

Design and Fabrication of Power and Space Saving Chattel for Engineers and Engineering Students

Dr. Noel D. Binag
Rizal Technological University
Mandaluyong City
Phillipines.

Engr. Lorenzo C. Caranguian
Rizal Technological University
Mandaluyong City
Phillipines.

Abstract - One of the concerns of practicing engineers and engineering students is the space and power bills when living in a room, apartment or dormitory in metropolitan areas with their necessary stuff. It has been a practice that small spaces when properly designed with light, ventilation and fixtures will provide an ultimate of well –balanced living. Others even convert tiny unit with study, desk and file cabinet, a staircase with built-in storage, a bookshelves and a meditation zone. Besides these they also spend power bills for their appliances and lightings. Thus, the feeling of unconformity can obstruct the motivation and the energy in attempting to study or work hard while in their rooms. In this context, a chattel was designed and fabricated as a multipurpose cabinet with solar system enables to save space and power consumptions. The study utilized the ergonomic principles and descriptive research in the evaluation of the project.

Keywords: *Space, Power, Chattel, Engineers, Engineering Students*

1. INTRODUCTION

Chattel is merely related to a personalized belonging that are movable. A good example of a chattel is movable furniture. Furniture is a movable object intended to support various human activities such as seating and sleeping. There are different types of furniture and each has their own distinctive features and purposes. Some are intended to hold objects at a convenient height for work with horizontal surfaces above the ground, such as tables and desks. While others function to store objects, such as cupboards and shelves. Furniture can be a creation of design and can be considered a form of decorative art. It can be made from a range of materials, including metal, plastic, and wood.

A cabinet is an example of furniture. It is a box-shaped with doors or drawers for storing miscellaneous items. Some cabinets are stand alone or separated, while others are built into a wall or are attached to it. They are typically made out of wood or of synthetic materials. This typical furniture can be used to store different other furniture in a small but usable space. Many people live in small spaces, especially in the big cities like Kuala Lumpur, Singapore and Manila. In current market, there are available space saving furniture suitable to be used to help people for saving space in different purposes which follows the design process flow starting from identifying the problem, recognizing the needs, engineering design specification, conceptual design, selecting the best design,

configuration design, parametric design and detailed design.

Further, solar system is one of the features that helps save power in this kind of endeavor. Thus, the study on chattel space and power saving for engineers and engineering students has different features - a multipurpose movable cabinet with different components that functions as a wardrobe, chair, bookshelf, folding bed, shoe rack, mini “sala” set, and a drawing table, drawing equipment drawer, display shelves, personal accessory cabinet that save space with solar systems that save power consumption for lighting and appliances.

2. LITERATURE REVIEW

In most metropolises in the world, people’s average living area is getting smaller and smaller. More and more young people tend to move to large cities for more opportunities and more active life style. However, this phenomenon decreases the average living area gradually. Now in Beijing China, the average living area is only 21 square meters per person. Moreover, high population density leads many other problems such as high gap between rich and poor, high energy cost and house price. These are common problems in metropolis nowadays. Transformable space saving furniture is one of the options to solve these problems.

According to Wang [1], he introduced the innovation designs, the hard wares, the application and future development, cost and price, and the important markets of transformable space saving furniture. This report helped people to understand the importance and the potential value of transformable space saving furniture in metropolises.

Many people had to live in small spaces, especially in the big cities like Kuala Lumpur. In current market, there are available a lot of space saving furniture suitable to be used to help by people for saving living space. Sofa bed also one of the space saving furniture. The objective of this project was to design a new concept of sofa bed by using space saving approach with the apartment living concept. The sofa was designed which has more than three or more function. Furthermore, literature studies on the sofa bed for current market and some online sources like patent followed the design process flow start from identify the problem, recognized the need, engineering design specification, conceptual design, select the best design, configuration design, parametric design and detail design.

All the product design use the morphological chart as guidelines to design a new concept of sofa bed. Five concept designs for sofa bed were used. The method used to select the best concept design among the five concept design was "weighted rating method". The highest weight rating of design concept will continue the future development in this project. All the part of sofa bed was draw by using Solid Works [2].

A single piece of furniture that was convertible to a number of different pieces of furniture, including a chair, desk, table and bed, shelves, and many other furniture types. This single piece of furniture full's many needs with its multiple uses and different styles while at the same time being cost efficient, space saving, and ergonomically adjustable. Currently, most home and office furniture serves a single use: chairs for sitting, beds for sleeping, shelving for storage, desks and tables for work surfaces, etc. There were a few dual-use pieces of furniture in common use, such as futons and fold-out beds which allowed a couch to be converted to a bed. This was the limitation of their utility. The Modular, Transformable Furniture System (MTHS) was cost effective because a person or household only needs one piece of furniture to serve many needs. It was ideal for college students, budget conscious or nomadic people and people living in apartments with space constraints. Each element of the frame was integral and non-unique making it easy to manufacture, assemble, disassemble, ship and store, saving space and cost and adding to its utility. The Modular, Transformable Furniture System (MTHS) could replace not only many different types of useful and aesthetically pleasing couches and chairs and beds, but also desks, tables and shelves. Indeed, four of these innately adjustable pieces of furniture were all that was needed to provide the simple furniture necessary for a small apartment: a bed, a chair, a table and shelves [3].

Based on the study of Varghese [4], a majority of Indian middle class population are living in small flats and homes 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 was designed and developed in 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 were 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 Quality Function Development (QFD) was generated. Priorities in the QFD were modular, flexible, shape and size. Product Disclosure Statement (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.

According to Bin CheZakaria [5], table was used as place to put anything on it. Beside that table can be used to writing, studying and making work such as doing drawing, homeworks and others. We already know many table have a big size and difficult to move at other place and bring it. Many designs right now become fordable table that have more easy to use, can fold, move to other place and bring it. Foldable table is thing that can fold from large to become a small size such as briefcase, box and others. Foldable table is the most interesting to people used to camping, picnic because easy to bring it. Many products at the market have different specification, shape and type when manufacture by different manufacturing company.

Table is used as a place to put things such as books and laptop. The main concept is table used to support things which have variable of weight. There are many types of table for notebook in market such as fixed table, foldable table and portable table. These tables come with different size and design. It depends on what kind of purpose for the table. The meaning of portable is comfort and easy to bring anywhere. The function of this product is to support a notebook where there are no suitable place to put the notebook. For example, corridor, field, park, and room with tables those are already full. For easy to carry on anywhere this table was designed to be fordable, and can easily fit in a notebook's beg.

This product commonly produces by sheet metal and steel. This items has been chosen because strength, light in weight, easy to fabricate and long life. This portable notebook table also commonly fabricated using welding method. This method has been chosen because can produce the durable, strong support for any notebook existed in market [6].

There is a trend recently of urban development in the big cities and population growth. This explains the need of increasing the housing stock, which often leads to the development of the less - and more affordable apartments. This type of apartments is good to be functionally and compactly equipped. In such conditions, the use of multifunctional furniture is a preferred option [7].

Overcrowded living space is a contributing factor to the social and economic problems in impoverished areas such as Jabal Al-Natheef refugee camp in Jordan. Addressing such a convoluted problem requires long-term planning and availability of resources. However, initiation of small projects to target pain points, employing technologies such as Building Information Modeling (BIM) to design solutions, and empowering the people to implement them could alleviate the impact of poverty. Giving the stakeholders the ability to build and reproduce the designed solutions will help communities grow by allowing individuals to provide for themselves. This will also create jobs and sets the stage for sustainable

development. This project is based on a field study initiated by Purdue University Global Engineering Program in collaboration with the School of Technology. This project illustrates the need and capability of multifunctional furniture design features in order to maximize space usage and improve the livelihood conditions of people living in underprivileged communities. The author designed a furniture piece which serves as a tabular unit, storage and seating units, as well as sleeping units based on the need and time of day. The design criteria should achieve easy-to-implement and aesthetically pleasing modular pieces of furniture. To facilitate a manufacturing process led by the locals, furniture design specifications, prototype diagrams, and clear graphics were produced. Options for raw material were described based on market availability and source of imported wood. Moreover, a potential forestation program that takes advantage of the fast growing poplar trees was examined to create a local timber industry in the long-term. The designs addressed common requirements of many families who had been interviewed in Jabal Al-Natheef. Floor plans of six of these families' homes were presented with 3-D rendering perspectives using AutoCAD, Google Sketch up, and Revit modeling software. This thesis addressed one specific problem in the overcrowded and poorly facilitated environment of Jabal Al-Natheef; however, there were many other challenges that required urgent attention. Hence, there was room for many more similar efforts as per the recommendations for further studies and future research projects [8].

According to Human Factors Journal, human factors and ergonomics are also known as comfort design, functional design, and user-friendly systems. It is the practice of designing products, systems or processes to take proper account of the interaction between them and the people who use them. The field has seen contributions from numerous disciplines, such as psychology, engineering, biomechanics, industrial design, physiology and anthropology. Furthermore, ergonomic research or the human factors research is the study of designing equipment and devices that fit the human body and its cognitive abilities. The two terms "human factors" and "ergonomics" are essentially synonymous.

The International Ergonomics Association defines ergonomics or human factors as the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. It is employed to fulfill the goals of occupational health, safety and productivity. It is relevant in the design of such things as safe furniture and easy-to-use interfaces to machines and equipment. It is also concerned with the "fit" between the user, equipment and their environments. It takes account of the user's capabilities and limitations in seeking to ensure that tasks, functions, information and the environment suit each user. To assess evaluate the fit between a person and the used technology, human factors specialists or ergonomists consider the job (activity) being done and the demands on the user; the equipment used (its size, shape, and how

appropriate it is for the task), and the information used (how it is presented, accessed, and changed).

According to Matthew Schieltz [9], an eHow contributor discussed the process and stages of design which vary depending on several factors, including the type of project you are working on, how big or small it is and for whom it is being completed. Phases associated with graphic design differ greatly from those associated with building and architectural design. However, each type of project includes a common thread of stages that builders, designers and artists, mechanical engineers and others go through, such as research, planning and project conceptualization phases.

The design process begins with research. Almost all projects require the builders or makers to ask a series of questions--of themselves or clients--about the purpose of the project and the needs to fill. For example architectural designers or home builders ask clients questions concerning the size of interior spaces, the types of people for whom the building is being built and any custom-tailored requests. Questions of style come into play during this phase as well. Other questions during the research phase concern a project budget and time line for completion. The maker or client may examine similar projects that have been successfully completed.

The conceptualization phase of the design process involves outlining the project. During this phase, designers may have a list of features or requirements that the project will include. They conduct brainstorming sessions to generate additional ideas. Some designers draw a rough paper-and-pencil or computer-generated sketch of what the result will look like, encompassing all project requirements and features. When conceptualizing, designers often modify the rough sketch or outline to satisfy a change in needs or preferences from clients (Schieltz, 2011).

The design development phase involves a closer, detailed look at the project. This phase involves creating detailed plans, drawings and drafts and devoting attention to each feature or specification. For example, architectural designers and builders use computer-aided design programs to model a new building to scale, ensuring the design, measurement and placement of doors, stairways and hallways. Art project designers, such as graphic and logo design artists, construct several drafts or proofs. Design development allows additional feedback from clients and last-minute changes to be made and approved. During this phase, designers or builders often assess final costs for the project.

The development stage involves creating and building the project itself. The designer gathers supplies to complete the project. Large designs and projects require continual involvement from all team members, including project managers, leaders and engineers, to ensure work goes according to plan. An architectural project may require on-site visits from a property owner to ensure satisfaction. Any last-minute changes or added requirements during this stage might result in additional expenses. When development is completed, the designer evaluates the project and shows the result to clients.

A drawing board (also drawing table, drafting table or architect's table) is, in its antique form, a kind of multipurpose desk which can be used for any kind of drawing, writing or impromptu sketching on a large sheet of paper or for reading a large format book or other oversized document or for drafting precise technical illustrations. The drawing table used to be a frequent companion to a pedestal table in a gentleman's study or private library, during the pre-industrial and early industrial era.

During the Industrial Revolution draftsmanship gradually became a specialized trade and drawing tables slowly moved out of the libraries and offices of most gentlemen. They became more utilitarian and were built of steel and plastic instead of fine woods and brass.

More recently engineers and draftsmen use the drawing board for making and modifying drawings on paper with ink or pencil. Different drawing instrument are used on it to draw parallel, perpendicular or oblique lines. There are instrument for drawing circles, arcs, other curves and symbols too. However, with the gradual introduction of computer aided drafting and design (CADD or CAD) in the last decades of the 20th century and the first of the 21st century, the drawing board is becoming less common.

A drawing table is also sometimes called a mechanical desk because, for several centuries, most mechanical desks were drawing tables. Unlike the gadgetry mechanical desks of the second part of the 18th century, however, the mechanical parts of drawing tables were usually limited to notches, ratchets, and perhaps a few simple gears, or levers or cogs to elevate and incline the working surface.

Very often a drawing table could look like a writing table or even a pedestal desk when the working surface was set at the horizontal and the height adjusted to 29 inches, in order to use it as a "normal" desk. The only giveaway was usually a lip on one of the sides of the desktop. This lip or edge stopped paper or books from sliding when the surface was given an angle. It was also sometimes used to hold writing implements. When the working surface was extended at its full height, a drawing table could be used as a standing desk.

Many reproductions have been made and are still being produced of drawing tables, copying the period styles they were originally made in during the 18th and 19th centuries.

Despite the prevalence of computer aided drafting, many older architects and even some structural designers still rely on paper and pencil graphics produced on a drafting table. Modern drafting tables typically rely on a steel frame. Steel provides as much strength as the old oak drafting table frames and much easier portability. Typically the drafting board surface is a thick sheet of compressed fiber board with sheets of Formica laminated to all its surfaces. The drafting board surface is usually secured to the frame by screws which can easily be removed for drafting table transportation.

The steel frame allows mechanical linkages to be installed that control both the height and angle of the drafting board surface. Typically, a single foot pedal is used to control a clutch which clamps the board in the desired position. A heavy counterweight full of lead shot is

installed in the steel linkage so that if the pedal is accidentally released, the drafting board will not spring into the upright position and injure the user. Drafting table linkages and clutches have to be maintained to ensure that this safety mechanism counterbalances the weight of the table surface.

The drafting table surface is usually covered with a thin vinyl sheet called a board cover. This provides an optimum surface for pen and pencil drafting. It allows compasses and dividers to be used without damaging the wooden surface of the board. A board cover must be frequently cleaned to prevent graphite buildup from making new drawings dirty. At the bottom edge of the table, a single strip of aluminum or steel may serve as a place to rest drafting pencils. More purpose-built trays are also used which hold pencils even while the board is being adjusted.

Various types of drawing instrument may be attached to the board surface to assist the draftsman or artist. Parallel rules often span the entire width of the board and are so named because they remain parallel to the top edge of the board as they are moved up and down. Drafting machines use pre-calibrated scales and built in protractors to allow accurate drawing measurement.

Some drafting tables incorporate electric motors to provide the up and down and angle adjustment of the drafting table surface. These tables are at least as heavy as the original oak and brass drafting tables and so sacrifice portability for the convenience of push button table adjustment [10].

Multi-purpose furniture that can be re-deployed as play-themed structures useable by children is disclosed. The multi-purpose furniture, in one version, includes slab-like cushion elements (e.g., foam cushions). An ornamental graphic having the appearance of vertical wooden logs typical of a fort, large stones typical of a castle wall, or some other graphic is disposed directly on the surface of the foam (if foam is used), or a material encasing the foam (e.g., a woven or nonwoven fabric). These cushion elements may then be connected with one another to assume different configurations, e.g., a comfortable chair, or a structure having the appearance of a fort or other themed context [11].

4. METHODOLOGY

The study used the descriptive research based on the ergonomic principles or the human factors research which is the study of designing equipment and devices that fit the human body and its cognitive abilities.

The chattel was conceptualized, planned, designed and constructed based on the combined concepts of different furnitures and lightings commonly needed by an engineering students and engineers in order to save space for a single room and save power consumption. The design is so simple yet compact with different components that functions as a wardrobe, chair, bookshelf, bed, shoe rack, mini "sala" set, drawers, and a drawing table that save space. The chattel includes installation of lightings powered by solar energy.



Figure 1. Design Process

Project Conceptualization is the start of the project design through exploration of ideas on how to save room space and power consumption of engineers and engineering students when living or renting a room or apartment most especially in metropolitan areas.

Planning is the stage of the design cycle where the ideas for the project shall be planned to ensure realization of the project such as availability of resources including skilled manpower for the design of the project, instruments and financial requirements.

Design and development. It is the stage of putting all the necessary ideas to be able to design the desired project. It is the process of evaluating closely the details of the chattel project through the creation of detailed plans, drawings and drafts and devoting attention to each feature or specification. In this study the researchers use computer-aided design programs to model the chattel project into scale, ensuring the design, measurement and placement of components.

The researchers followed the construction process below in the development of the project.

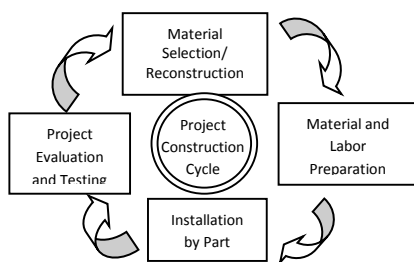


Figure 2. Construction Process

Material Selection/Reconstruction. The chattel was constructed using the laminated plyboard. However, other materials can also be utilized such as plywood, “paluchina” and other similar materials. Other materials such as screws, silicate glass, good lumber, nails, hinges, wood glue, contact cement, flanges, metal hanger, door handles, electrical wirings, fittings and fixtures; recharging battery, and solar panel. This is also includes the tools and equipment for the construction of the chattel such as power tool, screw driver, hammer, paint brush, sand paper, and tape measurement. After evaluation of the finish product, any component of the project that need to be improved shall be reconstructed to meet the need of the client.

Material and Labor Preparation. The selected wooden materials are cut and planed in accordance with the design and specification. Other materials such as metals, nails, metal hanger, screws, silicate glass, and flanges are ordered from a reputable supplier to ensure the effectiveness of the project. Wood glue, contact cement and other similar materials are purchased from the store following strictly the required brand and quality. Manpower for the labor requirement of the project needs skill and knowledge in the making of cabinet as a chattel for saving room space and power consumption.

Installation by Part. The project is constructed using the step-by-step process of installing the different components of the chattel project. Put together the base and attached the side panels using a similar glue-butt-joint-pilot-hole-screw process. Align the base so that the toe kick notches match up and all edges are flush. Use clamps, angle measures, and levels as necessary to ensure proper 90 degree angles.

Secure the top braces. Fit and glue into place one of the upper braces, such that the flat plane is flush with the back edge of the cabinet and should rest against the wall. Fit and glue the second brace at the front, so that the flat plane would rest against the countertop, once the countertop is installed.

Nail on a back panel. Trace the entire outside frame of the back of the cabinet and screw it into places.

Reinforce the connections. It is a good idea to reinforce all of the connections within the cabinet. Use corner brackets and screws.

Insert the shelves. Measure the height for the shelf or shelves and mark it on both sides. Use a laser level to make sure that the marks are level. Then, install four corner brackets per shelf (two to a side) for the shelves to rest on.

Assemble and install the face panels and glass. Using flat or mitered joint, assemble the face pieces the same way with the picture frame. Use pocket holes, dowels, or mortise and tenon joints to secure the pieces together. Then, glue and nail the single unit in place. With the nails countersunk, use wood putty and paint or stain to finish the cabinets.

Install the solar panel, electrical wiring, fittings and fixtures. Request for an electrician to install the necessary electrical wiring, fittings and fixtures, including solar panel as source of lighting and power for the appliances.

Fit and attach the cabinets. Fit the cabinets into their final location. Secure them in place by screwing through the back panel. Install the doors in accordance with the design.

Project evaluation and testing of the project is done in every step of the development of the project. The design and the finish product were assessed by the stakeholders using the evaluation principle of ergonomic research. Results of the evaluation were used to improve the project into perfection as expected by the users.

The overall size of the chattel is 3 meters in height, 2 meters in length, and 0.9 meters in width which is operated in accordance with its uses as planned in the design as follows:

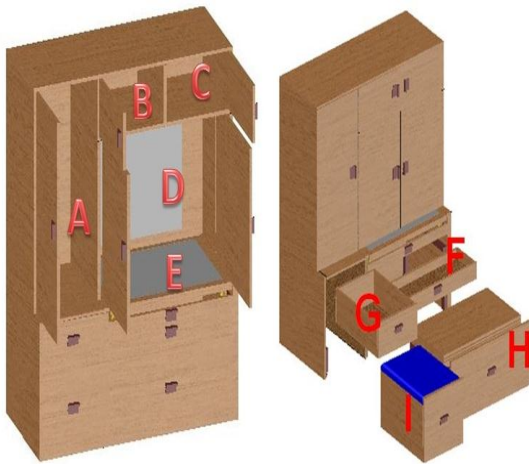


Figure 3. Operation Process

The doors of some of the components are designed to open through single and double-door such as **A, B, C, D** components. Other components are opened by pulling the drawer or the components and pushing when closing them such as components **E, G, F, I, H**. They were built using smooth sliding metals. This style of opening and closing save space when the components are not in use, not like other individual furnitures that require floor space for them to place during their life time.

For component **A**, it is a wardrobe use to keep clothes, pilows, towels, and other related belongings of the engineers and engineering students. For component **B** is use to store food supplies and component **C** for other supplies for bathing, and other body care products. Component **D** is a mirror needed by the engineers and engineering students for physical self assessment. Component **E** is a special drawing table with glass use for planning and designing projects and can also be used as study table. Component **F** is a drawer use for drawing supplies and instruments. Component **G** is a drawer for school and office supplies. Component **H** is a folding bed and at the same time can be transformed in to a chair. Component **I** is a stool with foam and below is the shoe rock.



Figure 4. Transformation of Chair to Table and Bed

Below is the operation of the lighting fixtures. The blue color flourescent set on top of the cabinet is a flourescent lamp for lighting with the recharging battery besides the cabinet. The source of power which is a solar panel is usually found outside or on top of the roof. The cabinet is provided with outlet for appliances purposes.

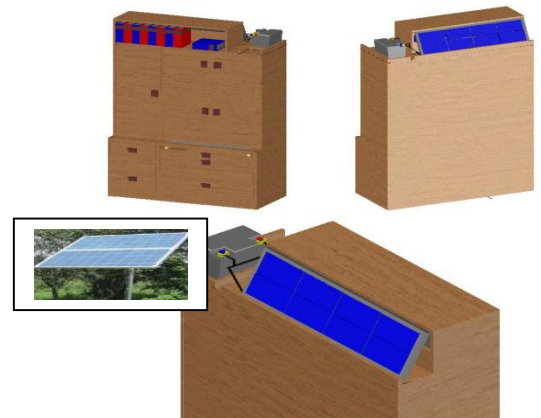


Figure 5. Solar Powered Chattel

For the assessment of the chattel, the study involved the participation of ten (10) engineering faculty and one hundred fifty (150) engineering students from different departments of the College of Engineering and Industrial Technology of the Rizal Technological University in the academic year 2014-2015.

After gathering and collecting the data, the researchers organized and analyzed information by using the tabulation, frequency and weighted mean. The rating scales used for the assessment of the design and prototype are from scales 1 to 5 as follows:

4.50- 5.00 = Very Satisfactory

3.50- 4.49 = Satisfactory

2.50- 3.49 = Neutral

1.50- 2.49 = Unsatisfactory

1.00- 1.49 = Very unsatisfactory

5. RESULTS AND DISCUSSION

Based on the evaluation of the design and prototype of the chattel, below is the table of the results:

Table 1

Criteria	Eng'g. Faculty		Students		Total	
	Mean	V.I.	Mean	V.I.	Mean	V.I.
1. Safety of lighting fixtures	4.80	VS	4.67	VS	4.73	VS
2. Safety of furniture	4.61	VS	4.54	VS	4.57	VS
3. Project design	4.75	VS	4.63	VS	4.69	VS
4. Environment friendly	4.82	VS	4.78	VS	4.80	VS
5. Easiness to operate	4.91	VS	4.89	VS	4.90	VS
6. Easiness to repair	4.86	VS	4.76	VS	4.81	VS
7. Cost effectiveness	4.10	S	4.23	S	4.16	S
8. Usefulness	4.96	VS	4.92	VS	4.94	VS
9. Affordability	4.72	VS	4.83	VS	4.78	VS
10. Durability	4.67	VS	4.64	VS	4.64	VS
Total (Mean)	4.72	VS	4.69	VS	4.70	VS

Project Plan and Prototype Assessment

As a result of the assessment the chattel is found to be very satisfactory with a total mean of 4.70. However, for cost effectiveness reveals satisfactory at 4.16 mean score.

Further, below are the photo documentations of the finish product:



Figure 6. Fabricated Solar Powered Chattel

As a result of the assessment of the plans and prototype model of the chattel, the researchers fabricated the chattel in accordance with the design specifications guided by the best carpentry practices and engineering principles. Figure 5 shows the finish product.

The project cost ranges from twenty-five thousand to thirty thousand depending on the materials used. This can be completed from ten to twenty working days.

The impact of the project to the engineers and engineering students is the provision of an opportunity to save and free from paying electric bills and able to have an adjustable furniture that can conserve a room space from 30% to 50% of the total area occupied by the individual furniture when they are not collapsible.

6. CONCLUSIONS

Based on the result of the study, the researchers conclude that:

1. The design and fabrication of the chattel can be modified according to the needs of the users.
2. Constructing a chattel provides flexibility in terms of materials to be used and availability of budget.
3. The project can be adapted in carpentry subject to improved student's skills and knowledge on advanced carpentry works.

7. RECOMMENDATIONS

Reference to the result and conclusions of the study, the following recommendations are being put forward:

1. Redesign the chattel base on personal needs of target users in order to increase effectiveness and functionality.
2. Select good and affordable materials to be used to reduce product cost.
3. The chattel should be a guide for the faculty in teaching carpentry subjects.
4. Other researchers should come up with other studies that save space and power for the users.

8. REFERENCES

- [1] Wang, S., An analysis of Transformable Space Saving Furniture, Beijing, China, 2013.
- [2] Chai, T.B., New Concept of Furniture Design by Using Space Saving Approach, Universiti Teknikal Malaysia Melaka, Kuala Lumpur, Malaysia, (No Date).
- [3] Kawiaka, K., Modular Transformable Furniture System, United States of America, 2013.
- [4] Varghese, et al, Design of Multipurpose Modular, Flexible, Space-Saving Dining Table, India, 2008.
- [5] Bin Chezakaria M.Z., Design and Fabricate Multipurpose Portable Desk, University Malaysia Pahang, Malaysia, 2008.
- [6] Bin Naziff, M.A.Z., Design and Fabrication of Portable Notebook Table, University Malaysia Pahang, Malaysia, 2009.
- [7] Dovramadjiev, et al, Design of Multifunctional Ergonomic Furniture made in Computer Environment Through Leading 3D Software Products. Technical University of Varna, Bulgaria, 2013.
- [8] Nasser, F., Multifunctional Furniture for Underprivileged Communities: A Milestone in Sustainable Development, Purdue University West Lafayette, Indiana, 2013.
- [9] http://ehow.com/list_6739142_phases-design-process.html
- [10] http://en.wikipedia.org/wiki/Drawing_board.
- [11] <http://freepatentsonline.com/y2012/0304389.html>