DESIGN OF MULTIPURPOSE MODULAR, FLEXIBLE AND SPACE-SAVING DINING TABLE

Emil Varghese, Sudhindra Kumar, Lohit H S
1-M.Sc. [Engg.] Student, 2-Asst. Professor, 3-Asst. Professor, Department of PD
M. S. Ramaiah School of Advanced Studies, Bangalore 560 058

Abstract
A majority of Indian middle class population are living in small flats and homes this is mostly because of their economy scale as well as the lack of space availability for living. But in the present scenario furniture occupies a majority of the space in the home interior. To overcome this problem the furniture should be modular or should have a multipurpose than their primary function. This study is to design and develop a multipurpose modular flexible, space-saving dining table for Indian middle class homes.

User study was conducted to understand the lifestyle, need and comfort as well as different activities associated with specific home interior and furniture. Several furniture design stores where visited in order to understand the present market scenario, demand and needs of the customers. Existing dining furniture was analyzed in detail including its components and parts and their assembly and sub-assemblies. After the data collection the user needs were analyzed and QFD was generated. Priorities in the QFD were modular, flexible, shape and size. PDS was arrived at based on the QFD. Five concepts were developed and based on PDS and one concept was finalized for further detailing. Final concept was selected using weighted ranking method by evaluating all the concepts. Drawings were developed for final concept, a prototype was made and ergonomic validation was done. In stowed form, the proposed concept is found to occupy just less than 25% of its deployed area. We thereby believe that the proposed design will largely suit the constrained space conditions of the urban segment in India.

Keywords: Multipurpose, Modular, Flexible and Space-Saving Dining Table

Nomenclature
- mm millimetre
- cm centimetre

Abbreviations
- CAD Computer Aided Design
- PD Product Design
- PDS Product Design Specifications
- QFD Quality Function Deployment
- STEP Standard for the Exchange of Product Data

1. INTRODUCTION

Furniture can be defined as a class of designed objects which provides utility functions such as sleeping supporting, service and sanitation. In the present scenario the furniture has become a style substance in each and every home. The family members give utmost care for the selection of their furniture and now it is a product considered to be as a form of decorative art. In olden times the furniture's are made up of woods and related items but now a lot of development has been happened and now the furniture's are made including material, plastic eco friendly materials etc [1].

1.1 Stainless Steel Pipe:
Stainless steel pipe, tubing, rectangle and square blocks are used in tables for variety of reason to resist corrosion and oxidation, to resist high temperatures, for cleanliness, and low maintenance costs, and to maintain the purity of materials which come in contact with stainless. [2]

1.2 Ergonomics in Design:
Dr. Subir Das [3], says that ‘Ergonomics in design’ is essentially the study and application of ergonomics principles throughout the process of design to make it user friendly, safe and cost effective with a view to get optimal human performance. It is concerned with people's strengths, capabilities and limitations, and with comfort, safety, convenience, and operational requirements. Therefore, all products must include ergonomics considerations from an early stage in their design.

1.3 Ecodesign:
Ecodesign [4] is an approach to the design of a product with special consideration for the environmental impacts during its whole lifecycle.

Eco furniture design now becomes a trendsetter in 2010. Design companies like West Elm and Pratt Design Incubator for Sustainable Innovation proudly presents furniture design through eco-friendly designs. Office furniture design gives pleasant environment and become trendsetter 2010. Eco designs have large collections that
can sustainable furniture design and their collection includes tables, chairs, LED lights that efficient in energy and cost.

2. THE DESIGN METHODOLOGY

A systematic design methodology is followed to achieve reliable and most suitable solution. It involves the following steps.

- Literature survey
- Market study and product study
- Bench marking product
- User study
- QFD Matrix
- PDS
- Concept generation and selection
- Physical modeling and validation

3. JOURNAL PAPERS AND PATENTS REVIEW

3.1 Patent 1

Douglas G. Wright says [6] that foldable type table and chair is desirable for apartments, who have limited living space and need to occasionally store bulky furniture. In this furniture including the hinge of the table which is serving as carry handle.

3.2 Patent 2

Morris Tolleson says that the table is design such a way that, have four independent circular rotatable trays stacked one on another, can rotate in its central axis. Its save space to accommodate the food stuffs [7]

3.3 Patent 3

St. John’s says that the main object of the invention is to provide a combination folding table and foldable chair for use in public halls, in restaurants and in house when the rooms are small. [8]

4. DATA COLLECTION AND ANALYSIS

4.1 Product Study

A table is a type of furniture featuring a flat and stationary horizontal upper surface used to support objects of interest, for storage and dining. The surface must be held stable by support from below by either a columnar base or legs. [11]

Tables come in a wide variety of materials, shapes, and heights that depends on their origin, style, and intended use. All tables are composed of a flat surface and a base with one or more supports, or legs. A table with a single, central foot is a pedestal table. Tables can be freestanding or designed for placement against a wall (a console table). Table tops can be in virtually any shape, although rectangular, square, round and oval tops are the most frequent. Long tables often have extra legs for support.

4.2 Different Types of Dining Table

- Wood Dining Table
- Veneer Dining Table
- Glass Dining Table
- Plastic Dining Table

All types of tables have some advantage and disadvantage. The customer buys the dining table according to their requirement. In terms of aesthetics, the choice of dining table material affects the look surrounding. For example, a wooden table looks more classic and warm than the glass and metal combination. [13] Different types of dining table shown in the Fig.
4.3 Types of Material

For manufacturing dining table commonly used materials are wood, plywood, glass, plastic, aluminum-frame and stainless steel-frame. They are shown in the Fig. 3.7.

4.4 Types of Table Hinges

Different types of table hinges are available, and the type best suited for table depends on the size, shape and weight of the table. Certain tables extend for more space, requiring the type of table hinge that slides and locks into place. Folding tables need a hinge that will fold and lock into place. Type of table hinges given in the Fig.

- Butler tray hinge
- Card table hinge
- Drop leaf table hinge
- Table leg hinge
- Pivot hinge
- Butterfly hinge
- Railway hinge
- Blotters hinge
- Butt hinge

4.5 Different Folding Mechanism Dining Tables

- Leg foldable type
- Wall attached
- Folding the table top as well as legs
- High adjustable type

4.6 Different Shapes of Dining Table

- Leg foldable type
- Wall attached

4.7 Market Study

A market study has been conducted on the furniture segment and studied the present market and collected various data shown below the output. The market study is having an important role in product design and new product development. So market trend and study of new arrival of products have been understood by conducting market study.
4.8 Bench Marked Product

Wood colour MFC board with environmental friendly painting, table top could be folded from the half position is shown in the Fig. 3.14. And then be turned round to be a small table which could be used as laptop table and tea table. When it is expanding, it has 8 positions if there are only four or two people, only need to fold it. Round and flat steel tube with powder painting, anti-rust aesthetic and easy to assemble. Easily control, can be stopped at any height from 250 to 800mm.

Fig. 28 Bench marked product

Features:
- It has a expandable and foldable platform
- It occupies less space in room
- It has height adjustable feature for multipurpose
- Aesthetically good in look
- It is a modular and light weight dining table

4.9 User Study

User survey and research is necessary and one of the most important steps in product development cycle. A proper survey helps in defining a problem and hereafter generating relevant concepts for improvements. Understanding user requirements is the starting step of any design activity. It now widely understands of the needs and requirements of the users.

Fig. 29 User study

Clips which is hold the plastic sheet are rested due to continuous contact with water
Sharpe edge of the table which get hurt in on the hand wrist area
Don’t have sufficient space while 2 people use the table
Sharpe corner and edges make harm to body while passing near by the table
Dining table was used as ironing table
Table is covered with the plastic sheet to avoid wood spoilage and easy to clean

4.10 Main Observation of User Study

- Existing dining furniture ranges was analyzed in detail including its function, assembly and parts
- Table is used as multipurpose like cutting vegetables, sometimes used as writing purpose
- Size if the table is 3 feet x 4 feet, 4 feet x 6 feet etc
- Most of them preferred wooden dining table
- In flat and apartment’s people feel uncomfortable, if a big table occupied their maximum space in the dining room space
- Cost of the table should be with in Rs.5000 to 9000
- The table should occupy around two to four peoples
- Dining table is not only used for dining but for other purpose
- Wood is the preferred material for the people
- People not comfortable with the current dining table
- Present dining table is immovable
- Table occupying more space in the dining room
- It’s not ergonomically designed, most of them are manufactured by the local carpenter
- People staying in flat have less space and keep big table is very difficult

4.11 Ergonomic

Fig. 15 Table height

5th Percentile = 634 mm
50th Percentile = 745 mm
95th Percentile = 825 mm
5. CONCEPT GENERATION AND SELECTION

5.1 Mind Mapping
Mind mapping technique is used to visualize various ideas. So this classification considered all the aspects for the concept design.

5.2 Life Style Board
Life style board was prepared to understand the Indian middle class life style.

5.3 Visual Theme Board
Theme board was prepared to understand the various products used by the user, which helped to generate the form of concepts. Other than the form, the design aspects in the product which help to generate concepts that can bring out hidden aspirations and user emotions were also considered during concept generation. iPod, mobile phone, chair, watch, pen drive are taken from fig. 20 to construct the theme board.

5.4 Doodles
Five different concepts were designed based on the PDS as shown below.

5.5 Concept 1
For making the concepts more modular and flexible the design of the table should be in such a way that it should be folded and can be easily stored. The first concept was derived from the folding mobile phone which is usually used by female users. The mobile is foldable making it handier than any other mobile in the market. This feature only attracts the users to use the particular mobile. The main theme of the concept was the folding theme in which the table was foldable; this makes the
concept more flexible and modular. The working principle of this concept is shown in fig. 22.

**Fig. 22 Different stages of the concept**

This concept comes in handy for entertaining guests. Multipurpose folding table is great for dining or for use as a serving table. Folding table made of wood are strong, durable, easy to transport and simple to setup. India is a home for attractive artwork that fascinates the combination of aesthetic as well as creative ideas.

**Fig. 323 Part details**

### 5.6 Concept 2

This concept is more modular and flexible that the design of the table should be in such a way that it should be folded and can be easily dismantled stored. This concept was derived from the laptop. The laptop is foldable making it handier. The main theme of the concept was the folding theme in which the table was foldable; this makes the concept more flexible and modular. The working principle of this concept is shown in the Fig.

**Fig. 33 Different stages of the concept**

In the closed condition two people can sit comfortable and have food. This concept comes in useful for entertaining guests. Folding table is great for dining or for use as a serving table. Folding table made of wood are strong, durable, the combination of aesthetic as well as creative ideas. Wooden folding tables have easy-slide action, with leg locks that gets engage when opened.

### 5.7 Concept 3

This concept was generated from folding chair the folding mechanism taken to this concept. The concept sketch was generated to suit the theme. In this concept rectangular shape frame is used. Hollow square rod are used so that easy to manufacture the frame. Folding type frame is used so that after used can fold the frame and save the space additional attachment given for making chapatti and vegetable cutting. It’s have a height adjustable mechanism when the user need more height. this concept is more modular multipurpose and flexible and space saving dining table that the design of the table should be in such a way that it should be folded and can be easily stored. This concept was derived from the folding chair.

**Fig. 345 Part details**

### 5.8 Concept 4

This concept was generated from compact watch and the folding mechanism taken to this concept. In this concept rectangular shape frame is used. Hollow square...
rod are used so that easy to manufacture the frame. Folding type frame is used so that after used can fold the frame and save the space. This concept is more modular multipurpose and flexible and space saving dining table that the design of the table should be in such a way that it should be folded and can be easily stored. More people can accommodate because of the oval shape. Different stage if the dining table is shown in the fig. 28.

![Fig. 378 Different stages of the concept](image)

Standard screws and hinges are used for folding mechanism. Round pipe is used for easy rotating. In the open condition the flat surface of the leg will butt to the top platform is shown in the Fig. 5.17

![Fig. 29 Part details](image)

5.9 Concept 5
In this concept hollow rectangle with E-shape frame is used in the fig. 30. This concept was generated from pen drive. Sliding and folding table top mechanism given to this concept. Hollow rectangle rod are used so that easy to manufacture the frame. This concept is more modular multipurpose and space saving dining table.

![Fig. 30 Different stages of the concept](image)

5.10 Final Concept Selection
Pugh's method is used to understand which among the selected concepts are best. In this method, all the features and specifications are compared to the benchmarked datum. Ratings are given in terms of plus, minus and same. At last all these individual ratings are summed up to get the total plus, minus and some of the individual concepts. After this process, the concept that comes high in ratings is taken as the final concept.

Concept 3 got high rating from the 5 concepts. Concept 3 is differing from other 4 concepts because of height adjustment facility and collapsible type. It was declared that ergonomics plays an important role in folding table design. Usability and functionality of the product should be appropriate when it comes to small homes. The height adjustment can do by manual.

![Fig. 32 Concept selection](image)

Comparing to all other concepts, concept 3 is the
ergonomically designed concepts and can fulfil the customer needs.

6. DETAILED DESIGN

Detailing of various parts of the selected concept has been done. Detailed engineering drawing and CAD drawing was done for making the prototype.

6.1 Selected Concept

Fig. 33 Selected concept

Fig. 384 Different stages of the concept

6.2 Final Concept Detailing

Fig. 35 Final concept detailing

6.3 Product features

- Easy to transport
- Collapsible
- Flexible storage
- Affordable
- After use hang it on wall
- Enough leg space
- Simple to set up
- Made of wood and hollow steel frames
- Fillet corner to avoid disturbance
- Strong and light weight

6.4 Prototype

Detailed drawing was created in CATIA as shown in Fig. 5.23. This drawing was 1:1 model and used the same as template for prototype.

i. Selection of the Material

The material is selected according to the model. Material used for prototype are plywood, fevicol, chrome paint, standard screws and nuts, clams, mica sheet, nails, welding rod, table hinge, 19mm square hollow rod and 20mm X 30 mm hollow rod are used.

ii. Machines and Tools Used for Mock Up Model

- Machines and tools used for mock up model
- Drilling machine
- Welding machine
- Painting machine
- Wood cutting machine
- Spanner
- Player

iii. Welding and Assembly of Frame

First as per the dimension the hollow rod was cut in to pieces and drilled holes in required area. Then weld the edges as per drawing and made the frame ready. Assemble the legs to the frame with nuts and bolts.

Fig. 36 Welding and drilling the frame

iv. Checking the Assembly and Mechanism

After assembling the legs to the frame, it is important to check the folding mechanism of the frame so after assembling the folding mechanism of the leg and the folding of the frame were checked. The frame was ready for assembling the top platform.

Fig. 37 Frame assembly

v. Sizing of the Top Platform

The plywood was machined to the required dimension.

Fig. 38 Plywood assembly

vi. Assembly of the top Platform and painting

After sizing the plywood, fixed it on the top of the frame and applied the fevicol on the plywood and sticks.
the mica sheet on the play wood. After assembly and sticking, painting has done on the frame and makes ready the folding table.

![Fig. 39 Painting and finishing](image)

vi. Final prototype model

Final working prototype is shown in the Fig. which is in closed and open condition is shown in the Fig. 40 and 41.

![Fig. 40 Final prototype model](image)

6.5 Validation

Validation of the selected concept was done by making working prototype. In order to understand the ergonomic issues of the dining table, validation has been done with some users. Manufacturability of the concept also was validated through the prototype. The final prototype was produced in front of users of targeted age group. Their opinion and suggestions for improvement were documented. The usability and ergonomics of the product was appreciated by the users. Main suggestion received for the improvement was to make the product more modular and compact.

![Fig. 41 Validation](image)

7. SUMMARY

This study has helped to develop the product design skills. The product study, market study and the user study helped to understand the present modular dining table in the market and the main problems the users face during the product interaction with the user. From the identified needs ergonomic design, mechanism and safety were prioritized by Quality Function Deployment. Product Design Specification was generated based on QFD and five different concepts were created through mind mapping technique. Digital modeling was done using Alias studio tools and hyper shot software was used for better visualization. Final concept selection was done using Pugh selection matrix by comparing the bench marked product. A prototype of selected concept was made for validating the final concept. In stowed form, the proposed concept is found to occupy just less than 25% of its deployed area. We thereby believe that the proposed design will largely suit the constrained space conditions of the urban segment in India.

8. REFERENCES


