

Development of a Multifunctional Dining Table Design Using the Ergonomic Function Deployment Method

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Abstract— The room that is not too wide makes the residents of the house have to be smart in the arrangement and selection of goods. That is why, the use of multifunctional furniture is needed to have more than one use in one product. By using multifunctional furniture, it is also useful in facilitating user activities because of its flexible nature. The concept of multifunctional furniture design to save space should take into account the rules of ergonomics by prioritizing user comfort and safety. The design of the multifunctional dining table in this study uses the Ergonomic Function Deployment method which is the development of the Quality Function Deployment method by considering the ENASE aspect (Effective, Comfortable, Safe, Healthy, and Efficient). The design proposed is comfortable to use and has flexibility that can be adjusted to the user's needs with limited space. This dining table is also equipped with storage space at the bottom and is easy to move around.

Keywords— Design, multifunction table, EFD.

I. INTRODUCTION

The population in big cities is increasing every year [1]. One example is Malang city, as the second-largest city in East Java Province which become a center of economic activity and education center [2]. The Central Statistics Agency (BPS) of Malang City released the results of the Population Census (SP2020) which recorded the population of Malang City in September 2020 was 843,810 people. In a period of ten years since 2010, the population of Malang City has increased by around 23,567 people. (<http://kominfo.jatimprov.go.id/read/umum/bps-sp2020-sum-penresident-kota-malang-843-810-jiwa>).

The increase in population has resulted in the development of industrial estates, housing complexes, and buildings in the city center. Population density results in cases of limited land for housing.[1] While the area of Malang City is 110.06 square kilometers, the density of Malang City is 7,636 people per square kilometer. This figure increased from the results of SP2010 which recorded a population density of 7,453 people per kilometer (<http://kominfo.jatimprov.go.id/read/umum/bps-sp2020-sum-penresident-kota-malang-843-810-jiwa>). Cluster housing is one solution to the growing population and rampant housing development in urban areas. The selling price of houses continues to increase and the movement of residents to cities is forcing people to live in houses with limited land [1].

One example is the Javelin cluster housing located at Jalan Atletik Tasikmadu Lowokwaru Malang City with a building area of 40 m² and a land area of 50 m² consisting of 2 floors and has 3 bedrooms, 2 bathrooms, living room, and an integrated kitchen. Type 40 houses are relatively smaller, suitable for small families of 3-4 people to live in. A room that is not too wide makes residents have to be smarter in the arrangement and selection of items stored in the room. Like the selection of furniture that is not too big so as not to give the impression of being cramped in the house [1].

The use of multifunctional furniture is needed where it is expected to have more than one use in one piece of furniture. By using multifunctional furniture, the space for movement becomes more spacious. Multifunctional furniture is also

useful in facilitating user activities because of its flexible nature. The concept of multifunctional furniture to save space has spread and become popular recently. However, only recently has the community realized the case for multifunctional furniture in terms of needs and comfort. [3]. Multifunctional furniture is very suitable for use in small residential areas. With only one piece of furniture, the user can get more than one use which is more efficient and offers more benefits [3].

The design of a multifunctional dining table in this study uses the Ergonomic Function Deployment method. In designing a product, the functional aspects are considered as the priority aspects to help solve existing problems. The function is the main aspect of the design so that the resulting product design has a clear function [4]. In addition, it is necessary to consider ergonomic aspects, namely analyzing and considering the interaction between humans and their products and work environment. Human activities when using products in the form of gestures and body movements will have an impact on the condition of the human body [4].

II. LITERATURE REVIEW

A. Product Development

Product development is very important nowadays considering that many products are made without considering the function of the product. The purpose of product development is to make work easier and improve work both at home and in the company environment. The stages to start product development are [5].

- Product planning.
- Identification of consumers, by knowing the needs and desires of the user or the user is expected to provide innovation and added value to the product to be designed.
- Provide decisions for product specifications so that the product designed can determine the components in this product.
- The preparation of the product concept must be seen from the design until the work system that will use on the customer.

- e. The aim of the concept product is to see and reassess product concepts that have been planned before based on customer needs.
- f. Concept testing is carried out so customer needs have been planned before being fulfilled.
- g. The design of the product architecture is carried out based on the product function that has been made and makes the components of the product.
- h. The industry design applied ergonomic aspects to avoid injury until the sense of security to use this product.
- i. The aim of design for a manufacturing process has made is to support the product that has been designed before so that the product created can provide benefit or value to the customer.
- j. Creating a prototype, like a product description before the product will be manufactured with dimension or actual size.
- k. Economic analysis is very important to make a decision whether the product is useful or not [5].

B. Ergonomic Function Deployment

Ergonomics is a discipline that includes safety, security, and comfort. Ergonomics is also concerned with optimization, efficiency, health, safety, and human comfort at work, at home, and in recreational areas. Ergonomics is the study of the interaction between humans, facilities, and their environment with the main goal of adapting the work environment to humans [4].

To overcome a problem, it is necessary to apply an ergonomic principle known as ENase (Effective, Comfortable, Safe, Healthy, and Efficient). Ergonomics has a function that can provide convenience for humans in doing a job. The main objective is the creation of an integrated human-machine system design so that effectiveness, productivity, and work efficiency can be optimally achieved and obtain a suitable, safe, comfortable, and healthy system and environment. The goal of ergonomics is to increase users so that they can achieve high work performance in comfortable, safe, and peaceful conditions [6].

The explanation about ergonomic aspects is:

1. Effective, this aspect put forward the goal have been planned before.
2. Comfortable, this aspect stated that the condition to avoid the anxiety.
3. Safety, this aspect put forward free from risk or the things can be injured by people.
4. Health, this aspect is the condition who avoid from disease or health problem.
5. Efficient, this aspect is the achievement a goal has been planned before by considering all sides, from costs, power, and time spent. [5]

Ergonomic Function Deployment (EFD) is a method of developing Quality Function Deployment (QFD). In product design, in addition to paying attention to the needs and desires of consumers, the ergonomic aspects of the product are also considered when used. EFD is a development of QFD (Quality Function Deployment) by adding a new relationship between consumer needs and the ergonomic aspects of the product [7]

by adding a new relationship between consumer desires and the ergonomics of the product. This relationship will complete the form of the house of the quality matrix which also translates into the desired ergonomic aspects [8].

The following explains the section on the HOE for the Ergonomic Function Deployment method [9].

1. Part A

Contains a number of customers' needs and wants, the determination of consumer wants is what is usually determined based on qualitative market research.

2. Part A1

Is a translation of consumer needs that are included in the aspect of ergonomics. This translation must be carried out properly in order to facilitate the design team in determining the characteristics of the technical aspects.

3. Part B

In part B, there are 3 pieces of information, namely: the level of interest, needs, and desires of consumers; data on the level of consumer satisfaction with products produced by companies and competitors; and strategic objectives for the new product or service will be developed.

4. Part C

Contains these technical characteristics that usually describe the product being designed. This technical character is usually a translator of customer wants. For each of these technical characteristics, the unit of measurement, the direction of goodness and targets to be achieved are determined. While the direction of goodness is divided into three:

- a) The more the better (MTB) or the bigger the better, the maximum target is unlimited.
- b) The less the better (LTB) or the smaller the better, the maximum target is zero.
- c) The is the best (TB) or optimal value, the maximum target is as close as possible to a nominal value, there is no variation around that value.

5. Part D

Contains management's assessment of the strength of the relationship between the elements contained in the technical requirements section (matrix C) to the consumer needs (matrix A) that it affects. The strength of the relationship is indicated by using certain symbols.

6. Part E

The fifth part of the HOE is the technical correlation, a matrix that looks like a roof. This matrix shows the relationship between one attribute and another.

7. Part F

The very bottom of this HOE shows a list of technical specifications that will satisfy consumer needs. This matrix contains three types of data, namely:

- a) Technical Response Priorities, order of importance (rank) of technical requirements.
- b) Competitive Technical Benchmark, information on the results of the comparison of the performance of the technical requirements of the products produced by the company to the performance of competitors' products.
- c) Technical targets, performance targets for technical requirements for new products or services to be developed.

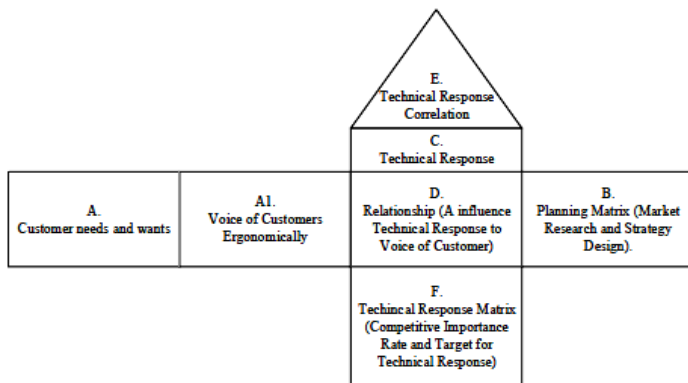


Fig. 1. Matriks House of Ergonomic

B. Anthropometry

Comfort in a commercial facility cannot be separated from the application of ergonomics, which of course is closely related to user comfort and the application of anthropometry [10]. Anthropometry is a field of science that deals with the dimensions of the human body. These dimensions are divided into statistical groups and percentile measures. If a hundred people were standing in a row from smallest to largest in order, this would be classified from the 1st percentile to the 100th percentile. This human dimension data is very useful in product design with the aim of finding the compatibility of the product with the humans who use it.

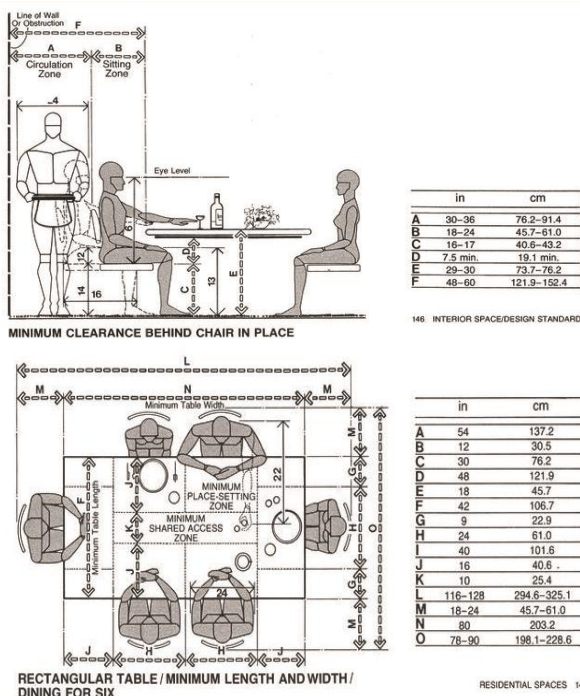


Fig. 2. Application of Dimensions on a Standard Dining Table Size of a Shared Dining Table (Source: Panero, 2003)

Anthropometry is widely applied in the product design process by considering ergonomic aspects. Anthropometric data will basically differ based on several data groups based on age, gender, ethnicity, occupation. and body position [11].

The anthropometric data obtained will be widely applied, among others in terms of [12]:

1. Design of work areas (work stations, car interiors, etc.).
2. Design of work equipment (tools, machines, etc.).
3. Design of consumer products (clothing, chairs, tables, etc.).
4. The design of the physical work environment.

Anthropometry used to determine table height is the anthropometric dimension of elbow height in a standing position. Meanwhile, the length of the table is determined from the anthropometry of the reach of the arm to the side, and to determine the width of the table, anthropometry of the elbow span is used when sitting.

III. METHODOLOGY

The method used in this research is the Ergonomic Function Deployment (EFD) method. This study uses primary data and secondary data. Primary data in this study is collected by distributing questionnaires to the residents of the housing complex. The questionnaires aim to explore comments and facts that support the formulation of problems and solutions to user wants and needs as solutions to problem-solving.

The stages in the research are as follows:

1. Survey of housing occupants who will use furniture later, aims to identify attributes tested from two references, namely product quality dimensions, and interviews.
2. Determine Research Problems and Objectives.
3. Literature Study
4. Data collection for the Ergonomic Function Deployment (EFD) method with primary data in the form of a questionnaire. The questionnaire contains seven statements to residents of 20 to 40 years in age. The statements cover the ergonomic aspects of ENASE (Effective, Comfortable, Safe, Healthy, and Efficient). Parameters used with Likert Scale. In the measurement, the form of opinion or agreement has five choices, namely strongly disagree, disagree, neutral, agree, and strongly agree. To find out the needs and desires of users.
5. The next step is to create a House of Ergonomics (HOE) by connecting the attributes that have been created by researchers and filled with respondents as users. The House of Ergonomics (HOE) finds out what the customer needs for the product to be designed. After knowing what the customer needs, determining the planning matrix, and prioritizing.
6. After determining priorities, the next step is to design a product concept [5].
7. Concept Selection
8. Several alternative multifunctional dining table designs were then selected for the concept. The choice of the concept is to compare the resulting prototypes. In the concept selection process, the assessment of the matrix on the resulting prototype is carried out. The assessment uses a rating scale [13].

IV. RESULTS AND DISCUSSION

The ergonomic Function Deployment approach is carried out to translate operator wants and needs into a more ergonomic form. This approach is carried out by using data analysis of the needs of dining table users wherefrom the wishes of existing users, it will produce a more specific need statement to fulfill the product concept in an ergonomic design.[14]

IV.1. Research Objects and Locations

The object and location of this research are the type of furniture in the cluster housing Royal Atletik Residence and Javelyn Tasikmadu Malang City with a narrow area of land area of 50 m² and 60 m² while the building area is 36 m², 40 m², and 50 m².

IV.2. Population and Sample

The population taken in this study is the owner of the house in the Javelyn Tasikmadu housing, Malang City. The method used in this sampling is random sampling, namely the sampling of population members is carried out randomly without regard to the existing strata in the population. The sample in this study was 60 homeowners, with the age range of 20-50 years.

IV.3. User Needs

The needs and desires of furniture users are related to ergonomic aspects (Ergonomic User Needs). Data processing starts from the Planning Matrix to the Technical Matrix which is a step in making the House of Ergonomic matrix for a multi-functional dining table. The results of data processing are obtained in the order of importance (rank) from the Technical Response according to the expectations of furniture users. The determination of the order was based on the highest normalized contributions is shown in the following table, regarding the ENASE principle.

TABLE 1. Analysis of User Needs Data

Aspect	Product Attributes	Rank
Effective	Portable and multifunctional dining table	5.0
	Flexible dining table	
Comfort	Comfortable dining table with ergonomic design	4.95
Safe	The dining table has long durability and is not easily damaged	4.89
Healthy	Easy to care	4.0
Efficient	Modern furniture	4.8
	Elegant color	

The order of importance (rank) from the Technical Response is used as the basis for making decisions in the design of a multifunctional dining table based on Ergonomic Function Deployment (EFD), so that an improvement strategy is produced to determine whether the design is ergonomic or not.

The technical specification of the dining table is an interpretation of the attributes obtained from identifying user needs. Determination of specifications is based on the derivation of the multifunctional dining table matrix. Making technical specifications consists of attributes, matrices, technical specifications, units, and criteria, as can be seen in

Table 3.

TABLE 2. Interpretation of User Needs on the technical aspects of the Multifunction Dining Table

Primary Needs	Secondary Needs	Tertiary Needs
Multifunctional dining table	Function	Comfortable furniture with an ergonomic design
	Price	Furniture prices at affordable prices
	Durability	Products has long durability and is not easily damaged
	Serviceability	Easy Maintenance Multifunctional
	Features	Modern furniture Elegant color

TABLE 3. Implementation of Design Criteria on Technical Specification

Design Criteria	Technical Specification
Portable and multifunction dining table	Folding system, easy operation
Flexible dining table	Dining table features
Comfortable dining table with an ergonomic design	Dining table dimensions
Products has long durability and is not easily damaged	Durable material
Easy Maintenance	Materials that are easy to clean and replace the components
Modern Furniture	Dining table shape
Elegant color	Design

The results of the calculation of anthropometric percentiles can be seen in Table 4 below.

TABLE 4. Anthropometric Calculation Results

Anthropometry	Percentile (cm)		
	5%	50%	95%
Elbow height when sitting	68	80	90
Side arm reach	66.5	72.3	76.75
Forehand reach	65.5	71.3	75.75

Design considerations:

- It has an ideal shape and structure for small dwellings with a minimalist concept.
- Compact product so that eating activities can be more accommodated.
- The product has a large storage capacity with a storage area at the bottom of the dining table.
- The product can be moved around as needed by being equipped with wheels on the legs of the table.

Based on the selection of the multifunctional dining table product concept, the design has several different positions and functions. The dining table can be used as a storage cupboard and has the flexibility of ease of use and storage.



Fig. 3. Multifunction dining table

Product specifications:

1. Table Material: Particleboard and medium-density fiberboard (MDF)
2. Finishing: HPL with white and wood motifs
3. The Multifunction Dining Table has dimensions of 80 cm long (normal), 125 cm long (if the table is extended); Width 35 cm (normal); Width 80 cm (if the table is extended); Height 78 cm.
4. The legs of the dining table are also equipped with wheels to facilitate the movement of the dining table.

V. CONCLUSION

Using the Ergonomic Function Deployment method, a multifunctional dining table design that can accommodate user activities is produced. This design is comfortable to use and has flexibility that can be adjusted to the user's needs with limited space. This dining table is also equipped with storage space at the bottom and is easy to move around. The dimensions of this multifunctional dining table are Length 80 cm (normal), Length 125 cm (if the table is extended); Width 35 cm (normal); Width 80 cm (if the table is extended); Height 78 cm.

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