

Multifunctional Bookshelf Inspired by Petronas Twin Towers

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Abstract: Due to high amount of population, majority of the people lives in apartment or condominium encountered the problems of limited space of storage especially for books and documents. This study aims to identify the design features of multifunction bookshelf, to design and to develop a prototype of multifunctional bookshelf inspired by Petronas Twin Towers. A total of 60 respondents who live in apartment or condominium at Kuala Lumpur were participated in the design characteristics determination using a set of questionnaires. The results from the survey were used for thumbnails, ideation, idea development, mock-up, technical drawing, and manufacturing of the multifunction bookshelf prototype. Findings in this study reported that respondents preferred a square multifunction bookshelf with 4 to 5 layers of shelf, 5 to 7 compartments, made from the wood-based panel and have wood colour with lock wheels. At the design process, a total of 101 thumbnails, 15 ideations, and 3 idea developments were done. Then, the final design was decided from the final design survey. Lastly, a prototype of multifunctional bookshelf fabricated from oil palm trunk namely in plywood was finished using laminated decorative with brown walnut pattern was done. The multifunctional bookshelf designed in this study probably will benefit any residents live in less space area.

Keywords: Bookshelf, Multifunctional, Petronas Twin Towers

1. Introduction

With a population of eight million citizens, this rapidly mega-urban region is significant in the context of urbanisation in the country which particularly in the Peninsular Malaysia (Idrus, 2015). In this era, increasing amount of population and limited amount of land had led architect to construct high rise house in order to fulfil the needs of residents (Akristiniy & Boriskina, 2018). Lack of storage place and workspace are among the problems that occur in the small space area such as apartment or condominium. Apart from that, many condominiums and flat being construct mostly small living area

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to fit many residents (Musa *et al.*, 2020). Furthermore, increase amount of monthly expenses make citizens chose to just rent a room and not a house.

Therefore, most of interior design has led to the evolution of the tiny house movement with space-saving furniture (Das *et al.*, 2019). Nowadays, furniture which it saves space is abundant in our daily lives. High population cause designer to design space saving furniture. One of space saving furniture are multifunction furniture. Multifunction also could be included in bookshelf. Several studies have been conducted on the multifunctional bookshelf (Indrianita, 2013; Li *et al.*, 2015). One of them was multifunctional bookshelf to support government programs for usage in villages with Taman Bacaan Masyarakat (Indrianita, 2013). Next, it is designed for those who read or eat in bed, and it can transform to a sitting posture for reading and then return to its natural shape for sleeping (Li *et al.*, 2015).

Common bookshelf is any shelving unit that holds books and magazines. Multifunction bookshelf could improve the functionality of the bookshelf itself. Space-saving beds and tables, as well as other furniture, fall into this category. Because they are the most frequently used furnishings, space-saving beds and tables have more functional properties than any other type of furniture. These types of furniture can lead to cost savings by Astonkar & Kherde (2015). Effective space saving does not involve downsizing, but rather clever ways of collapsing or making a piece of furniture more collapsible. Folding is perhaps the most observed and best practiced among the many space-saving mechanisms such as stacking, implosion, and bundling on furniture (Li *et al.*, 2015).

Therefore, this study proposed a multifunctional bookshelf influenced by Petronas Twin Towers. Apparently, Petronas Twin Tower has symmetry form that each of the light beams has cylindrical symmetry (Nikolić *et al.*, 2015). The geometry shape of the Petronas Twin Tower has been used to be an element of the multifunctional bookshelf design (Safari *et al.*, 2016). The significance of this study benefits the community who lived in condominium or apartment and stay in Kuala Lumpur to get maximize the use of allocated space. The multifunctional bookshelf design is being invent to users who want to use furniture with various functions at the same time. Space saving furniture is based on the concept of changing shape into multiple forms and having multiple functions, which saves time, space, and money (Dhiraj *et al.*, 2015). The aims of this study are to identify the design characteristics, to design and to develop a prototype of multifunctional bookshelf inspired by Petronas Twin Towers suitable for condominium or apartment users.

2. Literature Review

2.1 Multifunctional Furniture

There is a lot of space-saving furniture available on the market nowadays that may be used to assist consumers save living space (Mahmood Tahir & Ali Qaradaghi, 2020). Convertible furniture is used widely because of its multi-purpose and space-saving properties, but substantial professional skills are required to design practical convertible furniture (Zhou & Chen, 2018). Apart from that, the maximum use of space and the most effective use of space is defined by the demand of the person or group of people in it while using multifunctional furniture (Scientists, 2019).

2.2 Bookshelf

Any room may benefit from bookshelves. They can be built-in or free-standing. They might be large or modest in size. They might be as simple as screwed-together and painted plywood for use in a laundry room or as complex as formal library shelves fashioned from gorgeous hardwoods (Miller, 2006). Shelves have developed in perfect sync with the walls that support them, therefore the history of shelving is closely linked to the history of architecture (Mattern, 2021). Before shelf was invented, books were stored in spherical boxes called *Scrinia* and were discovered in rolls or knotted together.

These were frequently fashioned of beech wood and could be closed and sealed, allowing its owners to carry their books on long voyages with ease (Daybell *et al.*, 2019). Before our era, there are iconic shelves had been invented through the years which is from Agostino Ramelli's rotating book wheel (16th century) (Figure 1) (Mattern, 2021). There is various type of bookshelf especially for small house such as invisible bookshelf, industrial bookshelf, barrister bookshelf, cube bookshelf, glass bookshelf, bookworm bookshelf and asymmetrical bookshelf (Winston, 2019).



Figure 1: Agostino Ramelli, Le diverse et artificiose machine (Mattern, 2021)

2.3 Dimension of the Bookshelf

As stated by Munson (2019), the higher the number of shelves, the bigger the size of bookshelf. In their study, 32 inches height, 31 inches width, and 12 – 13 inches depth are the standard dimension for two-rack bookshelf. Meanwhile, 101.14 to 121.92 cm is the standard height for the three-rack bookshelf with 76.2 to 30 inches width and 30.48 to 33.02 inches depth. Apart from that, 54 inches, 24 inches, and 12-14.5 inches are the standard height, width and depth of four-rack bookshelf. And 182.88 - 195.58 cm, 78.74-93.98 cm, and 30.48- 33.02 cm are the standard height, width and depth of five-rack bookshelf (Munson, 2019; Pham, 2018).

2.4 Petronas Twin Towers

One of global icon of Malaysia's called the Petronas Twin Towers in Kuala Lumpur had succeeded attract tourists' interest which had expanding economy of Malaysia and being an aspiration. The Towers, which officially opened in 1999, was the world's tallest skyscraper for five years until it was surpassed by Taipei 101 in 2004 (Fourth Street, 2021). The interior designs are inspired by Malaysian handicrafts and weaving patterns, and the building is finished in a spectacular mixture of stainless steel and glass to generate exquisite Islamic designs. Each tower floor plate is based on simple Islamic geometric shapes of two overlapping squares forming an eight-pointed star. These architectural shapes symbolize the fundamental Islamic ideals of unity, harmony, stability, and wisdom (Petrosains, 2021). Geometry is the logic of shape relationships or the language of shapes. Since the dawn of time, geometry has been used to shape structures and cities (Safari *et al.*, 2016). A square concept can help put the Petronas Twin Towers in context as an iconic and symbolic structure. The regular geometry of a square can help to improve the layout of the area around KLCC. As a result, architects, tourist managers, and urban planners will find it valuable since it emphasises the necessity of effective components in maintaining accessible and social space, such as a square (Safari & Moridani, 2017).

3. Research Methodology

3.1 Questionnaire Development

This study applies a qualitative method by using a survey instrument to identify the design criteria required by potential users of multifunctional bookshelf to be designed. Firstly, this study had confirmed the scope of this study which focused on community who live in condominium or apartment at Kuala Lumpur. Next, this study had identified problems that had been occurred to be solved. From the problems, this study had to design the survey based on the need of the potential users. The need of potential users played a major role in the formation of survey. Potential users need include design criteria. This study also wants to know about the view of the respondents on having the multifunctional bookshelf. It has 3 sections: Section A (Demographics), Section B (Design criteria of the multifunctional bookshelf) and Section C (View of the multifunctional bookshelf). The questionnaire was distributed to 60 respondents through social media such as WhatsApp and Facebook which focused on community who live in condominium or apartment at Kuala Lumpur. The respondents are among individual, family or parents and live in the apartment or condominium.

3.2 Design Process

The results from the criteria obtained through the survey were used in the multifunctional bookshelf design process inspired by Petronas Twin Tower. Thumbnails are produced to give a small picture of a big or real picture of a product. The thumbnails produced were used as the main framework or important parts in the design that will be developed. This is the first step in the design process. Thumbnails are produced spontaneously, randomly and do not require correction using only pencil or pen and paper. There is no limit to the number of sketches specified to facilitate researchers to generate more ideas and not to hinder the creativity of study. The sketches include thumbnail, ideation, idea development and final design. Overall, there have 101 sketches for thumbnail, 15 ideation, 3 idea development, and one final design sketch. The final design selection process is done by taking the design that based on the survey and it would be processed to become a prototype.

3.3 Final Design Survey

The selection of final design was determined using design survey. The final design survey was distributed to the respondents. In this final design survey, two designs were included as the preferred design for prototype.

3.4 Mock-up

A 1:10 scale mock-up production process had been developed using balsa wood, PVA glue, black paper and cellotape. Cutter had been used to cut the balsa wood based on require length that needed. It is intended for the initial screening process to identify the improvements needed to improve the quality and appearance of the actual multifunctional bookshelf that was produced.

3.5 Technical Drawing

The production of technical drawings using AutoCAD and prototype formation was done after completion of the selected final design. The 2D and 3D drawings were done to perform more clearly product design.

3.6 Prototype Manufacturing

The material used for this study are oil palm plywood, decorative laminates, laminated plastics adhesive, thinner, flat hinges acrylic and foldable leg. Tools used are included the table saw, cutter, measuring tape, electric drill, and sandpaper. The manufacturing process was started from the measuring, cutting, sanding, gluing, and assembly to the finishing process. The shelf and tabletop are made from plywood while legs are made from metal. The plywood was measure according to the

dimension from the technical drawing. In this process, each part of the plywood needs to be sand. During the gluing process, a plywood was applied with the laminated plastics adhesive before laminate with the brown walnut pattern laminates on the plywood. During assembly, the electric drill was used to screw the joints between plywood. Next, screwed table with the foldable metal leg using the electric drill. After that, assembly the bookshelf and table with flat hinges. Finally, acrylic had been bend using source of heat and put the acrylic at the top shelf based on the final design.

4. Results and Discussion

4.1 Demographic of Respondents

The survey used in this study to seek input from respondents who also is a prospective purchaser or user to furniture products that will result from this study. The distributed questionnaire had three sections. Summary of the findings of the survey that has been distributed to 60 respondents around Kuala Lumpur is as shown in Table 1.

The demographic data and design criteria of multifunctional bookshelf are shown in Table 1. From observation, most of the respondents are female with a value of 62%. The highest respondents are given by 22-34 years (43.7%), followed by 35-44 years old (29.6%), 45-54 years old (16.9%), and 55-64 years old (8.5%). Meanwhile, majority of the respondents are Malay at a percentage of 43.7%, followed by Chinese (31%) and Indian (25.4%). In this study, majority respondents live at apartment or condominium in Kuala Lumpur, which is 90.1% and 93.8%. Majority of the respondents have degree as their highest educational level with the percentage of 64.8%. This followed by Master, Diploma, PhD, upper secondary and lower secondary, with the percentages of 12.7%, 9.9%, 1.4%, 4.2% and 7.0%, respectively. Next, majority of the respondents are full time employment at a percentage of 59.2%. Majority of the respondents in this study are a group of M40 (60%), followed by B40 (23.3%) and T20 (16.7%).

Table 1: Example of presenting data using a table (Author, year)

Details	Percentage (%)	
Demographic		
Gender	Male	38.0
	Female	62.0
Age	<20 years	0
	22 – 34 years	43.7
	35 – 44 years	29.6
	45 – 54 years	16.9
	55 – 64 years	8.5
	>65 years	1.4
Race	Malay	43.7
	Chinese	31.0
	Indian	25.4
Education level	PhD	1.4
	Master	12.7
	Degree	64.8
	Diploma	9.9
	Upper secondary	4.2
Employment Status	Lower secondary	7.0
	Full time employment	59.2
	Part time employment	14.1
	Unemployed	2.8
	Housewife	9.9
Student	9.9	
Retired	4.2	

Live at apartment / condominium	Yes	90.1
	No	9.9
Live in Kuala Lumpur	Yes	93.8
	No	6.3
Area in Kuala Lumpur	Bukit Bintang	5.0
	Titiwangsa	3.3
	Setiawangsa	3.3
	Wangsa Maju	13.3
	Batu	3.3
	Kepong	8.3
	Segambut	3.3
	Lembah Pantai	16
	Seputeh	5.0
	Bandar Tun Razak	21.7
	Cheras	6.7
Household income	T20 (RM10,961 – RM15,040 <)	16.7
	M40 (RM4,850 – RM 10,959)	60.0
	B40 (< RM2,500 – RM3,169)	23.3
Design criteria		
Preferred shape	Rectangular	36.7
	Square	58.3
	Triangle	1.7
	Round	3.3
Additional features	Stationary box	66.7
	Foldable table	93.3
	Hook hangers	25.0
	Cup holder	56.7
Preferred number of shelves	2-3 layers	31.7
	4-5 layers	68.3
Preferred number of compartments	2 to 4 compartments	6.7
	5 to 7 compartments	78.3
	8 to 10 compartments	11.7
	More than 10 compartments	3.3
Preferred colour	Natural wood	75.0
	Dark	8.3
	Light	16.7
Preferred material for bookshelf	Wood-based panel	76.7
	Metal	3.3
	Plastic	0
	Combination of materials above	20.0
Preferred bottom part for bookshelf	With leg (not moving)	18.3
	With leg (with wheel)	75.0
	Without leg (with pad protector only)	6.7
Preferred bookshelf legs	U-shaped	9.1
	I-shaped	9.1
	Square-shaped	36.4
	X-shaped	36.4
	Normal four legs	9.1
Preferred material for bookshelf legs	Wood	18.2
	Metal	81.8
	Plastic	0
	Combination of materials above	0
Preferred wheels	With lock	95.6
	Without lock	4.4

4.2 Design Criteria of Multifunctional Bookshelf

As tabulated in Table 1, majority of the respondents prefer the square shape for bookshelf with a value of 58.3%, while 36.7% respondent prefer the rectangular shape for the bookshelf, followed by triangle shape and round shape for the bookshelf which is 1.7% and 3.3%.

Besides, 93.3% of the respondents are strongly agree with foldable table as additional features. This followed by stationary holder, cup holder, and hook hangers, with the percentages of 66.7%, 56.6%, and 25%. Finding shows that majority (68.3%) of the respondents preferred 4 to 5 layers of shelves compared to 31.7% of the respondents preferred 2 to 3 layers of shelves. According to Munson (2019) and Pham (2018), the higher the number of racks will be affecting the size of the racks which is important in order to bookshelf remain sturdy for keeping books or other items. Meanwhile, majority (78.3%) of the respondents preferred 5 to 7 compartments. Followed by 2 to 4 compartments, 8 to 10 compartments and more than 10 compartments, with the percentages of 6.7%, 11.7%, and 3.3%.

As shown in Table 1, 75% of the respondents choose natural wood colour, followed by light colour (16.7%) and dark colour (8.3%). Apart from that, 76.7% of the respondents are strongly preferred with the wood-based panel as material for bookshelf rather than metal and combination material, with percentages of 3.3% and 20%. There is no one of respondents chose plastic as material for bookshelf. As shown in Table 1, 75% of the respondents preferred bottom part for bookshelf have leg with wheel. This followed by have leg (not moving) and not have leg (with pad protector), with the percentage of 18.3% and 6.7%. Finding shows that majority (95.6%) of the respondents preferred wheels with lock compared to 4.4% of the respondents preferred wheels without lock. Besides, majority of the respondents preferred metal as material for bookshelf legs with the percentages of 81.8% compared to wood with the percentages of 18.2%. As known that metal cannot easily being cracked like wood and can last long (Home Stratosphere, 2022). Furthermore, majority of the respondents preferred square-shaped and X-shaped as bookshelf legs with the percentages of 36.4%, followed by U-shaped, I-shaped, and normal legs with the percentages of 9.1%.

4.3 Sketches

A minimum of 101 thumbnail sketches were drawn using pen. Figure 2 shows thumbnail of multifunctional bookshelf. Thumbnails is inspired by the shape elements of Petronas Twin Towers which are pinnacles, triangle, square, circle and rectangle.

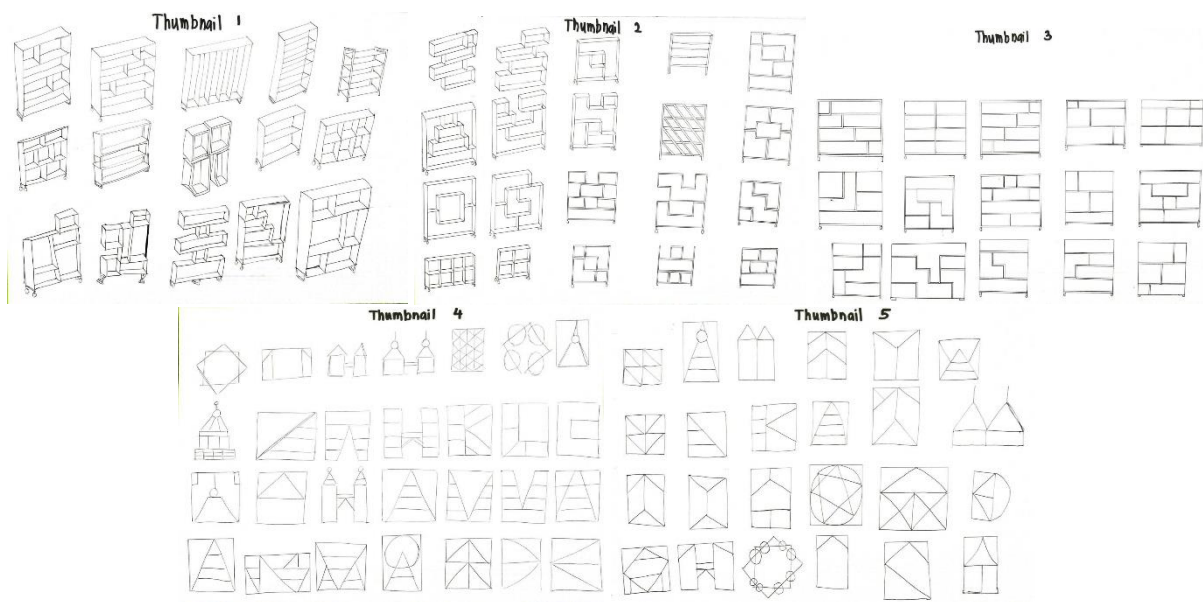


Figure 2: Thumbnail of multifunctional bookshelf

Based on the thumbnail sketches as well as the criteria obtained as a result of the distributed survey, the selection of idea sketch to be developed was made. With features such as square-shaped, 5 to 7 compartments, and the design of the Petronas Twin Tower as a source of inspiration, the sketch of Ideation 11, 12, and 13 meets these criteria. Therefore, Ideation 11, 12, and 13 was selected for the next process which is the idea development process. Figure 3 shows the ideation of multifunctional bookshelf.

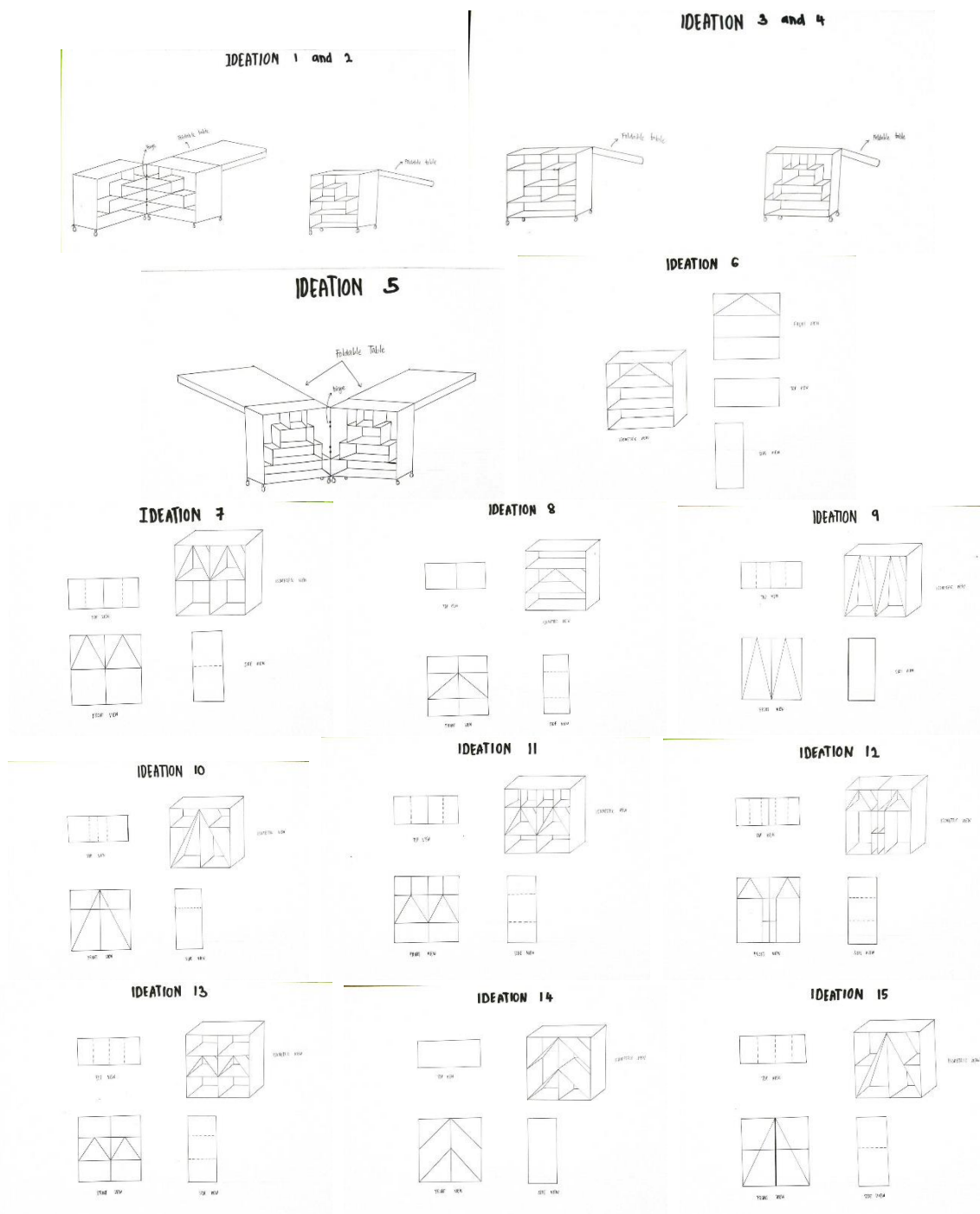


Figure 3: Ideation of multifunctional bookshelf

All the ideation selected which is Ideation 11, 12, and 13 have been further design development. In this process, design elements such as the type of bookshelf leg and additions features become the focal point of idea development for ideation sketch 11, 12, and 13 so that it better meets the criteria desired

by potential users. Based on criteria design, design have been enhanced additional features which had been the most chose by respondents. Figure 4 shows idea development of multifunctional bookshelf.

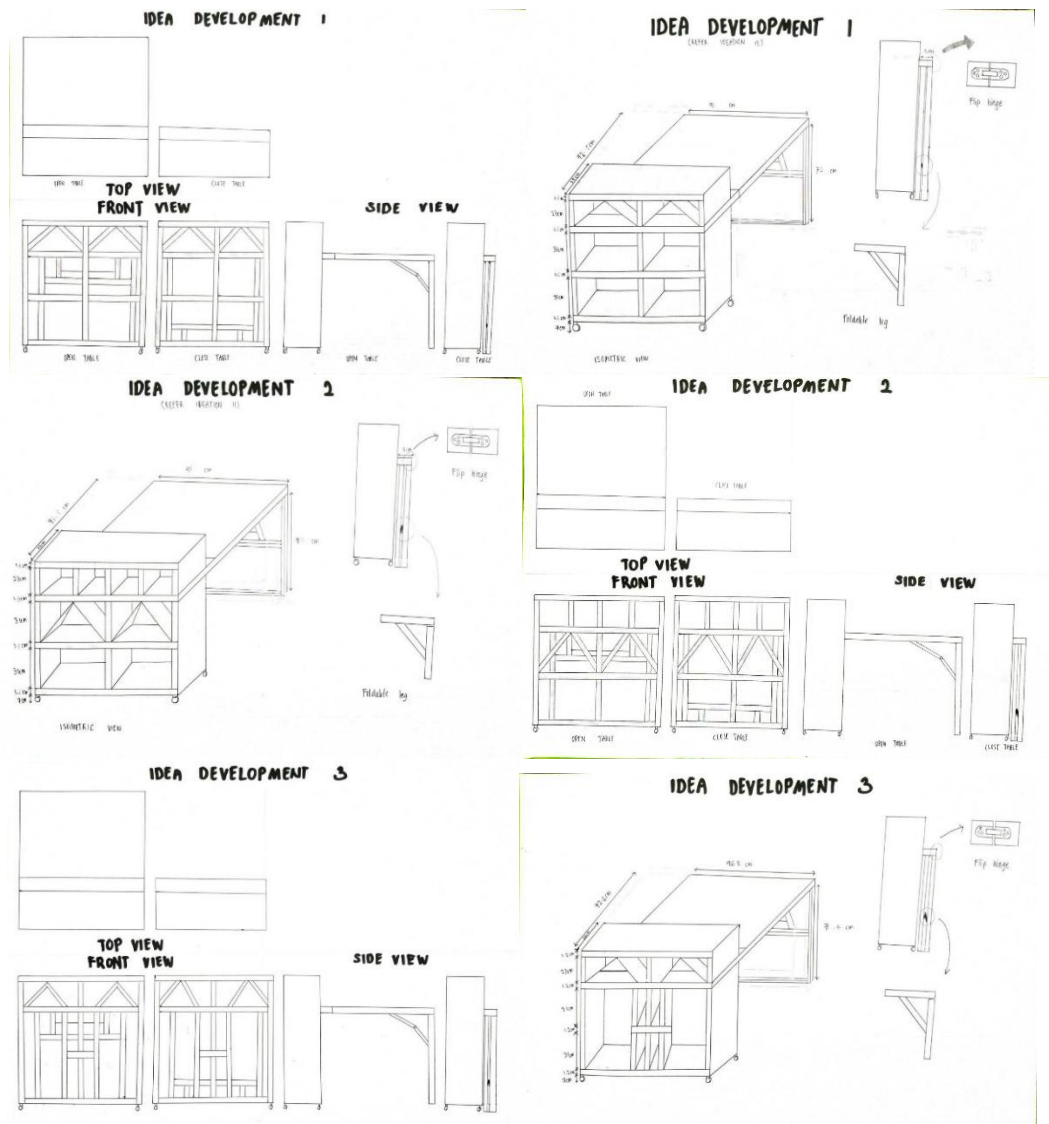


Figure 4: Idea development of multifunctional bookshelf

4.4 Final Design

The design survey was carried out through the selection of the final design by the respondents. Two designs were proceeded for design surveys to determine the final design and would be used to develop a prototype. Idea development 1 has been chosen as a final design and developed into a prototype. Figure 5 shows final design of multifunctional bookshelf.

4.5 Mock-up

A 1:10 scale mock-up production process had been developed using balsa wood, PVA glue, black paper and cello tape. Cutter had been used to cut the balsa wood based on require length that needed. It is intended for the initial screening process to identify the improvements needed to improve the quality and appearance of the actual multifunctional bookshelf that will be produced. Figure 6 shows mock-up of multifunctional bookshelf.

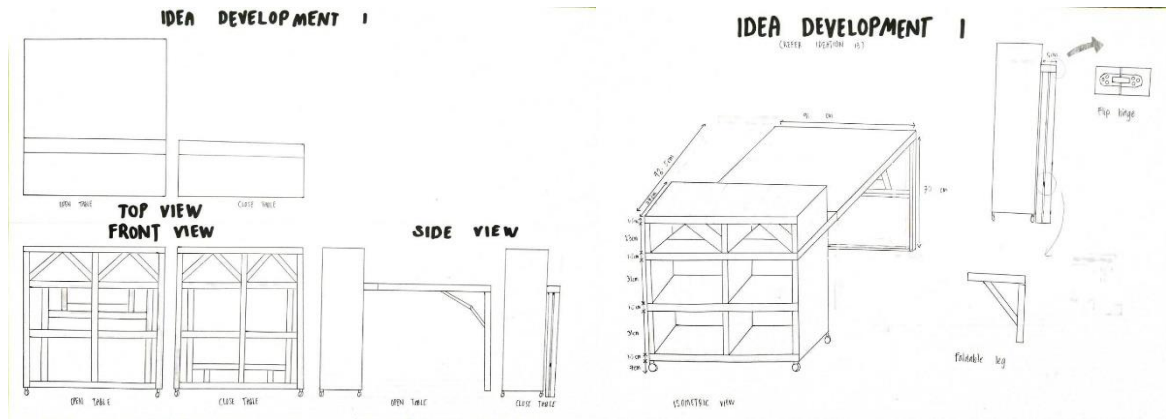


Figure 5: Final design of multifunctional bookshelf



Figure 6: Mock-up of multifunctional bookshelf

4.6 Technical Drawing

Figure 7 shows the 2D and 3D drawings. In both figures, the top, front, and side views of the multifunction bookshelf were illustrated.

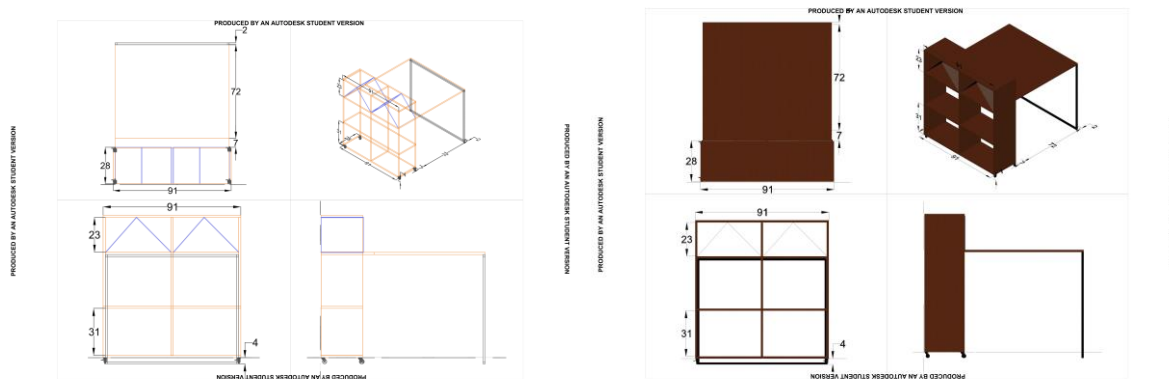


Figure 7: Technical drawing of multifunctional bookshelf

4.7 Prototype

Figure 8 shows the prototype of multifunctional bookshelf inspired by Petronas Twin Towers. The prototype was finished with brown walnut pattern decorative laminates to improve the appearance of the prototype (Ong *et al.*, 2018). The prototype has 3 shelves, 1 foldable table, ten open storages and lock castors. Besides, the height, the length and width of the prototype is 98 cm, 91 cm and 28 cm, respectively. The six storages in the top of the bookshelf are movable and able to rearrange according to users' preferences. The shape of the storages in the top of the bookshelf are inspired by the pinnacle

of the Petronas Twin Towers. The mechanism of the foldable table used spring as it is sturdy, and the table will not sway while lock castors can be lock or unlock according to users' preferences.



Figure 7: Prototype of multifunctional bookshelf inspired by Petronas Twin Tower

5. Conclusion

In conclusion, this study succeeded in achieving its objective. A new design was created to address the multifunctional bookshelf needs of apartment or condominium residential in Kuala Lumpur. The design criteria of multifunctional bookshelf inspired by Petronas Twin Towers are square shaped, having 5 to 7 compartments with lock wheels, based wood panel as the main material and its wood colour which had been obtained from the survey. There are fifteen ideation and three idea development were sketches according to design criteria. Idea development 1 had was selected as a final design and manufactured as a prototype which the selection made by final design survey. In this study, the multifunctional bookshelf prototype was successfully developed using the oil palm plywood and finished with brown walnut pattern laminates. With a multifunctional bookshelf design, it is able to solve problems or meet the desires of users such as lack of book storage and workspace. The finishing of the bookshelf using the brown walnut Formica make it more attractive in appearance and harmless which make users more interested and safer while using the multifunctional bookshelf. Future study should consider and redesign a suitable measurement of bookshelf to increase functionality of bookshelf.

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