Pilot Investigation on the Mismatches of Classroom Furniture and Student Body Dimensions in Malaysian Secondary Schools

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Abstract: Problem statement: This study is an investigation of the mismatch between chair and desk dimensions and student body dimensions. **Approach:** The objective of this study was to determine whether design improvement and further study is required in order to improve the conditions in Malaysian primary schools. **Results:** The supplied standard government issued classroom furniture was measured and anthropometrics measurements data were collected from 300 students from three pilot study schools in Kuantan, Pahang covering the age group between 13-17 years. The pilot data indicate a substantial degree of mismatch between the student body dimensions and the classroom furniture. The chair is either too high or too deep for the students. The data also shows that the desk is too high for most of the students. The variability between gender and age was found to have profound impact on the mismatch levels. **Conclusion/Recommendations:** The result is of great concern which could pose students with the risk of having back problems in the future.

Key words: Classroom furniture, anthropometric mismatch, student body dimension

INTRODUCTION

Malaysian school children spend a large part of their day sitting in a classroom environment comprising the normal school hours as well as the almost daily routine of tuition classes. This prolonged sitting posture most often without support from a backrest makes them susceptible to risk of suffering negative effects from badly design and ill fitting furniture (Evans *et al*., 1992). Furniture wrongly designed and ill fitted to the characteristics of a child can result in defective posture and the establishment of pathological states which could affect their performance in focusing in class and faster fatigue occurrence (Lane and Richardson, 1993). Various studies have shown that the ill fitted design of classroom furniture have contributed to the high incidence of musculoskeletal disorders among school children (Olsen *et al*., 1992). This trend might also be present in the Malaysia but currently there is no study which indicates this. The issue of back problems is prevalent in the industry whereby the cost of solving this problem is ever increasing. Tackling this problem at the initial stage in schools would be of great importance. The design of chairs and desks for the workplace has been studied with great interest and yet little interest has been shown in a school which under

the Malaysian OSHA Act constitutes as part of the workplace whereby the students must be given the same attention (Malaysian Occupational Safety and Health Act, 1994). Thus the design of chair and desk must be emphasized as required by the act. This study was conducted not to determine the existence of back problems among student but to asses the fitness of the chair and desk which could be an indicator of possible back problems among students. This pilot investigation examines the possible mismatches between the individual body dimensions of Malaysian primary students and the standard classroom furniture made available to them by the school authorities. This study would help in establishing and motivating the necessary further studies in classroom ergonomics with special attention to chair and desk.

MATERIALS AND METHODS

A total of 300 students consisting of equal numbers of male and female students were studied. Their ages range from 13-17 years old. The student were randomly selected covering each level of secondary school education. Measurement is done with a teacher present during the measurement. Figure 1 shows the desk and chair currently used in the schools.

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Fig. 1: Desk and chair currently used by both schools

Table 1: Students body dimensions

Parameter	Measurements method
Stature	Measured as the vertical distance from the floor to the top of the head, while the students stood erect, looking straight ahead.
Elbow height	Measured with the elbow flexed at 90, as the vertical distance from the bottom of the tip of the elbow to the student's seated surface
Shoulder height	Measured as the vertical distance from the top of the shoulder at the acromiom process to the student's sitting surface.
Upper arm length	Difference between the elbow height and shoulder height.
Knee height	Measured with knee flexed at 90, as the vertical distance from the foot resting surface to be top of the knee cap, just above the patella.
Popliteal height	Measured with a 90, knee flexion, from the foot resting surface to the popliteal space, which is the posterior surface of the knee.
Buttock-popliteal length (thigh length)	Measured with the knee flexed at 90, as the distance from the posterior surface of the buttock to the posterior surface of the knee or popliteal surface.

Body measurements: In this study, stature dimensions for each child are taken while they are standing. All other dimensions measured while they are sitting erect on chair with knees bent at 90. For both measurements they are barefooted flat on a flat horizontal floor surface. Students are dressed in light sports attire. Table 1 shows the body dimensions measured in this study.

Furniture measurements: For both schools the design and the size of the desk and chair are similar as it is standard government issued furniture. The dimensions of the classroom furniture are shown in Table 2.

Statistical analysis was employed in order to determine the mean, standard deviation and standard error of the anthropometrics data that have been collected.

Table 2: Chair and desk dimensions

Parameter	Measurement method
Seat height	Measured as a distance from the floor to the highest point on the front of the seat.
Seat depth	Measured from the back of the sitting surface of the seat to its front.
Seat slope	Direction and angle of the slope of the seat's sitting surface.
Desk height	Measured from the floor to the top of the front edge of the desk.
Desk clearance	Measured from the floor to the bottom of the front edge of the shelf under the writing surface.
Desk slope	Angle at which the writing surface of the desk slope.

Anthropometrics mismatches: The number and percentage of the students where the body match or mismatch with the furniture is calculated based on the rules adapted from (Parcells *et al*., 1999; Chaffin and Anderson, 1991). A mismatch is defined as incompatibility between dimensions of the student's body dimension. The mismatch rules are followed in order to determine mismatch between certain body dimensions and its corresponding design parameter as listed below.

Popliteal height and seat height mismatch: A mismatch is defined when the seat height was either >95% or <88% of the popliteal height.

Buttock-popliteal length and seat depth mismatch: A mismatch is defined when the seat depth was either >95% or 80% of the popliteal height.

Knee rest height and desk height mismatch: A mismatch is defined as occurring when a desk was <2 cm higher than the knee height.

Elbow rest height and desk height mismatch: According to Parcells *et al*. (1999) acceptable desk height is determined by the following equation:

$$hE = hEv+U \; [(1-\cos \theta)+\cos \theta(1-\cos \beta)] \qquad (1)$$

Where:

hE = The vertical distance from the top of the desk to the student's sitting surface
hS = The shoulder height
hEv = The elbow height
U = $hS-hEv$ is the upper arm length
(θ) = Shoulder flexion
(β) = Shoulder abduction

According to Chaffin and Anderson (1991), the minimum and maximum acceptable angle of the shoulder during writing is 0-25° for shoulder flexion and 0°-20° for shoulder abduction. For flexion angles the corresponding cosines are 1 (0°) and 0.9063 (25°) and for abduction angles the corresponding cosines are 1(0°) and 0.9397(20°). Applying the cosines to the

Eq. 1, desk height is determined by the following equations:

$$\text{Minimum desk height} = \text{seat height} + hE \qquad (2)$$

$$\text{Where } hE = hEV+U[(1-1)+1(1-1)] = hEv \qquad (3)$$

$$\text{Maximum desk height} = \text{seat height} + hE \qquad (4)$$

Where:

$$hE = hEv + U[(41-\cos\theta) + \cos\theta(1-\cos\beta)]$$
$$= hEv + U[(41-0.9063) + 0.9603(1-0.9397)] \qquad (5)$$
$$= 0.8517hEv + 0.1483\,Hs, \text{ since } U = hS - hEv$$

Based on the above dimensions, it is concluded that a mismatch of elbow-shoulder height and desk height is defined as when the desk was either shorter than the minimum desk height or taller than the maximum desk height.

RESULTS

School furniture dimensions: The design of the chair and desk is common for both schools which were issued by the state education's supplier. Each grade is provided with the same type of chairs and desk. The design is purely traditional using wood as the material. The measurement for the chair and desk is shown in Table 3. It is interesting to note there was no accommodation for back angle which would be commonly applied to support and reduce stresses at the lumbar back region.

Anthropometrics measurements of students: Table 4-8 shows the student body dimensions for each level of education. Table 9 is a summary of the overall anthropometrics data. The variability of growth at these ages has an influence towards the standard deviation.

Table 3: Average dimensions of the standard government issued chair and desk

Parameter	Dimension range
Seat height	42-43 cm
Seat depth	39.5-41cm
Seat slope	0
Desk height	77.9-79 cm
Desk clearance	63.5-65.5 cm
Surface angle	0

Table 4: Students aged 13 years old (n = 60)

Anthropometric	Boys (n = 60)								Girls (n = 30)							
Dimensions	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile
Stature	152.9	1.112	151.0	152.80	156.0	151.00	152.75	154.70	153.0	1.604	148.0	153.0	156.0	150.20	153.0	155.6
Elbow height	20.23	0.914	19.0	20.00	22.0	18.73	20.00	21.73	19.8	0.840	19.0	19.5	22.3	18.45	19.5	21.21
Sitting shoulder height	47.95	0.644	46.9	48.00	49.0	46.90	48.00	49.01	48.3	0.923	46.9	48.1	51.0	46.75	48.1	49.78
Upper arm length	27.72	1.161	25.7	27.65	30.0	25.82	27.65	29.62	28.4	122.000	26.4	28.5	31.0	26.43	28.5	30.43
Sitting knee height	48.06	0.635	46.9	48.00	49.4	47.02	48.00	49.10	48.1	0.798	46.9	48.0	50.4	46.83	48.0	49.42
Sitting popliteal height	39.84	1.015	38.0	40.00	41.0	38.17	40.00	41.50	40.0	1.125	38.0	40.1	42.0	38.14	40.1	41.83
Buttock popliteal height	39.56	0.956	38.0	40.00	41.0	37.90	40.00	41.13	39.6	1.110	38.0	40.0	43.0	37.73	40.0	41.37
Weight (kg)	40.44	1.270	38.0	40.75	42.5	38.38	40.75	42.53	40.1	1.319	38.0	40.0	43.0	37.95	40.0	42.28

Table 5: Students aged 14years old (n = 60)

Anthropometric	Boys (n = 30)								Girls (n = 30)							
Dimensions	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile
Stature	154.10	1.609	152.0	163.80	158.0	15.15	153.8	156.70	154.0	1.644	149.0	154.5	157.0	151.70	154.5	
Elbow height	19.76	0.814	19.0	19.50	215.0	18.42	19.5	21.09	19.5	0.560	19.0	19.5	21.0	18.58	19.5	
Sitting shoulder height	48.26	0.921	46.9	48.10	51.0	46.75	48.1	49.77	48.7	0.860	47.0	48.5	50.5	47.24	48.5	
Upper arm length	28.51	1.253	25.8	28.50	32.0	26.45	28.5	30.56	29.2	0.978	26.0	29.3	31.0	27.55	29.3	
Sitting knee height	48.35	1.013	47.0	48.20	51.0	46.66	48.2	50.04	48.8	1.052	47.0	48.5	51.0	47.07	48.5	
Sitting popliteal height	40.39	0.991	38.0	40.50	42.5	38.75	40.5	42.02	41.3	0.744	40.0	41.0	43.0	40.10	41.0	
Buttock popliteal height	39.93	1.054	38.0	40.00	41.5	38.20	40.0	41.66	40.0	1.055	38.0	40.0	41.5	38.25	40.0	
Weight (kg)	43.88	0.905	42.5	44.00	46.0	42.39	44.0	45.36	42.7	1.874	38.5	43.0	45.5	39.59	43.0	45.74

Table 6: Students aged 15years old (n = 60)

Anthropometric	Boys (n = 30)								Girls (n = 30)							
Dimensions	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile
Stature	157.420	2.470	154.0	157.25	163.0	153.370	157.25	161.50	155.30	2.449	149.5	154.75	160.5	151.20	154.75	159.30
Elbow height	19.437	0.562	18.5	19.50	20.8	18.515	19.50	20.36	19.34	0.581	18.0	19.40	20.8	18.38	19.40	20.29
Sitting shoulder height	50.333	1.802	47.0	51.15	52.5	47.379	51.16	53.29	49.17	1.028	48.0	49.00	51.0	47.49	49.00	50.85
Upper arm length	30.897	1.929	27.6	31.55	33.5	27.733	31.55	34.06	29.63	1.339	27.7	29.50	33.0	27.64	29.50	32.03
Sitting knee height	49.520	1.296	48.0	49.00	52.0	47.394	49.00	51.65	49.39	1.191	48.0	49.00	52.0	47.44	49.00	51.35
Sitting popliteal height	41.870	0.751	40.5	42.00	43.0	40.639	42.00	43.10	41.55	0.810	40.0	41.50	42.5	40.23	41.50	42.88
Buttock popliteal height	41.617	0.811	40.0	41.50	43.0	40.287	41.50	42.95	41.05	0.820	40.0	41.00	42.5	39.71	41.00	42.39
Weight (kg)	49.520	1.296	48.0	49.00	52.0	47.394	49.00	51.66	43.52	3.079	38.5	43.50	51.8	38.57	43.50	48.48

Table 7: Students aged 16years old (n = 60)

Anthropometric Dimensions	Boys (n = 30)								Girls (n = 30)							
	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile
Stature	162.10	3.25	158	162.0	170.0	157.0	161.8	167.0	156.5	35.0	149	155.0	164.0	151.00	155.0	162.30
Elbow height	19.19	0.46	18	19.1	20.0	18.4	19.1	20.0	19.19	0.6	18	19.0	20.5	18.30	19.0	20.11
Sitting shoulder height	53.27	1.84	49	53.4	57.0	50.6	53.4	56.0	49.61	1.2	48	49.8	51.8	47.70	49.8	51.55
Upper arm length	34.08	1.74	30	34.1	39.0	31.2	34.05	36.9	30.43	1.2	28	30.5	32.8	28.40	30.5	32.43
Sitting knee height	51.47	1.40	50	51.4	56.0	49.2	51.35	53.8	50.04	1.5	48	50.5	53.0	4.61	50.5	52.48
Sitting popliteal height	42.51	0.72	41	42.5	44.0	41.3	42.60	43.7	41.95	0.8	41	42.0	43.0	40.70	42.0	43.19
Buttock popliteal height	42.06	0.73	41	42.3	43.2	40.9	42.25	43.3	41.51	0.9	40	41.3	42.8	10.00	41.3	42.99
Weight (kg)	54.48	1.88	52	54.0	60.0	51.4	54.00	57.6	51.26	29.0	48	50.5	58.0	46.60	50.5	55.95

Table 8: Students aged 17years old (n = 60)

Anthropometric Dimensions	Boys (n = 30)								Girls (n = 30)							
	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile
Stature	164.90	3.97	158	165.0	174.0	158.0	165.0	171.0	157.50	3.7	150	157.0	164.0	151.0	157.0	163.50
Elbow Height	18.81	0.58	18	19.0	19.5	17.9	19.0	19.8	19.29	0.5	19	19.4	20.2	18.5	19.4	20.04
Sitting shoulder height	54.60	1.47	52	54.4	4.8	52.2	54.4	57.0	51.59	0.8	50	51.8	53.0	50.2	51.8	52.96
Upper arm length	35.79	1.57	33	35.5	40.2	33.2	35.5	38.4	32.30	0.8	31	32.5	34.0	30.9	32.5	33.69
Sitting knee height	53.99	1.32	52	53.9	57.5	51.8	53.9	56.1	51.74	1.3	50	51.8	55.0	49.7	51.8	53.81
Sitting popliteal height	44.12	0.93	43	44.0	46.5	42.6	44.0	45.8	42.63	0.7	41	42.5	44.0	41.1	42.5	43.82
Buttock popliteal height	43.61	0.88	42	43.6	45.5	42.2	43.6	45.0	42.33	0.8	41	42.5	43.5	41.1	42.5	43.60
Weight (kg)	56.03	2.70	53	55.0	64.0	51.6	55.0	60.5	54.27	2.8	49	54.4	60.0	50.0	54.4	58.52

Table9: Summary of anthropometry measurement for Students aged 13-17years old (n = 300)

Anthropometry dimensions		n	Mean	SD	Min	Median	Max	5%-ile	50%-ile	95%-ile
Stature	Boys	150	158.2830	5.34491	151.0	157.5	174.0	149.520	157.5	167.050
	Girls	150	155.2870	3.17456	148.0	154.5	164.0	150.080	154.5	160.490
Elbow height	Boys	150	19.4867	0.84156	17.5	19.5	22.0	18.107	19.5	20.867
	Girls	150	19.4300	0.65317	18.0	19.5	22.3	18.359	19.5	20.501
Sitting shoulder height	Boys	150	50.8847	2.98804	46.9	50.8	58.0	45.984	50.8	55.785
	Girls	150	49.4580	1.51390	46.9	49.0	53.0	46.975	49.0	51.941
Upper arm length	Boys	150	31.3980	3.48556	25.7	31.3	40.2	25.682	31.3	37.114
	Girls	150	30.0280	1.73820	26.0	29.7	34.0	27.177	29.7	32.879
Sitting knee height	Boys	150	53.9867	1.31751	51.8	53.9	57.5	61.826	53.9	56.147
	Girls	150	51.7400	1.25952	49.8	51.5	55.0	49.674	518.0	53.806
Sitting popliteal height	Boys	150	43.7933	0.81688	42.5	43.9	45.5	42.454	43.9	45.133
	Girls	150	42.6300	0.72671	41.0	42.5	44.0	41.438	42.5	43.822
Buttock -popliteal height	Boys	150	43.6067	0.87899	42.0	43.6	45.5	42.165	43.6	45.048
	Girls	150	42.3300	0.77423	41.0	42.5	43.5	41.060	42.5	43.600
Weight (kg)	Boys	150	56.0300	2.70101	52.8	55.0	64.0	51.600	55.0	60.460
	Girls	150	54.2700	2.59000	49.0	54.4	60.0	50.022	54.4	58.518

Level of mismatch between student body dimensions and chair and desk dimensions: Figure 2-6 shows the number of students who fits the chair for all age groups. For aged 13 almost all students were found to be using chairs that are too deep and too high for them. For aged 14 again almost all found the chair to be too high and too deep with only 26% shows a fit in seat depth. For aged 15 only 6% manage to fit both the height and depth while for the rest its either a combination of too high and too deep or only too high. For aged 16, 41% are able to fit the depth and height. The rest mostly found they are able to fit the depth but not the height and only 10% found they could not fit both the height and depth. For aged 17, 43% manage to fit both the height and depth. The rest still found the chair too high.
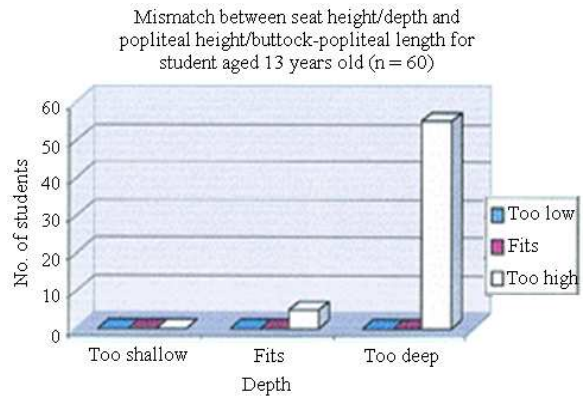

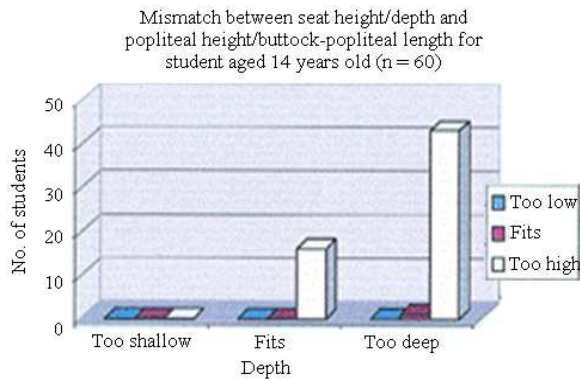Fig. 2: Percentage of students who fit the chair aged 13 years old

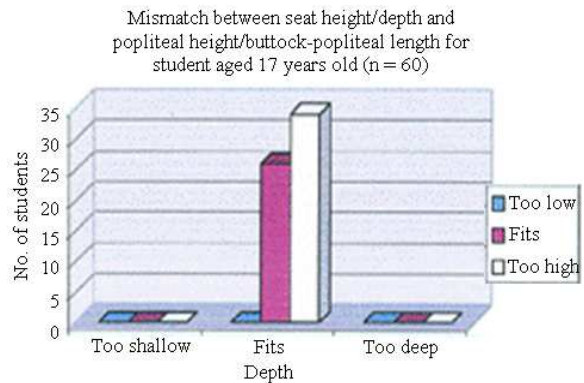Fig. 3: Percentage of students who fit the chair aged 14 years old
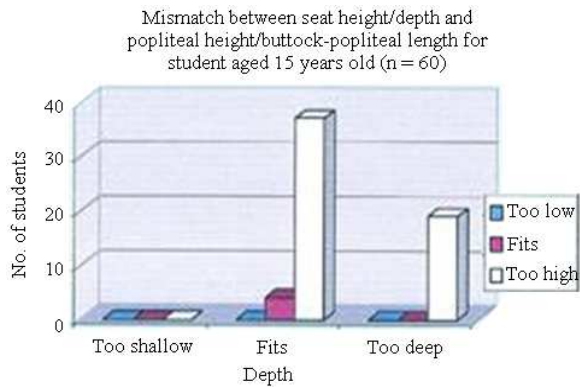

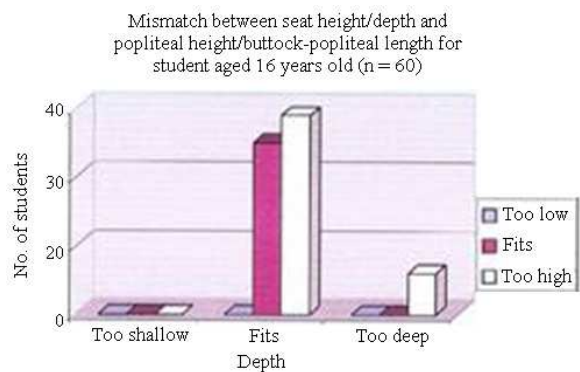Fig. 4: Percentage of students who fit the chair aged 15 years old

Fig. 5: Percentage of students who fit the chair aged 16 years old

The study also found that in all age groups the students have a functional elbow height of more than 8 cm from the acceptable functional elbow height.

Fig. 6: Percentage of students who fit the chair aged 17 years old

DISCUSSION

The objective of this study was to examine possible mismatches between Malaysian secondary student body dimensions and the classroom furniture. It was found that for all age group there were mismatches between student body dimensions and furniture dimensions. Based on the results it is obvious that a one-size-fit all design was implemented for the chair and desk. This indicates a lack of thorough design studies of school furniture for Malaysian students. The variability of student dimension has not been taken into consideration in the design of the chair and desk for both this school. The surge of growth among 13-17 age groups causes the variability of student dimension to be widened. Although the classroom furniture were provided by the government which is assumed to be designed to fit student body dimension this study found that the design of chairs and desk may not have been done through proper ergonomics considerations which cause these mismatches to arise. While this study is only a pilot study, the finding could be an indicator of similar problem in other schools through out the country. Since the chairs and desks are supplied by the government suppliers it could have profound effect towards the well being of the current and future school children. As the OSHA act ruling is indicative of governments concerns of health and safety in the workplace including schools measures must be taken to avoid schools being non-compliance of the act. It is suggested that further studies covering other parts of the countries would be needed in order to better understand the extent of the mismatches among Malaysian student population. It is also recommended that further research on Malaysian children furniture design to be conducted so as to provide better furniture in Malaysian schools. As

furniture and body dimension mismatches could potentially cause musculoskeletal problems, investigations of back problems among students would be necessary in order to investigate whether the above finding have taken effected Malaysian students.

CONCLUSION

The findings of this pilot study shows that further detail investigation is required. The finding could be just the tip of the iceberg where more information needs to be gathered to cater the variations of student population across age gender and location throughout Malaysia. Several issues that would be of concern are listed below for further investigation and research:

- The standard dimensions of school furniture may not be suited for Malaysian primary school children which suggest a need for children anthropometric database of Malaysian population for the purpose of design
- The design of classroom furniture involves a multidimensional problem whereby further studies are required in order to understand the key elements and its effect
- The variability of sizes requires new school furniture designs that could accommodate this variability across age and gender
- The effect of mismatches between school furniture and body dimensions have yet to be touched in Malaysian school children which suggest a study on its impact so that proper governmental regulation can be setup

Efforts are currently been made to conduct studies on the above issues which would help ensure the future work force of Malaysia are not affected by MSD which could hamper the nation building process.

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