

**ERGONOMIC DESIGN OF WALKING CHAIR FOR DISABLE CHILDREN IN
THE CLASSROOM**

MUHAMMAD FARISI BIN MD ZAIN

**This report is submitted
In fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering**

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

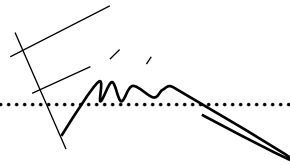
2020

DECLARATION

I declare that this project entitled “ERGONOMIC DESIGN OF WALKING CHAIR FOR DISABLE CHILDREN IN THE CLASSROOM” is the result of my own work except as cited in the references.

Signature

:.....



Name


:MUHAMMAD FARISI BIN MD ZAIN

Date

:.....26.08.2020.....

SUPERVISOR'S DECLARATION

I hereby declare that I have read this project report and in my opinion that it is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature : 

Name of Supervisor : DR. SHAFIZAL MAT

Date : 26.8.2020

DEDICATION

I dedicate this project to my beloved parents and family members, lecturers and friends that always give me encouragement, love, moral supports and pray for my success throughout this Final Year Project.

ABSTRACT

Children who are suffering from disabilities experience learning difficulties and need some extra care. Cerebral palsy (CP) is classified as one of the physical disabilities that occur among children. Children with physical disabilities most likely have difficulties in moving from one place to another. Although there are many aid tools that available in Malaysia to help them in their daily life, children with physical disabilities still have problem in moving around freely like other normal children. Therefore, the purpose of this project is introducing and develop an ergonomic walking chair to help them performing their daily life much easier. This new mechanism of walking chair also help them in rehabilitation for their own good. The process of this project started with an observation at Pusat Pemulihan Dalam Komuniti (PDK) to look closely for their difficulties in their daily life. House of Quality been produced to convert the customer requirement into engineering characteristics based on the observation. Then, Morphological Chart been made to translate it into some conceptual designs. In addition, final design was selected among the conceptual designs using Weighted Decision Matric. After that, 3D model of the final design was produced by using Solidworks 2016. Analysis and simulation been carried out to make sure the product design is safe to be use. The simulation and stress analysis has been running in the software to determine the safety of factor of the product. This mechanism of the product is far the most convenient for children with physical disabilities in Malaysia to use for their daily task and low maintenance.

ABSTRAK

Kanak-kanak yang menderita akibat kecacatan mengalami masalah pembelajaran dan memerlukan penjagaan yang lebih. Cerebral palsy (CP) diklasifikasikan sebagai salah satu daripada kecacatan fizikal yang terjadi dalam kalangan kanak-kanak. Walaupun telah banyak alat bantuan yang telah wujud di Malaysia untuk membantu dalam urusan harian mereka, kanak-kanak yang mengalami kecacatan fizikal masih mempunyai masalah dalam bergerak sekeliling mereka dengan bebas seperti kanak-kanak normal yang lain. Oleh sebab itu, tujuan projek ini ialah memperkenalkan dan mencipta sebuah kerusi berjalan yang ergonomik untuk memudahkan urusan harian mereka. Mekanisme baharu ini juga dapat membantu mereka dalam rehabilitasi untuk kebaikan mereka. Proses kerja dalam projek ini dimulakan dengan pemerhatian di Pusat Pemulihan Dalam Komuniti (PDK) untuk melihat lebih dekat kesusahan yang dihadapi dalam urusan harian mereka. House of Quality dikeluarkan untuk menukarkan permintaan pelanggan kepada karakter kejuruteraan berdasarkan pemerhatian yang telah dibuat. Kemudian, Morphological Chart dibuat untuk menterjemahkannya kepada beberapa reka bentuk konsep. Tambahan lagi, reka bentuk akhir dipilih berdasarkan reka bentuk konsep menggunakan Weighed Decision Matric. Kemudian, model 3D reka bentuk akhir dibentuk menggunakan Solidwork 2016. Analisis and simulasi dibuat untuk memastikan reka bentuk selamat untuk digunakan. Simulasi and analisis tekanan dijalankan dalam aplikasi untuk menentukan factor keselamatan produk. Setakat ini, mekanisme produk ini adalah yang paling senang untuk kanak-kanak dengan kecacatan fizikal di Malaysia menggunakannya untuk urusan harian mereka dan rendah dari segi kos penyelenggaraan.

ACKNOWLEDGEMENT

First, I would like to put highest of praises and thanks to Allah SWT for allowing me to complete my task for Final Year Project successfully. I am sincerely thanks and very grateful to have Dr. Shafizal Bin Mat as my supervisor. I would like to express my appreciation for his enormous technical guidance, encouragement, useful advices and suggestions, criticisms and tremendous knowledges throughout the completion of this project. Next, I would like to express my sincere gratitude towards my seminar panel and examiner, Mr Hairul Bin Bakri and Dr. Masjuri Bin Musa@Othman for giving me helpful ideas and constructive comments that help me improve the project.

I also would like to thanks and give huge appreciation to my beloved family especially my mother, Wan Zainab Binti Wan Dollah and my father, Md Zain Bin Hamzah who always give me love, encouragement and keep supporting me during completion of this project.

Not to forget, thanks to all lecturers that had taught me and give me undeniably kindness, love and patient in teaching me. A big thanks to all UTeM staff especially the staff at the workshop who help me in guidance and give me new knowledges in completion of this project. Lastly, special thanks to my precious friends who always give me moral support and stay with me through ups and downs.

TABLE OF CONTENT

DECLARATION.....	i
SUPERVISOR’S DECLARATION.....	ii
DEDICATION	iii
ABSTRACT	iv
ABSTRAK	v
ACKNOWLEDGEMENT.....	vi
TABLE OF CONTENT	vii
LIST OF TABLE.....	xi
LIST OF FIGURE	xii
LIST OF ABBREVIATIONS	xiv
CHAPTER 1	1
INTRODUCTION	1
1.1 Introduction	1
1.2 Background of the project.....	1
1.3 Problem statement:.....	4
1.4 Objective:	5
1.5 Scope of the project.....	5
1.6 Organization of Report.....	5
CHAPTER 2.....	7
LITERATURE REVIEW	7
2.1 Introduction	7
2.2 Disabled People.....	7
2.3 Facilities	13
2.3.1 Classroom design.....	14
2.4 Physical disabilities	16
2.4.1 Cerebral palsy	18
2.4.2 Walking stick.....	22
2.4.3 Wheelchair.....	23

2.5 Ergonomic	25
2.6 Ergonomic design of a wheelchair	26
2.7 Summary of chapter 2	30
CHAPTER 3	31
METHODOLOGY	31
3.1 Introduction	31
3.2 Identify customer needs	34
3.2.1 Result from observation	35
3.2.2 Result from survey	37
3.3 Benchmarking	38
3.4 House of Quality	39
3.5 Product Design Specification	42
3.5.1 Target Product Design Specification	43
3.6 Detail Design and Analysis	44
3.7 Selection of Material	44
3.8 Theoretical Calculation	46
3.9 Concept Generation	47
3.9.1 Morphological chart	48
3.9.2 Concept design A	50
3.9.3 Concept design B	51
3.9.4 Concept design C	52
3.10 Concept Evaluation and Selection	53
3.10.1 Weighted Decision Matrix	53
3.11 Design	55
3.11.1 Square hollow bar	57
3.11.2 Tyre Holder and Tyre	58
3.11.3 Square Hollow Bar H Shape	59
3.11.4 Seat	60
3.11.5 Circular rods	61
CHAPTER 4	63
RESULT AND ANALYSIS	63
4.1 Analysis of Product	63
4.1.1 Pressure on the seat	65
4.2 Mild steel	66
4.2.1 Seat	66

4.2.2 Tyre Holder	68
4.2.3 Top Part of Circular Rod	69
4.2.4 Square Hollow Bar H-shape	70
4.3 Stainless steel	71
4.3.1 Seat	71
4.3.2 Tyre holder	73
4.3.3 Top Part of circular hollow rod	74
4.3.4 Square Hollow Bar H-shape	75
4.4 Aluminium	76
4.4.1 Seat	76
4.4.2 Tyre holder	78
4.4.3 Top Part of circular hollow rod	79
4.4.4 Square Hollow Bar H-shape	80
4.5 Factor of safety	81
4.6 Structural Analysis	83
CHAPTER 5	84
CONCLUSION AND RECOMMENDATION	84
5.1 INTRODUCTION	84
5.2 CONCLUSION	84
5.3 RECOMMENDATION	86
REFERENCES	87
APPENDICES	91
APPENDIX A	92
APPENDIX B	93
APPENDIX C	94
APPENDIX D	95
APPENDIX E	96
APPENDIX F	97
APPENDIX G	98
APPENDIX H	99
APPENDIX I	100
APPENDIX J	101
APPENDIX K	102
APPENDIX L	103
APPENDIX M	104

APPENDIX N.....	105
APPENDIX O.....	106
APPENDIX P.....	107
APPENDIX Q.....	108

LIST OF TABLE

Table	Title	Page
3.1	List of Customer Requirement and Technical Voice	37
3.2	Benchmarking the mobility devices in Malaysia	39
3.3	Background of walking device	42
3.4	Target Product Design Specification	43
3.5	Material Properties	45
3.6	Comparison between the Materials	46
3.7	The ranges of target user	48
3.8	Morphological chart chosen for first concept	50
3.9	Morphological chart chosen for second concept	51
3.10	Morphological chart chosen for third concept	52
3.11	Weighted decision matrix table	54
4.1	Properties of mild steel material	66
4.2	Properties of Stainless steel	71
4.3	Properties of aluminium	76
4.4	Factor of safety of seat part	81
4.5	Factor of safety of tyre holder part	82
4.6	Factor of safety of circular hollow rod top part	82
4.7	Factor of safety of square hollow bar H-shape part	82

LIST OF FIGURE

Figure	Title	Page
2.1	GMFCS to classify how a child with cerebral palsy mobilises and are classified according to age	21
2.2	Nomenclature of a rigid frame wheel chair	23
2.3	Wheelchair configuration	27
2.4	Elbow angle (α) as a reference for the optimal vertical position of the rear wheels	28
3.1	Flow Chart of Project Outline	33
3.2	Classroom at PDK	35
3.3	Available standing Chair at PDK	36
3.4	House of Quality	41
3.5	Morphological chart for the new product design	49
3.6	First concept design	50
3.7	Second concept design	51
3.8	Third concept design	52
3.9	New design of walking aid	55
3.10	Foldable seat in the design	56
3.11	Bill of material of the new concept design	57
3.12	Square Hollow Bar	58
3.13	Tyre holder with holes	59
3.14	Square Hollow Bar H Shape	60
3.15	Seat	60
3.16	Bottom side of the seat	61

Figure	Title	Page
3.17	Circular Rods	62
4.1	Force acting on the seat	64
4.2	Force acting on the tyre holder	64
4.3	Force on top part	65
4.4	Von misses stress of the seat	67
4.5	Displacement of the seat	67
4.6	Von misses stress of the tyre holder	68
4.7	Displacement of the tyre holder	68
4.8	Von misses stress of the top part	69
4.9	Displacement of the top part	69
4.10	Von misses stress of the square hollow bar H-shape	70
4.11	Displacement of the square hollow bar H-shape	70
4.12	Von misses stress of the seat	72
4.13	Displacement of the seat	72
4.14	Von misses stress of the tyre holder	73
4.15	Displacement of the tyre holder	73
4.16	Von misses stress of the top part	74
4.17	Displacement of the top part	74
4.18	Von misses stress of the square hollow bar H-shape	75
4.19	Displacement of the square hollow bar H-shape	75
4.20	Von misses stress of the seat	77
4.21	Displacement of the seat	77
4.22	Von misses stress of the tyre holder	78
4.23	Displacement of the tyre holder	78
4.24	Von misses stress of the top part	79
4.25	Displacement of the top part	79
4.26	Von misses stress of the square hollow bar H-shape	80
4.27	Displacement of the square hollow bar H-shape	80
5.1	Dimension for Walking Chair (unit in cm)	85

LIST OF ABBREVIATIONS

WHO	World Health Organization
OKU	Orang Kelainan Upaya
CAD	Computer Aided Design
CP	Cerebral Palsy
GMFCS	Gross Motor Function Classification System
HOQ	House of Quality
FEA	Finite Element Analysis
PSM	Projek Sarjana Muda
UTeM	Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Introduction

The 'Projek Sarjana Muda' (PSM) also known as Final Year Project (FYP) is one of the major requirement subject which needed the student to do academic research based on Mechanical Engineering course. The knowledges that has been learned in Mechanical Engineering course such as design engineering, mathematical engineering, sustainability and safety have been used for this project. This chapter explaining about the importance and basis of the project such as background, problem statement, objectives, and scope.

Ergonomics Design of Walking Chair for Disable Children in classroom is the title of the research project for this PSM. Disable person or also known as 'Orang Kelainan Upaya' (OKU) can occur to both children and adult and they are part of the community in Malaysia. It is a disorder which may limit someone's mobility functions, or mental sensory to complete their task in the same way as a normal person. They may need assisting tools so they can overcome this obstacles.

1.2 Background of the project

Children with disabilities have difficulties in learning in their classroom so they need extra care or known as special educational needs. It is the process of educating the student in

some way that addresses their special needs and individual differences. Generally, this includes systematically monitored ordering and individually organized of teaching procedures, accessible settings, and adapted appliances and materials.

Special children need to go to school as normal children too. In Malaysia, they start their early school in pre-school and then they go to primary school and after that is secondary school. Usually pre-school begin when children reach age more than five years old while primary school a year later. For disabled children they can start their primary school at the age of six until 14 years old. On the other hand, secondary school can be start at the age of 13 until 19 years old. They must be certified as special children by medical practitioners and can take care of themselves without the help of others and according to the academic stream, after completion of pre-school, special education children may enter primary school. Special children that follow national curriculum may sit for formal examination such as UPSR, PT3, SPM and STPM as normal students in Malaysia.

Nowadays, there are many successful people around the globe and most of them are normal student. There only a few of them are from disabled students. Normal student basically have no problem in their studies and also get opportunity to pursue into higher education level while disabled student do not. Disabled student have many barrier for them to move freely in the classroom and this factor really effect their learning process, they should be provided with friendly environment and appropriate tools for them to move freely with or without assistance from others.

This project focus on children with Cerebral Palsy (CP). There is approximately 2-3 per 1000 live birth may get CP which can be considered CP is the most cause of childhood physical disability. Activity limitations and reduced participation is the result from abnormal fine and

gross motor functioning from CP. Musculoskeletal disorder, including spasticity, contractures and bony deformities may be experience by the people with CP (O'Connell et al., 2019).

CP could be one of the permanent movement disorder that appear in early childhood. Various sign and symptoms are shown among the people over time. Usually the symptom are poor coordination, stiff muscles, weak muscles, and tremors. They might have problems with their sensation, vision, hearing, swallowing, and speaking. Babies with cerebral palsy may not roll over, sit, crawl or walk as early as normal babies at their age. Person with CP may use higher energy expenditures, impaired mobility, and reduce autonomy because of movement and gait disorders. Over time, the degeneration of ligaments and cartilage and even immobility may result from spasticity and contractures in patients with CP (Tsitlakidis, Horsch, Schaefer, & Westhauser, 2019).

The main objective of this project is to design and develop an appropriate walking chair for disabled children so they can move freely in friendly environment classroom layout and ergonomically to suit their needs. For this design of application, it is specialized for the disabled children with CP and the design also must be suitable with the classroom based on their needs and the classroom space. It is also to create an appropriate environments to increase their involvement and participation in the classroom. The designing of ergonomics analysis in this project might improve the design facilities of workstation and the environments to maximize the involvement of the student and minimize their risk of harm.

1.3 Problem statement:

Children with disabilities deserve the right learning environment with their level of ability. The lack of facilities at school and high school level for disabled people has caused these people not to live a comfortable and perfect life like other citizens or students.

In the early years, the appearance of problem behavior could put this children on adverse development trajectories. This could be true with the early externalization of the behavior, which could lead to continued problems and poor academic performance(Fauth, Platt, & Parsons, 2017).

Special kids need an appropriate learning environment suited to their disabilities. The lack of institution in providing suitable facility for them make them experiencing difficulties in their learning. Furthermore, some institutions are not concerned with providing them with facilities for them to continue their learning. It is so tough for disabled children to pursue their study in higher education. Besides, because of this condition, some of the higher institutions refuse their request to continue their education in their institution. Moreover, available assistive tools available now does not give appropriate functions for those unlucky children.

In this centuries, the level of awareness of management toward providing enough and friendly facilities for disabled people still in low state. Therefore, this study should be conduct to give a chance for disable children to study comfortably in their classroom by providing ergonomic walking tool for them and then spread the awareness in providing the learning facilities that meets the needs of disabled people among the public. It also help the communities to be more alert in giving those unlucky children with suitable tools for them pursue their studies

into higher level of education. This study also give more opportunities for those children and hopes for them to feel like a normal students out there.

1.4 Objective:

1. To design and develop an appropriate walking chair for disabled children to move freely in friendly environment classroom.
2. To evaluate an ergonomic analysis, stress analysis and safety for the users.

1.5 Scope of the project

The outlined scopes of the project are:

1. Understand and study the problems that always occur among the disabled children in Malaysia.
2. Study the classroom environment that fulfills the safety requirement for disabled student.
3. Study and develop suitable walking aid used for the student with physical disabilities.
4. Design, develop and analysis the selected design by using Computer Aided Design (CAD) software and analytical software.

1.6 Organization of Report

This report explain detail on how to achieve the objectives in this project which is designing the chair for disable children. First chapter introduces the background, problem statement, objectives and the scopes of the project.

Chapter two gives the information for literature review of this study. The information will be extract from the journals and other sources from the internet.

Third chapter will explain more about the methodology for this case study. The method used are interview and observation at Pusat Pemulihan dalam Komuniti (PDK). Furthermore, this chapter also focus on the conceptual design. There are three conceptual design proposed for this project and this chapter explain briefly the designs and the methods used to choose the best concept. It also explain the details of the best design. The characteristic and functionality of the design was analyzed in this chapter.

Chapter 4 is result and discussion for this project. Two analysis were carried out which are structural analysis and ergonomic analysis.

Chapter 5 is the conclusion for this project. The recommendation also were provided for the future work on this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, it will discuss more about the issues relating to children with disabilities (OKU). This will include the definition of disabled people and their facilities requirements. This is important in order to study their needs properly and conduct this study precisely. The categories of disabilities and their types also been identified so this information will be useful for the reasonable facilities that should be propose to this group.

There are things that must be consider so that they can be independent to perform their daily tasks as normal students. The considerations will be mention in this chapter. Furthermore, some facilities that had been used to this century also been discuss in this chapter. Several previous studies that connected to this subject of the study been highlighted in this chapter. The information about this case study can be archive through trusted websites, journal, and books.

2.2 Disabled People

Basically, disabled people (OKU) is the people with any condition that makes it harder for a person to do certain activities or interact with the world around them. Physical, intellectual, developmental, mental, cognitive, sensory, or a combination of multiple factors can be these conditions or impairments. Impairments that cause disability can occur at birth or during the

lifetime of an individual. According World Health Organization (WHO), disabilities is a comprehensive term covering impairments, activity limits and participation constraints. Disability is a defect in the body's function or structure; a limitation of activity is a challenge faced by an individual while performing a task or action; restricting participation is a problem that a person encounters when engaging in life situations. Therefore, disability is not just a health issue. It is a complex phenomenon that reflects the interaction between the characteristics of the body of a person and the characteristics of the society in which he or she lives (WHO, 2018). In order to overcome the challenges faced by people with disabilities, intervention is required to eliminate environmental and social barrier.

Categories of forms of disability include multiple physical and mental impairments that may hamper or diminish the capacity of an individual to perform his or her activities. Such impairments could affect the person's condition to do their daily tasks. Mobility and physical impairments is one of the disability categories. This category include people with varying types of physical impairments such as upper and lower limbs disability, manual dexterity and disability in co-ordination with different organ of the body. Statistical reports have clearly shown that a certain group of people with physical disabilities have become less effective on the labor market. The discrimination between people with disabilities (75%) and people with disabilities (44%) is a harsh reality of our modern civilization in terms of the employment rate of working-age people (Protim, Abdullah, Pritom, & Chowdhury, 2019). Mobility deficiency can be either an inborn or acquired with age condition problem. It might also be a disease's effect. Individual with a broken bone also fall into this disability category.

Spinal cord disability or spinal cord injury (SCI) also one of forms disability categories. This disability means that spinal cord damage that induces temporary or permanent changes in

its function. Loss of muscle function, sensation, or autonomic function in the body parts served by the spinal cord below the injury level are the symptoms of this disability. SCI refers to spinal cord or cauda equine that been insult caused by vertebra fracture of dislocation with or without an open wound track. Approximately 14 percent for spinal injury cases suffer from SCI, most of it are mono-segmental. SCI occurs frequently in people aged between 30-40 years. The mortality rate of SCI patients was higher that of age-group controls(Huang et al., 2019). Injury can occur at any level of the spinal cord and can result in complete injury, with total loss of sensation and muscle function of incompleteness, which means that some nervous signals can travel past the cord injured area. The symptoms differ, from the numbness to paralysis to incontinence, depending on the location and extent of the injury. There is also a wide range of long-term results, from full recovery to permanent tetraplegia (also known as quadriplegia) or paraplegia. Muscle atrophy, pressure sores, infections, and breathing problems are complication for SCI patients. The injury in most cases occurs from physical trauma such as car accidents, gunshot wound, falls, or sport injuries, but it may also result from non-traumatic causes such as infection, poor blood flow, and tumors. SCI can be broken down into two phases; primary and secondary injury. The destruction of the spinal cord and its surrounding vascular tissues after mechanical trauma leads to local edema, ischemia, hypoxia, which are the causes of primary injury. The main causes of secondary injury are derived from primary injury which is ischemia and hypoxia, which triggers invasion of inflammatory cells and apoptosis and necrosis of neurons (Fan, Liao, Tian, & Nie, 2019).

Hearing disability or hearing loss is an inability to hear partially or completely. Hearing loss affects millions of people worldwide and is estimated to be the fourth leading disability cause worldwide. The World Health Organization (WHO) had estimated that there were 360