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Abstract – Sleep quality and bedroom's furniture design layout play important roles for humans in order to recuperate and revitalization. This project aims on designing ergonomic furniture by studying research papers and identifying the strengths of existed furniture. In addition, this project will also provide a few recommendations in the setting of bedding system to support users' musculoskeletal and prevent disorder problems. According to the results of survey papers, more storage units and multifunctional furniture are preferred by end-users. Based on observations and evaluations of patents from 2000 until 2015, this project suggests that furniture with ergonomics will be well-received. Besides that, the suggested design will focus on multifunctional, space-saving, ergonomic furniture to meet the needs and expectations of the current market. Copyright © 2016 Penerbit Akademia Baru - All rights reserved.

Keywords: Ergonomics, Loft bedding System, Quality, Customer Behavior, Multifunctional, Adjustable, Space-Saving Furniture, Biomimicry Design

1.0 INTRODUCTION

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Sleep quality is a vital factor that assists human beings to lead a healthy, safety, and happy lifestyle. It helps the human beings to perform their maximum performance in terms of work or daily life activities [1]. Furthermore, the average life of sleeping for human beings is approximate to one-third of their life span [2] and the optimal sleep time is within 6~8 hours at night [3]. The sleeping condition would affect the mental, mood, social interaction, and work efficiency of human beings which is controlled by their brains, where the brain functions to protect and preserve human's physical and psychology [4]. Hence, a poor quality sleepers will have less brain activation in self-regulatory regions of the brain compare to a good quality sleepers [5]. For examples, a pilot who does not have an adequate sleep before and during his duty, the rate of airplane crash increases thus placing the plane passengers life in a dangerous situation, so the co-pilot is needed to take turns to avoid unnecessary accident to happen.

Additionally, our daytime events or emotional stress events will induce the sleep quality and personality emotional control [6], so that it is essential for everyone in the present days to have a good and comfortable bedding system. The set-up of a good bedding system is crucial in maintaining a good sleeping posture [7] to protect our spine and to avoid body damage such as back pain, neck pain, shoulder pain, headache or spinal disorders' problems.



Human factors and ergonomics is the understanding of the interaction between people and all the elements within a system include human cognition, behaviour, well-beings, performance, productivity and safety in systems [8]. The term of "Ergonomics" has many definitions formed by scientists or ergonomists. For example, Nacy Howenstein states that ergonomics is human science that matches the environment, equipment, and process together with workers; incorrect ergonomics will lead to harm workers' body like fatigue and cumulative trauma disorder (CTDS) [9].

Good ergonomics is good economics [10] for society and industry, it helps to improve quality work life, health [11], safety, and also increase the productivity. In recently, many industrials and companies start to apply Human factors and Ergonomics (HFE) in their working environments [12].

The goal of ergonomics is to integral human characteristics into system and environment design. Ergonomics covers all activities of human daily life and play an important role in the conceptual of designing process that allows human to perform their work efficiently, comfortably, and safely [13]. In this project, the suggested design will base on the ergonomic aspects to create the furniture that meets end-users' requirements and improves their health with ergonomics design.

Along with the unstable economic, the rising oil price, the high unemployment rate, and the cost of housing increasing, many young generations need to rent a small apartment or room for working or studying. Hence, the multi-functional saving space furniture- Loft Bedding System was introduced and has become more and more popular nowadays. This project main target is to design and fabricate a Loft Bedding System that combines a bed, desk, chair, and other furniture. In addition, the fundamental of ergonomic knowledge will be incorporate into the suggested design in order to serve mankind.

2.0 LITERATURE REVIEW

2.1 Patents

The reviews and observations of existed furniture product are used to have a better understanding of creating a furniture product. The applicable and workable previous designed are used to examine the shortcomings and the improvement for furniture product.

a) Patent 1: US 6,353,945 B1

Multi-positionable bed is designed by James N.Jannetides, it is a bunk bed that combines a support frame, headboard, and footboard in order to provide a comfort seating and sleeping position to users [14]. Fig.1 shows the perspective view of the multi-positionable bed by inventor James N. Jennetides. Fig.2 is the enlarge side view showing the bed frame hinge in its angled or "couch" position. Fig.3 shows the perspective view of the first and second after assembling with a non-stacked position for viewing a television set.





Remark: 3-3- line ; 14,16- bed assembly; 22- footboard; 28,30,44-46- mattress support; 38- footboard; 47- back rest support; 48,57-61,84,86- stud; 49-53,69-73- post members; 54-56,74-76-crossbar members; 156,196-frame rail; 160-hinge





Remark: 44, 46- mattress support; 126-pins; 192, 196,198-frame rails; 200-hinge mechanism; 208-post-engaging plates; 212-coupled; 229-flange; 234,235,238,240-disposed legs; 242,244-support surfaces; 300,302-mattress support; 304,306,320,324-tube members; 308,314-plate members

Figure 2: Enlarge side view showing the bed frame hinge in its angled or "couch" position [14]





Remark: 10-bed; 14,16- bed assemblies; 22,38-footboard; 26,42-bed frame; 30,46-mattress; 50,52,70,72-post; 54,56,74,76crossbar members; 156-frame rails; 354-view of television

Figure 3: Perspective view of the first and second after assembling with non-stacked position for viewing a television set [14]

b) Patent 2: US 8,418,282 B2

The purpose of Michael E. Luft-Weissber's "Fold Up Dormitory" [15] is to provide a multifunctional furniture for working, sleeping, and storing small items. It is considered a mobile and easy to operate furniture. Its original feature is just like a big size briefcase but inclusive of many operations options. The overall structure is combined with a central core and a pair of folding frame. The first side of the central core is connected to bed platform, the second side of the central core is connected to the desk surface, and the storage shelving is designed within the central core. Fig.4 is a schematic view of the upright position of Fold Up Dormitory in a closed feature. Fig.5 shows the front oblique view of Fold Up Dormitory after basic deployment of all features.



Remark: 102- folding frame; 103- bed platform; 111- Levelling feet







Remark: 102- folding frame; 105- bed platform; 106- folding legs; 107- foldable desk surface; 108- storage shelving; 111-Levelling feet; 112- privacy barrier; 113- mattress or cushion; 116- mounting bracket; 1001- chair; 1002- computer

Figure 5: Front oblique view of Fold Up Dormitory after basic deployment of all features [15]

c) Patent 3: US 9,004,299 B2

The Storage Rack [16], inventor William R. Hardin highlighted the physical existing storage space problems. The assembly and disassembly features of the Storage Rack are very useful for temporarily storing items. The pieces by pieces of partitions make this furniture more flexible in combination for creating the pattern or shape that users need. Fig. 6 is the perspective view of the construction for additional shelf segment. Fig.7 shows the perspective view of the shelf by adding the vertical partition onto the centre. Fig.8 shows the perspective view of dissembling the storage rank.



Figure 6: Perspective view of the construction for additional shelf segment [16]





Remark: 6-additional vertical partition; 6A-matching slots; 7-additional shelf segment; 7A-slot

Figure 7: Perspective view of the shelf by adding the vertical partition onto centre [16]



Remark: 3-base shelf; 4-item; 4A-rotating storage rack

Figure 8: Perspective view of dissembling the storage rank [16]

d) Patent 4: US 9,084,489 B2

Geoff Gosling's invention, Modular Walls Incorporation Recessed and Extendable Furniture [17] is a modern design that incorporates interior wall design. It is an interconnected wall modular that folds the furniture onto the wall. It is a flexible and saving space furniture design. It can store many types of furniture inside like bed, sofa, chair, desk or etc. Fig.9 shows the perspective view of the extendable bed bunk and the ladder extends from the upper recessed.





Remark: 100a,102a, 102b-modular wall; 106,106a-exterior tiles; 110a,110b-extendable bed; 112-pocket; 114a-bed frame; 116-mattress;120-mechanisims; 122-tiles; 130frame brackets; 194a-bed frame corner; 196-extendable shelf; 200-head board; 206-locker;210-ladder



e) Patent 5: US 9,125,496 B2

Blair Wieland *et. al* creates a modern and multifunctional furniture design by transforming the back support of sofa into sleep surface configuration. This design has used the linkage mechanism to do the direct or indirect connection to the frames or components that need to transform [18]. The benefits of this design are save space and time. Fig. 10 shows the perspective view of the transformation from sofa to bed system. Fig. 11 is the perspective view of the linkage mechanism for bed system.





Remark: 402-front leg; 406-leg support; 408-back; 410-back front surface; 412-rear back surface; 428,430,432-arms; 440footrest; 448,450,452-seat; 560-furniture system

Figure 10: Perspective view of the transformation from sofa to bed system [18]



Remark: 806,828-mechanism link; 818-assit cylinder housing; 820-mechanism hack link; 822-mechanism back link; 826mechanism front link; 830-mechanism mount link; 832-mechanism back attachment plate

Figure 11: Perspective view of the linkage mechanism for bed system [18]

f) Patent 6: US 9,131,775 B1

The purpose of this ergonomic design of "Adjustable Seating" invented by Joel H. Elsenberg, Paulden [19] is to use the movable base surface to do the different direction movements without leaving his original seating position. It also provides the adjustable back support to solve the spinal problems for prolonged seating. Fig.12 shows the side view of the features for the different positions seating. Fig.13 is the perspective view of the back seat with its mechanism J bar.



Remark: 10-seat; 14-base; 16-back support; 18-23- pieces of back seat; 26-motion curve; 27-motion of seat back; 29-height of seat surface; 30,31-seat guide; 38,42-seat glider; 46-hinge; 50-column; 54-support portion; 58-wheel

Figure 12: Side view of the features for the different positions seating [19]



Remark: 131-detent

Figure 13: Perspective view of the back seat with its mechanism J bar [19]

g) Patent 7: US 9,179,769 B1

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The purpose of the Seat Desktop Conversion Device inventor by Larry Port is to utilize the function of the mounting member to support desk on the back seat surface [20]. The additional mounting member added the value or function of this chair so that it can have one more function of putting computer or other stuff on the extendable desk. Fig.14 shows the perspective view of the movement of desk support.





Remark: 10-seat; 12-support structure; 14-legs; 16-bottom portion; 18-back portion; 20-desk components; 22, 24-seat mounting system; 26-horizontal support

Figure 14: Perspective view of the movement of desk support [20]

h) Patent 8: US 9,198, 517 B2

Larry Port's invention, titled Adjustable Working Platform on Sitting Furniture [21] is an ergonomic design and it meets the requirements of current customers who need to work or study for a prolonged period. The adjustable and armrest support's platform can adjust in many ways for the different tasks such as reading, studying, and playing computer. Fig.15 shows the perspective view of the overall adjustable working platform on sitting furniture with a pair of armrests. Fig.16 is the perspective view of the adjustable backrest's seating furniture.



Remark: 11-first end; 12-second end; 21-top wall; 30-armrest cover; 31-top surface; 32-bottom surface; 100-lounge chair **Figure 15:** Perspective view of the overall adjustable working platform on sitting furniture with a pair of armrests [21]





Remark: 13-middle section; 20-support member; 100-lounge chair; 101-back support; 102-back rest; 103-bottom rest; 104foldable back rest

Figure 16: Perspective view of the adjustable platform on reading position [21]



Remark: 100-lounge chair; 101-back support; 103-bottom rest; 104-foldable back rest



i) Patent 9: US 9,212,497 B2

Keith Chlapaty, Ostrander describes his invention as a user-friendly and simple design. It is easy to assemble and disassemble which ease with the transport and store. The adjustable length has the ability to adjust according to different height and weight of users' body and minimized the storage size as transport [22]. Fig.18 shows the perspective view of the transformation for the portable chair.





Remark: 118-pool wall attachment assembly; 120-seat assembly; 122,124- adjustable support members; 126132,134-lengthadjustable cross members; 128,130-pool desk support hooks; 132,124-support members; 136-front cross member; 138-seat; 144A,B,C-lockers; 146,148-wall contact supports; 156,158-telescoping inner tubular members; 160,162-outer tubular members



3.0 MARKET STUDY

3.1 Market of Malaysia Furniture

Malaysia is the 10th largest exporter of furniture in the world today and it exports approximate 80% of furniture production around the world [23]. Malaysia's wood based furniture is wellknown due to Malaysia has a plenty of natural resources. Malaysia government sets a target of 6.5 % annual growth for wood based furniture by the year 2020, expected to hits RM 53 billion. In order to hit the target, Malaysia starts to shift from producing general product towards design its own furniture.



Figure 19: The distribution of countries that export Malaysia furniture [23]



A new programme named "Professional Designer Programme(PDP)" was developed by the Malaysia Timber Industry Board (MTIB) [24]. The purpose of this programme is to encourage young local designers to design more creative and innovative furniture.

In conclusion, Malaysia needs to develop and invest more time or money in this furniture design field in order to hit the 6.5% annual growth's target by 2020. The local designers need to put more efforts into furniture design to meet the requirements of customers and the competitive of the global market.

3.2 Factors Influencing Furniture Choice

There are many elements or factors can affect the customer in the purchasing furniture's process, the elements include satisfaction and ergonomic factors such as usability, durability, function, interaction, materials, shape, color, and etc [25]. Every furniture has its own purpose to be designed and it depends on how its performance, efficiency, and whether it is satisfied by end-users, it is described as "usability" [26]. Different kind of furniture will have different standards that are used to prescribe minimum requirements for that product.

Factor that influences furniture choice are divided into four major group that are product, service, price, and place [27]. The analysis of its survey form shows that the product factor occupies the major elements to influence the choice of furniture, shown in Figure 20 below. It shows that the quality, function, and size of furniture are the top three elements that influence purchasing furniture choice.





3.3 Customer Behaviors and Decision Making Toward Furniture Market

The customer is the main key that shows and decides the value of furniture product so that the study of customers' behavior on selecting furniture is very important in preparing marketing strategy. There are many factors that affect the behavior such as cultural, social, personal, and psychological.





Figure 21: Characteristics Influencing Consumer Behavior

(i) Cultural Characteristics

Cultural factors are separated into the culture, subculture, and social class factor.

- Culture is related to the customs, belief, and social behavior of a society. The background and families outline will pass on and reflect their children's purchasing behavior. Every country or society will have different and its own culture that affects the furniture purchasing behavior of every end-users [27].
- Subculture is a specific and smaller exit in each culture. Subcultures consist of religions, genders, ages, racial group, and nationalities [27].Consumers normally will have more than one subculture group and they combine together to make the decision in purchasing.
- Social Class is related to a hierarchy that means relatives will have similar behaviors or interest in the purchasing process. The factors are combined by occupation, education, income, and other factors.

(ii) Social Characteristics

A social factor will be influenced by reference groups, family, and roles factor.

- Reference group member can come from a different cultural characteristic that defines as any people who significantly influences other individual's behavior or thinking. It can be any size and either tangible or intangible.
- Family is related to marriage, blood, and adoption that stick two or more people together [28]. It plays an important factor in purchasing furniture such as husband, wife, and children will have different requirements and suggestions in order to buy the most suitable product.
- Some people believe that furniture will show his or her social status and express one's personality or identity [27]. An individual person plays different position or role in each group, such as family and organization.

(iii) Personal Characteristics

- Personal characteristics are subjective, one that influenced by age, occupation, economic status, lifestyle, and personality.
- Age of every person will keep changing and increasing over person's lifetime. The mind and taste in products will also change related to the age of a person. Purchasing behavior affected by the stage of person life cycle.
- Different personal's occupation will have their own purchasing style that depends on their own needs and wants.



- The economic situation of a purchaser will affect the sales rate of furniture product. The price of a product is the crucial element that influences the choice of product purchasing.
- Different person will have different lifestyle and interest in purchasing processes such as product color, pattern, shape, and other elements.
- Different people will have a different personality that refers to psychological characteristics such as motivation, beliefs, perception, attitudes, and learning. This can be explained by the Maslow's Hierarchy of Needs [29].

Furthermore, Nicole Ponder discusses that the new generation (Gen Y) will have the different view and opinion of purchasing furniture product such as environmental friendliness will win the favor of them and the significant life change of Gen Y is also a factor to lead they to purchase furniture products [30].

Furniture is an expensive and durable product that consumers do not purchase it very frequently [30], hence to sell the product successfully the first step is the producer or company need to understand consumers' decision-making process. Consumer decision-making process is arranged orderly by need recognition, information search, evaluation of alternatives, purchase decision, and post-purchase evaluation [28].

Consumers normally will purchase the product that they need that is called need recognition. Hence, a value product should be specified and discovered by company's marketing team in order to meet the requirements of consumers. After need cognition, consumers will start to collect product's information in order to have more knowledge about the product through personal sources or public sources such as the relative, social media, and marketplace. Hence, a producer or a company needs to ensure the product is in good quality and fulfill the standards in order to have a good public reputation for building the trust in consumers. After information collection was done, the evaluation of alternatives will be processed based on the product's reliability, price, quality, and other factors among different companies. The company needs to have strong market's strategy to attract the heart of consumer in purchasing its own product. The purchase decision will make out by combining all the consumer behavior related to purchase intention and product that meet their needs. After purchasing the product, the feedback of satisfaction or dissatisfaction of consumers need to be surveyed and take into consideration for the product improvement and further development. Fig. 22 shows the consumer decision- making process.



Figure 22: Consumer Decision-Making Process [27]



4.0 Design Layout Study



Figure 23: 10 Principles of Ergonomics [31]

Ergonomics is the study of a mixture between a human body and environment by setting the correct equipment, tools, and body postures to meet the maximum human performance and avoid injury. 10 principles of ergonomics include work in neutral postures, keep things in easy reach, reduce excessive force, work at proper heights, minimize pressure points, reduce excessive motions, minimize fatigue and static load, provide clearance, maintain a comfortable environment, and move, exercise, and stretch [31].

- Principle 1: Work in neutral postures are to keep the elbows, wrists, necks, lumbar and others body sections in a neutral posture when working. The neutral posture means to relax the body muscles as doing work.
- Principle 2: Keep things in easy reach is to minimize the body movement by rearranging the layout of the workstation.
- Principle 3: Reduce excessive force is to decrease the force impact toward human body by using the correct technique to move the object from one place to another place without excessive force.
- Principle 4: Work at proper heights mean different kind of work will need different height, the proper height of work will increase the ability to perform the task correctly.



- Principle 5: Minimize pressure points is to reduce the sharp corner of the object and add some support to reduce the risk of injury.
- Principle 6: Reduce excessive motions is used the correct technique or manual design layout to save time and strength.
- Principle 7: Minimize fatigue and static load mean to reduce the pain or fatigue by adding support or improving tools to ease the task.
- Principle 8: Provide clearance means to have enough space and clean surface in order to leave away from hazards.
- Principle 9: Maintain a comfortable environment is the correct setting of temperature, lighting, and others equipment are important to a human for performing the task efficiently.
- Principle 10: Move, exercise, and stretch mean human cannot stay in one posture for a long time, need to move or stretch body muscles after a certain time.

Work smarter, not harder. Ergonomics does not use only for work but also use for our daily life activities. Hence, try to understand and apply it to tasks or works will make tasks become easier, faster, safer, and more efficient.



a) Furniture layout without ergonomics



b) Furniture layout with ergonomics

Figure 24: Ergonomics and non-ergonomics furniture display and arrangement [32]

The differences between ergonomics and no ergonomics furniture are very obviously showed on Fig.24. The yellow color circle from part (a) shows that the red color chair on the upper-left corner is blocking the door and it increases the risk of injury for users, so it would not be considered in ergonomics design layout. The viewing position should be in a well-positioned



chair towards the television like part (b) blue and orange arrows are parallel with a certain degree of an angle which is related to ergonomics. The red color circle shows the lighting system of part (b) is brighter than part (a), it provides a better vision condition to users while using this living room. Fig.24 shows ergonomics and non-ergonomics furniture display and arrangement [32].



Remark: a- Headrest; b- Backrest; c-Seat; d-Armrest; e- Keyboard and Mouse; f- Footrest; g- Monitor **Figure 25:** The standard computer chair and ergonomic computer chair [33]

The improvement of ergonomics design is shown on the Fig.25 (a) and (b), the design is more flexible and adjustable in order to meet the ergonomics and human dimensions in different ages. The new design improves the comfy of computer work by supporting the users' body in a balanced way for any working position. Changing position from time to time allowed the body to relax the stretch body parts and users can work for a long time without pain. Different kind of sleeping or working position can be produced by this ergonomics chair, refer on Fig.26. Besides that, the additional parts of footrest and armrest can provide support to the human body.

5.0 ADVANCEMENTS IN FURNITURE TECHNOLOGY

5.1 Multipurpose Saving Space Design

The living space environment is one of the elements that affects the purchasing decisionmaking process [34]. A good furniture design does not only consist of the aesthetical and ergonomic works, it also needs to form design related to the furniture structural system and its materials. It helps to improve the original design to become more innovative and creative.





Figure 26: The changing position of ergonomics chair [33]

According to the International Research Journal of Engineering and Technology (IRJET), the furniture choices of consumers start to shift toward multipurpose furniture by using save space approach [35]. People tend to move into big cities to get greater employment opportunity and better life conditions. As the urban population becomes crowded, the limited urban land will cause the living space to decrease. This is a good chance and opportunity to develop the transformable space saving furniture in order to save energy and lower the cost of living for people who live in large cities but only can afford small department. Fig. 27, Fig. 28, Fig. 29, and Fig. 30 show the transformation space saving furniture design.

The space-saving dining table used the slider mechanism to do the extension and compression motion. The transformable feature of this design can save space when it is not in use and it provide large entertaining space when it is in use. It is an aesthetic furniture and this technique is suitable for those who live in small apartment.

The transformable space-saving furniture is user-friendly and saving space product. It combines two set of furniture that involves bed and desk. One main point of this design is users do not need to move items from the desk as transforming it into bed [36].

The designer, Dripton Roy called this furniture as "Magic Chair" because it can be assembled and disassembled by wood parts together. It not only is an aesthetic product but also present the resemble works of art. This design's advantage is less cost compare to a regular one.





a) Enclosed features of dining table



b) Mechanism system of dining table



c) The dining table is extended by mechanism system

d) The completed configuration of the dining table by adding additional boards

Figure 27: Multipurpose dining table [35]





a) The closed position of space saving furniture



b) The open position of space saving furniture



- c) The enlarge feature of the opening position for this furniture and it shows that it does not need to remove any stuffs from desk as transformation process
 - Figure 28: Transformation of space saving furniture [36]



Figure 29: Assembly of Capsule Shape Seating Arrangements [37]





Figure 30: Disassembly of Capsule Shape Seating Arrangements [37]

5.2 Biomimicry Design



Figure 31: The level of biomimicry [38]

Biomimicry is the study of natural that helps to solve human problems and to give the inspiration of design ideas for designers[39]. In the future, furniture designers will look forward to the biomimicry design by learning from nature in order to achieve the most efficient multifunctional structures and to get the optimum solution from them. Natural is a big factory that keeps minimum faults and selects the most suitable material to get the positive results[40]. The stronger point of biomimicry design is it modelled the features materials and forms from nature. It covers many areas like lightness, stability, self-repairing direction, resistance to dynamic and static loads, and figural structural properties enabling in energy saving. Fig.32 shows the characteristics of the level of biomimicry which are the environment, community, and organism. Fig.33 is the six design stages of biomimicry approach.





Figure 32: The biomimicry "Top-down "approach in design stage [38]



a) The Lotus Flower b) The lotus armchair ideas comes from Lotus flower **Figure 33:** Fiori Divano's Lotus Armchair[40]



Figure 34: Praying Mantis and Mantis Table [40]

The Rasha Mahmoud used the biomimicry as a problem-solving methodology in interior architecture and gets effective solutions that include the elements of thermal comfort, durability, daylighting, energy efficiency, and productivity[38]. Biomimicry is a new design method that will contribute significant development in designs with the system, technique, colour, harmonic, proportion, and others. Fig.33 shows the designed idea comes from the shape



of Lotus flower. Fig.34 shows the design of a table that was inspired by the Mantis standing posture.

6.0 MAIN OBSERVATION

The observations of patents are simplified into:

Patent 1 and Patent 6 are ergonomics and adjustable furniture designed. Patent 1 is a multiposition bunk bed and it can adjust or transform to become a television sofa with a certain angle to support lumbar. Patent 6 is an adjustable and motion chair, it can adjust the chair seat to meet the different height of users and have the back rest to support lumbar. The weaknesses of them are tangible and not easy to assemble [14] [19].

Patent 2 and Patent 8 are foldable, adjustable, and multifunctional furniture. Patent 2 is a set of furniture that comprises of a desk, bed, and storage units, it is usable for a multitasking person to do more than one task in a limited space. Patent 8 can adjust armrest and fold the base rest to meet different seating postures and support lumbar. The weaknesses of them are the material selections need to be light but have the enough strength to do the foldable motion [15] [21].

Patent 3 and Patent 9 are furniture that can be assembled or disassembled which are easy to store and build. Patent 3 is a storage rack that can easy to form by adding the additional partitions and disassembly as no need to use it. While, Patent 9 is a pool seating chair that is portable and adjustable to meet the different height of people. The weaknesses of them are the strength of the connection parts need to be strong enough to sustain a weight of objects [16][22].

Patent 4, Patent 5, and Patent 7 are transformation furniture which can open it when there is a need to use or close it when not in need to use. Patent 4 is simply to hide the bed system into wall modular in order to save space. While, Patent 5 is transforming the sofa into bed system by folding the backrest. Patent 7 is just simply open and close the desk by pressing the button. The weaknesses of them are the mechanism systems need to have enough stress to sustain repeating motion [17] [18] [20].

7.0 FURTHER DEVELOPMENT

The global trade volume of wooden bedroom furniture has reached US\$8.33 billion in 2012 [41]. China becomes the largest furniture exporter and the United States becomes the largest importer in this global furniture market. While Malaysia wood furniture still in innovation and development process [42]. Fig.35 shows the research results on numbers of journals for global, Asia, and Malaysia Furniture on online database website Science Direct from 2005 to 2015. The research keywords focus on global, Asia, and Malaysia furniture's market and development. On the observation of Fig.35, the research papers or journals of furniture are keeping increase that means it becomes more and more important recently. Malaysia Furniture occupied a very small proportion in either global and Asia' furniture field. Hence, the furniture field in Malaysia will have the further development's potential.

Along with the universalization of education and the improvement of human living standard, human beings pay more attention to their health and safety. Meanwhile, they also start to find any technique or new knowledge that can improve their living lifestyle. Hence, the term of



"Ergonomic Furniture" was introduced and the need of it increases sharply. Fig.36 shows the number journals on ergonomic furniture a sudden increased from 2014 to 2015. The ergonomics design should embrace the widest possible range of users with different needs [43]. The ergonomics need to consider the human cognition, human sensory, human body structures, anthropometry, and the environment. The ergonomics can reduce the rate of risk for musculoskeletal disorders [11] and prevent the complaints of work-related musculoskeletal injury from workers [44]. The ergonomics' scope is very broad, it can relate to working, standing and seating postures need to be correct to protect our spinal; the arrangement of components, equipment, and furniture should be in correct position for reducing the unnecessary body movement or injury. For example, the workspace and workstation design are ergonomically into minimising employee injury [45]. Hence, ergonomics furniture can be applied in working and housing environment to improve the work efficiency and life comfort.



Source: http://www.sciencedirect.com/science/journals/all. Keywords used: Global furniture, Asian furniture, Malaysia furniture. Figure 35: Journal search results on global, Asia, and Malaysia from 2005 to 2015





Source: http://www.sciencedirect.com/science/journals/all. Keywords used: Ergonomics furniture **Figure 36:** Journal search results on Ergonomics Furniture

Every house must have the design of bedrooms' space for resting and sleeping. The sleeping quality is crucial for human beings so that the bedroom furniture selection is the key element that makes users comfortable and enjoyable when they use it. Fig.37 shows the numbers of the research interest's journal on bedroom furniture is increase recently.



Source: http://www.sciencedirect.com/science/journals/all. Keywords used: Bedroom furniture.

Figure 37: Journal search results on bedroom furniture from 2005 to 2015



7. SUMMARY

From review done, the following points can be summarised as:

- Numbers of patents show that the inventors who develop their patents tend to design multifunctional, adjustable, foldable and ergonomic furniture in order to meet the current customers' needs.
- Market study shows that the potential and development of the Malaysian Furniture is growing rapidly and it starts to shift from producing general product towards design its own furniture.
- The highest product factor that influences the sale rates of furniture is the quality. This shows that customers do not mind to spend more if they can get a good and better quality of products. The inventors need to create a furniture design that is high quality but at a reasonable cost in order to fulfil the customers' requirements.
- The understanding of factors that influence customer behaviours and customers decision-making process in purchasing product are important to the procedures of designing a furniture product. Four characteristics that can influence the consumer behaviour toward buying a product that includes cultural characteristics, social characteristics, personal characteristics, and psychological characteristics.
- Design layout study is basically focused on the furniture design layout with or without ergonomics and compare the original design with ergonomics design product.
- Advancement in Furniture Technology:
 (i) Multipurpose Saving Space Design focuses on multi-tasking and functional design to save space and reduce materials cost in manufacturing.
 (ii) Biomimicry Design is a new design technique that inventor is inspired by the natural to create the innovation furniture and do the further development or improvement on the furniture product.
- From the reviews of numbers of journal:
 (i) An increasing trend of the numbers of the journal in Malaysian Furniture from the year of 2005 until the year of 2015.

(ii) A slow rise of about 15.84 % in the advance Malaysian Furniture for about 11 years starting from 2005, 4.84% of numbers of journals as compared to 2015.

(iii) The numbers of ergonomic furniture have been increasing rapidly in the recent year of 2015; it shows that the needs of ergonomics furniture are keeping increase.

• After literature review done, it can state that bed lofting system has a little amount of ergonomics features. Hence base on the literature review survey, it is intended to design and fabrication an Ergonomics Loft Bedding System that incorporates foldable ladder into chair and vice versa, extendable shelf/ unit storage, the adaptable baby cot to the main bed frame, the folding mechanism to the main unit, and etc.

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