ANTHROPOMETRIC MEASUREMENT FOR DISABLED STUDENTS

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UNIVERSITY OF MALAYA

KUALA LUMPUR

2017

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SUBMITTED TO THE

FACULTY OF ENGINEERING

UNIVERSITY OF MALAYA, IN PARTIAL

FULFILMENT OF THE REQUIREMENTS FOR

THE DEGREE OF MASTER OF SAFETY, HEALTH AND ENVIRONMENTAL ENGINEERING

2017

UNIVERSITY OF MALAYA

ORIGINAL LITERARY WORK DECLARATION

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Name of Degree: MASTER IN SAFETY, HEALTH AND ENVIRONMENTAL ENGINEERING

Title of Research Report ("this Work"): ANTHROPOMETRIC MEASUREMENT FOR DISABLED STUDENTS

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ANTHROPOMETRIC MEASUREMENT FOR DISABLED STUDENTS

Abstract

The aim of this study is to collect an anthropometric data of disabled students in Special Education School and Integrated Special Education Program at selected primary schools in area of Kuala Lumpur and Selangor. Fifty two students at mean age of 10 and 9 and standard deviation of 2 for male and female students with hearing disability, vision disability and learning disorder disability are involved in this study. Anthropometric data of selected body dimension which are stature, sitting height, sitting popliteal height, sitting shoulder height, sitting arm height, hips breadth and shoulder breadth are measured and recorded. Current furniture dimensions such as seat height, seat width, backrest height, and arm rest height, desk height and desk width are recorded as well. Current furniture measurement collected are compared with selected body dimensions to identify whether it is suitable for the children. Analysis of the data between current furniture measurement and anthropometric data found that particular dimension of the furniture does not suitable with the anthropometric measured from survey. Therefore, recommended dimension for suitable furniture measured is proposed.

PENGUKURAN ANTROPOMETRI BAGI MURID-MURID KURANG UPAYA

Abstrak

Kajian ini bertujuan untuk mengumpul data antropometri dalam kalangan murid-murid pendidikan khas di Sekolah Pendidikan Khas dan Program Pendidikan Khas Integrasi di sekitar Kuala Lumpur dan Selangor. Seramai lima puluh dua orang murid dengan purata umur 10 dan 9 tahun dengan sisihan piawai dua bagi murid lelaki dan perempuan dengan masalah penglihatan, masalah pendengaran dan masalah pembelajaran terlibat dalam kajian ini. Data antropometri untuk dimensi badan iaitu ketinggian, ketinggian ketika duduk, ketinggian popliteal duduk, ketinggian bahu ketika duduk, ketinggian lengan ketika duduk, lebar punggung dan lebar bahu telah diukur. Perabot yang dipakai ketika ini juga turut diukur untuk dimensinya iaitu ketinggian kerusi, lebar kerusi, ketinggian penyandar belakang kerusi,, ketinggian lengan kerusi, ketinggian meja dan kelebaran meja turut diukur.Analisis daripada data untuk perabot yang diguna ketika ini dan data antropometri yang dikumpul mendapati bahawa sebahagian dimensi perabot sedia ada tidak sesuai dengan data antropometri yang dikumpul. Cadangan telah dianjurkan bagi menyediakan dimensi perabot yang sesuai.

Acknowledgement

Thank you everyone!

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List of Symbols and Abbreviations

PPKI	-	*Program Pendidikan Khas Integrasi*
OKU	-	*Orang Kurang Upaya*
PWD	-	Person With Disabilities
JPN	-	*Jabatan Pendidikan Negeri*
MSD	-	Musculoskeletal Disorder
WHO	-	World Health Organization
ICF	-	International Classification of Functioning, Disability and Health
KPWKM	-	*Kementerian Pembangunan Wanita, Keluarga dan Masyarakat*
BPK	-	*Bahagian Pendidikan Khas*
SPSS	-	Statistical Package for Social Sciences
M	-	Mean of the sample
X_i	-	I^{th} measurement
N	-	Sample size
X	-	Calculated percentile value
F	-	Multiplication factor for corresponding percentile required
S	-	Standard deviation

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CHAPTER 1: INTRODUCTION

1.1 Background of the Study

Throughout the century, our nation has been expanding not only in terms of its development but it include as well the education sector. Nowadays, the education could able to cater to many age starting from youngster till the golden age generation. Even Ministry of Education has highlighted the pathway for the education sector in Malaysia according to different categories in which it has been divided into preschool, primary school, lower and upper secondary school as well as post-secondary school. Under these categories, lots of government and private school has been built to cater to the need of education in Malaysia. This is proven by the establishment of *Sekolah Kebangsaan, Sekolah Jenis Kebangsaan Cina, Sekolah Jenis Kebangsaan Tamil, Sekolah Pendidikan Khas, Sekolah Agama, Sekolah Modal Khas* and *Sekolah Rendah Agama Bantuan Kerajaan* by the government for the primary school student. As for the secondary school student, government offered few public school for the student to attend to which are *Sekolah Menengah Kebangsaan, Sekolah Seni, Sekolah Berasrama Penuh, Sekolah Sukan, Sekolah Menengah Kebangsaan Agama, Maktab Rendah Sains Mara, Sekolah Menengah Teknik* and *Maktab Tentera Diraja.* As of May 2016, about 5,074,612 students enrolled with 200,684 preschool students, 2,685,402 in primary school and the rest were in secondary (*Kementerian Pendidikan Malaysia*, 2017).

Those enrollment data doesn't include only normal students but it include as well the population of special education students. As for the special education students, they are entitled for Special Education School or known as *Sekolah Pendidikan Khas*. Nowadays, besides having Special Education School for students with disability, the government has also established Integrated Special Education Program (PPKI) in *Sekolah Kebangsaan* to cater to the needs of students with disability. Students with disability are

entitled to Person With Disabilities (*OKU*) card as well as monthly allowance of RM150 given by the State Education Department (*JPN*) (Ahmad Afip, Hanapi, & Zakaria, 2013).

Education plays vital role in life as it help us to build our knowledge as well as enhance on our skills. Among important aspects that would contribute to quality education is the facility of the school as it positively affects the teaching and learning process in the school. Good facilities would provide extra learning and leisure opportunities that would affect the performance of the student and productivity of the teacher. In another situation despite being underprivileged, disabled people are also entitled for education same like the opportunities that have been given to the normal people (Ibrahim, Osman, Bachok, & Mohamed, 2016). Besides facilities provided in school, accommodation is important as it is needed to provide comfort to the students so that they are able to learn in conducive environment. However, most of the facilities and accommodation provided in the school are not really disabled friendly. Most of the infrastructure provided in the school does not cater to disable people but it focused more on the well-being of normal students. It is believed that furniture provided in the classroom has been designed to suit normal students more compared to disabled students.

1.2 Problem Statement

Nowadays, most of the furniture being used in the classroom in school is of the same design which cater more to the usage of normal school students. Even disabled students need to use the same chair and desk provided as classroom furniture from manufacturers was not designed to accommodate to different type of user (C. Parcells, S. Manfred, & Hubbard, 1999). These days, children spent most of their time in school from morning till evening which is about 8 hours per day and most of the activities was done in the class which required the student to be sitting posture for long periods of time with less or no breaks (Oyewole, Haight, & Freivalds, 2010). Sitting for a prolonged period of

time could contribute to musculoskeletal disorders as more muscular force and control is needed to maintain stability and equilibrium of the body. If one experience this for long enough time, he or she will feel fatigue and discomfort (C. Parcells et al., 1999). Therefore, in order to prevent MSD at such a young age, the design of school and chairs in the classroom needs to be done ergonomically by referring to the right anthropometric data. However, at the moment anthropometric data are only available for normal school student and none have been available for special education student or student with disability.

1.3 Objective of the Study

The purpose of this study is to develop anthropometric data for special education students. Following are the objectives of the study:

- To collect anthropometric measurement of special needs education students.
- To analyze classroom furniture design based on anthropometric data measured.

1.4 Scope of Study

In order to achieve the objectives, the scope of the project are limited to:

- The students involved in this study are primary special needs education students.
- Type of disability of the students are vision, hearing and learning disorder.
- The study area are restricted to schools in Selangor and Kuala Lumpur.
- Anthropometric dimension to be taken are limited to weight, height, sitting height, sitting shoulder height, sitting popliteal height, sitting arm height, shoulder breadth and hips breadth.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

As of 2016, World Health Organization (WHO) estimated around 15 per cent per one billion people experienced some form of disability in the world. From this estimation, it is deduced that between 110 million to 190 million people are disabled in certain part of the body and it is said that the rates kept on projecting due to ageing of the population and increment in chronic health conditions. Under The International Classification of Functioning, Disability and Health (ICF), disability is defined as a term for impairments, activity limitations and participation restrictions as it affect the interaction between individuals with health condition such as cerebral palsy, Down syndrome and depression as well as personal and environmental factors (WHO, 2016). People with disability have problem in performing their activities and to interact with the world surrounding them. According to WHO, impairments of a person means that one may have malfunction in his or her body structure such as loss of a limb, loss of vision as well as memory loss. Meanwhile for, activity limitation, it would mean that one may struggle in walking, hearing, vision or problem solving. As for person with disabilities, they are face restrain when doing their normal daily activities such as when conversing with others and limited health care and preventive services (WHO, 2016). People with disability are also related to poverty, poor education, low employment rates, unaffordable healthcare costs and limited access to healthcare aid (Mitra, Posarac, & Vick, 2013). Therefore, arise the needs to overcome challenges faced by people with disabilities so that they will be able to cherish their life in which individual, family, health workers, and the community need to work together to abolish personal, environmental and personal barriers (Mulligan et al., 2017).

2.2 Person With Disabilities in Malaysia

In Malaysia, Person With Disabilities Act 2008 defined disability as people who experienced long term physical, mental, intellectual and sensory impairment in which interaction with different barrier my hinder their full and effective participation in society in which it is related to the one defined by ICF previously (Laws of Malaysia, Persons with Disabilities Act 2008). In Malaysia, person with disabilities are registered to *Jabatan Kebajikan Masyarakat* which is governed by Ministry of Women, Family and Community Development (*KPWKM*) in which their welfare are taken care of (Jabatan Kebajikan Masyarakat, 2017). As of 2016, the number of registered person with disabilities has increased year by year. Figure 2. 1 represents the statistics of registered persons with disabilities from year 2014 to year 2016 (*Jabatan Kebajikan Masyarakat*, 2016).

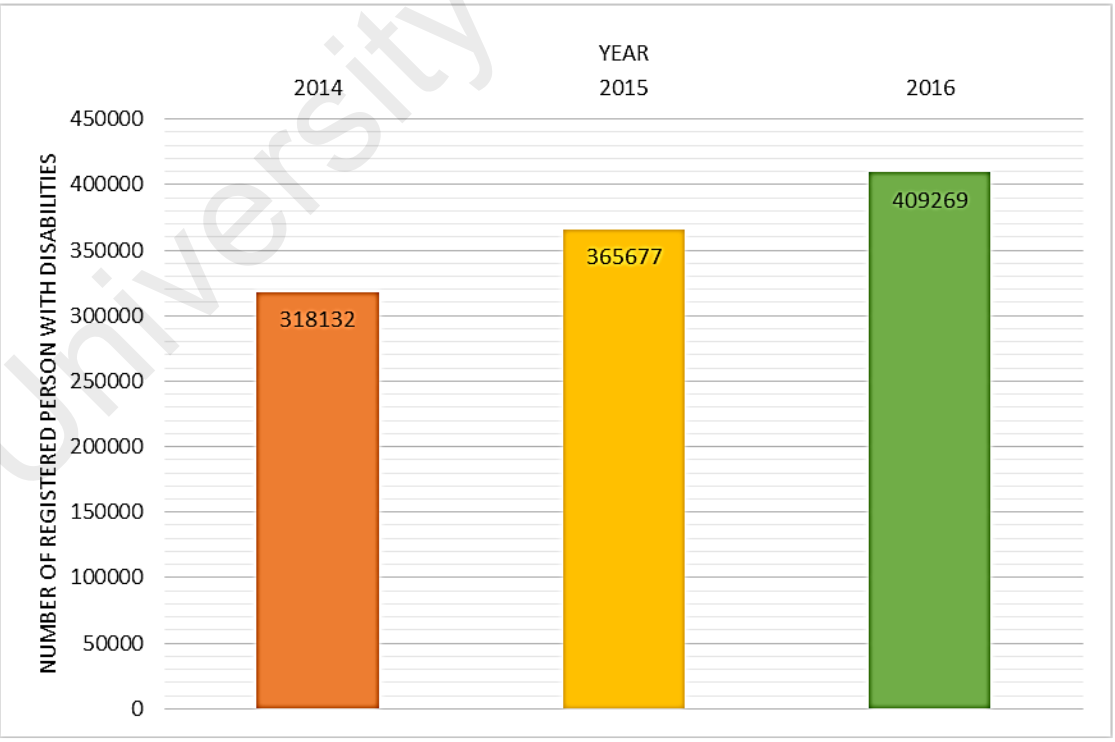

Figure 2. 1: Statistics of registered person with disabilities in Malaysia from 2014 to 2016 (*Jabatan Kebajikan Masyarakat*, 2016)

Person with disabilities are characterized into few categories which are disabilities in vision, movement, thinking, remembering, learning, communicating, hearing, mental health and social relationships. In Malaysia, data of person with disabilities were collected by the Department of Social Welfare every year. Table 2. 1 and Table 2. 2 represents statistics of person with disabilities by state and categories (*Jabatan Kebajikan Masyarakat*, 2016). The data recorded shows that Selangor is the highest state with people with disabilities followed by Johor and Kedah.

Table 2. 1: Statistics of person with disabilities by state in Malaysia of 2016 (*Jabatan Kebajikan Masyarakat*, 2016)

State	**2016**
Johor	50312
Kedah	36435
Kelantan	29264
Melaka	20059
Negeri Sembilan	19171
Pahang	24350
Perak	36099
Perlis	5002
Pulau Pinang	24775
Sabah	25593
Sarawak	28159
Selangor	63514
Terengganu	20467
W.P. Kuala Lumpur	24913
W.P. Labuan	1156
Total	**409269**

Table 2. 2: Statistics of person with disabilities according to category in Malaysia of 2016 (*Jabatan Kebajikan Masyarakat*, 2016)

Disabilities Category	**2016**
Visually Impaired	36692
Hearing	31937
Physical	142600
Learning Disabilities	143334
Speech	2104
Mental	33518
Others	19084
Total	**409269**

These types of disabilities are described in Table 2. 3 (*Jabatan Kebajikan Masyarakat*, 2017).

Table 2. 3: Categories of disabilities (*Jabatan Kebajikan Masyarakat*, 2017).

Category of disabilities	Description
Disability in hearing	Disability to hear clearly on both sides of ear be it by using hearing aid or not.
Disability in vision	Disability in seeing or having limited vision on both eyes even though the person used vision aid kit such as glasses or contact lenses. PWD in vision is categorized into two which is limited and blind.
Physical disability	Impairments of any part of body resulted from losses of body parts or weak muscles which prohibit them from performing physical activities such as self-grooming, movement and change of position.
Learning disorder	Weak performance of their brain despite of their age.
Mental disorder	PWD with mental disorder are people who have been diagnosed by the psychiatrist with diseases related to mental problem.
Speech	Disability to talk in which resulted to problem in communicating with other people.

2.2.1 Government Effort in Facilitating PWD

In order to facilitate and help PWD, the government has established *Dasar Orang Upaya 2016 ke 2022* to facilitate to them in which ten strategic core plans are highlighted. These ten cores are illustrated in Figure 2. 2. According to the plans aligned by The Ministry of Women, Family and Community Development (2016), one of it was to increase PWD's access to education and in order to provide better access to education, it would means that the necessary plan should start from early age of education by providing good facilities and environment for the PWD during their school session.

Figure 2. 2: Ten strategic core plan in *Dasar Orang Kurang Upaya 2016-2022* (The Ministry of Women, Family and Community Development, 2016)

2.2.2 Education for Person with Disabilities in Malaysia

For the betterment of individual and development of the nation, education is vital in which today's education does not only serve the purpose of enriching one's intellectual and personal trait but it is significant in order to get employed (Singal, Mahama Salifu, Iddrisu, Casely-Hayford, & Lundebye, 2015). In Malaysia, education for disabilities are supervised by Special Education Department (*BPK*), Ministry of Education in which programme for special needs students are being planned and managed. In order to facilitate to special needs students, the ministry established BPK to plan and prepare education programme for three types of disability which are vision, hearing and learning

disorder. Special needs students are entitled to go to Special Education School or Integrated Special Education Programme (*PPKI*) (Ministry of Education, 2017). Statistics of students with vision, hearing and learning disorder disability are presented in Table 2. 4 to Table 2. 9 respectively with a total of 61774 students for year 2016.

Table 2. 4: Data on students with vision disability in special education school (*Bahagian Pendidikan Khas*, 2016)

Student	**2012**	**2013**	**2014**	**2015**	**2016**
Preschool	19	13	16	18	11
Primary school	250	276	236	214	199
Secondary school	141	152	162	127	147
Total	410	441	414	359	357

Table 2. 5: Data on students with hearing disability in special education school (*Bahagian Pendidikan Khas*, 2016)

Student	**2012**	**2013**	**2014**	**2015**	**2016**
Preschool	76	69	102	84	68
Primary school	1186	1068	1027	796	706
Secondary school	319	266	292	300	310
Total	1581	1403	1421	1180	1084

Table 2. 6: Data on students with learning disorder disability in special education school (*Bahagian Pendidikan Khas*, 2016)

Student	**2012**	**2013**	**2014**	**2015**	**2016**
Preschool	15	8	10	39	44
Primary school	131	164	183	250	314
Secondary school	269	325	340	385	470
Total	415	497	533	674	828

Table 2. 7: Data on students with vision disability in *PPKI* (*Bahagian Pendidikan Khas*, 2016)

Student	**2012**	**2013**	**2014**	**2015**	**2016**
Preschool	-	-	3	3	6
Primary school	133	149	165	265	265
Secondary school	311	321	321	344	330
Total	444	470	489	612	601

Table 2. 8: Data on students with hearing disability in *PPKI* (*Bahagian Pendidikan Khas*, 2016)

Student	**2012**	**2013**	**2014**	**2015**	**2016**
Preschool	9	7	14	30	29
Primary school	471	500	502	673	666
Secondary school	957	979	1112	1401	1368
Total	1428	1479	1628	2104	2063

Table 2. 9: Data on students with learning disorder disability in *PPKI* (*Bahagian Pendidikan Khas*, 2016)

Student	**2012**	**2013**	**2014**	**2015**	**2016**
Preschool	641	662	690	714	689
Primary school	28839	29391	28985	30833	29739
Secondary school	19462	21274	21796	24399	23185
Total	48942	51327	51471	55946	53613

According to Ministry of Education, Datuk Seri Mahdzir Khalid, as of August 2017, there are about 78, 310 student with disability nationwide. In fact, the government are keen on ensuring that education for students with disability are equipped with skills, knowledge and professional special education teacher. It is also important to ensure that the instructor are equipped with the right knowledge to improve the accessibility of the student (Mansor, 2017). Improving the facility and accommodation of their surrounding are also important as education are not only restricted to the process of delivering material to the pupils and student verbally but it is also a process comprises of accommodating sufficient conditions that need to be actualized which will allow the student to learn without affecting their health in a bad way. Apparently, it is also one the way to ensure that both party which is the students and teacher can work together in a safe environment (Žunjić et al., 2015).

2.2.3 Challenges in Special Needs Education

Previous research by Abdul Nasir and Efendi (2016) identified six elements that is related to the challenges in special needs education. The researchers stated that facilities, readiness, resources, lack in appropriate teaching materials, early intervention programme and equitable accredited examination for students with learning disabilities. Facilities is identified as one of the crucial element since it will affect the environment for the students. Improvement needs to be made to the infrastructural in which it need to be more reachable and disabled-friendly (Abdul Nasir & Efendi, 2016). Mohd Yasin et al. (2013) stated that the classroom of special education students should be designed to accommodate the students in which by having the right accommodation will motivate the students. Besides that, other infrastructure such as barrier-free facilities, wheelchair access and safety need to be considered in order to have well ambient during teaching and learning. Inadequate infrastructure in terms of tables, fans, chairs, teaching aids (*BBM*), computers provided need to be improved as well. Enhancement on the integration of special education programs in terms of accessibility are important to ensure that it is not being disregarded (Yasin, Toran, Tahar, & Bari, 2010)

2.3 Ergonomic

Ergonomic is defined as the science of work in which it is the science of fitting the job to the worker and product to the user. Among ergonomic approach in designing is the design should be done in a way that it will serve its purpose to its human users physically and mentally by establishing the best possible match between product and its users (Pheasant, 2003). In the industry, the purpose of ergonomics are to enhance our life by promoting human health, safety and performance as well as it will affect the productiveness and financial status for a company or industry. Cases related to musculoskeletal disorders (MSD) of the back, neck, and pains of the body are due to

awful ergonomic practices. Early detection of the symptoms and causes that could lead to MSD would prevent health problem (Yusuff, Ny, & Aziz). It is important to ensure that good ergonomic design in workplace are implemented.

2.3.1 Role of Ergonomic in School

As mentioned previously, one of the purpose of ergonomic is to improve the quality of human's health. In school, ergonomic can be related to the furniture that are being used by the students daily. It's been know that student spend most of their time at school in which they attend school from morning to the evening doing activities and learning session and out of this time, most of them sit for a long time. Previous research by Castellucci, Arezes, and Viviani (2010) stated that about quarter day were spent by student in a sitting posture doing their school work and this result of the research indicate that it is a necessity to provide the right school furniture as to promote better sitting posture. Percentage of mismatch that was analyzed during the study revealed that the percentage are high which indicate that furniture provided to the student are not ergonomic. Ergonomically designed furniture will promote good sitting posture and the right sitting posture need to be developed at younger age as it is part of process related to habit. If bad habit are being implemented since young, it will be harder to change when they are ageing (Žunjić et al., 2015). Besides of having bad postures, sitting on seat that are too high would increase compression on the popliteal arc that runs through the underside of the thigh and would cause discomfort. This is due to the high seat height would not allowed their feet to touch the floor and would cause the students to advance forward on the seat of the chair. Besides, seat width of the chair are supposed to be wide as to be able to accommodate student's hips and the seat width should be bigger than the measured anthropometric data to allow for movement. Let say if the seat are equipped

with arm rest, then extra space to be made available for seat width (Biswas, Zahid, Ara, Parves, & Hoque, 2014).

According to Yahya, Palaniandy, Zainun, and Mohammad (2013); Žunjić et al. (2015), one of the most important criteria that need to be taken seriously is preserving health of the pupils and students in the process of education but this criteria was not practice for whatever reason it is. In order to do that, anthropometric measurement is one of the criteria that need to be considered in designing classroom furniture as to help them adopt the right sitting posture. Anthropometric dimensions and design features of school furniture are among criteria that can contribute to student posture and establishing anthropometrics data for Malaysian primary school children is very prioritizing to decrease mismatch between the furniture design and human body dimension that will issue MSD problem (Yahya et al., 2013).

Musculoskeletal disorder (MSD) among school children are usually related to incorrect sitting posture and heavy load on the back (C. Parcells, S. Manfred, & Hubbard, 1999; Dockrell, Simms, & Blake, 2015). Previous research by Dockrell et al. (2015) stated that carrying back pack to school was one of the factor that trigger MSD especially on the shoulder as the level of discomfort was high which was about 63.4 % and this is due to majority of them had the bag on their back for about ten minutes per day. As for sitting posture, improper designed furniture resulted in more muscular force and control needed to support the stability and equilibrium. Bad posture in turn would affect neck or back and contributed to fatigue and discomfort and it was supported by C. Parcells et al. (1999) who stated that this would lead to abnormalities in the spinal column. The researcher also stated that these consequences can be prevented by designing school furniture ergonomically.

2.4 Anthropometry

Anthropometry is a term that is derived from a combination of Greek words anthrop which means human and metricos in which it is defined as measurements. Scientifically it has been referred as measurement and collection of data related to human physical characteristics such as body dimensions, body volumes, masses of body segments, centre of gravity, and inertial properties (Gupta, 2014). Anthropometry is one of the important element in ergonomic as well (Pheasant, 2003). Data collected on anthropometry measurement are used to produce products that will fit and suit as many people as possible. When product are designed based on body dimensions of prospective users, accidents, decreased productivity, ineffectiveness and user discomfort can be lessen and MSD can be avoid (Barli, Sari, Ehmali, & Aydintan, 2006). As for children, anthropometric data are different for different age groups, genders and countries as well (Yahya et al., 2013). In countries outside of Malaysia, awareness on anthropometric measurement has improved over the years as many research regarding classroom furniture and anthropometric measurement has been done (Afzan et al., 2012; Altaboli, Belkhear, Bosenina, & Elfsei, 2015; Biswas et al., 2014; Chung & Wong, 2007; Dianat, Karimi, Asl Hashemi, & Bahrampour, 2013; Panagiotopoulou, Christoulas, Papanckolaou, & Mandroukas, 2004; Prado-León, Avila-Chaurand, & González-Muñoz, 2001; Taifa & Desai, 2017; Yanto, Lu, & Lu, 2017)

In Malaysia, few research has been done in establishing anthropometric data for students population which cater from primary, secondary and higher institution or university students (Afzan et al., 2012; Dawal, Zadry, Nadya Syed Azmi, Rusyida Rohim, & Julia Sartika, 2012; Yahya et al., 2013; Zainon, S, Mat Salleh, & Ghazli @ Ghazali, 2009). However, out of this, no anthropometric data are available for special needs students or student with disability.

2.4.1 Anthropometric measurement

Anthropometric measurement excluded stature are taken in while they were sitting in an erect position on a horizontal surface with their upper and lower legs at perpendicular angle and feet lay horizontally on adjustable footrest (Castellucci et al., 2010). In order to develop anthropometric data, body dimension are needed and the dimension needed is illustrated in Figure 2. 3 and Table 2. 10.

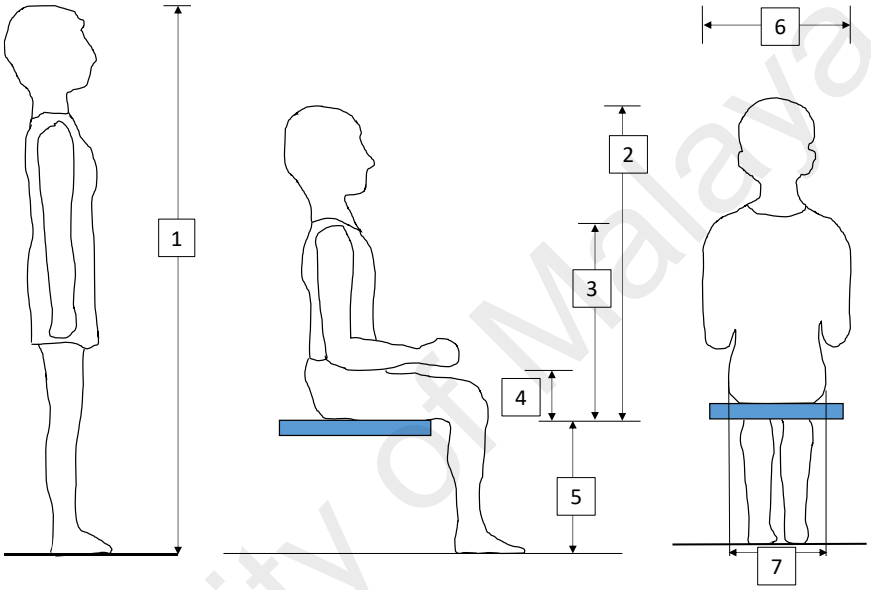

Figure 2. 3: Representation of anthropometric measurement. Redrawn from Castellucci et al. (2010)

Table 2. 10: Anthropometric dimension with its description (Zainon et al., 2009)

No	Dimension	Description
1	Stature	The vertical distance from the floor to the crown of the head
2	Sitting height	Vertical distance from the seat surface to the crown of the head
3	Sitting shoulder height	Vertical distance from the seat surface to the acromion
4	Sitting elbow height	Vertical distance from the seat surface to the underside of the elbow.
5	Sitting popliteal height	Vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps muscle insert into the lower leg
6	Shoulder breadth	Maximum horizontal breadth across the shoulder
7	Hip breadth	Maximum horizontal distance across the hips in sitting position

Anthropometrics data obtained could serve as a reference for the designer or manufacturer of a product in designing product or furniture that would be able to fit the users and helps to reduce discomfort (Aminian & Romli 2012).

2.4.2 Statistical Analysis of Anthropometrics Data

Data acquired on anthropometric measurement can be analyzed using Statistical Package for Social Sciences (SPSS) or Excel. Findings by Zainon et al. (2009) stated that statistical distribution that usually used is normal distribution since it can approximate most anthropometric data quite closely. Important parameters needed are mean and standard deviation. Mean is used to identify the central tendency of the data or measurement as illustrated in Figure 2. 4. Formula for mean and standard deviation is shown in Equation 2.1 and Equation 2.2

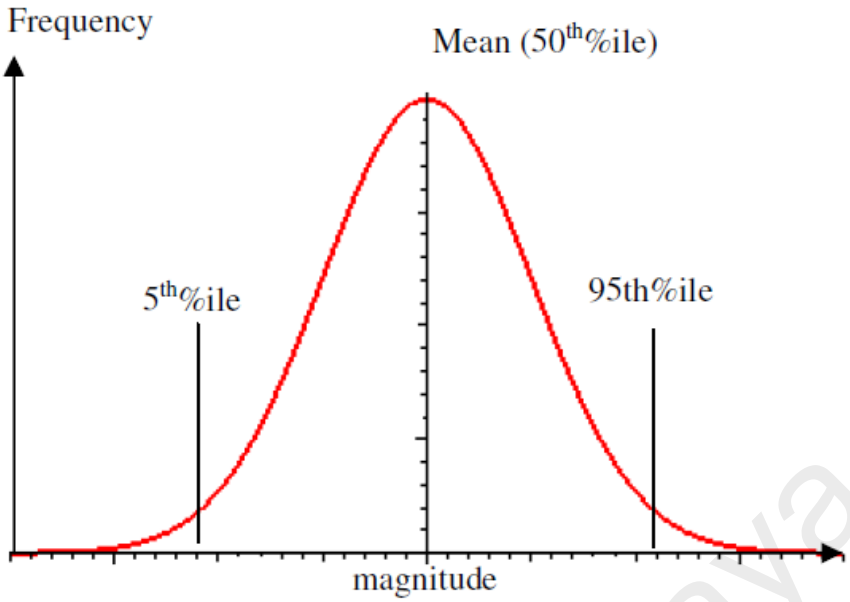

Figure 2. 4: Normal distribution curve

Formula for mean and standard deviation is shown in Equation 2.1 and Equation 2.2

$$M = \Sigma(X_i)/N \qquad \text{Equation 2.1}$$

M is the mean of the sample

Xi is the ith measurement

N is the sample size

$$s = \sqrt{\left(\frac{\Sigma(X_i - M)^2}{N-1}\right)} \qquad \text{Equation 2.2}$$

Data acquired would be used to calculate the percentile. Percentage of the population of a certain body dimension is presented by the percentile value. Formula for percentile is shown in Equation 2.3 and multiplication factor is presented in Table 2. *11*.

$$X = M + F \times s \qquad \text{Equation 2.3}$$

X is the calculated percentile value

M is the mean of the distribution

F is the multiplication factor corresponding to the percentile required

S is the standard deviation

Table 2. 11 Multiplication factor (F)

Percentile	F
1st	-2.326
5th	-1.645
10th	-1.282
25th	-0.674
50th	0
75th	0.674
90th	1.282
95th	1.645
99th	2.326

2.5 Previous Research Related to Anthropometric Data in Malaysia

There are few research that has been done in order to establish anthropometric data for Malaysian student from primary school student to university student.

2.5.1 Malaysian Primary School Children Anthropometrics Data

Previous research by Yahya et al. (2013) investigate on the measurement of anthropometric dimension of primary school children and factors that are associated to MSD among the students in which the subjects involved primary school students aged 7 to 12 years old of mixed races and gender. The measurement are done manually by using anthropometer. Figure 2. 5 illustrate on MSD prevalence among school children in which higher prevalence of MSD were reported higher among male students compared to female students due to different gender as well as physical and physiological characteristics of

both gender vary (Yahya et al., 2013). Findings of the study identified that most of the students complained of foot pain, followed by wrist pain and upper arm pain.

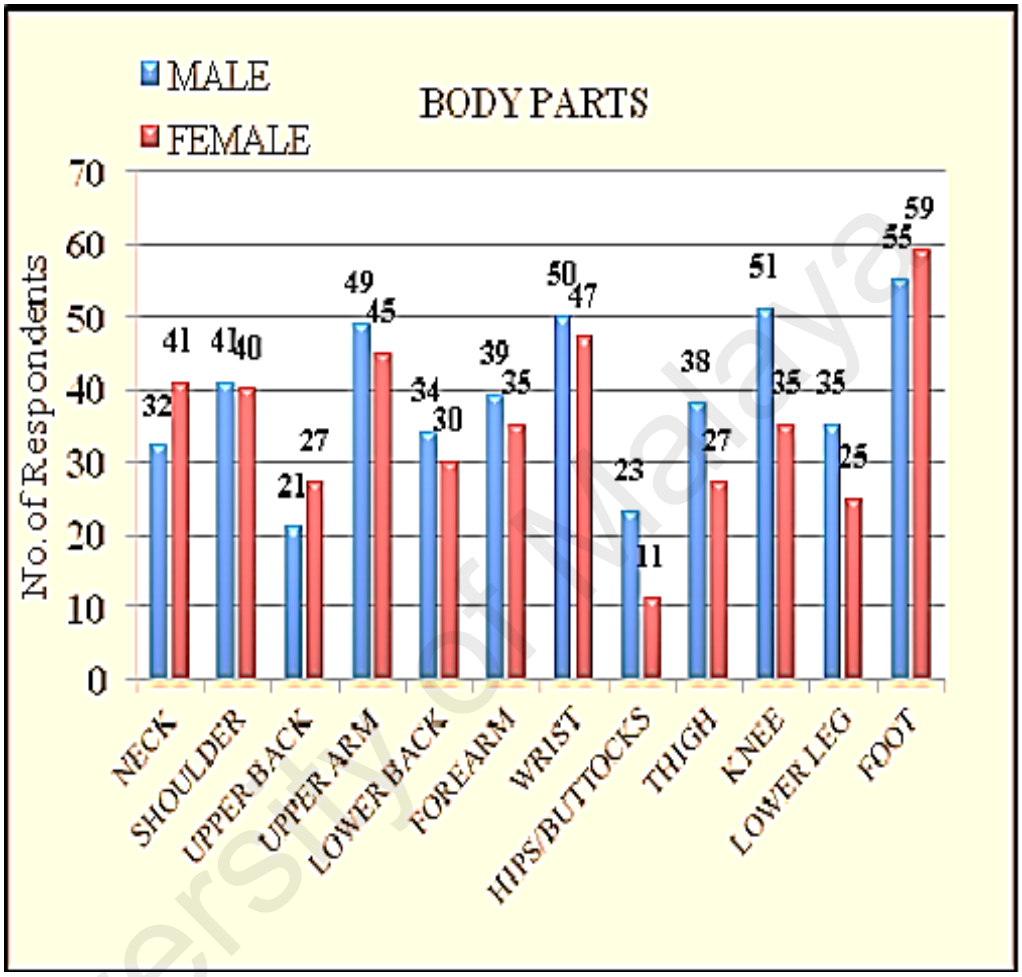

Figure 2. 5: MSD prevalence among primary school children (Yahya et al., 2013)

Table 2. 12: Anthropometric data of primary school student (Yahya et al., 2013)

Classifications	SAMPLE (n=167)				SAMPLE (n=99)			
	Male				Female			
	5th percentile	50th percentile	95th percentile	Standard Deviation	5th percentile	50th percentile	95th percen-tile	Standard Deviation
1. Stature (cm)	112.44	126.2	145.52	11.29	110.2	129.1	151.3	13.63
2. Sitting Height (cm)	57.94	65.2	73.9	4.94	57.3	66.3	79.4	6.84
3. Sitting - Shoulder Height (cm)	34.5	40.6	49.2	4.13	35.2	42.1	50.5	5.04
4. Popliteal Height (cm)	30.2	31.3	40.56	3.15	30.3	31.9	40.8	3.62
5. Hip Breadth (cm)	20.34	24.3	34.6	4.49	19.6	23.5	32.5	4.1
6. Elbow-Seat Height (cm)	10.18	14.4	18.46	2.55	12.6	17.5	22.4	2.56
7. Buttock-Popliteal Length (cm)	26.68	32.5	39.26	3.71	26.3	33.4	42.5	4.85
8. Buttock-Knee Length (cm)	34.24	39.5	49	4.36	34.1	42.3	52.4	5.69
9. Thigh Clearance (cm)	7.74	9.7	13.6	1.73	6.8	9.6	14.3	2.23
Weight (kg)	18.84	25.5	51.36	10.17	17.9	25.9	50.7	10.87

Anthropometric data recorded from the research were tabulated in Table 2. 12 in which it shows that the data obtained during the study had very good reliability with alpha of 0.913. The collected anthropometric data was further used to propose new design of the chair and desk with upgrade on the chair and desk height adjustable range, backrest height equipped with lumbar support and armrest which could be convenient and decrease musculoskeletal pain. Yahya et al. (2013) also stated that the proposed design should be based on anthropometric data for 5^{th} percentile and 95^{th} percentile school children. The following guidance to measure proposed measured is tabulated in Table 2. 13.

Table 2. 13: Guidance on anthropometric measurement (Yahya et al., 2013)

Item	Chair and desk features	Guidance
1	Seat width	95th percentile of hip breadth
2	Seat height	5th percentile of popliteal height
3	Armrest height	5th percentile of elbow seat height
4	Backrest height	95th percentile of sitting shoulder height
5	Desk height from the floor	5th percentile of elbow seat height+popliteal height

2.5.2 Mismatch Between School Furniture and Anthropometric Measures among Primary School Children in Mersing, Johor, Malaysia.

The study has been conducted by (Afzan et al., 2012) to identify the mismatch between school furniture and athropometric measurement among primary school student in Mersing, Johor. About 91 primary school students in Mersing were involved in the study comprises of 46 male and 45 female students. The study was also aimed on investigating the variant between genders in athropometrics measurements find that no significant difference was found except for shoulder height of Year 5 student between both genders in which the students involved are normal with no disability. The researcher stated that this is due to growth rate of the child in which boys' growth are a little bit late compared to the girls and the parameter might gradually increase but it makes not big difference due to sex and it is supported by Prado-León et al. (2001). High mismatch has been identified for Year 2 students in terms of its seat height, seat depth, and desk height while the case is different for Year 5 student in which high mismatch was also identified for backrest height. The analysis indicate that the furniture used are non-ergonomic and are of the same size for all ages (Afzan et al., 2012). Table 2. 14 shows the application of measure to identify mismatch.

Table 2. 14: Application of measure to identify mismatch

Parameter	Application of measures equation
Popliteal height against seat height	$(PH+3)\cos 30° \leq SH \leq (PH+3) \cos 5º$
Hip width against seat width	$HW \leq SW$
Shoulder height against backrest height	$SH \leq BH \leq 0.8SH$
Elbow height against desk height	$EH + (PH+2) \cos 30° \leq DH \leq (PH+3) \cos 5º + 0.8517\ EH + 0.1483\ SH$

In this research mismatch was characterized into high mismatch, match and low mismatch. When the minimum limits of the application measures equation is higher than the children anthropometric while low mismatch is defined as when the maximum limit of the application measures equation is lower than children anthropometrics. Match is when the children anthropometric is within limits.

2.5.3 Anthropometric Data for Secondary School and University Student in Malaysia

Previous research by Dawal et al. (2012) identified anthropometric database for high school and university students in which 41 secondary school students and 143 university students participated in the project. The data of the study obtained could be used in designing product that will be ergonomic for the user. Results obtained shows that measurement of body dimensions vary significantly for different gender except for buttock popliteal length, sitting elbow height and thigh clearance (Dawal et al., 2012). The data obtained was tabulated in Table 2. 15, Table 2. 16, Table 2. 17 and Table 2. 18 respectively.

Table 2. 15: Anthropometric data for male secondary school student (Dawal et al., 2012)

No.	Anthropometry[a]	*M*	*SD*	*CV*	5th Percentile	95th Percentile
1	weight (kg)	52.13	13.02	.25	37.20	76.40
2	stature	160.04	7.32	.05	150.00	169.60
3	interscye breadth	29.47	3.68	.12	25.00	37.00
4	back waist length	44.86	4.69	.10	38.50	53.25
5	shoulder breadth	39.28	3.71	.09	34.40	44.80
6	hip breadth, sitting	32.98	4.68	.14	27.00	42.40
7	arm reach forward	75.65	17.86	.24	31.20	87.75
8	forearm–hand length	44.77	2.06	.05	42.00	48.05
9	buttock–knee length	53.00	3.09	.06	49.70	57.85
10	buttock–popliteal length	42.54	2.07	.05	39.25	45.55
11	sitting height	82.37	14.41	.17	71.40	87.00
12	sitting eye height	70.64	13.85	.20	58.20	76.05
13	sitting shoulder height	55.51	12.69	.23	47.50	59.25
14	sitting elbow height	24.75	23.05	.93	13.75	66.50
15	shoulder–elbow length	35.25	5.08	.14	32.00	38.50
16	knee height	51.05	2.55	.05	47.00	54.75
17	popliteal height	41.14	1.86	.05	39.30	44.60
18	thigh clearance	11.58	2.36	.20	9.70	15.45
19	span	163.11	8.04	.05	154.00	175.05
20	elbow span	86.09	9.19	.11	77.25	94.55

Table 2. 16: Anthropometric data for female secondary school student (Dawal et al., 2012)

No.	Anthropometry[a]	*M*	*SD*	*CV*	5th Percentile	95th Percentile
1	weight (kg)	47.40	7.84	.17	35.95	62.00
2	stature	152.54	6.83	.04	142.24	161.60
3	interscye breadth	25.02	1.55	.06	22.75	27.24
4	back waist length	36.22	3.26	.09	31.44	40.34
5	shoulder breadth	36.48	2.38	.07	33.19	39.72
6	hip breadth, sitting	32.62	3.67	.11	27.33	37.94
7	arm reach forward	77.04	4.51	.06	70.74	84.20
8	forearm–hand length	42.20	1.92	.05	39.64	44.68
9	buttock–knee length	51.25	5.18	.10	44.85	55.81
10	buttock–popliteal length	44.23	7.56	.17	39.75	48.85
11	sitting height	77.56	14.90	.19	67.22	85.49
12	sitting eye height	68.11	12.06	.18	60.80	74.28
13	sitting shoulder height	52.55	11.87	.23	42.95	62.33
14	sitting elbow height	17.48	3.17	.18	12.44	23.07
15	shoulder–elbow length	33.20	1.98	.06	30.43	35.75
16	knee height	47.26	3.65	.08	40.66	51.85
17	popliteal height	39.03	2.51	.06	34.74	41.79
18	thigh clearance	11.71	1.82	.16	8.47	14.29
19	span	155.02	7.85	.05	144.84	163.46
20	elbow span	81.26	14.64	.18	70.71	86.62

Table 2. 17: Anthropometric data for male university student (Dawal et al., 2012)

No.	Anthropometry[a]	*M*	*SD*	*CV*	5th Percentile	95th Percentile
1	weight (kg)	67.28	13.52	.20	53.00	95.00
2	stature	170.49	5.40	.03	162.07	179.10
3	interscye breadth	30.73	3.22	.10	26.29	35.70
4	back waist length	46.15	4.72	.10	38.07	53.55
5	shoulder breadth	42.36	2.83	.07	38.63	47.31
6	hip breadth, sitting	33.59	4.25	.13	25.69	40.35
7	arm reach forward	81.88	10.33	.13	70.00	94.62
8	forearm–hand length	46.11	2.20	.05	42.57	49.27
9	buttock–knee length	54.27	3.79	.07	48.79	59.94
10	buttock–popliteal length	43.09	4.48	.10	34.27	49.71
11	sitting height	89.31	4.31	.05	81.86	95.98
12	sitting eye height	77.55	4.62	.06	71.64	85.04
13	sitting shoulder height	60.48	3.85	.06	54.65	67.24
14	sitting elbow height	17.91	2.86	.16	15.08	21.08
15	shoulder–elbow length	35.31	2.94	.08	31.86	39.11
16	knee height	52.01	5.24	.10	47.65	57.18
17	popliteal height	42.54	5.66	.13	37.00	47.07
18	thigh clearance	13.85	1.97	.14	11.75	15.92
19	span	173.31	7.89	.05	162.04	185.49
20	elbow span	86.96	7.28	.08	74.30	97.79

Table 2. 18: Anthropometric data for female university student (Dawal et al., 2012)

No.	Anthropometry[a]	*M*	*SD*	*CV*	5th Percentile	95th Percentile
1	weight (kg)	54.17	11.31	.21	41.63	73.38
2	stature	157.29	5.74	.04	150.38	167.77
3	interscye breadth	27.44	3.26	.12	22.06	32.84
4	back waist length	39.32	4.56	.12	32.92	48.78
5	shoulder breadth	37.21	3.39	.09	32.85	41.74
6	hip breadth, sitting	35.10	3.63	.10	30.19	40.91
7	arm reach forward	76.03	7.05	.09	68.65	82.34
8	forearm–hand length	42.44	4.73	.11	37.95	46.55
9	buttock–knee length	51.79	5.04	.10	46.65	56.69
10	buttock–popliteal length	42.14	3.87	.09	36.55	48.24
11	sitting height	82.08	5.89	.07	76.12	88.97
12	sitting eye height	71.35	5.74	.08	64.72	78.20
13	sitting shoulder height	54.91	4.32	.08	48.58	61.13
14	sitting elbow height	19.35	0.21	.01	19.22	19.49
15	shoulder–elbow length	33.02	4.14	.13	29.29	36.01
16	knee height	47.96	4.23	.09	39.73	52.68
17	popliteal height	39.95	3.93	.10	33.83	45.14
18	thigh clearance	12.05	1.48	.12	11.11	13.00
19	span	154.54	13.06	.08	140.10	165.70
20	elbow span	81.38	11.79	.14	74.04	85.05

2.5.4 Mismatch between Anthropometric Body Dimensions and Classroom Furniture in Malaysian Universities

Previous study by Aminian and Romli (2012) highlighted possible mismatch between measured body dimensions of the students and classroom furniture. In the study, physical anthropometric data was compared to dimensions of current furniture available in the classroom. Methodology adopted in the study is as shown in Figure 2. 6. It is found that from the comparison between classroom furniture and anthropometric measurement, mismatch were identified and it is concluded that improvement on furniture design are needed..

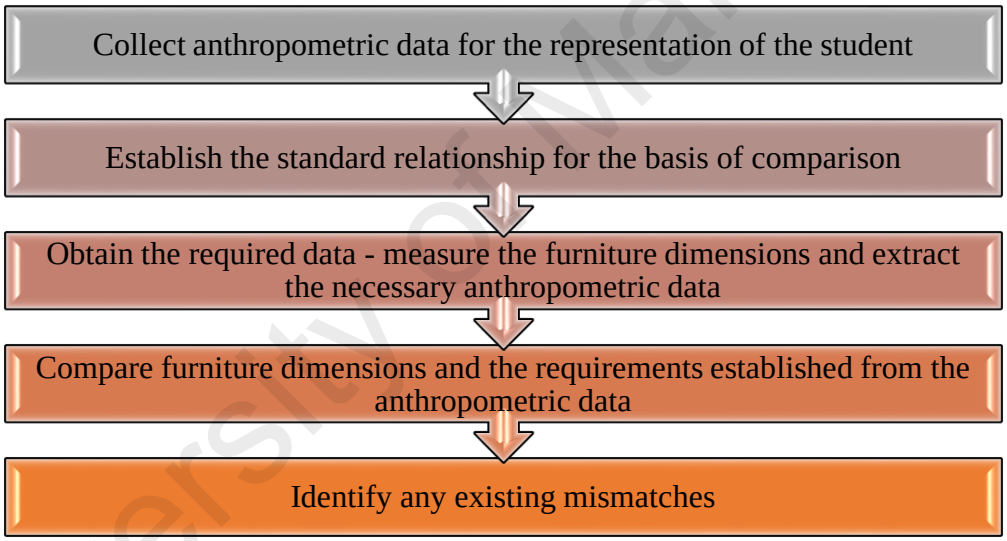

Figure 2. 6: Methodology adopted in the study by Aminian and Romli (2012)

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents on the methodology undertaken in this study. The purpose of this study is to develop anthropometric data on special education students in primary school in Malaysia. In order to achieve the purpose stated, the listed process has been done is simplified in Figure 3. 1.

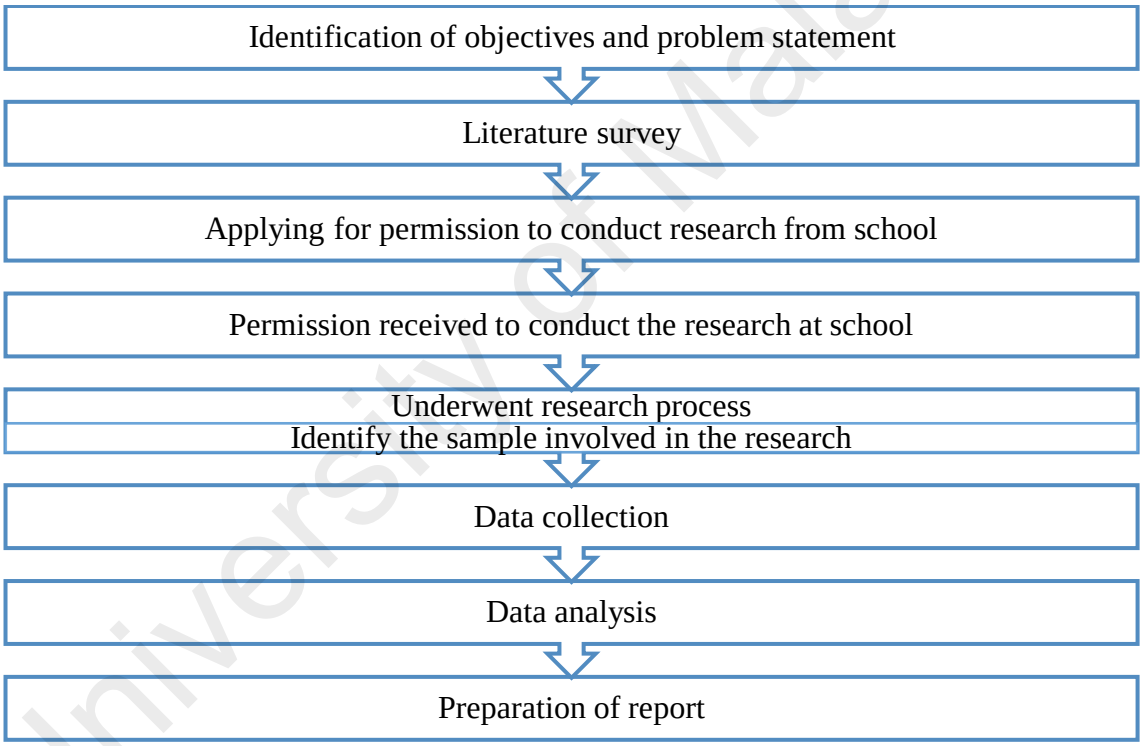

Figure 3. 1: Research flow chart

3.2 Ethics

The study was done in special education school and primary school with Integrated Special Education Programme. Permission was applied to Ministry of Education of Malaysia to conduct research at selected schools. Application was made to Special Education Division and Educational Research and Planning Division, Ministry of

Education of Malaysia before proceeding with the project. Photo of the student were not taken as part of the request of the selected school.

3.3 Sample of the Study

In this study, fifty two students participated in anthropometric data measurement from five school. Students were selected randomly on the day of the visit as the number of students in those school are small. Participated students were students with disabilities which are vision disability, hearing disability and learning disorder disability.

3.4 Location of the Study

Five schools were selected to participate in this study. Selection of the schools was made based on type of disabilities of the students which are students with vision disability, hearing disability and learning disorder disability. Selection of the school was limited to school in Kuala Lumpur and Selangor with easy access. Selected school are as listed in Table 3. 1.

Table 3. 1: List of schools participated.

Name of School	**Type of disability**
Sekolah Pendidikan Khas Jalan Peel, Kuala Lumpur	Hearing disability
Sekolah Pendidikan Khas Jalan Batu, Kuala Lumpur	Vision disability
Sekolah Pendidikan Khas Selangor	Hearing disability
Sekolah Kebangsaan Putrajaya Presint 9 (2), Wilayah Persekutuan Putrajaya	Learning disorder
Sekolah Kebangsaan Puchong Utama (1), Selangor	Learning disorder

3.5 Research Instrument

In this study, research instrument used was anthropometrics data form. Demographic background of the student participated which was age, height, weight, type of disability and selected body dimensions were recorded in the form. Selected body dimension was limited to certain body dimensions only which are related to classroom furniture. Anthropometrics form are attached in the Appendix.

3.6 Research Procedure

Prior to the execution of the project, selected schools were briefed on the project first before the project can be done.

3.6.1 Anthropometric Measurement

Selected students were measured for their anthropometrics data while they were wearing light clothing and no shoes. Students were in relaxed position. The measurement was recorded in centimeters unit and kg for weight. Weighing scale was used to weigh and anthropometer set was used to measure the selected body dimensions. All measurement were taken while they were sitting and standing. Anthropometrics dimension that were measured in this study consists stature, sitting height, sitting shoulder height, sitting arm height, sitting popliteal height, shoulder breadth and hips width. Measurement while standing was taken while the students stand straight with their hand by their sides. As for anthropometry while sitting, students were asked to sit on chair with the elbows bent at 90° across the chest. Posture employed while measuring are shown in Figure 3. 2. Measurement was taken three times per body dimension and the average value was calculated and recorder in the form.

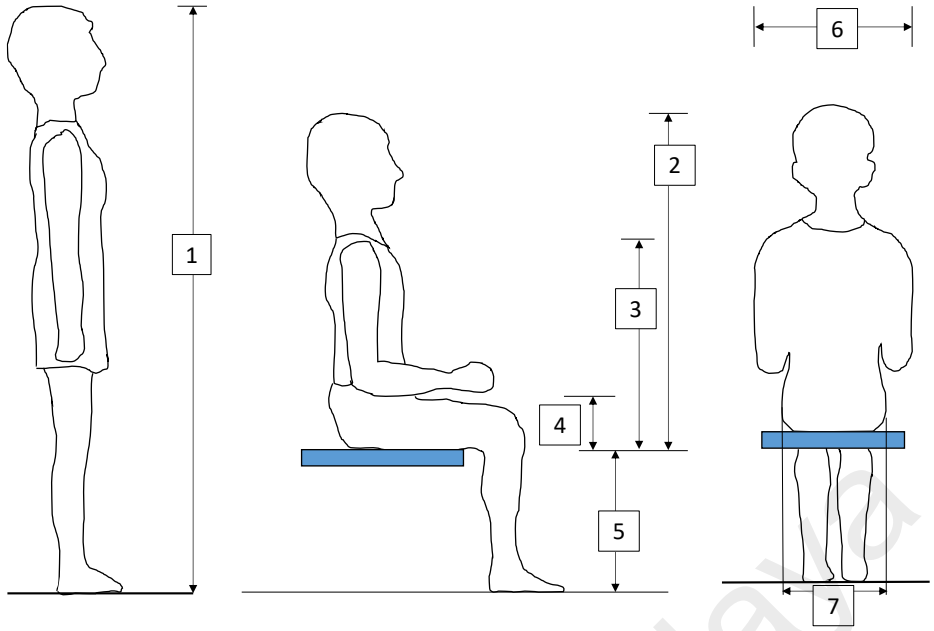

Figure 3. 2: Representation of anthropometric measurement. Redrawn from Castellucci et al. (2010) in which all legend number explained in Table 3. 2.

Table 3. 2: Representation of dimension as shown in Figure 3.2

No	Dimension	Description
1	Stature	The vertical distance from the floor to the crown of the head
2	Sitting height	Vertical distance from the floor to the crown of the head
3	Sitting shoulder height	Vertical distance from the seat surface to the acromion
4	Sitting elbow height	Vertical distance from the seat surface to the underside of the elbow.
5	Sitting popliteal height	Vertical distance from the floor to the popliteal angle at the underside of the knee where the tendon of the biceps muscle insert into the lower leg
6	Shoulder breadth	Maximum horizontal breadth across the shoulder
7	Hip breadth	Maximum horizontal distance across the hips in sitting position

3.7 Data Analysis

Recorded data was analyzed by using SPSS and Excel. The data was analyzed for its mean, standard deviation, 5^{th} percentile value and 95^{th} percentile value. The value for its mean and standard deviation is obtained from SPSS while the value for 5^{th} percentile and 95^{th} percentile is calculated by using Equation 2.3 and the multiplication factor is obtained from Table 2.11 respectively. Calculated data is then tabulated and presented in Chapter 4. Calculated value of 5^{th} percentile and 95^{th} percentile of particular body dimensions is then used to compare with current furniture dimension. Furniture dimension of each school is recorded and averaged and presented in Chapter 4. Furniture dimension is recorded for its seat width, seat height, backrest height, armrest height and desk height from the floor. Selected dimensions of school furniture are among important criteria in designing school furniture. Analysis of the current furniture dimension based on anthropometry data is important in identifying whether furniture provided are suitable for the students and proposed furniture dimension is presented in this study.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents on the results and discussion of the data. The data obtained throughout the study is analyzed by using SPSS and Excel. The results and discussion of the analyzed data is discussed in the next section.

4.2 Background of the Student

This section presents data on the gender, type of disability and age of the students participated in this study.

4.2.1 Gender of the Student

Table 4. 1: Data on gender of the students

Gender	Frequency	Percentage
Male	24	46.2
Female	28	53.8
Total	52	100.0

Table 4. 1 presents data on gender of the students participated in this study. From the study, 24 male and 28 students participated in the study. Percentage of the students involved is shown in Figure 4. 1 in which more female students participated in the study compared to male students.

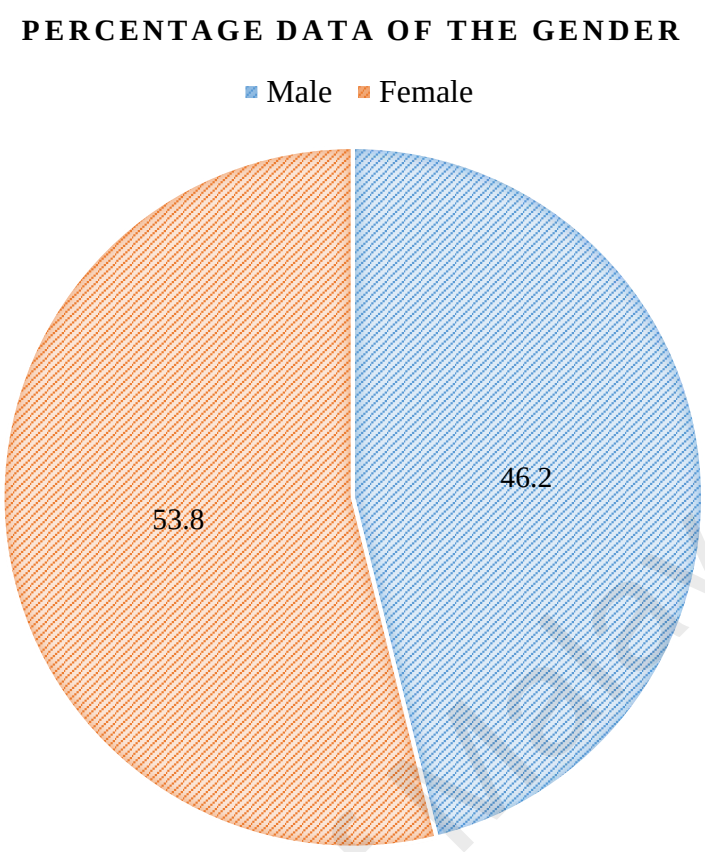

Figure 4. 1: Percentage of the students characterized by gender

4.2.2 Disability of the Students

Table 4. 2: Data on type of disability of the students participated in the study

Type of disability	Frequency	Percentage
Learning disorder	22	42.3
Hearing disability	20	38.5
Vision disability	10	19.2
Total	52	100.0

Table 4. 2 presents data on type of disabilities of the students in which students with learning disorder and hearing disability is more than the number of students with vision disability. This is due to out of five schools visited, only one of it is special education school for vision disabilities students while the other four are hearing disability and learning disorder with both two school respectively in both categories. Percentage distribution of the type of disability of the students is illustrated in Figure 4. 2 respectively.

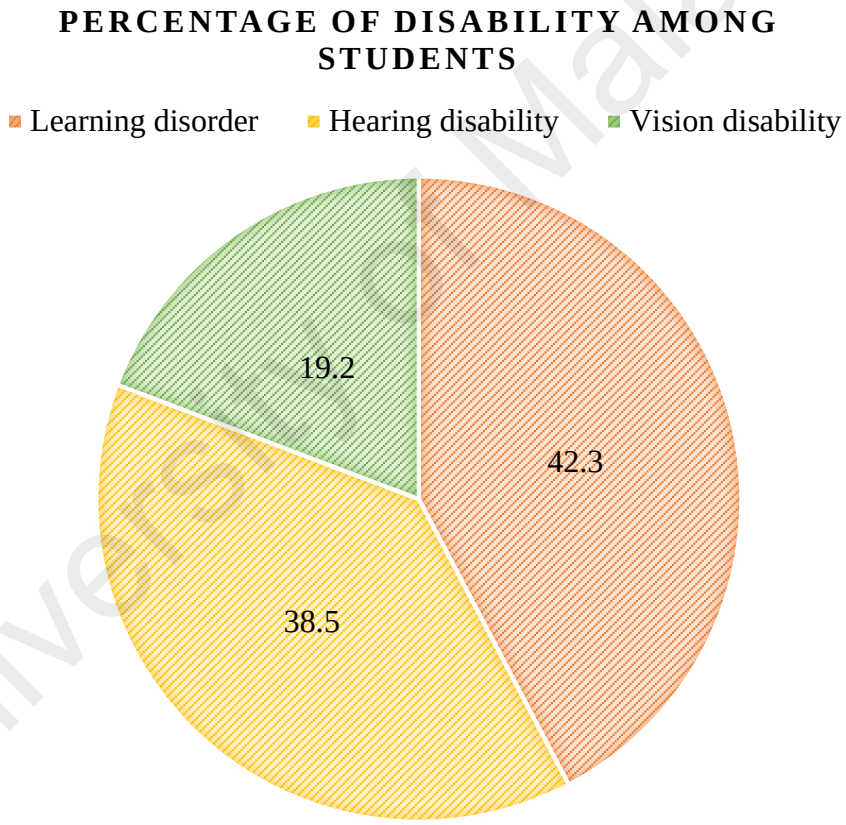

Figure 4. 2: Percentage of the students characterized by type of disability.

4.2.3 Age of the Student

Table 4. 3: Data of the students categorized by age

Age	Frequency	Percent
6	3	5.8
7	8	15.4
8	8	15.4
9	11	21.2
10	9	17.3
11	3	5.8
12	8	15.4
13	1	1.9
14	1	1.9
Total	52	100.0

Table 4. 3 presents data on age of the students participated in the study. Students involved aged from 6 years old until 14 years old. This is because in special education school or PPKI, not all of the students are divided into class based on their age which has been done mostly in the normal education school. Some of the students are divided into classes based on their ability to learn and understand the knowledge. In one of special education school or PPKI with learning disorder, the students were sorted out based on their ability to understand and learn as according to the syllabus or outlines of the level and not based on grades unlike the normal education school.

Interview with one the teacher stated that same aged students with learning disorder disability might not have the same intellectual disability in which with one of them might be better than the other one which makes more the reason they were not categorized same as the one that have been done in normal education. This also apply to students with other disability in which students in Grade 6 would not necessarily a student who is age of 12 years old but he or she might be 13 or 14 years old. This is essentially important to ensure that the students are able to be acknowledge on their ability to learn

and understand. Figure 4. 3 illustrates on the percentage of age of the students characterized by age in which most of the students are age of nine years old.

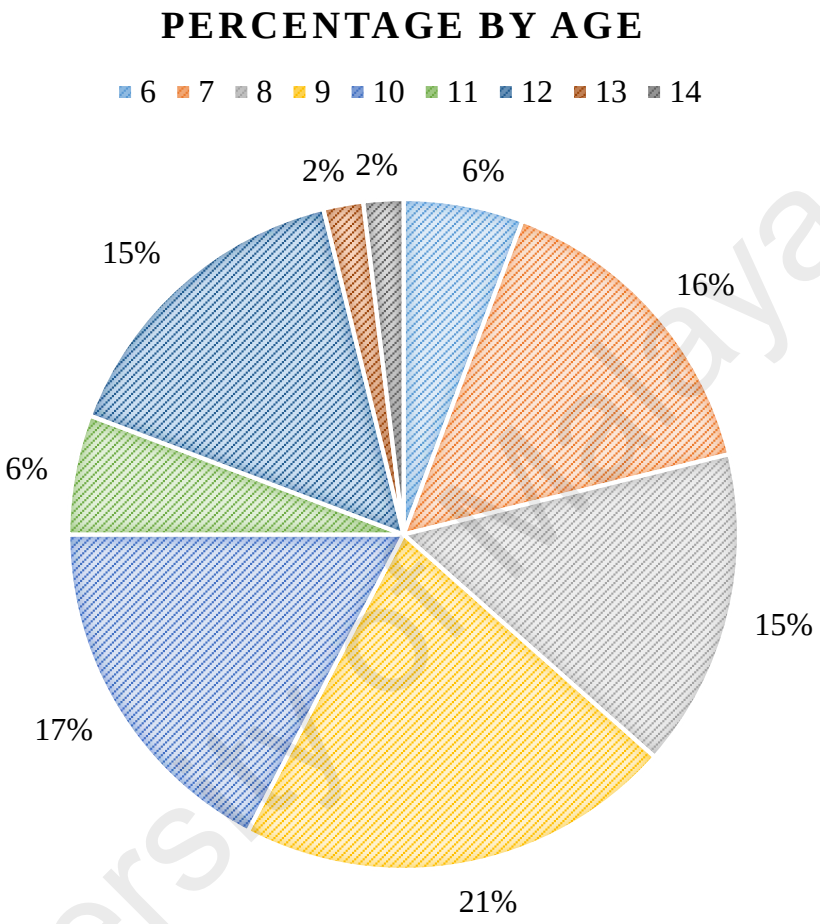

Figure 4. 3: Percentage of the students characterized by age

4.3 Anthropometric Data of the Students

Table 4. 4: Anthropometric data analyzed from collected data during visit to the school

Anthropometric Dimension	Male (N=24)		Female (N=28)	
	Mean	Standard deviation	Mean	Standard deviation
Age	10	2.0	9	2.0
Weight	30.3	12.1	29.8	12.2
Height	128.1	15.9	128.5	13.9
Sitting height	63.1	7.0	62.5	8.6
Sitting popliteal height	36.2	5.3	35.2	4.5
Sitting shoulder height	46.6	3.6	47.7	3.9
Shoulder breadth	30.5	4.4	29.5	3.5
Sitting elbow height	21.9	4.1	23.5	4.2
Hip breadth	24.5	3.7	24.3	3.7

Table 4. 4 presents data on the analyzed anthropometric data that have been collected during visit to the school. The data presented in the table was analyzed by using SPSS for its age, weight, height, sitting height, sitting popliteal height, sitting shoulder height, shoulder breadth, sitting elbow height and hip breadth with reliability of 0.823. The data presented is in centimeter unit and weight is in kg unit. The data shows that the measurement of female students is higher in the dimension such as height, sitting shoulder height and sitting elbow but the values doesn't vary much from each other. This is supported from previous research by Prado-León, Avila-Chaurand, and González-Muñoz (2001) which stated that the parameter might gradually increase but it makes no big difference due to different gender.

4.4 Calculated Anthropometric Data for 5th Percentile and 95th Percentile

Table 4. 5: Data on calculated anthropometric data for 5th percentile, 50th percentile and 95th percentile

Anthropometric Dimension	Male (N=24)				Female (N=28)			
	Mean	Standard deviation	5th	95th	Mean	Standard deviation	5th	95th
Weight	30.3	12.1	10.4	50.2	29.8	12.2	9.6	49.9
Height	128.1	15.9	102.1	154.2	128.5	13.9	105.7	151.3
Sitting height	63.1	7.0	51.6	74.6	62.5	8.6	48.4	76.6
Sitting popliteal height	36.2	5.3	27.5	44.9	35.2	4.5	27.8	42.6
Sitting shoulder height	46.6	3.6	40.7	52.5	47.7	3.9	41.3	54.0
Shoulder breadth	30.5	4.4	23.3	37.6	29.5	3.5	23.8	35.3
Sitting elbow height	21.9	4.1	15.2	28.6	23.5	4.2	16.6	30.5
Hip breadth	24.5	3.7	18.3	30.6	24.3	3.7	18.2	30.3

Table 4. 5 shows calculated data on the 5th percentile and 95th percentile. Calculated data shows that body dimension of male students is bigger than female students in weight, sitting height, sitting popliteal height and hips breadth. However, dimension of female students in sitting popliteal height is bigger than male students at 95th percentile. As for the calculated dimension of hips breadth, the difference of data between both genders does not vary as the difference is small. Calculated data also shows that body dimensions of female students is bigger than male students in sitting shoulder height, shoulder breadth and sitting elbow height. However, the calculated data for male students is bigger than female students for 95th percentile of shoulder breadth. The data shows that calculated dimensions of male students is bigger than female students for most of the body dimensions. The data calculated is important to be used in designing the proper size of furniture. Previous research by Yahya et al. (2013) proposed that design of furniture should be based on anthropometric data on particular body dimension at 5th percentile and 95th percentile of school children. According to the researcher, seat width and backrest height of the chair should be designed based on 95th percentile dimension to accommodate the bigger body size while 5th percentile dimension are used in the design of seat height, armrest height and desk height from the floor to accommodate smaller body size.

4.5 School Furniture Dimension

Dimension of school furniture used in each school was measured for its average value of seat width, seat height, backrest height, desk height and desk width. Recorded data was calculated and summarized in Table 4. 6. The recorded data is then used in comparing the purpose dimension for the furniture design used in school.

Table 4. 6: Dimension of school furniture

Furniture Dimension		Average value (cm)
Chair	Backrest height	39.4
	Seat height	30.2
	Shoulder width	39.4
	Seat width	39.4
Desk	Desk height	66.0
	Desk width	64.4

4.6 Analysis of School Furniture Dimensions Based on Anthropometry Data

Anthropometric data obtained is analyzed to purpose the school furniture dimension that are used in current school. Selection of anthropometrics data for the proposed furniture dimension is made based on studied by Yahya et al. (2013). Selection guideline is made according to guidance shown in Table 4. 7. Previous research by Aminian and Romli (2012) is also referred when comparing the school furniture dimension and anthropometric measurement taken. Comparison of current dimension and anthropometric dimension is presented in Table 4.8.

Table 4. 7: Guidance on athropometric measurement (Yahya et al., 2013)

Item	Chair and desk features	Guidance
1	Seat width	95^{th} percentile of hip breadth
2	Seat height	5^{th} percentile of popliteal height
3	Armrest height	5^{th} percentile of elbow seat height
4	Backrest height	95^{th} percentile of sitting shoulder height
5	Desk height from the floor	5^{th} percentile of elbow seat height+popliteal height

Table 4. 8: Comparison between current measurement and anthropometric measurement

Dimension	Current Measurement (cm)	Anthropometric Measurement (cm)
Seat width	39.4	30.6
Seat height	30.2	27.5
Backrest height	39.4	47.7
Armrest height	None	15.2
Desk height	66	42.7

From Table 4. 8, it is shown that current measurement of seat height, seat width, and desk height is higher than the proposed anthropometric measurement. The seat height is higher than the anthropometric measurement by 3.7 cm and this would means the chair would not be suitable for all students as students with popliteal height less than 30.2 cm would need extra force to be able to put their feet on the floor. This situation could put stress on their muscle as well as cause them to feel uneasy while sitting. Previous research by Biswas, Zahid, Ara, Parves, and Hoque (2014) stated that sitting on seat that are too high would increase compression of the thigh and would cause discomfort as high seat would prevent their feet from touching the floor and more movement is needed to advance forward.

As for the seat width, data obtained shows that measurement of current dimension is bigger than the anthropometric measurement by 8.8 cm. Current dimension of school furniture are suitable to be used as it would be able to accommodate the measured anthropometric data as the selected anthropometric data was made based on 95^{th} percentile. This results could be related to research by Biswas et al. (2014) in which in order to accommodate student's hips and arm rest, then the seat width should be bigger as part of making extra space for the arm rest.

In terms of desk height, the current furniture dimension of the desk height is higher than the measured anthropometry by 23.3 cm and this difference is relatively big. This dimension would be mismatch for about 98% of the students involved in this study in which only one students would be able to fit into the dimension. The rest on the 98% of the students would have to exert forces to ensure that their feet would touch the floor.

Current furniture measurement for backrest height of the chair is smaller than the anthropometric measurement for shoulder height by 8.3 cm. It is suggested that new measurement is proposed which is 47.7 cm for the backrest height of the chair to provide better back support for the students. This would promote good siting posture as C.

Parcells, S. Manfred, and Hubbard (1999) stated that bad sitting posture would affect neck or back and contributed to fatigue and discomfort that would contribute to abnormalities in the spinal column. Castellucci, Arezes, and Viviani (2010) stated that good sitting posture is defined as a situation when the students are sitting in an erect position on a horizontal surface with their upper and lower legs are at perpendicular angle and feet laid horizontally on an adjustable footrest as illustrated in Figure 2.3.

Current furniture provided in school does not provide any arm rest. The purpose of the arm rest is to reduce load on the spinal column as less force is needed to support the body since the arm laid on a perpendicular position across the chest. As mentioned previously, good sitting posture is important to prevent neck and back pain and in the same time reduce MSD among the students. The desk width of the current furniture is suitable to be used as the value is bigger than the seat width and extra space provided would allow for clearance. The newly proposed design for special education students is tabulated in Table 4. 9. Finding also indicates that method used by previous researcher in determining mismatch between anthropometric measurement and classroom furniture of normal students are suitable to be used on special education students. During the visit to the school, it can be observed that students of special education used classroom furniture that is of the same dimension of normal student in which in their cases, they should be provided with suitable furniture that would be able to support them from falling down as they have limited ability compared to normal students. Unsuitable furniture provided to them required them to come up with their own option to ensure that the furniture used are suitable to be used.

Table 4. 9: Proposed dimension for school furniture

Dimension Name	Proposed Dimension (cm)
Seat width	39.4
Seat height	27.5
Backrest height	47.7
Armrest height	15.2
Desk height	42.7

CHAPTER 5: CONCLUSION

5.1 Conclusion

In conclusion, this study provide better understanding of anthropometrics data for special education primary school students is being used in designing the classroom furniture. Selected anthropometric data measurement was used in the furniture design such as sitting height, sitting popliteal, sitting shoulder height, sitting arm height, hips breadth, shoulder breadth and stature of the school students and classroom furniture dimension was measured before it is compared to get the purpose dimension. The finding of the study shows that current classroom furniture being used are unsuitable for most of the students as only certain dimension seems to be fit for them while the other could not match to their body dimension. Current furniture dimension is higher than the anthropometric measured for seat width, seat height and desk height in which these dimension are among important element in ensuring good sitting posture among the students. This study also highlight that classroom furniture is being provided with concerning on ergonomic features of the furniture which could resulted in risk for development of musculoskeletal disorder in the future. Therefore, proposed dimension should be considered for better classroom furniture.

5.2 Recommendations

Throughout the research period, there are few elements or aspects that can be improvised for further study and with this few recommendations are proposed. This study suggest that further research are done on the collection of anthropometric data on special education students in a way that number of students involved in the measurement should be bigger than this study to obtain data that is more accurate than this study.

Besides that, the location of the study should be expanded to special education school outside of Selangor and Kuala Lumpur to get varying data. With wide selection of school, the reliability on the data can be improved. Another recommendation is that a model chair is designed to measure anthropometry data, so that the posture during measurement will be centralized.

REFERENCES

Abdul Nasir, Muhamad Nadhir , & Efendi, Alfa Nur Aini Erman (2016). Special education for children with disabilities in Malaysia- Progress and obstacle. *Malaysian Journal of Society and Space, 12*(10), 78-87.

Afzan, Z. Z., Hadi, S. A., Shamsul, B. T., Zailina, H., Nada, I., & Rahmah, A. R. S. (2012, 9-12 July 2012). *Mismatch between school furniture and anthropometric measures among primary school children in Mersing, Johor, Malaysia.* Paper presented at the 2012 Southeast Asian Network of Ergonomics Societies Conference (SEANES).

Ahmad Afip, Liyana, Hanapi, Nurul Fatihah, & Zakaria, Khuzaiton. (2013). *Persepsi dan Pengalaman Guru Pendidikan Khas dalam Menghadapi Permasalahan Disleksia dalam Kemahiran Literasi*. Pusat Pengajian Bahasa dan Pembangunan Insaniah Universiti Malaysia Kelantan (UMK).

Altaboli, Ahamed, Belkhear, Maleha, Bosenina, Amera, & Elfsei, Nora. (2015). Anthropometric Evaluation of the Design of the Classroom Desk for the Fourth and Fifth Grades of Benghazi Primary Schools. *Procedia Manufacturing, 3*, 5655-5662.

Aminian, Negin Ozve, & Romli , Fairuz I. . (2012). *Mismatch between Anthropometric Body Dimensions and Classroom Furniture in Malaysian Universities.* Paper presented at the Proc. 2012 Canadian Enginering Education Association (CEEA12) Conf.

Bahagian Pendidikan Khas, Kementerian Pendidikan Malaysia. (2016). *Data Pendidikan Khas 2016*: Kementerian Pendidikan Malaysia.

Barli, Onder, Sari, Reyhan Midili , Ehmali, Derya , & Aydintan, Erkan (2006). Anthropometric Evaluation of the Creches Children Furniture in Turkey. *Coll. Antropol, 30*(4), 853-865.

Biswas, Bhadrabati, Zahid, Farzana Bintay, Ara, Rahat, Parves, M.S, & Hoque, A.S.M. (2014). *Mismatch between classroom furniture and anthropometric measurement of Bangladeshi primary school students*. Paper presented at the International Conference on Mechanical, Industrial and Energy Engineering 2014, Khulna, BANGLADESH.

C. Parcells, S. Manfred, & Hubbard, R. (1999). Mismatch of classroom furniture and body dimensions. Empirical findings and health implications. *Journal of Adolescent Health, 24*(4), 265-273.

Castellucci, H. I., Arezes, P. M., & Viviani, C. A. (2010). Mismatch between classroom furniture and anthropometric measures in Chilean schools. *Appl Ergon, 41*(4), 563-568.

Chung, J. W., & Wong, T. K. (2007). Anthropometric evaluation for primary school furniture design. *Ergonomics, 50*(3), 323-334.

Dawal, Siti, Zadry, Hilma, Nadya Syed Azmi, Sharifah, Rusyida Rohim, Siti, & Julia Sartika, Sari. (2012). Anthropometric Database for the Learning Environment of High School and University Students. *International Journal of Occupational Safety and Ergonomics (JOSE) 2012, 18*, 561-472.

Dianat, I., Karimi, M. A., Asl Hashemi, A., & Bahrampour, S. (2013). Classroom furniture and anthropometric characteristics of Iranian high school students: proposed dimensions based on anthropometric data. *Appl Ergon, 44*(1), 101-108.

Dockrell, S., Simms, C., & Blake, C. (2015). Schoolbag carriage and schoolbag-related musculoskeletal discomfort among primary school children. *Appl Ergon, 51*, 281-290.

Gupta, D. (2014). Anthropometry and the design and production of apparel: an overview. 34-66.

Ibrahim, Nuraihan Mohd, Osman, Mariana Mohamed, Bachok, Syahriah, & Mohamed, Mohd Zin. (2016). Assessment on the Condition of School Facilities: Case Study of the Selected Public Schools in Gombak District. *Procedia - Social and Behavioral Sciences, 222*, 228-234.

Jabatan Kebajikan Masyarakat, JKM. (2016). Laporan Statistik Jabatan Kebajikan Masyarakat (JKM) 2016.

Jabatan Kebajikan Masyarakat, JKM. (2017). Official Website Jabatan Kebajikan Masyarakat. Retrieved 1st August, 2017, from http://www.jkm.simple.my/index.php?lang=en

Kementerian Pendidikan Malaysia. (2017). Statistik Bilangan Sekolah, Murid dan Guru. from https://www.moe.gov.my/index.php/en/statistik-kpm/statistik-bilangan-sekolah-murid-guru

Laws of Malaysia, Persons with Disabilities Act 2008.). from http://www.ilo.org/dyn/natlex/docs/ELECTRONIC/86297/117930/F139356912/MYS86297.pdf

Mansor, Jannah. (2017, August 3, 2017). Kerajaan jamin pendidikan khas untuk kanak-kanak kurang upaya terus diperkasa-Mahdzir, *Sarawak Voice Daily*. Retrieved from https://sarawakvoice.com/2017/08/03/kerajaan-jamin-pendidikan-khas-untuk-kanak-kanak-kurang-upaya-terus-diperkasa-mahdzir/

Ministry of Education. (2017). Bahagian Pendidikan Khas. Retrieved 1st August 2017, from https://www.moe.gov.my/index.php/my/korporat/jabatan-dan-bahagian/bahagian-pendidikan-khas

Mitra, Sophie, Posarac, Aleksandra, & Vick, Brandon. (2013). Disability and Poverty in Developing Countries: A Multidimensional Study. *World Development, 41*(Supplement C), 1-18.

Mohd Yasin, Mohd Hanafi, Toran, Hasnah, Tahar, Mohd Mokhtar, Bari, Safani, Ibrahim, Siti Nur Nadirah, & Zaharudin, Rozniza. (2013). Current Special Education Classroom and Its Limitation Towards Teaching Process. *Asia Pacific Journal of Educators and Education, 28*, 1-9.

Mulligan, Hilda, McCoy, Lorna, Wilkinson, Amanda, Hawke, Jenny, Sullivan, Joanne, Kirk, Eliana, . . . Potterton, Joanne. (2017). Disability facilitators' views of their work with children/youth with disability in South Africa. *Children and Youth Services Review, 82*, 13-18.

Oyewole, Samuel A., Haight, Joel M., & Freivalds, Andris. (2010). The ergonomic design of classroom furniture/computer work station for first graders in the elementary school. *International Journal of Industrial Ergonomics, 40*(4), 437-447.

Panagiotopoulou, G., Christoulas, K., Papanckolaou, A., & Mandroukas, K. (2004). Classroom furniture dimensions and anthropometric measures in primary school. *Appl Ergon, 35*(2), 121-128.

Pheasant, Stephen. (2003). *Bodyspace: Anthropometry, Ergonomics and the Design of Work, Second Edition* (pp. 257).

Prado-León, Lilia R., Avila-Chaurand, Rosalío, & González-Muñoz, Elvia L. (2001). Anthropometric study of Mexican primary school children. *Applied Ergonomics, 32*(4), 339-345.

Singal, Nidhi, Mahama Salifu, Edward, Iddrisu, Khadijatu, Casely-Hayford, Leslie, & Lundebye, Helen. (2015). The impact of education in shaping lives: reflections of young people with disabilities in Ghana. *International Journal of Inclusive Education, 19*(9), 908-925.

Taifa, Ismail Wilson, & Desai, Darshak A. (2017). Anthropometric measurements for ergonomic design of students' furniture in India. *Engineering Science and Technology, an International Journal, 20*(1), 232-239.

The Ministry of Women Family and Community Development. (2016). *Pelan Tindakan Orang Kurang Upaya (OKU) 2016-2022*: MPH Group Printing (M) Sdn. Bhd.

WHO. (2016). Disability and health. Retrieved 1 October 2017, 2017, from http://www.who.int/mediacentre/factsheets/fs352/en/

Yahya, Mohd Shahir, Palaniandy, Thiyagu, Zainun, Noor Yasmin, & Mohammad, Musli. (2013). Development of Malaysian Primary School Children Anthropometrics Data for Designing School Furniture Parameters. *Applied Mechanics and Materials, 465-466*, 1191-1195.

Yanto, Lu, C. W., & Lu, J. M. (2017). Evaluation of the Indonesian National Standard for elementary school furniture based on children's anthropometry. *Appl Ergon, 62*, 168-181.

Yasin, Mohd Hanafi Mohd, Toran, Hasnah, Tahar, Mohd Mokhtar, & Bari, Safani. (2010). Teacher's perspective on infrastructure of special education's classroom in Malaysia. *Procedia - Social and Behavioral Sciences, 9*, 291-294.

Yusuff, Rosnah Mohd., Ny, Yoh Sun, & Aziz, Faieza Abdul. *Ergonomics Evaluation of School Furniture Design For Primary School Children in Malaysia*. Paper presented at the The 9th Southeast Asian Ergonomics Society Conference.

Zainon, Nooraizedfiza, S, Zakaria, Mat Salleh, Mokhtar, & Ghazli @ Ghazali, Mohd llah. (2009). *Anthropometry data for 4th year UniMAP student.* Paper presented at the Proceeding of the National Symposium on Advancements in Ergonomics and Safety (ERGOSYM2009).

Žunjić, Aleksandar, Papić, Goran, Bojović, Božica, Matija, Lidija, Slavković, Goran, & Lukić, Petar. (2015). The role of ergonomics in the improvement of quality of education. *FME Transaction, 43*(1), 82-87.