

Development of Convertible Table and Shelf

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Abstract : This convertible table and shelf is a multipurpose furniture designed to help the small room owner to save more space by using dual function furniture in a small room. It is one of the developments that helps small room owners to consume a lot of free space after minimising the amount of furniture used. This type of problem is common among students and small room or house owners. This furniture may function as both a table and a shelf at the same time, or it can function fully as a shelf or even entirely as a table by transforming using a slider mechanism. It has the features of being portable, user friendly and reduces the space used in a room. It can be placed in a less or equal to 100 ft square size room. Both the table and the shelf can hold a maximum load up to 35 kg based on the stress and strength analysis simulation that had been done using SolidWorks software. In the ergonomic aspect, the height of the furniture can be adjusted according to the comfort of the user when functioning as the table. Moreover, this convertible table and shelf also has an important aspect for safety conscious users which is the safety lock function. The lock system will prevent the furniture from changing or folding from one shape to another. This will be accomplished using fasteners, and it will only be able to convert after the lock feature is gone. This dual function furniture is designed using SolidWorks software. The physical design is created in accordance with the work sequence, which includes measuring, cutting, drilling, welding, and finishing.

Keywords: Space Saving, Ergonomic, Multipurpose, Drilling, Cutting

1. Introduction

A table is a piece of furniture with a flat top and one or many legs. Table usually utilized as a surface for office work, utility work, serving and consuming meals and for placing items on. Some common types of tables are the study table, coffee table, dining room table and bedside table. Other than that, there are also a variety of specialist tables such as drafting tables and sewing tables which are used to create architectural drawings [1].

A shelf is a long, flat, and horizontal plane used to display or store items on it. Shelves can improve the usage of storage capacity, so it is one of the essential pieces of furniture to have in every home. The usage of shelves makes it easier for users to remove, insert, arrange, and count items without any disturbance. There are various types, sizes, and designs of shelves in the market that allow users to store a variety of items inside the shelf.

Convertible means being able to change in terms of forms, functions, or characteristics. The convertible concept explained that something or any object can be transformed from one thing to another thing [2]. In this case, we will transform a table into a shelf or a shelf into a table. This concept of transformation is called convertible furniture [3]. By combining two sets of furniture units as inputs, we can create convertible furniture objects, which can transform into a compact form.

The main purpose of the development of the convertible concept in furniture is to reduce time and efforts on finding two types of furniture that have different functions. Besides, the money spent also can be reduced since the convertible furniture has a multipurpose function in one product. In addition, it can help users in saving space because it takes up very little space in a room or space. The purpose of the convertible concept is not only that but also make it a lot easier for the users when shifting to a new home because they do not have excessive furniture to be moved.

The objective for this project is to design a study table that can be converted into a bookshelf anytime needed. Besides, to fabricate the convertible table and shelf as per design and last to analyze the strength of the convertible table and shelf.

2. Materials and Methods

After making an initial proposal for the design concept, the design details are developed virtually by generating part drawings and assemblies using SolidWorks 2022 software. Then the fabrication process is carried out based on the design results and material selection.

2.1 Part design using SolidWork software

Part design for the convertible table and shelf was drawn with SolidWorks 2022 software as shown in Figure 1. The part designing begins by drawing a base shown in **Figure 1(a)**. This base is sketched using a rectangle and expanded to a certain thickness. Then, this section gets hollowed by shell features. A 10 mm hole gets created by the extruded cut features for the adjusting system. The next part to draw is the adjustable base shown in **Figure 1(b)**. This adjustable base is sketched using a rectangle and expanded using extrude boss features to a certain thickness. Then, this section gets hollowed by shell features. Ten 10mm holes get created by the extruded cut features.

After that, the Handle 1 section for the Convertible Table and Shelf is sketched using rectangles and circles at both ends of this section as in **Figure 1(c)**. This part gets expanded using extruded boss features before making two holes using extruded cut features. The Handle 2 section was sketched like Handle 1 using rectangles and circles at both ends. This part gets expanded using extrude boss features before making three holes using extruded cut features shown in **Figure 1(d)**. The next part is the safety pin shown in **Figure 1(e)**, the part is sketched using a circle and extruded into a cylinder. One end of the cylinder gets drawn with a larger ring and then extruded to create a second cylinder. Use the same

steps to build the third cylinder. Then, draw six more circles around the edge of the third cylinder and cut it using extrude cut features. Create a thread with 0.10 cm pitch on the first cylinder using the tread features.

The Washer is sketched using two circles. This part gets expanded using extrude boss features and fillet all edges using fillet features shown in **Figure 1(f)**. **Figure 1(g)** shows a hexagon-headed bolt drawn starting by sketching a hexagon shape on the top view. Then, the section gets extruded using extrude boss features to a certain thickness. Then, a circle was drawn on the extruded hexagon shape and extruded the sketch with extrude boss feature. Thread on the bolt gets created using tread features with 0.10 cm pitch. Next, the connector shown in **Figure 1(h)** is sketched using a rectangle and expanded to a certain thickness. Then, this section gets hollowed by shell features.

Figure 1(i) shows a nut drawn starting by sketching a hexagon shape and a circle on the top view. Then, the section gets extruded using extrude boss features to a certain thickness. The thread in the nut gets created using tread features with 0.10 cm pitch. The side panel was drawn by sketching two rectangles with two circles. Then, the section gets extruded using extrude boss features shown in **Figure 1(j)**. The next part to draw is Top Panel 1. This section is sketched using a rectangle (253 x 600) mm and extruded to a thickness of 9.0 mm shown in **Figure 1(k)**. The next part to draw is Top Panel 2. This section is sketched using a rectangle (253 x 614) mm and extruded to a thickness of 9.0 mm shown in **Figure 1(l)**.

The wheel section shown in **Figure 1(m)** builds with the support part and wheel part. The support part gets created by sketching rectangular and round shapes. Then, both sketches expanded and used the extruded cut command to make a wheel slot hole at both sides of the support part. On top of the expanded rectangular shape, we sketch another rectangular and extrude it with extrude boss features. Then, four holes get created using the extrude cut feature. The wheel part gets built by sketch line and arc according to the required measurement. Then, we revolved the sketch to create a wheel using revolved base features.

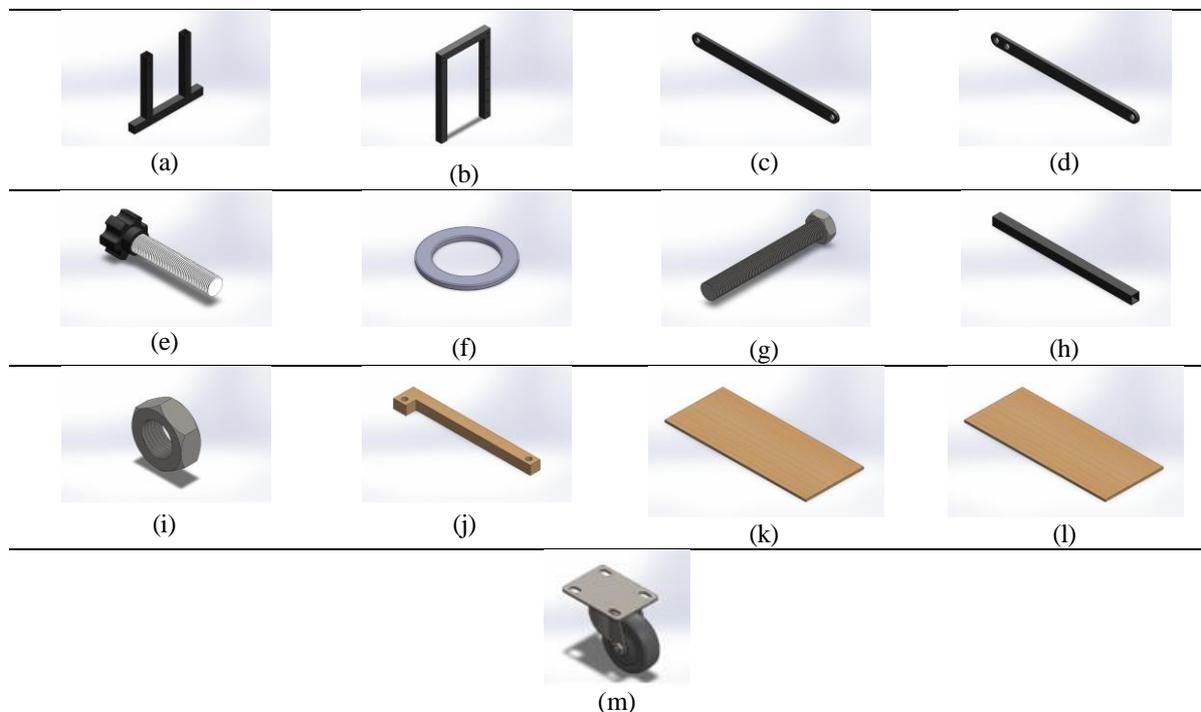


Figure 1: Design parts (a) Base, (b) Adjustable base, (c) Handle 1, (d) Handle 2 (e) Safety pin, (f)Washer, (g) Bolt, (h) Connector, (i) Nut, (j) Side panel, (k) Top panel 1, (l) Top panel 2, (m) Wheel

2.2 Assembly design using SolidWork software

Figure 2 shows the assembly design based on the Convertible Table and Shelf design using SolidWork 2022 software.

The assembly shown in **Figure 2(a)** begins with the base section by connecting the base and adjustable base. Then, the adjustable base connects with Handle 1, Handle 2 and the side panel by bolt, nut and washer. All the handles get connected to the side panel by bolt, nut and washer. Next, all the top panels get connected to the top of the side panels. The wheel gets attached to the bottom of the base. **Figure 2(b)** shows the Convertible Table and Shelf in exploded view.

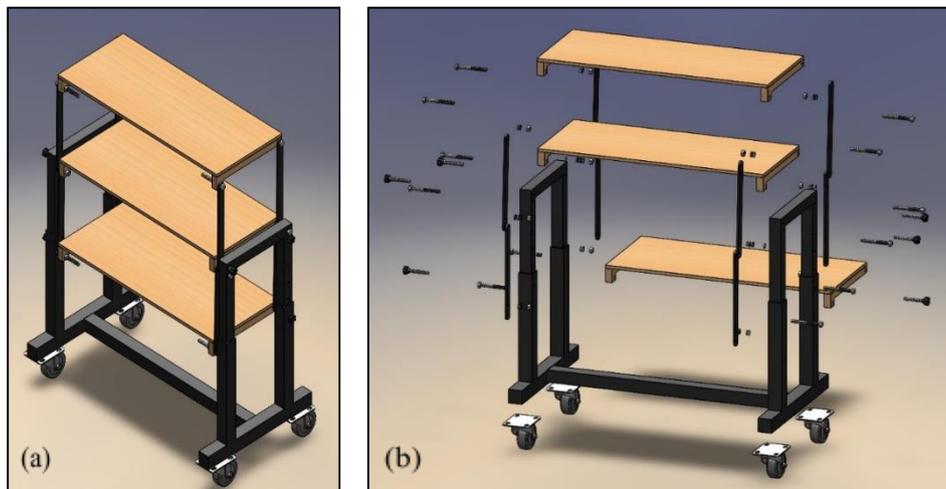


Figure 2: (a) Assembly design and (b) Exploded view

2.3 Equations

$$\text{Moment of Inertia, } I = \frac{1}{12}bh^3 \quad \text{Eq. 1}$$

$$\text{Distributed Load, } q = \frac{W}{L} \quad \text{Eq. 2}$$

$$\text{Maximum Deformation for table, } \delta_{max} = \frac{qL^4}{384EI} \quad \text{Eq. 3}$$

$$\text{Maximum Deformation for shelf, } \delta_{max} = \frac{5qL^4}{384EI} \quad \text{Eq. 4}$$

A maximum load of 35 kg is applied for all the analyses. All analyses use a maximum load of 35 kg. Similarly, to the prior logic behind the simulation, there is theoretically no relevance in putting the load of 35 kg to the table because the likelihood of such a load being applied to the table is negligible. However, to replicate the worst-case situation, the analysis on the table with 35 kg of weight is still performed. In the worst-case situation, users may lay very heavy goods on the tabletop while utilizing the table to support their upper limb, putting their upper extremity's weight on the table as well. The moment of inertia and distributed load are calculated for the maximal deformation using **Eq. 1** and **Eq. 2**. The maximum deformation for the table and shelf is found using **Eq. 3** and **Eq. 4**.

2.4 Fabrication

The fabrication process of a Convertible Table and Shelf is based on the design which has been sketched in SolidWork 2022. It consists of plywood with a thickness of 9 mm measured to the required dimension. Two sheets with a measurement of (25.3 x 60.0) cm, a sheet with a size of (25.3 x 61.4) cm and six sheets of (4.0 x 25.3) cm plywood. However, the (2.3 x 2.3) cm hollow section with a thickness

of 0.1 cm gets cut into six pieces. Four pieces with a length of 31.25 cm and the other two with a length of 40 cm. The (3 x 3) cm hollow section with a thickness of 0.1 cm gets cut into four bars with a length of 37 cm and two bars with a length of 25.3 cm. Four pieces of the metal plate (2 x 27.5) cm with 0.3 cm thickness were used in this project. Next, the measured plywood is being cut using a saw. Then, the hollow section and plywood get punched to create a required hole according to SolidWorks drawing. The hollow section is welded together and painted with black paint shown in **Figure 3(a)** and **Figure 3(b)**. Then, all the panels get painted with wood varnish shown in **Figure 3(c)**. Lastly, the convertible table and shelf were assembled using a nut, bolt, and washer.

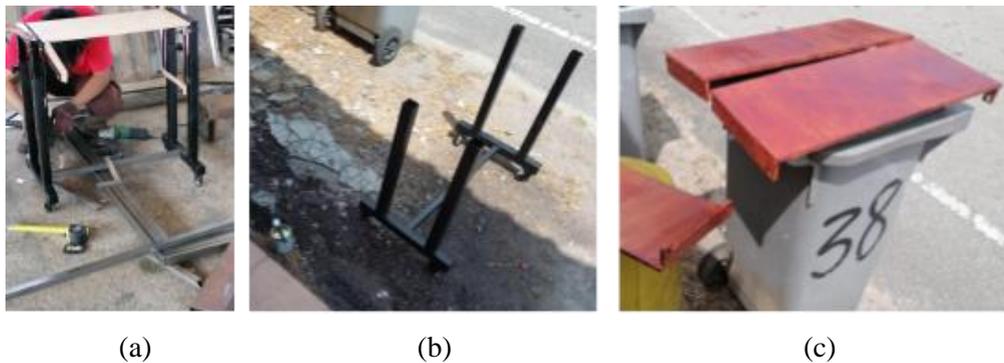


Figure 3: Fabrication process of convertible table and shelf, (a) The hollow section getting welded together, (b) The hollow section painted black, (c) The panel with wood varnish

3. Results and Discussion

The Convertible Table and Shelf is a type of product that uses a slider mechanism. This product has an ergonomic concept for the comfort of the user. This product makes it easier to move from one place to another room than a normal table. The main factor of this product is its cheaper manufacturing cost despite having two functions in one product. This innovative product also has other characteristics such as being lighter and cheaper. In addition, this product is also very convenient to use.

3.1 Results and discussion

There are several analyses that need to be implemented on the convertible table and shelf. All of this process and analysis is important to ensure that the project results can work well and smoothly. The proposed invention was conceptualized and designed to support two functions, namely the table and shelf. Hence, the proposed invention presents improved universality. When the table is in the kitchen area, it can be turned into a shelf so that the items can be placed on it. But, if the table is in the room area, it can be either to put items or a study table. The dimensions of both the proposed inventions found that it occupied less space than the single-function furniture. Thus, it has the capacity to reduce space usage. There is a strong, positive, and significant correlation between the space - saving effectiveness of interchangeable convertible table and shelf with ergonomic performance, functionality, stability, transformation process and invention ability to save space [4].

3.2 Simulation of Finite Element Analysis (FEA) using SolidWorks 2022

The profile stress distribution image of Finite Element Analysis (FEA) simulation using SolidWorks 2022 software when distributed force is applied on the panel with variables (100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100) N. From observed, the maximum stress distribution has occurred at the area of the hole where it is the connection part of the adjustable base, handle 1 and handle 2. The holes usually work under complicated conditions which have a high chance of failing.

3.3 Cost, size, and safety analysis

Every project needs to do comparative analysis. This research has decided to compare the specification on costs, sizes, and safety analysis between wall mounted table multi- functional folding laptop desk writing table with storage shelves, convertible bookshelf and kitchen table wall mounted foldable and convertible table shelf [6].

Table 1: Comparative analysis of the specifications of the Convertible Table and Shelf with regular table and shelf on the market

Cost/ unit	Wall Mounted Table Multi- Functional Folding Laptop Desk Writing Table with Storage Shelves	Convertible Bookshelf and Kitchen Table Wall Mounted Foldable	Convertible Table Shelf
Manufacturing cost	RM 195	RM 370	RM 320
Sale cost	RM 266	RM 580	RM 420
Size (mm)	Fold size: (596.9*152.4*508) Unfold size: (596.9*508*508)	Table size: (1240*635*730) Shelf size: (635*330*1080) Shelf base size: (635*330) Shelf level size: (600*300)	Fully shelf: Maximum Height (700*400*1040) Minimum Height (700*400*790) Semi shelf: Maximum Height (700*400*790) Minimum Height (700*400*530) Fully Table: Maximum Height (700*400*790) Minimum Height (700*400*530)
Weight (kg)	Load capacity of each shelf: 5 kg Load capacity of desktop: 20 kg	100 kg	35 kg
Portable	No	No	Yes
Save space	Yes	Yes	Yes
Mechanism	Hinge folding	Slider	Slider
Adjustable	Yes	Yes	Yes

After doing some research, there are few comparisons of prices between wall mounted table multi-functional folding laptop desk writing table with storage shelves, convertible bookshelf and kitchen table wall mounted foldable and convertible table shelf as shown in **Table 1** above.

3.4 Work Principle

In this product, the conversion of the tables to shelves or the other way around using a slider mechanism. This product consists of a horizontal table that can turn into full shelves and an ‘L’ shape product that has a dual function which is a table and a shelf. It also has extra features that will prevent the user from getting into an accident which is a safety lock function. Users can adjust the height of this product according to their own preference by loosening up the bolt and nut at the table leg to unlock the height position. Then, the user can tighten up the bolt and nut based on the holes of the preferred height position they wanted.

3.5 Product specifications

The product has eight important parts for it to function properly. specification in **Figure 4** shows the parts for Convertible Table and Shelf and **Table 2** shows the characteristics for each of the parts used in this product.

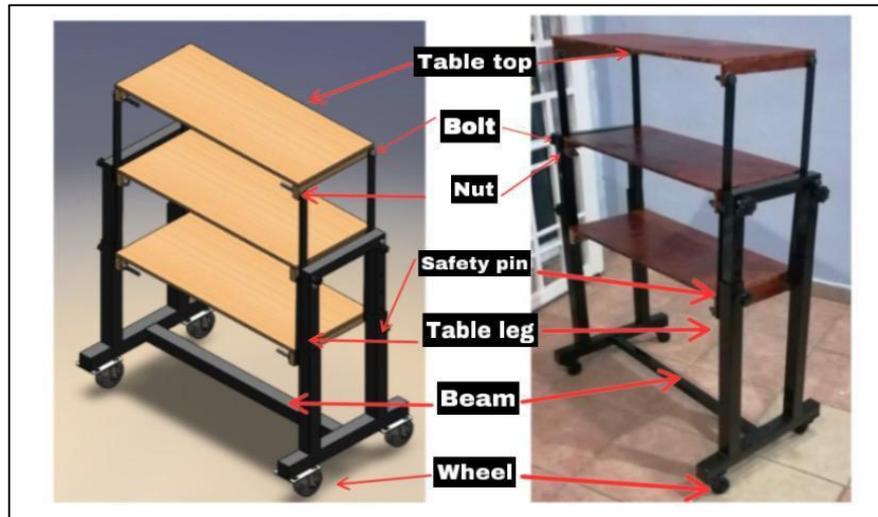


Figure 4: Design of the part for the Convertible Table and Shelf

Table 2: Product parts and description

Parts	Characteristics
Table top	Made from wood and serves as a place to put the items or table to study
Table leg	Made from steel which is used as a table frame
Beam	Made from steel to support the table
Wheel	Made from plastic and serves to move the table
Safety pin	Made from metal rod and serves as a retainer for the furniture from open after the transformation process is underway
Bolt	Made from steel and used to hold materials or objects together and to position the object
Nut	Made from steel and used to provide a clamping force and prevent axial movement
Washer	Made from steel and used to distribute the load of a threaded fastener

4. Conclusion

In conclusion, the innovation of this project succeeded in designing a convertible table and shelf that serves to save space and provide two functions as a table and shelf using a sliding mechanism. This convertible table and shelf can be both a table and a shelf at the same time, or it can function fully as a shelf or even entirely as a table. This convertible table and shelf is very user friendly because it is portable and it saves cost and operating time. The convertible table and shelf that has been designed has some weaknesses, especially the potential of the table to rot because the tabletop is made from wood. Besides, it cannot accommodate a weight exceeding 35 kg. The improvement can be made by using a steel so that it can accommodate heavier weights at the same time, not easily decomposed and durable.

Acknowledgement

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