

DESIGNING AND FABRICATION MODULAR PRODUCTS WITH THE
INCORPORATION OF DIY ASSEMBLY METHOD (STUDY TABLE)

MOHD HAFIZZOL BIN KARIM

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SUPERVISOR DECLARATION

‘I hereby declare that the quality of the thesis written is sufficient for the award of
Bachelor of Mechanical Engineering (Design & Innovation)’

Signature :
Supervisor : SITI NURHAIDA BTE KHALIL
Date : JUNE 2012

**DESIGNING AND FABRICATION MODULAR PRODUCTS WITH THE
INCORPORATION OF DIY ASSEMBLY METHOD (STUDY TABLE)**

MOHD HAFIZZOL BIN KARIM

**A report submitted in partial fulfilment of the requirements for the degree
Of Bachelor of Mechanical Engineering (Design and Innovation)**

**Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka**

JUNE 2012

DECLARATION

“I declare that this report entitle “Designing and Fabrication Modular Products with the Incorporation of DIY Assembly Method (Study Table)” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree”

Signature :

Name : MOHD HAFIZZOL BIN KARIM

Date : JUNE 2012

To my beloved family. Thank for all your support.

ACKNOWLEDGEMENT

Alhamdulillah, by the name of Allah swt., first and foremost, I would like to thank a lot to my project supervisor Miss Siti Nurhaida Binti Khalil for the valuable guidance and advice which has inspired me greatly to work on the project with willingness to motivate me in completing half of the project.

Honourable mention goes to my friends especially all my classmate for their help, supports, caring, and understanding who did not mind to share their knowledge as well in completing this final report. Last but not least goes to my family for understanding and supporting.

Finally, I really want to thank you at all my lecture for guidance and support. I really glad because I manage to finish this research with all my friends.

ABSTRACT

Table is a product that is widely used in human daily life including study table, where this study table is often used for placing the bookcase, stationery, personal computer, and learning activities. Objective of this project is to develop a study table that incorporate with the modular product design concept and DIY assembly method. A scientific research related to both these concepts has been carried out to obtain a clear picture of the development process of a study table. A good modular design study table has been constructed after the application of engineering design process in this project development. DFMA guideline has been implemented and as the result, a study table with DIY assembly method has been produced. A downscale 1:2 prototype has been fabricated to illustrate the shape and general attribute of the study table.

ABSTRAK

Meja merupakan produk yang digunakan secara meluas dalam kehidupan harian manusia, termasuk meja belajar, di mana meja belajar ini sering digunakan bagi meletakkan buku, alat tulis, komputer peribadi, dan aktiviti pembelajaran. Objektif projek ini adalah untuk membangunkan meja belajar yang menggabungkan konsep reka bentuk modular dan kaedah pemasangan sendiri (DIY). Penyelidikan saintifik yang berkaitan dengan kedua-dua konsep-konsep ini telah dijalankan untuk mendapatkan gambaran yang jelas tentang proses pembangunan sebuah meja belajar. Meja belajar yang mempunyai reka bentuk modular yang baik telah dibina selepas pengaplikasian proses reka bentuk kejuruteraan dalam pembangunan projek ini. Garis panduan DFMA telah dilaksanakan dan sebagai hasilnya, sebuah meja belajar dengan kaedah pemasangan DIY telah dihasilkan. Sebuah prototaip berskala 1:2 telah dibangunkan untuk menggambarkan bentuk dan sifat am meja belajar tersebut.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF FIGURES	xi
	LIST OF TABLE	xiii
	LIST OF ABBREVIATIONS	xiv
	LIST OF APPENDICES	xv
1	INTRODUCTIONS	
	1.1 Background	1
	1.2 Objective	2
	1.3 Scope	2
	1.4 Problem Statement	3
	1.5 Conclusion Remark	3
2	LITERATURE REVIEW	
	2.1 Introduction	4
	2.2 Conceptual Design	4
	2.2.1 Problem Definition	5
	2.2.1.1 House of Quality (HoQ)	5
	2.2.1.2 Product Design Specification (PDS)	6
	2.2.2 Concept Generation	7

	2.2.2.1 Functional Requirements	7
	2.2.3 Concept Selection	9
	2.2.3.1 Pugh's Evaluation Method	10
2.3	Product Architecture	12
	2.3.1 Benefits of Modularity	13
2.4	Configuration Design	14
	2.4.1 Engineered Wood Product	14
	2.4.1.1 Medium Density Fibreboard (MDF)	15
	2.4.2 Materials Selection Software (CES EduPack)	17
2.5	Parametric Design	17
	2.5.1 Designs for Manufacturing and Assembly (DFMA)	18
	2.5.1.1 Designs for Manufacturing (DFM)	18
	2.5.1.2 Designs for Assembly (DFM)	19
	2.5.1.3 DFMA Software	19
	2.5.1.4 Boothroyd-Dewhurst DFA Methodology	20
2.6	Detail Design	21
	2.6.1 Computer-aided Design (CAD)	22
	2.6.2 Structural Analysis	22
2.7	Ergonomics	23
	2.7.1 Engineering Anthropometry and Workspace Design	24
	2.7.1.1 Humans Percentile	24
	2.7.2 Workspace Design for Study Table	25
2.8	Do It Yourself (DIY) Assembly Method	26
	2.8.1 DIY Subculture	27
	2.8.2 Modern DIY Communities	27
2.9	Conclusion Remark	28
3	METHODOLOGY	
	3.1 Introduction	29
	3.2 Define Problem	31
	3.3 Concept Generation	31

3.4	Concept Selection	32
3.4.1	Pugh's Concept Selecting Method	32
3.5	Product Architecture	33
3.6	Configuration Design	33
3.6.1	Generating Alternative Configuration	33
3.6.2	Analysing Configuration Designs	34
3.6.3	Evaluating Configuration Designs	34
3.7	Parametric Design	34
3.8	Detail Design	35
3.9	Prototyping and Testing	35
3.10	Conclusion Remark	35
4	RESULTS	
4.1	Problem Defined	36
4.1.1	Survey	36
4.1.1.1	Questionnaires	36
4.1.1.2	Survey Result	37
4.1.1.3	Survey Analysis	41
4.1.2	Benchmarking	41
4.1.2.1	Benchmark Product	42
4.1.2.2	Part Analysis on Benchmark Product	43
4.1.2.3	Engineering Characteristic of Benchmark Product	48
4.1.3	House of Quality (HoQ)	49
4.1.4	Product Design Specification	50
4.2	Concept Generation	53
4.2.1	Concept Design – Alpha	55
4.2.2	Concept Design – Beta	56
4.2.3	Concept Design – Charlie	57
4.3	Concept Selection	58
4.4	Product Architecture	59
4.5	Configuration Design	61
4.5.1	Standard Part	63

	4.5.2	Special-purpose Part	64
	4.5.3	Preliminary Selection of Materials	66
4.6		Parametric Design	66
	4.6.1	Material Properties	67
4.7		Detail Design	68
	4.7.1	Detail Drawing	69
	4.7.2	Structural Analysis	73
	4.7.3	DFA Analysis	74
4.8		Prototyping	75
4.9		Conclusion Remark	76
5		DISCUSSION	
	5.1	Engineering Design Process	77
	5.2	Modularity	78
	5.3	DIY Assembly Method	78
6		CONCLUSION AND RECOMMENDATION	
	6.1	Conclusion	80
	6.2	Recommendation	81
		REFERENCES	82
		APPENDIX 1	87
		APPENDIX 2	89
		APPENDIX 3	94

LIST OF FIGURE

NO	TITLE	PAGE
1	HoQ Matrix Translate Costumer Requirement Into Engineering Characteristic	6
2	Product Component Decomposition Diagram	8
3	Product Function Decomposition Diagram	9
4	Example of Pugh's Evaluation Chart	11
5	The Relative Sizes of Different Percentile Humans	25
6	Flow Chart of the Methodology Process Regarding the Project	30
7	Brainstorming Flow	32
8	Relative Frequency of Response	38
9	Costumer Choice over Joining Type of Study Table	39
10	Costumer Choice Over Total Width of Desk	39
11	Costumer Choice Over Total Width of Open Surface of Bookcase	40
12	Costumer Willingness to Pay More If the Improvements (Question 1 - 8) They Value with a 5 Or 4 Rating Is Available On The Market	40
13	EXPEDIT Desk Combination with Bookcase	43
14	Desk and Bookcase Combiner	44
15	Set of Connecting Fitting Screw	44
16	Support Bar for Top Panel and Side Panel Connection	45
17	Adjustable Feet Screw, Located At Bottom Surface of Side Panel	45
18	Upside Down Position Of the Desk Configuration	46
19	Figure 19: The Bookcase Configuration	47
20	Wooden Tie Rode and Its Connection Method	48
21	HOQ of Streamlined Configuration as Applied On Study Table	50

22	PDS Template of Modular Study Table with DIY Assembly Method	52
23	Product Component Decomposition of Study Table	54
24	Product Function Decomposition of Study Table	54
25	First Generated Concept Design, Labelled as “Alpha”	55
26	Second Generated Concept Design, Labelled as “Beta”	56
27	Third Generated Concept Design, Labelled as “Charlie”	57
28	Pugh Concept Selection Method Diagram	58
29	Changing of Modularity Over Side Panel and Vertical Frame	59
30	New Part Label for Modular Product Design	60
31	Basic Dimension of Study Table	61
32	Panel A Basic Dimension	62
33	New Design of Study Table	63
34	General Shape of Straight-Type Patch (Left) and L-Type Patch (Right)	64
35	Position of L-Type Patch and Straight-Type Patch on Study Table Design	65
36	Basic Shape of Adjustable Feet Screw	65
37	Final Design	67
38	Basic Mechanical Properties of MDF, Extracted from CES Edupack 2005 Software	68
39	Final Engineering Design for Study Table	69
40	Plat ‘A’ Design, Function As Side Panel and Vertical Panel	70
41	Design of Horizontal Panel for Bookcase	71
42	Design of Desk	71
43	Design of Straight-Type Patch	72
44	Design of L-Type Patch	72
45	Total Deflection of Desk When a 50kg Load Was Given	73
46	Prototype Product to Illustrate the Shape of the Product	75

LIST OF TABLES

NO	TITLE	PAGE
1	Advantages and Disadvantages of MDF	16
2	Anthropometric Data for Male Malaysian Citizen, All Units Are In mm	26
3	Anthropometric Data for Female Malaysian Citizen, All Units Are In mm	26
4	Summary of Responses from Costumer Survey for Study Table	38
5	DFA Analysis Result	74

LIST OF ABBREVIATIONS

CAD	Computer Aided Design
DIY	Do It Yourself
DFA	Designs for Assembly
DFM	Designs for Assembly
DFMA	Designs for Manufacturing and Assembly
PDS	Product Design Specification

LIST OF APPENDICES

NO	TITLE	PAGE
1	Gant Chart for Final Year Project 1	87
2	Gant Chart for Final Year Project 2	88
3	Engineering Drawing for Desk	89
4	Engineering Drawing for Plat A	90
5	Engineering Drawing for Horizontal Panel for Bookcase	91
6	Engineering Drawing for L-Type Patch	92
7	Engineering Drawing for Straight-Type Patch	93
8	Boothroyd-Dewhurst Manual Handling Time Table	94
9	Boothroyd-Dewhurst Manual Insertion Time Table	95
10	Boothroyd-Dewhurst Alpha and Beta Rotational Symmetries for Various Parts	96

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The early history of table exist at the time of the ancient Egyptian society, where material for the construction of the table at the time was based on the rock and it is used to place objects on it. Evolutionary changes in the construction of a table can be seen in terms of design and functionality of a table, in line with developments in technology and living standard of mankind (Wikipedia, Table (furniture), n.d.).

At this present time, the table is one of the most important furniture in human life where it can function in various aspects, and in the context of this project, study table is functional as furniture or equipment to help people implement the learning process or work associated with it. In the modern era, the design of a study table came in many variations and concept. One well-known concept is ready-made study table, where the fabrication and installation was done by the manufacturer at the factory. This means that the user does not need to struggle to perform the installation process the table because it already installed by the manufacturer and configuration of the table cannot be changed randomly because it is a fixed configuration according to the manufacturer's original design plan. These sometimes cause discomfort to the user because they cannot change the basic configuration of the table due to the determination of the manufacturer's design plan and this fixed condition results the table has only one configuration instead of multi configurations according to user's need (Kuznetsov, 2009).

This matter has caused a new trend emerging in the world of furniture, it is modular furniture and study table is no exception in this case where there are a lot of modular study table on the market. In the same time, another phenomenon has emerged in the furniture market, which also adopted alongside with these modular design products. We are no stranger to the DIY assembly methods for furniture. This assembly method is a system that is contrary to the ready-made system, where the purchaser or user must install the products at their homes based on their skill and manufacturer manuals. One company that successfully pioneered this field is IKEA, they have been developing and creating new innovations in modular furniture including study table (Rosner, 2009).

1.2 OBJECTIVE

The project purposed is to design and develop a study table that meets the desirable traits of DIY assembly method and modular design concept. In this project, methods and techniques used in the study of modular design concept, DIY assembly method and DFMA of a product development applied to obtain optimum final product that meets customer needs.

1.3 SCOPE

First scope of this project is applying the key concepts of modular design in the production of study table. Each of the concepts included in the project will be examined as possible so that the modular design concept can be applied properly.

Secondly, develop a study table that can meet the needs of DIY assembly method. This DIY assembly method must be easily understood and carried out by the user without the help of experts.

The third focus of this project is the implementation of the basic principles of DFMA in the process of developing the study table.

1.4 PROBLEM STATEMENT

Design of the furniture is important to ensure that it can be adapted easily to the layout of a space. One of the main problems that can be seen in the design of ready-made system is the configuration of developed study table cannot be changed with the various environment. Configuration of this type of study table is fixed based on the manufacturer's original design and users who use ready-made study table will be struggling to adjust their study table into their furniture layout (Kirk, 1990).

To overcome this problem, the modular design study table is proposed so that this study table can be adapted to the various aspects of the furniture layout. Through creativity and customer needs, they are able to adjust the study table in a various conditions based on various configuration of the study table (Snead, 1992).

In other aspect, DIY assembly method for furniture, including study table, became trending among consumer. This method most required basic skill of users to understand the configuration and design of that study table. But, some of this study table are manufactured with slightly high level of complexity and cause difficulty for the user to perform the DIY assembly process. To reduce the burden experienced of the users, design principal of study table should be easy, simple, lightweight, and at the same time must be stable so that it can be assemble easily by the users (Kuznetsov, 2009).

1.5 CONCLUSION REMARK

This chapter introduces the major objectives of this project. The background for this project was briefly described to get a clear view on what problems that arise regarding this project. Details on the scope of this project have been discussed so that all the work and processes are relevant and within the main objective of this project.

CHAPTER 2

LITERATURE RIVIEW

2.1 INTRODUCTION

Literature review is a step of understanding every data related to this project. The data are come from all kind of research including journals, magazines, internet, any reference books or other kind of sources including having a survey, interviews and even taking seminar which is relevant to the project. Literature review is essential to get specific knowledge and information before making any development of the project. We can consider literature review as guidance for the progression and to make sure the ongoing project is still on the area of study. This chapter will summarize on the details of the scope of project, any equipment used and technology involved in the design of study table.

2.2 CONCEPTUAL DESIGN

The engineering design process has been depicted as a stream of potential designs for a new product that will fit the needs of a targeted group of consumer. Product development begins by determining what the needs are that a product must meet and problem definition is the first of the whole product development process, where understanding any problem that occur is crucial to reaching the best solution (Glegg, 1969).

2.2.1 Problem Definition

Further step to be taken in early stage of product conceptual is gathering information related to the product literature itself. The information that related to do the engineering design is of many types and occurs in many forms other than the written word. Some examples are come from costumer surveys and feedback, specs and drawings for previous versions of the product, and so many more relevant sources. By placing the gathering information step between the problem definition and concept generation step, we are able to find the crucial information needed to perform a creative concept solution (Dieter, 2009).

2.2.1.1 House of Quality (HoQ)

The House of Quality (HoQ) develops the relationships between what customers want from a product and which of the product's features and overall performance parameters are most critical to fulfilling those want (Dieter, 2009). The HoQ matrix (Figure 1) is the most recognized and widely used form of this method. It translates customer requirements, based on marketing research and benchmarking data, into an appropriate number of engineering characteristics to be met by a new product design (Terninko, 1997).

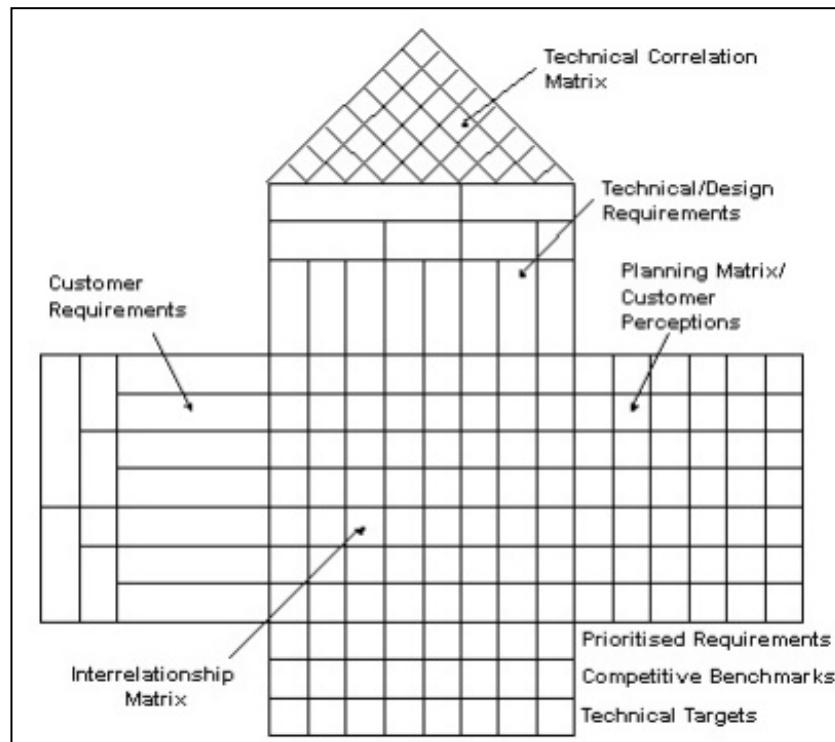


Figure 1: HoQ matrix translate customer requirement into engineering characteristic
(Source: Terninko, 1997)

2.2.1.2 Product Design Specification (PDS)

The product design specification (PDS) is a document listed the critical parameters, specifications and requirements for the product and it is a statement of what the product should be and should do (Dieter, 2009).

The PDS will constantly change throughout the project progresses as more information is gained. Detail is added as the design grows. The PDS is will be based on customer needs and the constraints imposed upon the system. The detail that will included in this project PDS are:

- Product identification
- Key project deadlines
- Physical description of the product

2.2.2 Concept Generation

Concept generation is a step in the product development when alternative design concepts are generated, evaluated, and selected. Terms design concept can be defined as an alternative that includes at least physical principles, abstract embodiments, geometric properties, and many more.

To get the best selection of design concept, brainstorming session must be included in the design process for generating creative ideas. The very first step in performing the best brainstorming session is defined the problem occur. Participants in brainstorming session must come out with their own free-flowing ideas and react to ideas of other participants by recalling their own thoughts about the same concepts (Dieter, 2009).

2.2.2.1 Functional Requirements

The engineering design specification is important to get the information on costumer and company requirements. But, sometime the information may lack sufficient details on specific function or sub function of the product. To overcome this problem, product component decomposition and product function decomposition is the way to clarify the product functional decomposition (Ullman, 1997).

Component decomposition diagram can be drawn by disassembled the product into their own respective components. It is a diagram of the parts and subassemblies that built up the product. The diagram (Figure 2) shows the hierarchical structure of component forms instead of functions. Subdivided the individual subassemblies into their own respective components, a better overall understanding of how individual component interact with each other is obtained (Eggert, 2005).