimensions of Chairs and Tables for Primary School (Reference: ISO-DIN 1980)

		Dimension (mm)			Mean of SH	
Label	**Description**	**Group 1**	**Group 2**	**SH Ratio***	**Group 1**	**Group 2**
h1	height of table top (tolerance 10)	460	520	0.41	489.3	555.8
h2	min. height of leg room	*350*	*410*	0.38	453.5	516.3
h3	min. height of knee zone	*350*	*350*	0.38/III+ult	453.5/408.4	513.3/473.6
h4	min. height of tibia zone	*250*	*250*	III	328.5	379.8
h5	height of seat	260	300	0.25	298.4	339.7
h6	max. height to bottom of backrest	*120*	*130*	0.12	143.2	163.0
h7	height to top of backrest —	*min* 210 *max* 250	250 280	017	202.9	231.0
t1	min. depth of table top	*450*	*500*	0.39-0.5	465.5-596.8	529.9-679.4
t2	min. depth of knee zone	*300*	*300*	0.34/bkl	405.8/400.7	464.0/463.7
t3	min. depth of tibia zone	*400*	*400*			
t4	effective depth of seat (tolerance 10)	*260*	*290*	0.24/sd	286.4/328.7	326/380
B	inclination of back rest	*95° - 106°*	*95° - 106°*			
S	angle of seat	*0° - 4°*	*0° - 4°*			
W	reference point for b	*160*	*170*			
b1	min. length of top (single table)	*600*	*600*			
b2	min. width of knee zone	*450*	*470*	0.4	477.4	543.5
b3	min. width of seat	*250*	*270*			
b4	min. width of backrest	*250*	*250*	0.25/sw	298.4/222	339.7/257.7
r2	min. radius of backrest	*300*	*300*	0.25	298.4	339.7

Note: Number in Italic were adapted from ISO-DIN

* Ratio derived from SH (Tan, GLE,1984) and data of part-body collected.

In Table 7, there are two sets of measurements for both SH-groups. The dimensions illustrated in Italic were adapted from the ISO-DIN and used as control; while those shown under the Mean of SH for PM column were derived from the ratio of body height (Tan, G.L.E., 1984) and also from the data collected. The two sets were shown to compare and to ensure that the measurements used for the design of children's furniture will take into consideration the means of the child populace.

Distribution of furniture sizes

The proposed approximate distribution (%) of school furniture sizes in primary schools according to SH group with respect to Year configuration are shown in Table 8. While Year 1 to 3 can be accommodated by the SH-group 1 and 2, the Year 4 to 6 would require another group (Group 3) to satisfy the SH-range. The SH-range for Group 3 were therefore obtained from preliminary data collected from a secondary school near FRIM in Kepong (Hamdan *et. al.* - unpublished).

Table 8: Approximate distribution of chairs and tables for each year based on the SH-Group

Group / Year	1 1080 - 1230 mm	2 1235 - 1400 mm	3 1405 - 1590 mm
	Primary School		**Secondary School**
1	70%	30%	
2	50%	50%	
3	30%	70%	
4		70%	30%
5		50%	50%
6		30%	70%

The distribution of furniture according to the standing height ranges requires total support from the Ministry concerned. This is particularly important since the use of the same furniture for the morning and afternoon school sessions may pose problems to the effectiveness of this programme. For example, a Group 1 student in the afternoon session may have to use a Group 2 furniture from the morning session in the same classroom.

CONCLUSION

This paper proposed a new set of measurements for chairs and tables for primary school children based on their standing heights (SH) instead of the age-group method. The study has clearly indicated the marked difference in measurements observed from the data analysed

as compared to the current measurements. While it is strongly recommended to have more SH groupings, other important factors such as cost and the two sessions of schooling currently in practice has to be taken into consideration. The results obtained from this study, although derived from small samplings and preliminary, can still be used as a basis for the designing of primary school furniture. The ultimate aim of this study is to propose a comfortable set of furniture to the children.

In addition, the anthropometric data of school children from urban and rural areas in other states should also be carried out by the Ministry concerned to further refine these findings. This is particularly important since furniture design based on anthropometric data and ergonomic information will provide a healthy and comfortable environment for the students.

The survey was also able to compile information on the anthropometric data of other part-body measurement of primary school students which could be used later for the design of other types of school furniture. With the measurements made available, the furniture manufactured will then be more appropriate to the local children's requirements. Participation from the industry is required to ensure the effectiveness of this study.

ACKNOWLEDGMENTS

The authors are thankful to the officers and staff of Research and Development Department, Ministry of Education, the State Education Departments, and the officers and staff of Forest Products Technology Division and the Techno-Economics Division, FRIM who have assisted in the collection and analysis of the data. The authors are also indebted to all the headmasters, teachers and students of the schools involved for their cooperation and patience during the data collection.

REFERENCES

Anonymous (1977). International Standard Organisation (ISO 5970, July 1977).

Anonymous (1979). School Furniture Handbook. Volume 1. UNESCO.

Anonymous (1980). British Standards Institution Educational Furniture (BS 5873, Part 1).

Anonymous (1980). Deutsche Industrie Norm (DIN 5970, July 1980).

Anonymous (1987). It's Never Too Early for Back Up - Ergonomic Furniture for Schools and Kindergartens. In Back Problems in Schools. BackUp - Germany.

Damon, A., Stoudt, H. W &. R.A. Mc Farland (1966). The Human Body in Equipment Design. Cambridge MA: Harvard University Press.

Hamdan, H., Abd. Hamid, S., Tom, S. & Arshad, S. (1992). Anthropometric Data of Children Age 7 - 12 Years Old from Selected Primary Schools in Peninsular Malaysia. Unpublished.

Hamdan, H., Abd. Hamid, S., Tom, S. & Arshad, S. (1992). Preliminary Anthropometric Data of Students Age 13 - 18 Years Old from a Secondary School in Peninsular Malaysia. Unpublished.

Personal communication (1997). Jamilah, Planning and Research Division, Ministry of Education, Malaysia.

Sheath, R.H. & Vickery, D.J. (1971). A study of Utilization, Design and Cost of Secondary Schools in West Malaysia. Study 12. A Report to the Minister of Education, Government of Malaysia. UNESCO.

Tan, G.L.E (1984) Anthropometric Data and Its Use for Education Building and Furniture Design in Educational Building Digest No. 18, UNESCO Regional Office for Education in Asia and the Pacific. Bangkok, Thailand.

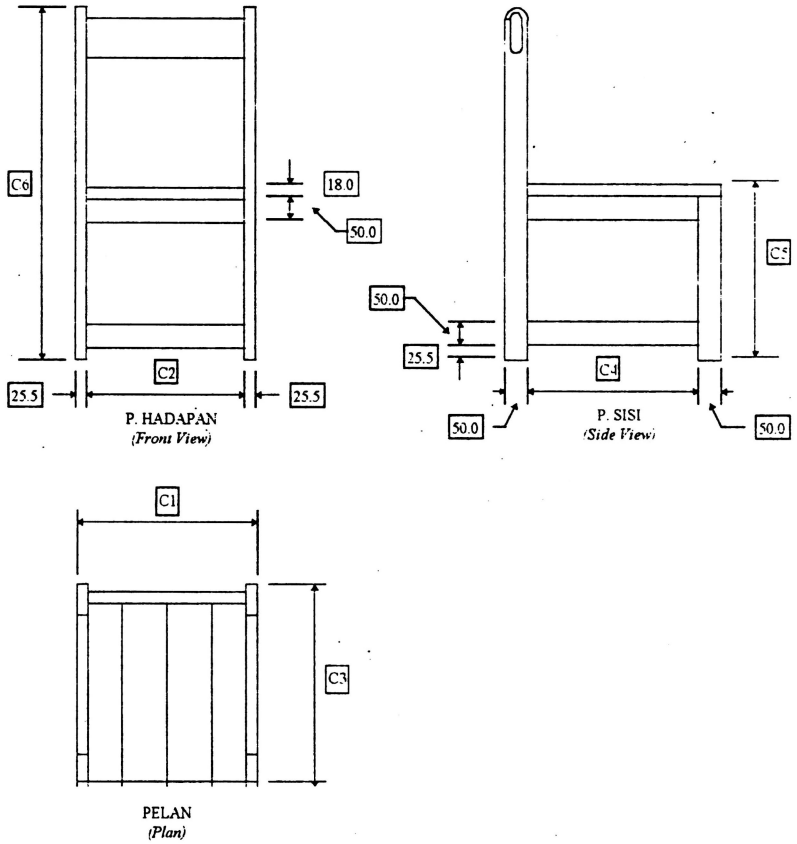
Vickery, D. J. (1964). Comparative Anthropometric Data. D - Application of Data. An Occasional Paper - School Building: No. 6. UNESCO.

Appendix 1A

KEMENTERIAN PENDIDIKAN MALAYSIA

SIRIM / KPM / MM / 88 / 01

SCHOOL CHAIR AND TABLE DESIGN AND DIMENSIONS (mm)
(Source : Ministry of Education)

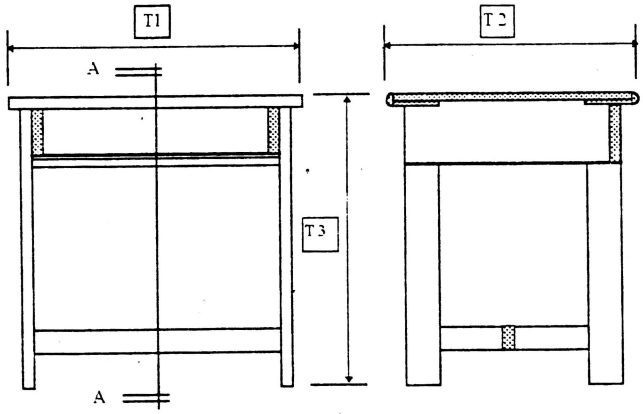


Appendix 1B

KEMENTERIAN PENDIDIKAN MALAYSIA

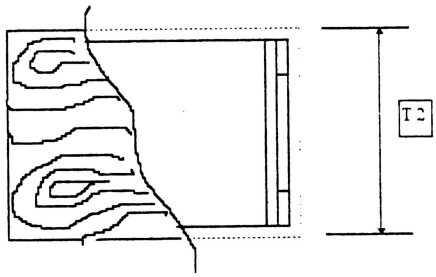
SIRIM / KPM / MM / 88 / 01

SCHOOL CHAIR AND TABLE DESIGN AND DIMENSIONS (mm)
(Source : Ministry of Education)



P. HADAPAN
(Front View)

KERATAN RENTAS A - A
(Cross-section A - A)



PELAN
(Plan)

Appendix 2

SOAL SELIDIK ERGONOMIK PERABOT SEKOLAH (1992)

JAWATANKUASA TEKNIKAL:

Kementerian Pendidikan Malaysia
Institut Penyelidikan Perhutanan Malaysia (FRIM)
Institut Standard dan Penyelidikan Perindustrian Malaysia (SIRIM)

1	NEGERI / DAERAH	
2	SEKOLAH	
3	UMUR	
4	BANGSA	
5	JANTINA	
6	BERAT	
7	DARJAH / TING.	
8	PEKERJAAN IBUBAPA	

NO.	INCI
1	rt
2	td
3	rt
4	bh
5	ehs
6	shs
7	ews
8	uh
9	sh
10	ehi
11	ewb
12	lll
13	el
14	sd
15	bkl
16	x
17	ult
18	x
19	shi
20	sw

* Ukuran adalah berpandu kepada kedudukan tulang