



UNIVERSITI TEKNIKAL MELAKA MALAYSIA

THE DEVELOPMENT OF MODULAR PRODUCT DESIGN: BOOK SHELVES

Thesis submitted in accordance with the requirements of the Malaysia Technical
University of Malacca for the degree of Bachelor of Engineering (Honours)
Manufacturing (Design)

By

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BORANG PENGESAHAN STATUS TESIS*JUDUL: THE DEVELOPMENT OF MODULAR PRODUCT DESIGN; BOOK SHELVESSESI PENGAJIAN : 2006/2007Saya MOHD TAJUDDIN BIN HARON

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APPROVAL

This thesis submitted to the senate of Universiti Teknikal Malaysia Melaka (UTeM) and has been acceptable as fulfilment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Design). The members of the supervisory committee are as follows:



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ABSTRACT

Most products in furniture industry are using integrated concept in which the manufacturer should have more designs for product radiations, more complex parts for assembly and disassembly, the interactions between blocks are ill-defined and may be incidental to the primary function of the product, the functional element of a product is implemented using more than one block and changing a block in an integrated product may influence many function elements and require changes to several related blocks. Besides, the customer demands products that are specifically address their needs, short delivery time, high quality, low price and a product that they can give added-value when buy the product. Moreover the customer demand is changing dynamically and difficult to forecast. Therefore modularization is concept that can offer competitive advantage to overcome this complexity. Modularization is a concept where each functional element of the product is implemented by exactly one module, and in which there are a few well-defined interactions between the modules with the simple definition this concept will reduce part so that the assembly process will easy. In order to visualize the concept of modular product, the design of book shelves is used in this project. Initially the concept of modular product, the advantages of modular product and comparison between modular and integrated product are presented. This is followed to by market survey about customer requirements in which the customer demands are identified and then translated by using simplified Quality Function Deployment (QFD) in order to strike balance between customer requirements and technological capabilities. Finally, several conceptual designs of book shelves from visualizing modular book shelves are presented so as to verify the practicality of the project.

ABSTRAK

Banyak produk di dalam industri perabot menggunakan konsep bergabung/berpadu (integrated concept) di mana pihak pengeluar harus ada lebih banyak rekaan untuk variasi produk, penggunaan banyak bahagian yang kompleks untuk pencantuman dan nyahcantuman, perhubungan antara blok yang boleh menyebabkan berlaku kerosakan dan mungkin kesan sampingan turut kepada fungsi utama produk. Fungsi elemen pada produk dijalankan menggunakan lebih dari satu blok dan pertukaran blok dalam produk pergabungan akan mempengaruhi banyak fungsi elemen dan memerlukan pertukaran beberapa blok yang berkaitan. Selain itu, permintaan pengguna khususnya kepada keperluannya, masa penghantaran yang singkat, tinggi kualiti, harga rendah dan produk boleh ditambah nilai apabila membeli produk tersebut. Bagaimanapun permintaan pengguna berubah secara dinamik dan sukar untuk meramalkan. Oleh sebab itu permodulan merupakan konsep yang menawarkan faedah persaingan untuk mengatasi kekusutan ini. Permodulan merupakan konsep di mana setiap fungsi elemen pada produk dijalankan dengan tepat menggunakan satu modul dan di mana diertikan perhubungan antara modul akan mengurangkan penggunaan bahagian menyebabkan proses pemasangan menjadi mudah. Untuk mengkaji penggunaan konsep modul, rekaan rak buku digunakan. Konsep produk modul, kelebihan dan perbandingan dibincangkan. Ini diikuti oleh kajian pasaran tentang permintaan pengguna yang akan dikenalpasti dan ditukarkan menggunakan QFD untuk mengetahui keseimbangan permintaan dan keupayaan teknologi. Akhirnya beberapa rekaan rak buku dari konsep modul akan dipersembahkan dan direka untuk pemilihan yang terbaik.

DEDICATION

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LIST OF ABBREVIATIONS

GT	-	Group Technology
C	-	Circuit
QFD	-	Quality Function Deployment
m ³	-	Meter cubic
s	-	Second
g	-	Gram
RM	-	Ringgit Malaysia
N	-	Newton
In	-	Inch
mm	-	Millimeter

CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

In this first chapter, an overview of the project is provided for the reader to become acquainted with this subject. The project's background and a short discussion about the problem are discussed followed by presentation of project's objective, scope and study approach.

1.2 PROJECT BACKGROUND

Manufacturing industries are facing proliferation of finish product, shorting product life cycles, quick response to market, fragmented market, unpredictable and dynamic customer demand that lead many companies to adopt a new concept to remain competitive in the global market. The scenario of current market most products for example in furniture industry are using integrated concept. A product embodying an integrated architecture is often designed so as to maximize a certain performance measure. Modifications to one component or feature may require extensive redesign of the product. Implementation of functional elements may be distributed across multiple blocks. Boundaries between the blocks may be difficult to identify or may not even exist. Besides, the customer demands products that are specifically address their needs, short delivery time, high quality, low price and a

product that they can give added-value when buy the product. Moreover the customer demand is changing dynamically and difficult to forecast. This leads company to high inventory cost wherever their product become obsolete and low return of investment in which they have to sell the product at very low price in order to empty out the warehouse. Therefore modularization is concept that can offer competitive advantage to overcome this complexity.

1.3 PROBLEM STATEMENT

The scenario of current market most products for example in furniture industry are using integrated concept in which the manufacturer should have more designs for product radiations, more complex parts for assembly and disassembly, the interactions between blocks are ill-defined and may be incidental to the primary function of the product, the functional element of a product is implemented using more than one block and changing a block in an integrated product may influence many function elements and require changes to several related blocks as shown in Figure 1.0.

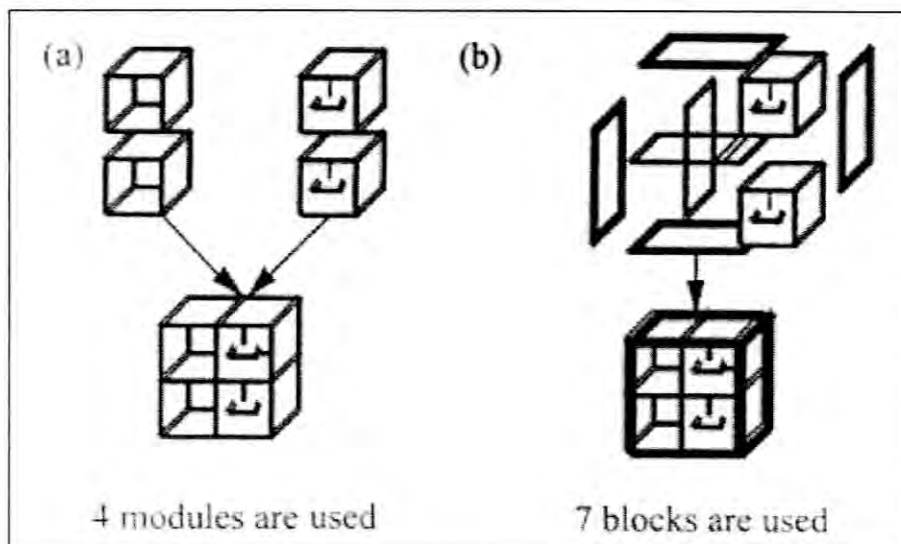


Figure 1.0 · Two design of a pieces of a domestic furniture [1]

The product is not easy to assemble where more parts should be combined to become a finished product. From the figure, it can be seen that the design needs a lot of joining parts such as screw, fastener, etc for assembly operation.

As a solution for this problem with using the modular concept two types of functions, the drawer and the open space, are allocated to separate modules, which in fact are mounted together and make up a piece of domestic furniture. The most modular architecture is the one where each functional element of the product is implemented by exactly one module, and in which there are a few well-defined interactions between the modules [1]. Therefore in this project the right attributes of modular product that perfectly match customer real demand are studied. In order to determine the optimum attributes of modular product, the customer true needs and desires are identified through market survey.

1.4 OBJECTIVES

The objective of this project is to develop conceptual design of book shelves through modular product based on the customer real demands.

1.5 SCOPES OF PROJECT

The scopes of this project are as follows:

- 1) Literature review of modular concept and product development.
- 2) Define customer's need through market survey and translation customer's need by Quality Function Deployment (QFD).
- 3) Development of conceptual design of modular design book shelves.
- 4) Analyze the conceptual design of modular design book shelves.

1.6 STUDY APPROACH

- 1) Questionnaire – to collecting the information data refer to student correspondent as a customer would like the concept design of the modular book shelves.
- 2) Quality Function Deployment (QFD) - a structured approach to defining customer needs or requirements and translating them into specific plans to produce products to meet those needs.
- 3) Function diagram - created based on customer requirements, identifying the input and output flows of materials, energies and signals, as well as the global function of the product.

CHAPTER 2

LITERITURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to provide an overview of integration design, modular design and QFD which enable a comprehensive understanding of integrated product, modular product and related issues. In the topic of modular design, an overview of definition, the drivers of modularity, the types of modularity and advantages of modular design. While the topic of QFD explain the definition of QFD, the history, the process and the tools of QFD.

2.2 MODULAR DESIGN

2.2.1 THE DEFINITION

There are several definition of modular product has been introduces by different scholars and practitioners. Some of the definitions are:

Scholars / practitioners	Definitions
Pahl and Beitz	<i>Modular products</i> refer to products, assemblies and components that fulfill various functions through the combination of distinct building blocks (modules) [2].
Pahl and Beitz	<i>Modular components</i> refer to components whose functional, spatial, and other interface characteristics fall within the range of variations allowed by the specified standardized interfaces of a modular product.
Langlois and Robertson	The mixing and matching of modular components in a modular product design can generate a potentially large number of different products in a modular product model consisting of distinct combinations of components that give each model distinctive functionalities, features, and/or performance levels [3].
Sanchez	An important form of <i>strategic flexibility</i> [4], i.e., flexible product designs that allow a company to respond to changing markets and technologies by rapidly and inexpensively creating product variants derived from different combinations of existing or new modular components.

In modular product the term of modularity is used to describe the use of common units to create product variants. It arises from the division of a product (part) into independent components, thus allowing one to standardize components and to create a variety of products. Modularity aims to identify of independent, standardized, or interchangeable units to satisfy a variety of functions. According to Huang, function modules help to implement technical functions independently or in combination with other functions and it can be classified into *basic*, *auxiliary*, *adaptive*, and *non-modules* [5], as listed below;

- 1) A *basic module* is a module implementing *basic functions*. Not variable in principle and are fundamental to a product or system.
- 2) An *auxiliary module* corresponds to *auxiliary functions* that are used in conjunction with the basic modules to create various products.
- 3) An *adaptive module* is a module in which *adaptive functions* are implemented. Adaptive functions adapt a part or a system to other products or systems. Adaptive modules handle unpredictable constraints.
- 4) A *non-module* implements *customer-specific functions* that do occur even in the most careful design development. Non-modules have to be designed individually for specific tasks to satisfy the customer needs.

2.2.2 CONCEPT OF MODULAR DESIGN

An important characteristic of product architecture is its modularity. The most modular architecture is the one where each functional element of the product is implemented by exactly one module, and in which there are a few well-defined interactions between the modules. The advantages of modular designs are such as a modular architecture allows a change to be made to one module without generally affecting other modules so that the product can function correctly. Besides, each module may also be designed quite independently of other systems.

Some of the motivators for product change are: upgrades, add-ons, adaptation, wear, consumption, use flexibility, and reuse and also modules allow changes to be made to a few isolated functional elements of a product without necessarily affecting the design of other elements.

2.2.3 THE DRIVERS OF MODULARITY

When it comes to system design, whether at an application level, platform level, production level or content level, modularity is critical to a successful design solution.

From the perspective of the owner/operator of the system, modularity is the key to ensuring the maximum return on the investment. Flexibility, maintainability, extensibility and scalability are all attributes that accrue to a modular system design. For example, at a platform level, a modular design makes possible the delivery of an environment that may be configured for different circumstances, while providing a framework in which the development of various parts of the system can evolve independently.

Modularity is also a key to the end user experience, making possible the delivery of experiences that are adaptive and dynamic. For example, a modular information architecture design makes possible the deployment of data driven, customizable web pages where both the composition and layout can adapt based on information contained in the users profile, such as level of experience or topics completed. Applied at the application level, a modular design permits the delivery of open-ended interactive exercises and tools, in which users are active participants, provided the opportunity to create, construct and configure the objects they are presented.

2.2.4 CLASSIFICATION OF MODULARITY

Based on the interactions within a product, three categories of modularity have been defined [6]:

- 1) *Component-swapping modularity* occurs when two or more different *basic components* are paired with a module, thus creating different product variants belonging to the same product family.
- 2) *Component-sharing modularity* is complementary to component-swapping modularity. Various modules sharing the same *basic component* create different product variants belonging to different product families.
- 3) *Bus modularity* occurs when a module can be matched with any number of *basic components*. Bus modularity allows for variation in the number and location of basic components in a product while component-swapping and component-sharing modularity allows only for the types of basic components to vary.

2.2.5 ADVANTAGES OF MODULAR PRODUCT

One of the most common motivators for promoting modularity is the need to allow a large variety of products to be constructed from a much smaller set of different modules and components. The result is that any combination of modules and components, as well as the assembly equipment, can be standardized discussed by Ulrich and Tung [6]. Potential benefits of modularity include [8]:

- 1) Economies of scale. Since each module will usually be produced in relatively large quantities, natural economies of scale arise.
- 2) Increased feasibility of product/component change. Since each module interface is strictly specified, changes can be made to a module

independently of other modules, provided the interfaces remain within specifications.

- 3) Increased product variety. The use of modules means that a great product variety can be achieved using different combinations of modules.
- 4) Reduced order lead-time. Since modules are manufactured in relatively large volume, the logistics of production can be organized so as to reduce manufacturing lead time. Hence, the order lead time can be reduced.
- 5) Decoupling tasks. Since the interfaces and modules have been standardized, their interfaces enable design tasks and production tasks to be decoupled. This decoupling can result in reduced task complexity and in the ability to complete tasks in parallel.
- 6) The ease of product upgrade, maintenance, repair, and disposal. Since a product is decomposed into modules, only certain modules need to be replaced when repair is done. For the same reason, upgrades, maintenance, and disposal are also made simpler.

Modular Product Architecture provides the following cost-saving benefits while enabling product differentiation [9]:

- 1) Reduce Product Complexity
- 2) Increase Part Re-use
- 3) Reduce Part Count
- 4) Enable Configurable Products
- 5) Enable both top down and bottom up design processes for optimal efficiency