A NOMADIC FURNITURE DESIGN FOR COLLEGE STUDENTS

BY

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THESIS

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ABSTRACT

The moving experience is a nightmare for most college students, who tend to move more than other groups of people. Heavy, large bulky furniture, clothes and many other items take a lot of time and energy to move. Moving typically involves removing items from the chest-of-drawers and closet, packing items in boxes, suitcases, bags and other containers and loading them in a vehicle and transporting them to a new location where the process is repeated. This is chaotic and time consuming. Another issue is that due to the limited storage space available in the typical dormitory or apartment a way to create more efficient clothes storage is needed. Eco-friendly materials should also be emphasized to build the product that be durable and last long. In this thesis design a new Nomadic Furniture Design for College Students is created that addresses five major design issues: functionality (i.e. storage convenience, etc.), enhanced form quality (aesthetics), flexibility, simplicity and durability (eco-aspect) to promote long-term use. Existing dormitory furniture does not adequately address college students' needs for clothes storage and moving frequency. This thesis explores design alternatives and makes suggestions for improvement.

Keyword: dormitory clothes storage, nomadic furniture, eco-friendly materials, flexible storage

To Father and Mother

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CHAPTER 1: INTRODUCTION

1.1 Overview

The moving experience is a nightmare for most college students, who tend to move more than other groups of people. Kirsten Ruby, Assistant Director of Housing for Marketing of the University of Illinois at Urbana-Champaign (UIUC) Housing Department indicates that most of the 7,000+ freshman students move out a the end of the year. Interviews by the designer conducted during spring semester, 2010 that included a total of 25 junior, senior and graduate students, indicated that this moving frequency appears to stay relatively constant at twice a year (in and out). Heavy, large bulky furniture, cooking utensils, clothes and many other items take a lot of time and energy to move. One only has to witness the spectacle of move-in day at a typical university to see the problem first hand.

A particular problem is storing and moving clothes. The typical furnished two person dorm room at UIUC provides basic clothes storage in the form of two chests with several drawers for storing clothing and two closets with a rod for hanging clothes and a shelf at the top of the closet (Figure 1.1).

Figure 1.1: photo of one side of the typical two person dorm room at UIUC (Illinois Street Resident Halls)

Moving into a dormitory typically involves two students removing items from a vehicle, going up several flights of stairs (elevators, if available as these are typically busy) and unpacking the items, and placing them a chest of drawers and closet. Moving out nine months later involves the same process to be repeated. This process is unorganized, time consuming and labor intensive and present a number of important design issues/problems for the designer to address. These include the need to address a nomadic lifestyle, limited storage space, lighting, accessibility, temporary clothes storage, inflexibility, unsustainable materials.

Students are essentially nomads with nomadic lifestyle. Appropriately designed nomadic furniture is needed to accommodate this lifestyle. The existing moving and storage system is inefficient, chaotic and disorganized. Moving clothes requires many “found” containers of different sizes and shapes that are inconvenient to lift and carry and must be removed and repacked and placed alternatively in a vehicle and in closets and chest of drawers. Many of these moving containers are discarded in university dumpsters afterward, which is wasteful as they are not reused and may or may not be recycled. The dormitory chest of drawers is bulky and heavy and not designed to be easily moved, even in the dormitory room. Moving in or out by university staff can require two or more people and a furniture dolly and a truck if it is transported any distance. Drawers are loose and need to be moved separately or secured during moves. The chest-of-drawers does not facilitate moving clothes to and from the vehicle. A better “nomadic design” is needed that is easier to use, store and transport clothes.

The storage space provided by the small closet and chest of drawers is limited. The typical two-person dorm room at UIUC is 12 ft. wide, 13 ft. long and 8 ft. feet high. Chest-of-drawers and closet system of dorm room provides clothes storage which is not adequate. The dormitory closest provides a rod for hanging clothes storage and a shelf above. Based on observations by the designer this is not sufficient storage for all clothing. Extra clothes are typically stored in cardboard boxes or other containers on the closet floor and shelf. Most dormitory students interviewed by the designer indicated that clothes storage space was not sufficient (student interviews, fall of 2010).

Lighting is generally poor or not existent in chest of drawers making reading labels and color matching difficult. Typical is a ceiling or lamp light. No lighting is available in the closet or in the chest-of-drawers.

Accessibility (Human Factors) is not considered well. In the chest of drawers, the lower drawers closer to the floor are inconvenient to use and present particular difficulties for people with disabilities such as those with limited mobility requiring wheel chair use. Wheelchair users in particular have difficulty accessing elevated storage shelves and storage in closets in general. More flexible storage arrangements are needed to respond to appropriate human factors and provide easier access to clothes storage and use.

Temporary Clothes Storage for frequently use clothing is also not adequate. Frequently worn clothing such as coats and hats are frequently placed on chairs or beds or tables.

The current storage system in dorm room is inflexible. The chest-of-drawers provides only bulk temporary storage of items. One size is provided to fit all user needs. No differentiation is made for male or female users, size and strength of the user or to accommodate user special needs. Customization for user preferences or needs is not possible. The closet has similar problems with high shelving that is difficult to reach without a chair. Extra clothes containers on the floor are also not easily accessible.

Unsustainable materials are in use. The materials used to fabricate the chest drawers used in UIUC dormitories are not considered eco-friendly and sustainable. The primary construction material is particle board covered with a glued plastic laminate. The particle board used for construction is covered in a thermoset plastic laminate. Traditionally, particle board was made with formaldehyde resin, a known carcinogen. Off-gassing is a particular problem with new material containing formaldehyde. According to the USEPA it can cause eye and nose irritation, headaches and an increased risk of cancer (Aung & Tanaka, 2005). The designer was not able to ascertain if the existing chest of drawers utilizes formaldehyde in its manufacture, eco-friendly alternatives are available and should be considered if this material is any new design. Also, the plastic laminate glued to the surface of the particle board is a thermoset plastic and is difficult to recycle. It cannot be melted and reformed and is usually must be ground up or placed in a landfill. Again, better eco-friendly and more sustainable materials should be used in any new design.

1.2 Designer's motivation

There are primarily two reasons the designer chose this thesis design project. First, as an international college student for over two years at UIUC, the designer experienced the need for improved dormitory clothes storage. As "nomads", students frequently move all their belongings in and out of the dormitory at least twice each year. Existing chest of drawer furniture and built-in closets are more or less fixed in place and are not designed to move with the user. Based on this observation, the designer felt that a new nomadic furniture design that would store and move clothes would be an interesting problem to investigate.

A second reason the designer was interested in this thesis topic was an awareness of the importance of designing to avoid harm to the environment. This project provided an opportunity to learn more about using materials that do not adversely impact the environment and people. Materials used in existing dormitory furniture are difficult or impossible to recycle and may harm the environment if disposed of improperly. The environment and human activity are two complex systems that closely interact with each other. The consequences of current interactions are increasingly predictable. Many of us, including the designer, do not want our industrial society to continue damaging the environment. More sustainable product development will help insure that our future world is livable for future generations.

Designers and people in general are becoming more and more concerned about environmental damage caused by our existing industrial manufacturing system. As a result, “eco” has become a key buzz word in product circles. Millions of products in people’s everyday lives are powerful tools to improve the quality of their lives, and every one of these products has an individual impact on our living environment. While some products may have just a small impact individually, collectively these products can cause tremendous harm to our planet.

Therefore, even though this thesis is just about ways of designing small products such as storage furniture, the designer feels it is meaningful to design these products to embrace the principles of sustainable design, helping not only our environment, but also ourselves. For these reasons the designer felt this was a challenging thesis design problem.

Additionally, the designer emphasized on understanding the trends throughout recent product markets. From a benefit-to-consumers standpoint, by understanding the market, designers can better interpret consumers' behaviors and general preferences. A consumer group is always a key start point for a design project. Only by fully understanding a user group - their daily lifestyle, their manners and behavior, their emotions and feelings and their values – are designers able to develop the perfect products for users and truly design for them; this is a way to develop products' benefits for users. From a benefit-to-brands standpoint, by understanding what the market would like to see and what would stimulate consumption activity, design can lead a brand to hit the market right on target.

Therefore, before starting the design project, it is essential for us to examine the current design trends in the market. This can lead the design process somewhat, as the design should follow some of these trends. In the meantime, at the end of this project, we can use these trends to help evaluate the design results.

According to an article named "Top 7 Design Trends" (Butcher, 2008), seven top design trends included: Global, Green, Personal, Interactive, Simplex, Feminine and Health.

CHAPTER 2: RESEARCH OF COLLEGE STUDENT NEEDS

The designer is a matriculating student at UIUC and was able to frequently observe the clothes storage and moving problem in first hand. It is obvious that Students are nomads and move frequently.

As such they frequently experience moving and storage problems. One can easily see the problem by observing a move-in day at the beginning of every school year.

Figure 2.1: Move-in day in the Catholic University of America

2.1 Research types

a. Interview research.

To assess student moving and storage needs the designer interviewed 30 students - junior through graduate level students living in UIUC dormitories. The result showed that the majority of them move quite frequently, at the average of twice a year (including moving in and out).

b. Observation research.

The designer also spent a great deal of time observing students moving in and out of their dormitory rooms. College students and their family members were heard to complain about how the awful moving was. To the designer, moves look like “fights” between humans and their large number of personal goods. Moving day appeared to remind people how much stuff they have purchased.

Figure 2.2: College move-in day

Based on the designer’s observations and interviews with students, they have great difficulty with storage because of two facts. First, they have limited space for storing existing items as well as new purchases. Second, students do not stay in one place for very long and they frequently;

this confirms the need for more flexible furniture storage options in keeping with their temporary nomadic lifestyles.

2.2 Lifestyle research of college students

As a college student herself, college students make up most of the designer’s network of friends. In order to fully understand the college students and storage, the designer talked with dozens friends, listened to what they said about everything related to this issue. The designer also observed people and how they behaved on moving day at UIUC.

The designer generalized her findings into three perspectives. First of all, the size of the spaces the students owned and how space they were used for storage was studied. Secondly, the quantity of items stored and the types of storage used were observed. Finally, their average moving frequency was studied.

The goal of this research was to determine college students’ basic needs for storage furniture. The user needs defined during research were used to guide the design development process.

2.2.1 Living space

The majority of college students can be divided into two groups: one living in school dormitories, fraternities or sororities.

The size of UIUC dormitory rooms has been the same for many years, and due to increasing cost of new construction they are not likely to increase in size anytime soon. Deb Lo Biondo, Assistant Dean of Residence Life at Duke University said, “I think it is important for students to personalize their residence hall room, especially since it is their home away from home. Their room is also the place where they spend the vast majority of their time – so it needs to feel comfortable and hopefully a place where students can feel productive” (College Bed Lofts, 2010).

As a student at the University of Illinois at Urbana-Champaign, the designer observed the room arrangement in most resident halls on campus. They had different rooms that could hold one, two or three people in a single room. Rooms with two beds (Figure 2.3) make up the majority in school resident halls. Therefore double bed room is the most typical type of dormitory. On the other hand, no matter the room size and number of occupants, the space per student is essentially the same. Take a two bed room for example. The room is approximately 12 ft. x 13 ft. x 8 ft. Each student has one twin size bed, one desk either under the bed or beside the bed, one chair, one small chest of drawers, one pedestal cabinet and one book shelf (Room and Furniture Dimensions in Residence Halls, 2010). Each room seldom has an individual bathroom. In most cases, rooms on one floor will share a huge bathroom, or one small bathroom will be shared between two rooms. One floor shares a laundry facility as well. Sometimes there is one or two big kitchens on each floor, and sometimes they do not provide kitchen.

The designer also researched typical living and storage space available to students living in privately owned apartments located around the university as well as fraternities or sororities. While students in these environments may have better facilities, the living space for each person is almost identical with dormitory living. For this reason, the designer decided to narrow the scope of the research to the typical two-person UIUC dormitory room and storage.

Figure 2.3: Residence hall at University of Illinois (Lincoln Avenue Residence Halls)

For the second group, they are living in rented apartments or houses. Because of economic limitations, and since youths are more likely to share their daily lives with friends, college students usually share houses or apartments with roommates. The living space for this group of people is a little bit bigger than for the first group. An apartment usually has one to four bedrooms, while a house has up to eight rooms. Commonly, one person has an individual bedroom and one to two people share a bathroom. The entire apartment or house shares one kitchen and one living room. Some houses may have basements, which should provide good storage. However, through talking with some of her friends, the designer found that many people are unwilling to use basements. The reason is that the basement is shared by everyone, but only a few people put an effort to cleaning it every week or month, so it is always dirty and messy. No one cares because everyone thinks of themselves as tenants; since they will move out after the lease ends, the mess will not affect them later on. Therefore, everyone shuts the basement door and chooses not to see anything. Worse becomes even worse, people want to keep away from that part of the house and no one wants to use it anymore. It is used mostly for wasted goods, and no one will put their daily storage there. Therefore, the basement can hardly be counted in terms of living space. The bedroom is usually 12 ft. x 12ft. x 8 ft, or may be even bigger. Each bedroom is basically equipped with one bed, one chest of drawers and one closet.

It is obvious that no matter where a student is living, in a dormitory, fraternity, sorority, apartment or house, all have very limited living and storage space, and they share bathrooms, kitchens and living rooms with others. Since students living in dormitories have more limited space than ones in apartment, the designer decided to consider students in dormitories as main target group. One design that can fit the needs of students in dormitories is able to fit needs of ones in apartment as well.

2.2.2 Clothing Storage

This thesis will focus on the problem of clothing storage, with a final goal of creating a better design for clothing storage. According to the research on students’ living space, the basic clothing storage facilities for each student consist of one closet and one chest of drawers.

Based on the information provided by University Housing at Illinois, the chest of drawers they generally provide for students has three drawers and measures: 28”W x 23-1/2”D x 30”H; each drawer inside is 22-1/2”W x 17-1/4”D x 5-3/4”H. The closet provided in the dormitory is 3’ x 3’ (Room and Furniture Dimensions in Residence Halls, 2010).

The designer also found that the amount of clothing each student has varies greatly. Take only hangers (“tees”) for example: some people may have around fifteen, while others interviewed had more than fifty. Also, quite a few students are keen on purchasing new clothes, so their clothing storage needs increase over time. Therefore, the designer found that it was not possible to determine the exact amount of storage needed for an individual student. Virtually all students interviewed indicated that they needed more storage space it is safe to say that there is need for additional storage in addition to typical chest-of-drawers and closet. .

Figure 2.4: Students create extra storage (resident rooms at Ikenberry Commons North Resident Halls)

In most student rooms examined, students use additional bags and cardboard boxes and other containers for extra storage (Figure 2.4). Boxes made of cardboard are a popular choice. Stacked cardboard boxes can be found in closets, under beds, above shelves, behind doors or in corners. There are several reasons for people choosing this storage method. First, these boxes cost less and are easier to get compared to other storage containers. Boxes are easy to collect them from daily packages or other sources. Secondly, cardboard boxes are foldable, so when not in use, they can be easily folded into a flat piece that takes up little space. The last reason is that cardboard boxes are useful on moving day; people do not need to figure out another way to move their stuff to another place. Besides these boxes, people also pin bags on their walls for extra storage. These bags also take up little space and it is easy to organize. The bags commonly used are paper bags or plastic bags. People usually put accessories in these bags.

On the other hand, the designer observed that most students like to hang up their tops in order to keep them neat and to avoid wrinkles. Pants, dresses, jeans and shorts are usually folded in chest-of-drawers, as well as underwear and other clothing accessories.

2.2.3 Moving frequency

College students move more frequently. More than half of the college students the designer talked to said they move around once at the beginning of school and once at the end of the school year. A few moved more frequently, at the beginning and end of each semester. Students who live in the dormitories may change their residence halls each year, or even choose to rent apartments if they are allowed to live off campus. Students who live in fraternities or sororities may not move out of their houses, but they usually move from one room to another each year. Students who live in rented apartments or houses have more uncertainties due to the condition of their buildings, leases and roommates. They prefer to extend their leases at the end of the school year so that they do not have to move so frequently as long as the apartment or house is not in a bad condition. However, the moving frequency of this group is still around once a year. Almost every student the designer talked to complained about their moving experiences. Students dislike moving because they waste too much time and energy in the process of packing – moving – unpacking and related activity.

Moving frequency and related difficulties underscores the need for any new furniture storage design to be of a size and weight that is easy to move and use. When people move, they typically call friends and family members to help; this is not a job for a single person or persons with limited physical ability. Even with assistance, the size and the weight and sheer volume of stuff moved makes moving difficult. Traditional storage furniture is heavy and is not collapsible, and therefore is extremely difficult to move.

As most college students use their own car or family car to move the cargo volume alone with the dimensions of trunk and door openings should be considered in the design of any new nomadic storage furniture. The designer observed that most students drive small gas efficient vehicles, although family members sometimes drive larger models such as SUVs or pickup trucks to campus to help students move. When we consider the design in dimension of students' economic vehicles, the design can also be fit the parents' big vehicles. Therefore, a new design should be able to be moved in smaller economy sized vehicles.

About.com (www.about.com), an online neighborhood of helpful experts sharing knowledge is recognized as a "top 15 content site". In 2010, this site released a report named "Top 10 Cars for Teens." In this report, the author mentioned that reliable, affordable and easy to drive are the top three considerations for students when choosing a vehicle. The report also listed the top ten vehicles preferred by students (Gold, 2010) (Figure 2.5):

1. Ford Focus
2. Honda Civic
3. Honda Fit

4. Honda Insight

5. Kia Forte

6. Nissan Versa

7. Pontiac Vibe

8. Smart Fortwo

9. Subaru Impreza

10. Suzuki SX4.

Figure 2.5: Top 10 cars for students

This report confirmed the designer's on observations regarding the type of vehicle that students' drive on campus in the U.S. An exception is number 8, the Smart Fortwo that is popular in European areas. Excluding the Smart Fortwo, the designer researched the cargo volume and dimensions of the rest of these cars (since the vehicle companies don't provide specific statistic of the width of cargo, the rear track width can be seen as the relative reference of the width of cargo). The results are listed below:

	Vehicle Type	**Rear Track Width (in.)**	**Cargo Volume (cu. ft.)**
1	Ford Focus	58.1	13.8
2	Honda Civic	60.2	12.0
3	Honda Fit	58.1	20.6 (Rear seats up) / 57.3 (Rear seats down)
4	Honda Insight	58.1	15.9 / 31.5
5	Kia Forte	61.6	14.7
6	Nissan Versa	58.5	17.8 / 50.4
7	Pontiac Vibe	59.9	20.1 / 49.4
9	Subaru Impreza	58.9	19.0 / 44.4
10	Suzuki SX4	58.9	38.1 / 54.3

Table 1: Vehicle rear track width and cargo volume of the top 10 cars for teens

Source: Ford, Honda, Kia, Nissan, Pontiac, Subaru and Suzuki official websites (2010)

According to Table 1, in the following design process, the measurement of the final outcome has to fit the smallest numbers for both rear track width and cargo volume, which are 58.1 inches of width and 12 cubic feet of volume.

2.3 Students' perspective

The designer also spoke with dozens of college student friends. They were asked what is most important to them in terms of storage furniture, and what performance they would like from their storage furniture. Their answers can be summed up in five key words: function, form, flexibility, simplicity and durability. In the following design process, these five words are considered carefully.

2.3.1 Function

Almost everyone pointed out that functionality is the first characteristic they consider in selecting storage furniture. A good piece of furniture should be able to solve the problems people usually meet in storing things. For example, many friends mentioned that they would like to store their stuff by category, so they asked for storage furniture with lots of boxes or pockets.

2.3.2 Form

Besides function, students also value the appearance of products. They believe storage is a good way to keep everything organized, and to display them. Storage is a brilliant idea to help people present their possessions right in front of them, so that people are able to look at them every day and exhibit them to their friends and families. These items thus become one part of the image of their owners. Students would therefore like to have storage furniture that is capable of even turning some of their junk into something that looks valuable. Many of them also pointed out that they want consistency among the individual pieces of a design. Half of them also said they would like the storage furniture design to be fun, playful, exciting and attractive.

2.3.3 Flexibility

According to the previous analysis, students usually have limited space, so storage furniture should occupy less space while creating storing things more efficiently. At the same time they are also looking for furniture that can be adjusted to meet varying storage needs. Since they are changing their living places frequently, they want storage that can extend when they get a bigger room and shrink for a smaller room. On the other hand, they all like to buy new things, so the amount of stuff they need to store is constantly changing as well. Therefore, they need an adjustable structure for their storage furniture that can meet their changing storage needs.

2.3.4 Simplicity

A large majority of people the designer talked to said they would like their storage furniture to be both simple to assemble and simple to use. Simple to assemble means they do not need to put too much effort into assembly. Some students complained that they spent more than 2 hours assembling one IKEA storage product. Simple to use means the storage should be user-friendly so that people can easily understand the products without spending too much time reading instructions.

2.3.5 Durable Long-term Use

Students would like to use their storage furniture for as long as possible, so that they do not need to keep buying new furniture and wasting money. Therefore, the material used to build the furniture should be durable. Also, they would like the furniture to be able to fit most environments or statuses; in other words, even when they are changing from students to working individuals or changing living environments, they can still keep using the same furniture.

CHAPTER 3: SUSTAINABLE ECO-FRIENDLY MATERIALS

One set of eco-concerns is focused on the ways in which we use energy and materials. The basic step to address all eco-concerns is to understand a material choice and its consequences. This thesis is written from a material perspective, which involves the environmental aspects of materials' production, use, their disposal at the end of their lives and ways to choose and design products to minimize adverse influences.

3.1 Definition of sustainable (eco-friendly) materials

As consumer concerns regarding the care and preservation of the environment gains momentum, more manufacturers are feeling the pressure to "go green" and introduce sustainable products, practices and services (Walker, 2009). In fact, all sectors of the consumer product industry are under pressure to innovate by using eco-friendly formulations. Designers, manufacturers and consumers have thousands of materials to choose from, some of which have little or no harm to the environment, while others have an adverse environmental impact, including depleting of non-renewable resources; releasing toxic or hazardous emissions into the air, water or land and by generating large quantities of solid waste (Fuad-Luke, 2009).

Nowadays, companies are not only using traditional criteria to select materials, which includes the physical, chemical and aesthetic properties as well as cost and availability, they increasingly use new parameters that consider embodied energy, carbon footprint and resource depletion.

These parameters are helping usher in a new and more sustainable paradigm of material use and reuse to minimize adverse effects to the environment. The following is a checklist offering a way of considering the overall potential environmental impacts of a material:

Material attribute	**Low environmental impact**	**High environmental impact**
Resource availability	Renewable and / or abundant	Non-renewable and / or rare
Distance to source (the closer the source the less the transport energy consumed) km	Near	Far
Embodied energy (the total energy embodied within the material from extraction to finished product) MJ per kg	Low	High
Recycled fraction (the proportion of recycled content) percent	High	Low
Production of emissions (to air, water and / or land)	Zero / Low	High
Production of waste	Zero / Low	High
Production of toxins or hazardous substances	Zero / Low	High
Recyclability	High	Low
Reusability	High	Low
End-of-life waste	Zero / Low	High
Cyclicity (the ease with which the material can be recycled)	High	Low

Table 2: Checklist for selecting eco materials (Fuad-Luke, 2009)

According to Table 2, an eco material is one that has a minimal impact on the environment but offers maximum performance for the required design task.

3.2 Eco-attributes of materials

Energy embedded in the process of one material’s lifecycle is a key fact in evaluating the eco level of that material. All materials represent stored energy captured from the sun or already held in the lithosphere of the earth (Fuad-Luke, 2009). Some materials take more energy to produce than others, such as aluminum, so these materials are high-embodied-energy materials. Others require just a little processing, for example plastic is labeled low-embodied-energy materials. Most man-made materials tend to possess medium to high embodied energy. Table 3 is a list of embodied energy values for common materials:

Material type	**Typical embodied energy (MJ per kg)**
Biosphere and lithosphere materials	
Ceramic minerals, e.g., stone, gravel	2-4
Wood, bamboo, cork	2-8
Nature rubber (unfilled)	5-6
Cotton, hemp, silk, wool	4-10
Wood composites, e.g., particleboards	6-12
Technosphere materials	
Ceramics – bricks	2-10
Ceramics – glass	20-25
Ceramics – glass fibre	20-150
Ceramics – carbon fibre	800-1000
Composites – titanium-carbide matrix	600-1000
Composites – alumina fibre reinforced	450-700
Composites – polymer – thermoplastic – Nylon 6 (PA)	400-600
Composites – polymer – thermoset – epoxy matrix – Kevlar fibre	400-600
Foam – metal – high-density aluminium	300-350
Foam – polymer – polyurethane	140-160
Metal – ferrous alloys – carbon steel	60-72
Metal – ferrous alloys – cast iron – grey (flake graphite)	34-66
Metal – light alloys – aluminium – cast	235-335
Metal – non-ferrous alloys – copper various alloys	115-180
Metal – non-ferrous alloys – lead various alloys	29-54
Metal – precious metal alloys – gold	5600-6000
Polymer – elastomer – butyl rubber	125-145
Polymer – elastomer – polyurethane	90-100
Polymer – thermoplastic – ABS	85-120
Polymer – thermoplastic – nylon	170-180
Polymer – thermoplastic – polyethylene	85-130
Polymer – thermoplastic – polypropylene	90-115
Polymer – thermoset –melamine	120-150
Polymer – thermoset – epoxy	100-150

Table 3: List of embodied energy values for common materials, adapted from Cambridge Engineering Selector, version 3.0, Granta Design Ltd, UK (Fuad-Luke, 2009)

A single product usually involves more than one material, so calculations of embodied energy and length of life cycle are important to define the more eco-friendly products (see the detailed calculation please check the book of "Materials and the Environment" (Ashby, 2009)). A high-embodied-energy material may have a durable and long product life, while a low-embodied-energy material may have a short product life. Therefore, in order to attain an accurate eco-calculation, the whole lifecycle of a product has to be considered. This includes nature resources used, material production, product manufacture, and product use and product disposal. The category of product disposal includes recycling, re-engineering, re-use, landfills and combustion (Figure 3.1).

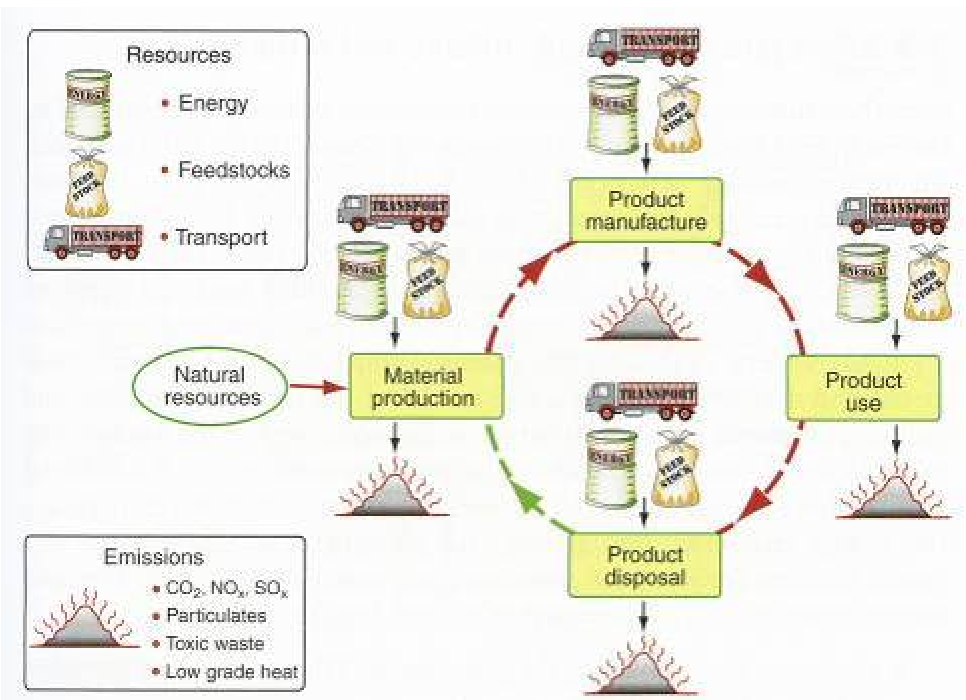


Figure 3.1: The material life cycle (Ashby, 2009)

Figure 3.2, 3.3 and 3.4 together illustrate the energy involved in these different stages using PET water bottles as an example.

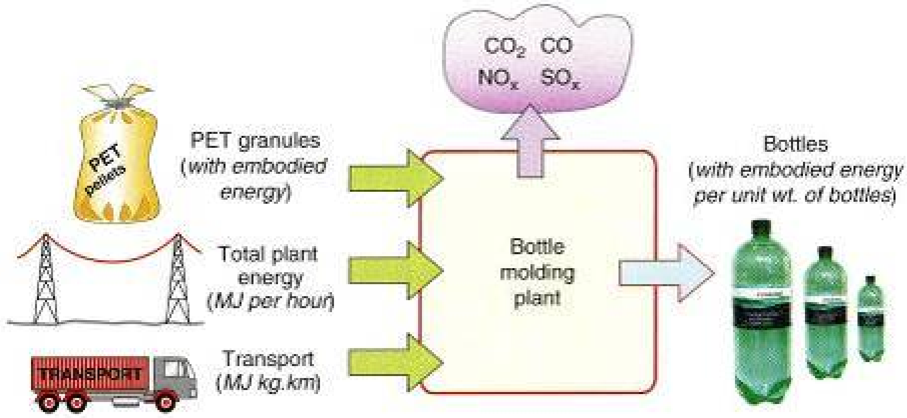


Figure 3.2: Manufacture: the blowing-molding of PET bottles (Ashby, 2009)

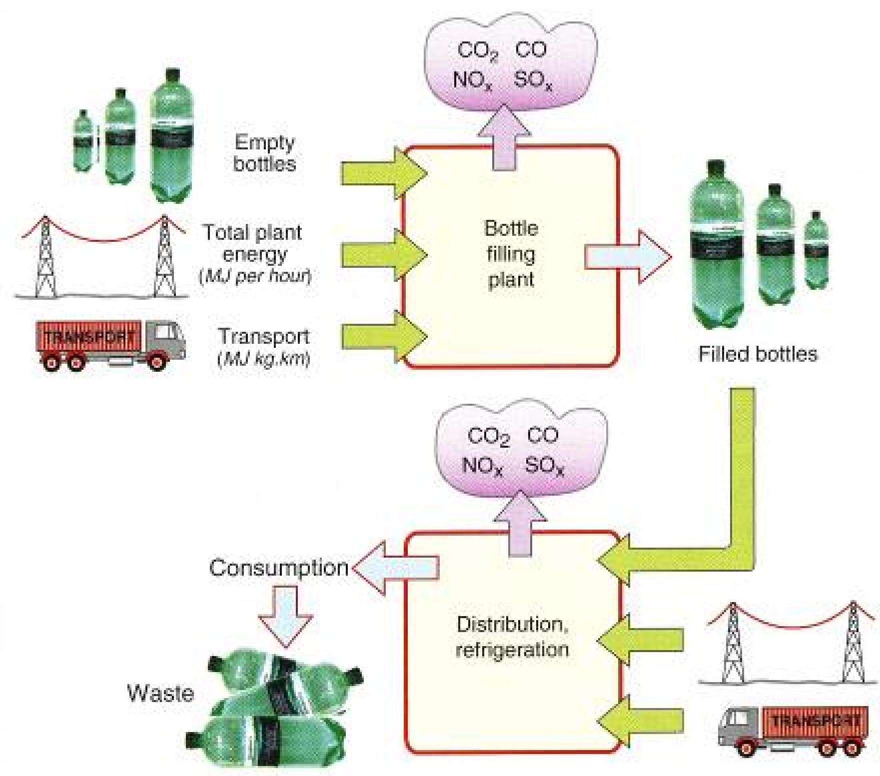


Figure 3.3 The use phase of PET water bottles from "Materials and the Environment": filling,

distribution and refrigeration. Energy is consumed in transport and refrigeration (Ashby, 2009)

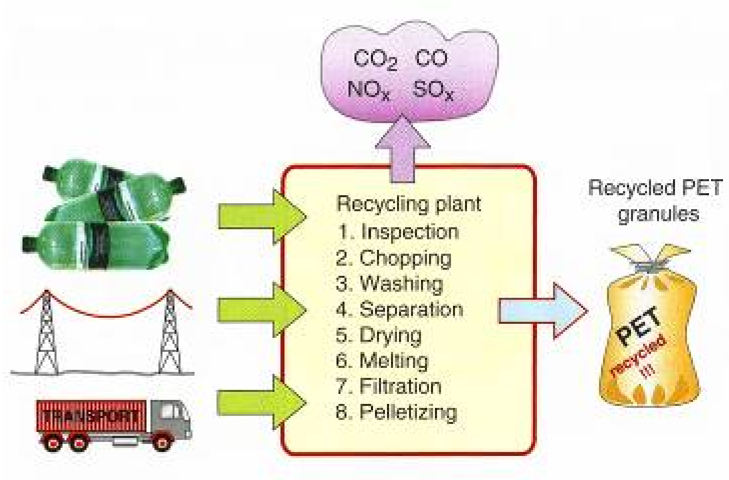


Figure 3.4 Recycling from "Materials and the Environment": many steps are involved, all of which consume some energy, but the embodied energy of the material is conserved. (Ashby, 2009)

From these figures, we can very clearly see that every instance of possible energy use in each step is considered carefully in the final evaluation. This is an excellent way to measure the energy use of a product. Usually what people do wrong is that they just see the energy embodied in a material itself and ignore the energy used in its manufacture and transport, and they also ignore the energy savings gained in the recycle step. For example, let us compare a sophisticated wooden chair and a cheap plastic chair. A sophisticated wooden chair may take more energy to make and transport according to the process from the raw material to a crafted product. Therefore, at this point, it seems that the wooden chair uses more energy than the plastic chair. However, when viewing the entire lifecycle, it is easy to determine that the well-made wooden chair lasts much longer than the cheap plastic chair. The wooden chair can be passed from one generation to another without any problem, while the plastic one is less durable and is disposed of in just a few years, usually going to a landfill (thus the disposal phase may have some toxic impact on the environment) where quite a lot of energy may be wasted trying to recycle it. Therefore, the wooden chair wastes less energy and is more eco-friendly than the plastic chair. Thus we should not be misled by just a single part of the manufacturing process, but instead we must look at the entire product lifecycle.

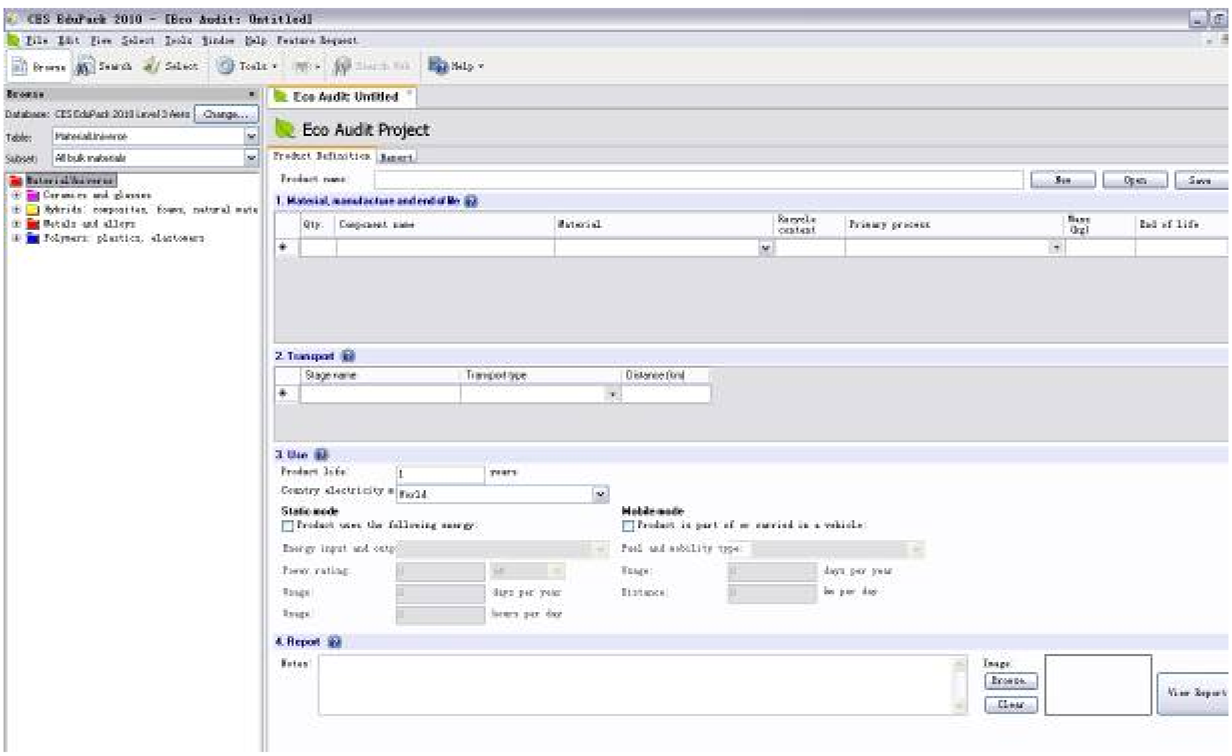


Figure 3.5: Interface of CES Selector software by Granta Company

“CES Selector” software (Figure 3.5) is released by Granta Company (http://www.grantadesign.com) that aids critical decisions on materials, processes, and eco design. Its database contains the “Material Universe” data, which provides property data for virtually every purchasable engineering material. It is a unique tools and datasets for choosing the right materials and defining application processes. The “Eco-Audit” tool allows user to make an entire list of material, and it helps estimate the energy usage and CO2 output. (Figure 3.5) The software helps optimize performance, cost, and environmental properties of design.

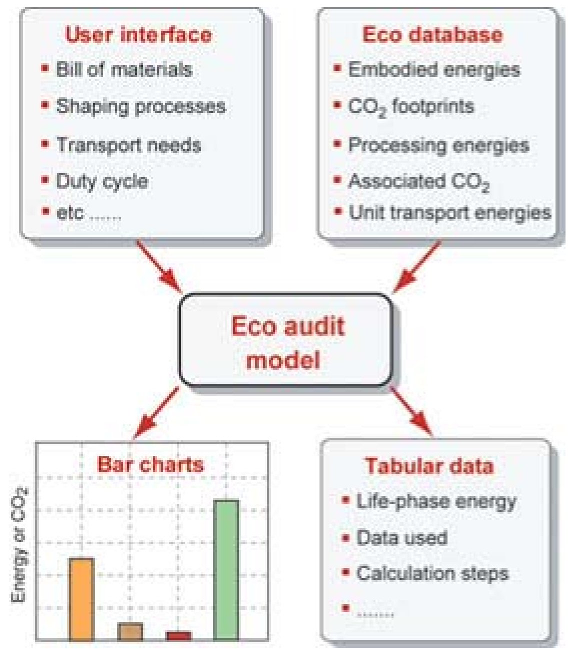


Figure 3.6: Inputs and outputs of Eco-Audit tool in CES Selector software (Granta, 2010)

In this thesis design study, the designer used CES Selector in Chapter 6 for estimating the energy usage and CO2 output of final design, and compared the result with current chest-of-drawer in dormitory.

3.3 Materials used in storage furniture design

The scope of materials studied was narrowed to those currently used to manufacture clothes storage furniture. The most commonly used materials in storage furniture design are: timber, particle board and plywood (prefabricated sheets), metal, plastic, cardboard, paper, glass, fabric and cane. Typical woods used include softwoods (conifers, e.g. pine, etc.), hardwoods (angiosperms, e.g. birch, etc.) and hardwoods (monocotyledons, e.g. bamboo, etc.) (List Of Woods, 2010). Metal (e.g. steel, aluminum, etc.) are used for accessories such as pull knobs and handles and floor skids and wheels. Materials used to assemble furniture components include several types of resin based glues, nails, screws and related fasteners.

3.3.1 Timber

Timber is commonly used in traditional storage furniture design. Historically, furniture made from timber was passed from generation to generation since it was stable and durable. According to its long-term lifecycle while in use, timber can be seen as one of the most eco-friendly materials available. The only disadvantages of this material are that it usually requires more effort to manufacture and preventative measures are needed to protect it from corroding and insects, so the price of thus furniture is usually high. In addition, the weight of storage furniture made from timber is always pretty heavy and thus difficult to move and costly to ship.

Figure 3.7: Big timber storage cocktail table by Flexsteel Furniture

3.3.2 Prefabricated Board

Prefabricated Board here means wood fabricated from wood ships (particle board) and layers thin sheets (plywood) that involve using various resins or glues (which have significant embodied energy) to “fix” the material in a sheet form for further processing into furniture components. This is generally a fairly complicated and eco-unfriendly process. Also, the specific material processing can impact specific material characteristics such as durability, hardness, waterproofing, strength, flexibility, etc. Different types and finishes can be achieved depending on the different raw woods (i.e., hardwood or softwoods) and processing methods used. Therefore, there are thousands of different boards vary in thickness from fractions of an inch to an inch or more, such as plywood, MDF board, meadow board, particle board and so on. Thanks to recent improvements in technology, companies can also produce light and thin pre-manufactured boards that are strong and durable. The price of storage furniture made from pre-fabricated boards is usually lower than furniture made from lumber. The disadvantage of boards is that the material process used to make some boards may involve certain glues or other additives, which may be toxic or have some bad impact on the environment, or some others may not going to have a long lifetime such as particleboard used in Figure 3.6. Therefore, not all kinds of boards are eco-friendly.

Figure 3.8: The all-in-one storage wardrobe by IKEA made from particleboard

3.3.3 Metal

Metals are used for a wide variety of storage furniture and storage shelving designs. Fabricated metal components include drawers (Figure 3.9), shelves (Figure 3.10), handles and fixed wall storage systems. The most commonly used metals are steel and aluminum. Metals are ideal in terms of their stability and durability, and they are easy to recycle. Metal has good ductility, so pieces can be made thin, and are thus lighter than other materials with the same strength properties. Metal is an excellent material for both design and the environment, because of its strength and stiffness that allow the use of sheet metal to reduce the weight and thus the embodied energy. Also metal can be made to the way easily to recycle (melt down and form new sheets).

Figure 3.9: 4 drawer dresser by Art Van Furniture fabricated from painted steel sheet

Figure 3.10: Metal gravity shelf unit by Solutions Company

3.3.4 Plastic

Plastic is one of the most popular materials used today. It is everywhere in our daily life and is one of the most successful synthetic materials (Fuad-Luke, 2009). There are millions of different plastics available today. Plastic is easy to produce and manufacture and most plastics are light and inexpensive to buy if one does not consider the adverse environmental impacts associated with their manufacture and reuse. However, as mentioned previously, the life-span of plastics is usually short (especially if degraded by sunlight), and they must be replaced or renewed more frequently than materials such as wood, steel and glass. Recycling the plastics used in clothes storage furniture presents certain is problematic. Some plastic glues contain formaldehyde and other toxic chemicals that are known carcinogens and are there form hard to reuse or recyclable. When disposed of improperly, they may also do harm to the environment by releasing harmful chemical into air, soil and water.

There are some plastics that are more easily recycled, not carcinogenic, such as certain PET、PE、PP、PS、PA. However, all plastic lose quality when recycled – they are downcycled, mixed with virgin material, and it still takes a great deal of energy to recycle these materials. At the same time, biodegradable plastics are more expensive than non-degradable ones, if one does not consider the cost to the environment. Therefore, we have to reduce the use of toxic plastic materials in product design, or use them in ways that make it easier to reuse them.

Figure 3.11: Plastic storage container by Flexicon

3.3.5 Corrugated Fiberboard (Cardboard)

Corrugated Fiberboard (Cardboard) boxes are commonly used by students to store clothes. Cardboard boxes are easy to manufacture and inexpensive, Students typically obtain discarded cardboard shipping boxes from stores for free and plain new ones can be purchased at various retail outlets at minimal cost. There are a number of specially designed colorful cardboard storage containers such as those by Green Party Goods (Figure 3.12) and Adler in (Figure 3.13). These boxes they are usually lightweight and collapsible, so they are flexible to arrange and move around. When not in use they can be collapsed and stored. They are hard to be displaced by other materials since its convenience of use. Cardboard is also an eco-friendly material, as it is biodegradable. Various printing inks and plastic coatings and glued labels used to make the boxes more colorful and durable can be problematic if they contain toxic chemicals. Even with reinforced paper or plastic coatings, cardboard is not as durable and strong as wood or metals, so students generally use cardboard boxes for auxiliary or temporary storage.

Figure 3.12: Recycled cardboard storage boxes and seats-set of 3 by Green Party Goods Company

Figure 3.13: Stackable and collapsible hotel boxes by Designer Adler

3.3.6 Paper

Cardboard can be considered a type of paper. Beside fiberboard (cardboard), there are many other types of paper used in manufacturing. Paper is universally light; collapsible; easy to store, carry and move. Almost all papers have the same advantages as cardboard; they are easy to recycle and reuse or to degrade in nature. Recycled paper is also popular, as seen in the market. However, paper is not strong or hard enough for most storage, and water is the bane of paper, causing it to rapidly deteriorate.

Figure 3.14: Holiday storage box by the Container Store

3.3.7 Glass

Glass is excellent in terms of clarity, corrosion protection and sealing properties. Depending on thickness and whether tempered or not, the material breaks when hit with sufficient force. Disadvantages are it heavy weight in comparison to other materials and the fact that it breaks when hit with sufficient force. Glass is usually used as a supplementary material in storage design, such as glass cabinet doors or shelves (Figure 3.15) or for small containers, such as glass jars (Figure 3.16). Glass has a really long life if not broken. It is also recyclable and reusable, and lots of energy can be saved in this process. It is one of the best and easiest materials to recycle as it loses little if any of its original properties when recycled and it therefore an eco-friendly material. However, because of its heavy and usually fragile, so it is not so friendly in terms of transporting and moving it.

Figure 3.15: Glass wall unit cabinet décor by Iterluebke, Germany

Figure 3.16: Glass jars by Viola

3.3.8 Fabric

Fabric is used mostly as a cover for storage furniture, but it can be used as small storage containers itself, as the pictures show. Fabric is lightweight and easy to carry. When not in use, it is easy to store fabric storage containers. Fabric materials require low energy in their manufacture, use, recycling, reuse and degrade phases of life cycle use. As a result, fabric is inexpensive and friendly to the environment. The disadvantage is that fabric cannot be used as a hard container by itself, thus a hard structure must be added inside the fabric for storage purposes. Whether a fabric is eco-friendly or not depends on the material used to make the fabric. Cotton for instance, requires huge amounts of water to grow. Plastic fabrics have the same issues as mentioned under the materials section above.

Figure 3.17: Fabric bins by Sewing Momma's shop

3.3.9 Cane

Cane is made from small pieces of certain plants such as bamboo. Since it is a natural material, it is also easy to recycle, reuse and biodegrades. By using appropriate weaving methods, this material can be made strong, flexible and durable. However, the drawback is that, this material gradually loses its durability over the years, which reducing the product's life expectancy. Usually, cane needs a metal frame to hold it while in use.

Figure 3.18: Tier rattan basket storage shelf by SEI 3

3.4 Aesthetic value of eco-friendly materials

As mentioned in the previous chapter, students not only care about function, but also the aesthetic value of their furniture. Therefore, we have to look at eco materials from an aesthetic perspective too. Some eco materials have a unique inherent beauty, while others can achieve beauty through specific applications. Eco materials can impart the following aesthetic values to designs:

3.4.1 Unique texture and pattern

Manufacturers are searching for new materials to help achieve eco-friendly designs with. The use of advanced biological materials and recycled materials is booming in global markets. Thanks to these new materials, companies can distinguish themselves as a leader in the sustainable eco industry. Unique and interesting textures or patterns may be given to their products by utilizing these new materials' characteristics. Some new materials may be pleasant to touch, giving a soft or hard feeling to a product while others may create in appealing pattern. One example is 3form Inc., a U.S. company dedicated to the new eco material industry. Varia Ecoresin (Figure 3.19) is their signature product. It is made standard from a minimum of 40% pre-consumer recycled material. After the manufacturing process, various unique patterns are given to different types of Varia Ecoresin. They press various recycled materials with their unique ingredients to achieve a final new material in order to form various aesthetic patterns. Varia Ecoresin was awarded Building Green's 2006 Top 10 Green Building Products award (Varia Ecoresin, 2010).

Figure 3.19: Varia Ecoresin from the 3form Inc. website

On the other hand, existing materials can also achieve new textures and patterns by creating new manufacturing techniques. For example, Figure 3.20 – a sweet candy wrapper handbag – is made from a mix of 100% recycled candy wrappers, soda labels and food packages. A new weaving method gives these recycled packages a new pattern and texture, which contribute to an elegant handbag. Figure 3.21 – the Socorro shoulder bag – is made from recycled pull-tabs from cans. The reuse idea and new sewing technology contribute to this eco-chic design.

Figure 3.20: Sweet candy wrapper handbag by Eco-Handbags

Figure 3.21: The Socorro shoulder bag by Escama

3.4.2 Use of nature materials fashion

Certain materials, such as timber, wood, cane, etc. have few artificial marks and look natural. By applying these materials creatively to a design, their “natural aesthetics” can create a unique and natural style for a product. Figure 3.22 shows two fashion boutique interior designs from Ilan Dei Studio.

Figure 3.22: Fashion boutique interior designs by Ilan Dei Studio

In the designs shown in Figure 3.22, the furniture is primarily wooden materials including shelves, ceilings and chairs, creating a natural look throughout the store interior. The raw color and patterns used also make the interiors look more natural, while the curves and shapes look modern and fashionable. This is a good example of applying natural materials in modern design correctly, leading to a combination of tradition and fashion. This is an example of how an effective use of natural materials can create traditional Eastern styled furniture, such as combining wood with paper, or extensive use of cane in furniture. In this way, the design brings a sense of the calm, natural, quiet and mystery of eastern aesthetics to the value of a variety of products.

3.4.3 Simple and elegant use of materials

Metals such as steel and aluminum are some of the most eco-friendly materials and can be used to create simple forms as the basis of an elegant design. Examples are steel closet organizer with the simple and elegant lines in Figure 3.23 and steel garage storage rack in Figure 3.24.

Figure 3.23: Closet organizers

Figure 3.24: Garage hanging storage rack by Small Furnish

We can see that both are primarily made from simple steel rods that are lightweight and collapsible. The designs look both simple and well-organized, which creates an elegant feeling. In addition, metals have a certain metallic luster that lends to their aesthetic appeal, as the garage storage unit shows. By applying and displaying this luster well in a design, such as combining it with other materials for comparison, lends itself to an appropriate eco-friendly modern style. While steel generally receives high marks for its sustainability and ability to be recycled at the end of its useful life, the plastic coatings on these closet organizers are not so eco-friendly.

CHAPTER 4: NOMADIC

4.1 Definition of nomadic furniture

According to the book “Nomadic Furniture,” written by James Hennessey and Vector Papanek in 1973, nomadic furniture means furniture that is easy to make, lightweight but foldable, collapses, stacks, inflates or knocks down. It can be disposable while being ecologically responsible, which means environmentally friendly when recycled or thrown away (Hennessey & Papanek, 1973).

Much of the furniture in our lives is bulky, heavy, fragile or in other ways difficult to move. However, the idea of nomadic furniture is the opposite. It relies on the power of certain mechanics, material choices and simple manufacturing technology to offer benefits to people who move frequently. It enables these people to have more by owning less.

While in use, nomadic furniture is easily assembled and durable. Ideally, it should be flexible for use in different environments, which means it is adjustable according to various space conditions. While not in use, nomadic furniture should be easily collapsed, and it should require minimum space to store. Also, when being moved, nomadic furniture should not take too much room and it should be lightweight and easily carried.

The concept of nomadic furniture is thousands of years old. In recent years, this idea has experience a rebirth as the pace of the world has become faster and people move from one place to another more frequently. College students, the target user group of this thesis, are moving even more often, so they have a particularly urgent need for nomadic furniture. The nomadic design provided on the following pages were chosen by the designer for their unique and appealing design simplicity including their elegant and appropriate use of sustainable and eco-friendly materials.

4.2 Commonly used structures to achieve nomadic designs

By studying hundreds of existing examples of nomadic furniture, the designer found out that there are several structures commonly used by manufacturers to make nomadic furniture, as listed below.

4.2.1 X structure

X Structure is commonly seen in foldable furniture design. This structure has two benefits. One is that it is easy to fold during a move or when being stored; the other one is that the structure of X is stable when bearing force, so that the furniture is safe to use. Now, designers and manufactures sometimes will make slight changes in this structure for some aesthetic goal or another; they might add a few curves to it (Figure 4.1), or tie three or even more sticks at one point to obtain a multi-x-structure (Figure 4.3). One product might have more than one X structure on it (Figure 4.2) for foldability and stability. A chain or strap might also be used to lock the X structure, in order to ensure its stability.

Figure 4.1: Wine barrel folding chair by Whit McLeod Chairs

Figure 4.2: Collapsible chair by Gracemount Limited

Figure 4.3: Fishing chair with pouch by Promochoice

4.2.2 Origami structure

Origami is an art form that utilizes one or more pieces of paper to create a 3D figure by only folding and cutting, without using any glue. It shows many ways to turn a 2D object into a 3D one. Therefore, designers will sometimes be inspired by origami when making foldable or easily assembleabled structures. Designers and manufacturers are folding other materials just like paper, as in the two structures pictured below, which offer a sense of origami technology used in furniture design.

Figure 4.4 is an origami structure example, which shows how by popping up a pocket, the original two-layer flat sheet is plumped up into a round chair. While in transport, the chair can be pressed back into a flat sheet again.

Figure 4.4: The flux chair

The design in Figure 4.5 won the Dutch Design Award in 2007. It is a chair that can be assembled by inserting slotted, separated sheets together into a single object. Using a simple construction process, one sheet of board is built into a children’s chair. Similar slot structures are used in collapsible furniture quite often.

Figure 4.5: Finish Your Self by David Graas

4.2.3 Flexible honeycomb structure

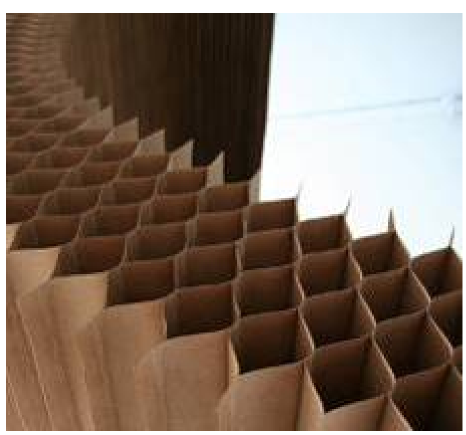


Figure 4.6: Honeycomb structure

Designers usually use this flexible honeycomb structure (Figure 4.6) with recycled paper or other similar materials. As the picture shows, this structure is relatively soft and expandable at a horizontal level, while stable at a vertical level. Therefore, products using this structure can be very adjustable at the horizontal level. The following example applies this structure to a chair design.

The Flexible Love chair (Figure 4.7) is an expandable chair made entirely of recycled paper and recycled wood waste. The seating area can be changed from holding one to as many as sixteen individuals with ease by simply pulling at each end to change the length and the shape.

Figure 4.7: Flexible Love chair by Chisen Chiu

4.2.4 Deployable structure

Foldability can be easily achieved by adding a simple deployable structure. Some fold like paper, while others rotate to fold. By using a deployable structure, the size of products becomes adjustable for different situations.

Figure 4.8 is an example of the use of a deployable structure. When in use, people just flip up the table's surface and rotate the legs underneath to support the surface. Two tables can be put together to make a big one or a long one. While not in use, people just need to rotate the back two legs and turn back the top surface. Due to the slightly bent skids, the table can stand elegantly. A little room is required for storage.

Figure 4.8: Foldable table by Akka

4.2.5 Fillable structures

Usually, when purchasing furniture with a fillable structure, consumers buy a basic crust first. They then fill the crust with certain filling materials according to their personal needs. The most popular filling materials are air, water and foam. The representative products shown below are an inflatable bed (Figure 4.9), a waterbed (Figure 4.10) and a beanbag sofa (Figure 4.11). By changing the amount of filling materials used, people can adjust the furniture from hard to soft. The beanbag sofa is even flexible in its shape. When storing or moving these pieces, people can remove the filling materials and leave the cover.

Figure 4.9: Nappak sleeping cube

Figure 4.10: Waterbag by Spa Suite

Figure 4.11: Beanbag sofa by Bedzine

4.2.6 Trolley structure

A trolley structure involves adding wheels underneath a product in order to ease moving activity; usually two or four wheels are added. Products with four wheels can be moved around a room all the time, while products with only two wheels may have legs to help them stand stable. When these structures need to be moved, people can push the wheel side and leave the leg side vacated so that it moves on its wheels.

Figure 4.12: Hardwood bar trolley by Strathwood Talbot

Figure 4.13: Trolley table by Patrick Frey & S. Boge

4.2.7 Stackable structure

By design, products in certain shapes are able to stack one on one. The advantage of a stackable structure is that it saves lots of space when stacking them for storage. Take Figure 4.14 for example, from the Italian Magis company, designed by German-born Jerszy Seymour. We can see clearly that by stacking them together, nine chairs take up space than two separate chairs take when separate. At the same time, the various but vivid colors also contribute to the beauty of the chairs staying together.

Figure 4.14: Magis stackable chair by Jerszy Seymour

There are also some innovative stackable structures, such as the product shown in Figure 4.15. Instead of stacking one upon the other, stacking is done by inserting one chair into the other, one by one, from biggest to smallest, just like a Russian nesting doll.

Figure 4.15: Magic chair by Puur Design Studio

4.2.8 Soft cover

Sometimes products come with covers on them. Foldable or collapsible products' covers are always made from soft materials, such as fabric or mesh. The reason is that these soft covers will not influence their foldability or flexible characters. Also, these materials are lightweight.

Figure 4.16: Outdoor chairs by Ocho

Figure 4.17: Folding mesh moon chair by Brylane Home

Sometimes, these soft materials can be used to make an entire piece of furniture. Shown is one hanging organizer made entirely from fabric (Figure 4.18).

Figure 4.18: Hanging fabric organizer by Burda Style

4.2.9 Box unit

The designer asked many friends, “What comes to mind first when you hear the word ‘storage?’” More than half of them replied, “a box.” We use plenty of box-shaped storage units in our daily lives. Designing storage is just like making boxes and organizing them well within a product to fit a room. On many occasions, designers build a basic box unit and duplicate it. Consumers are then able to purchase as many as they want and arrange them by themselves. The box unit can be in cube shape or it can be in an irregular shape. Special joint mechanisms may be applied between units. Box units can also be moved separately in order to ease moving pressure.

Figure 4.19: 9 cube organizer by Seville

Figure 4.20: White stackable 9 cube organizer by Martha Stewart Living

Figure 4.21: Arrow shelf by Timothy Ben Furniture

4.3 Applying nomadic concepts to the current issue

There are two problems that can be solved by applying nomadic concepts. The first problem is weight. The regular storage furniture students commonly use to store their stuff, such as chests of drawers, is way too heavy to carry. In addition, it is nearly impossible to disassemble this furniture when moving. Students need lighter furniture and an easier way to take their belongings with them from place to place. Nomadic furniture has is characteristically lightweight and collapsible, that can help solve this problem. The second problem is limited living space. Limited by financial conditions as well as facility conditions, students are always living with others and therefore have less room for both living and storing their clothes and other belongings. However, they still need substantial storage space since they are more likely than others to buy new things. Thus a design creating more space for storage while taking less room away from their living areas is badly needed. This goal is the same as one of the nomadic concept.

Therefore, in the following section, the designer focuses on developing nomadic concepts as a way of easing college students' moving nightmares.

CHAPTER 5: DESIGN CONCEPTS

5.1 Key parameters to consider in the development of new design

Based on the results of research to identify the needs of college students for nomadic furniture for clothes storage reviewed in Chapter 2 of the thesis, the following parameters were established to help guide the design of new and improved furniture:

- Target Users: college students
- Material Requirement: eco-friendly
- Size Limit: Should fit vehicle with 58.1 inches in rear track width and 12 cubic feet in cargo volume
- Moving Capability: meet students' demand for high moving frequency
- Direction of Feature: Functionality, Enhanced form quality, Flexibility, Simplicity, Durability to promote long-term use

5.2 Initial concept brainstorm

In this stage, the designer did a large amount of concept sketches for inspiration and put them in groups as follows.

5.2.1 Stackable unit

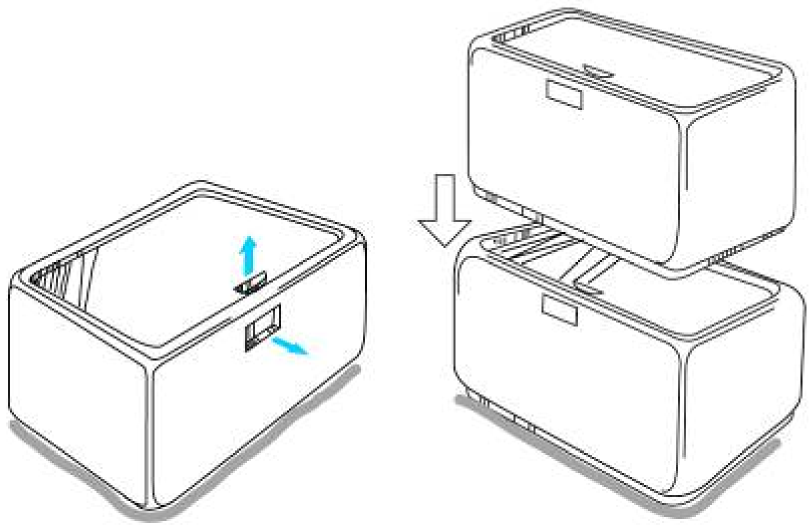


Figure 5.1: Initial concept sketch 1; the drawer can be pulled out to create twice the space for storage, and several drawers can be stacked on each other

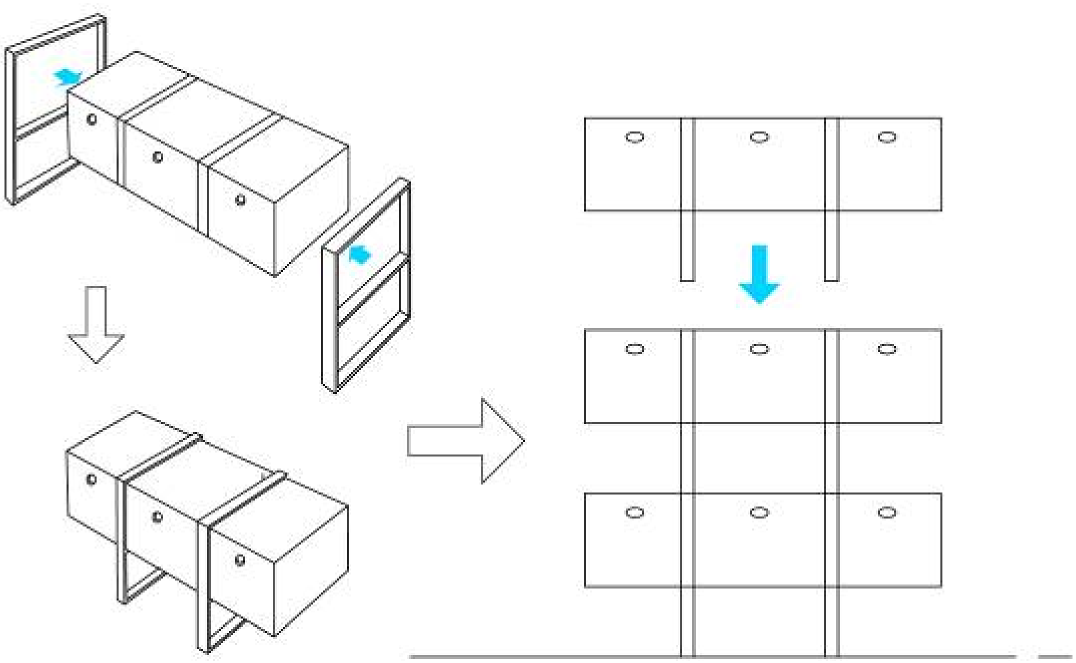


Figure 5.2: Initial concept sketch 2; the concept involves two frames and a drawer body assembled together, and it is stackable

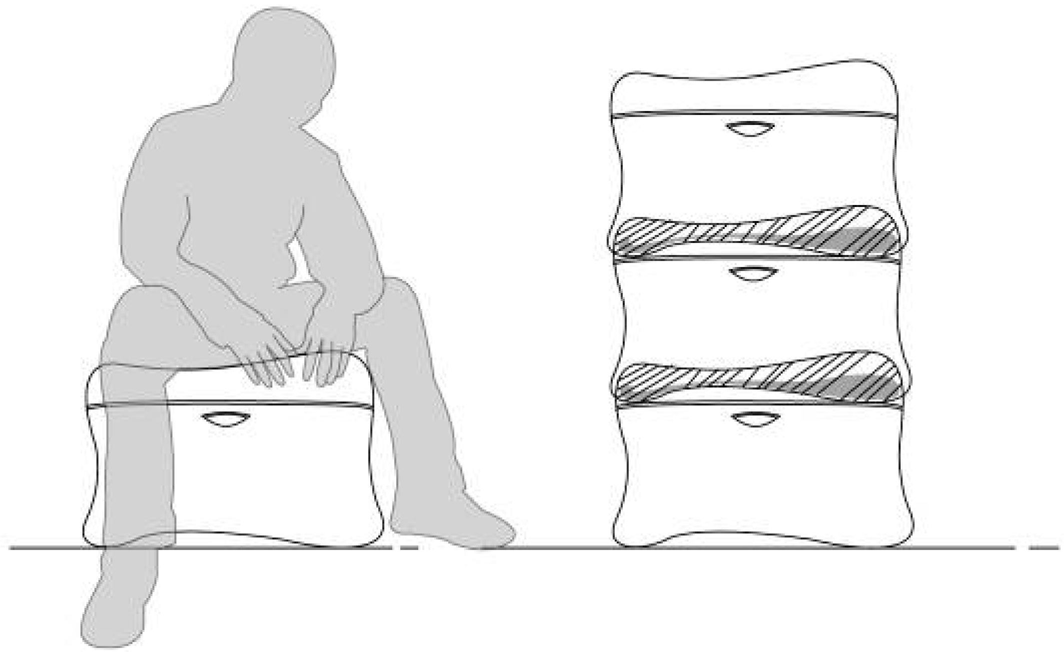


Figure 5.3: Initial concept sketch 3; the concept has organic curve for additional seating function, and it is stackable

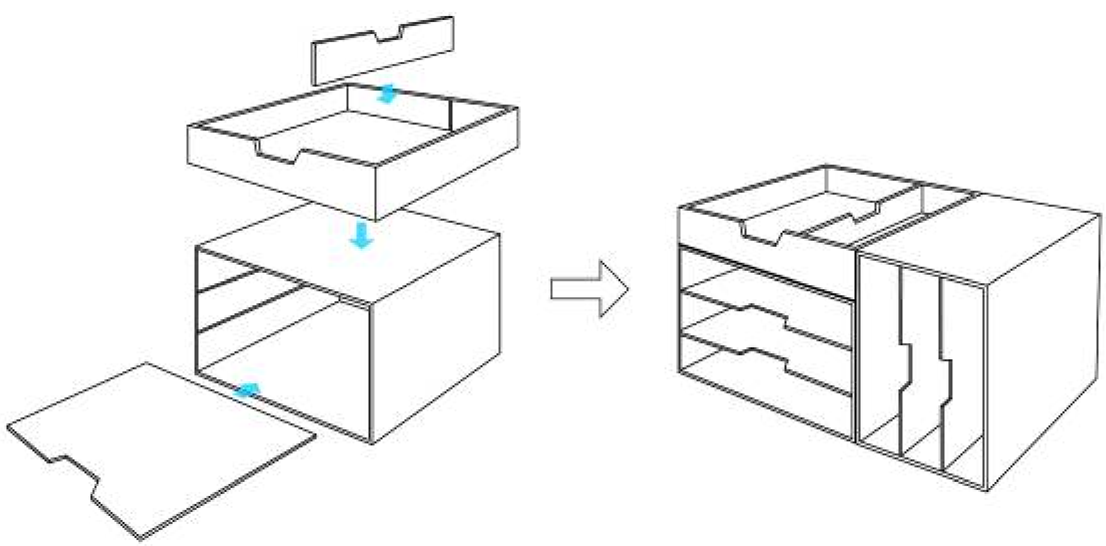


Figure 5.4: Initial concept sketch 4; the arrangement of space is adjustable according to users' customized needs

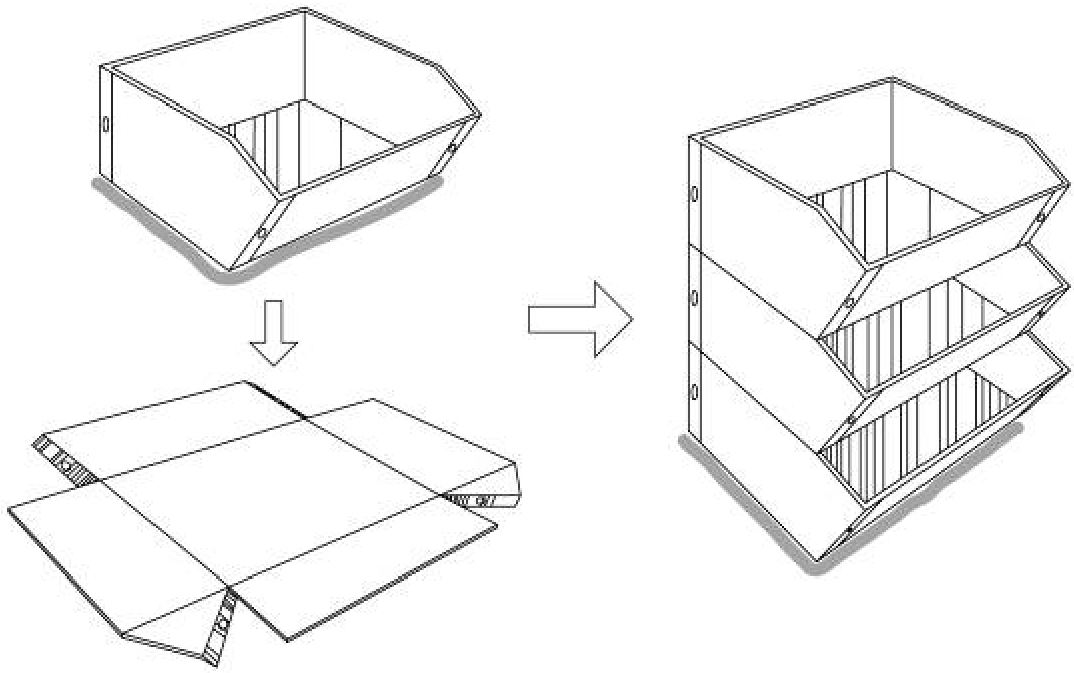


Figure 5.5: Initial concept sketch 5; the concept is collapsible and stackable

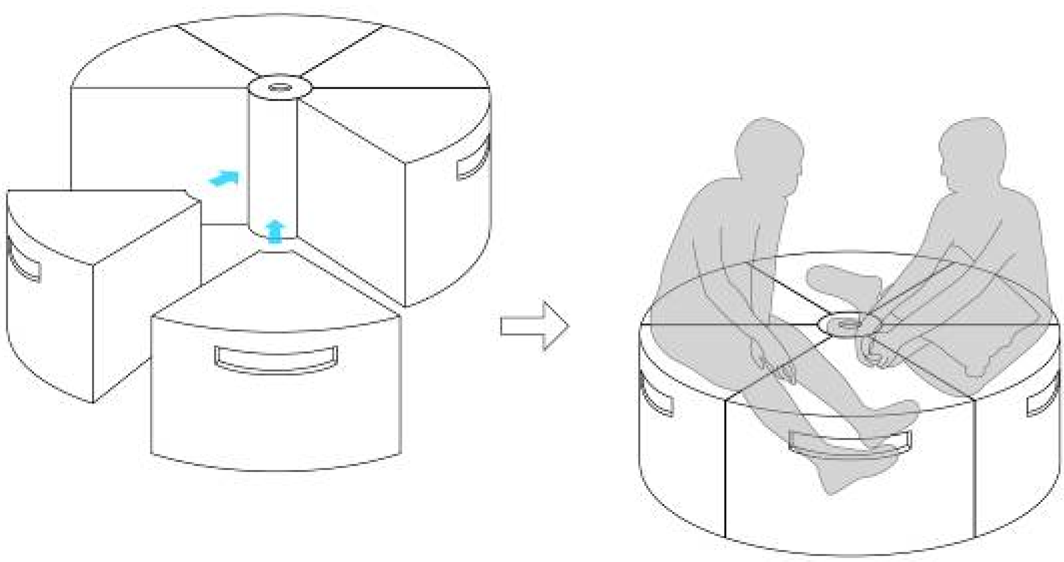


Figure 5.6: Initial concept sketch 6; the concept involves a cylinder divided into several individual storage pieces, and it can also be used as sofa

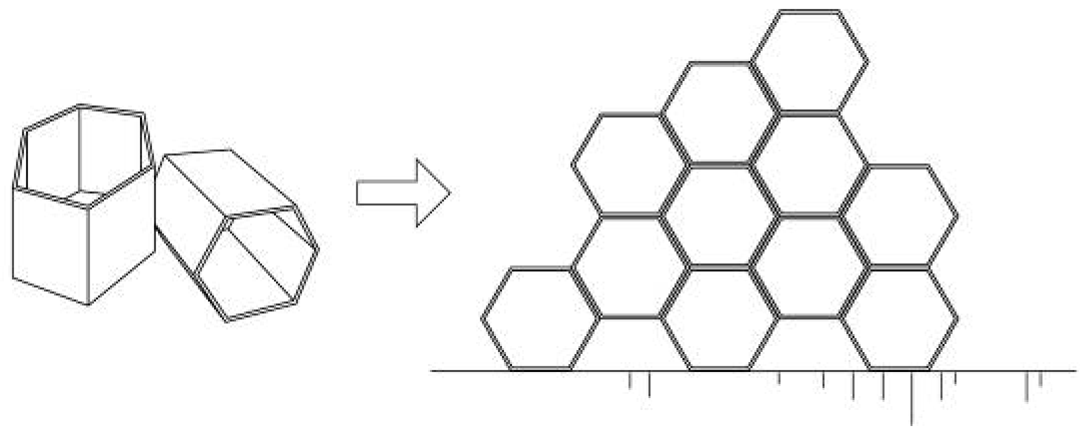


Figure 5.7: Initial concept sketch 7; the concept uses a hexagon shape for unique stacking way

Initial concept sketches 1 – 7 are seven initial designs trying to create stackable units for storage. The idea is to create a special stacking method, as well as to add some other functions, such as creating adjustable space (initial concepts 1 & 4), collapsibility (initial concepts 2 & 5) and an additional feature as a seat (initial concepts 3 & 6).

5.2.2 Frame structure

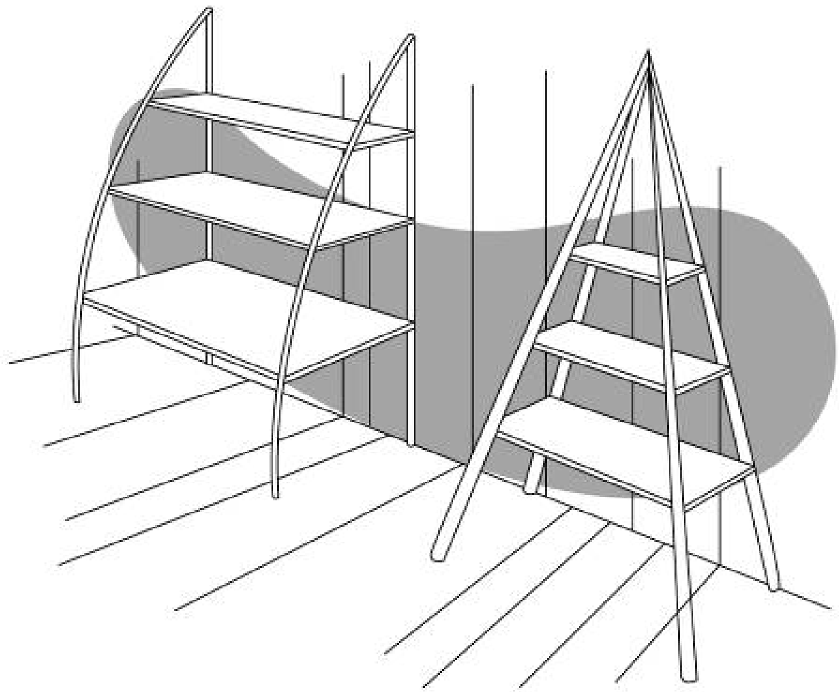


Figure 5.8: Initial concept sketch 8; the concepts are designed to lean against a wall.

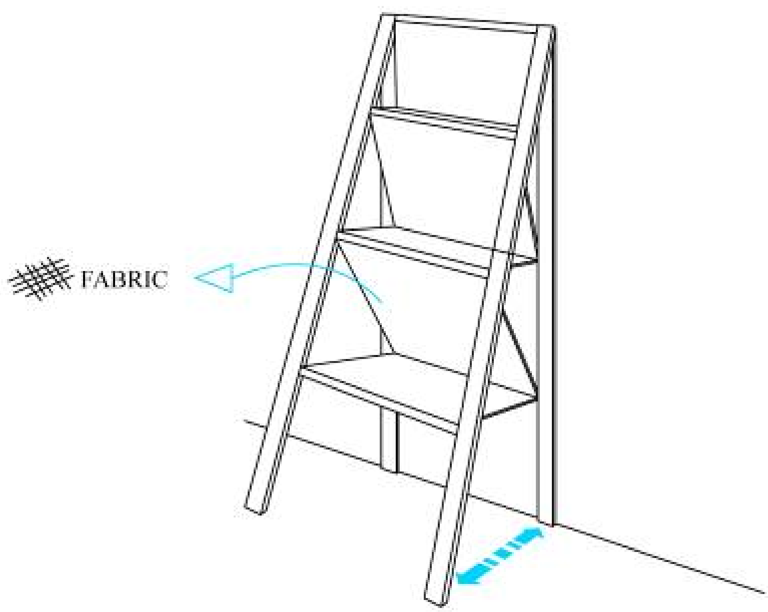


Figure 5.9: Initial concept sketch 9; the concept is leaning on a wall, and the fabric pockets are adjustable according to the angle

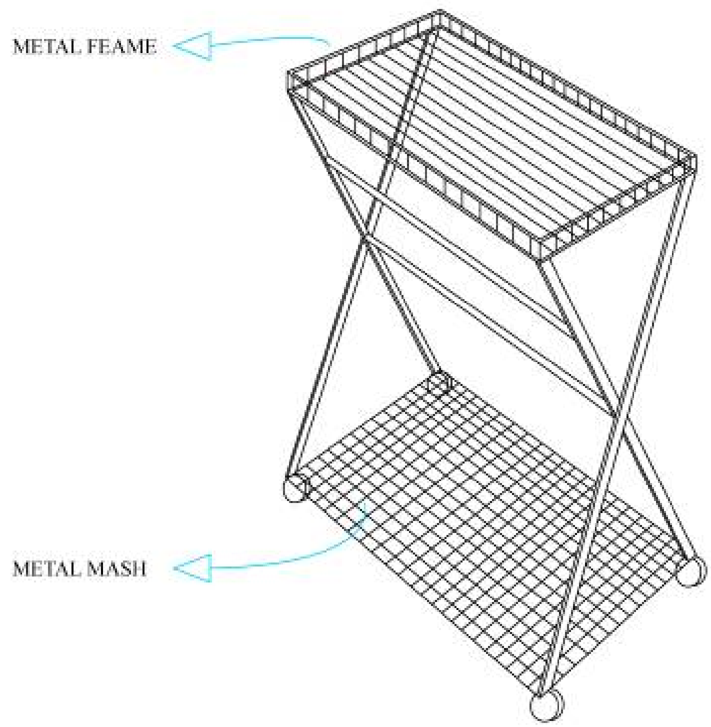


Figure 5.10: Initial concept sketch 10; the concept involves two shelves and two hanging sticks, and wheels help solve moving problem

Figure 5.11: Initial concept sketch 11; the concept works as an attachment to a regular chest of drawers

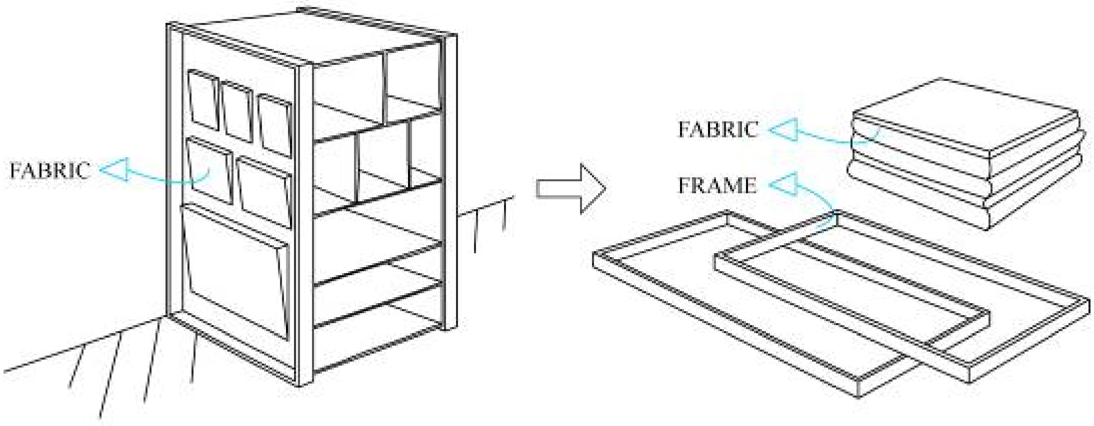


Figure 5.12: Initial concept sketch 12; the concept can be collapsed as two flat frames and one foldable fabric

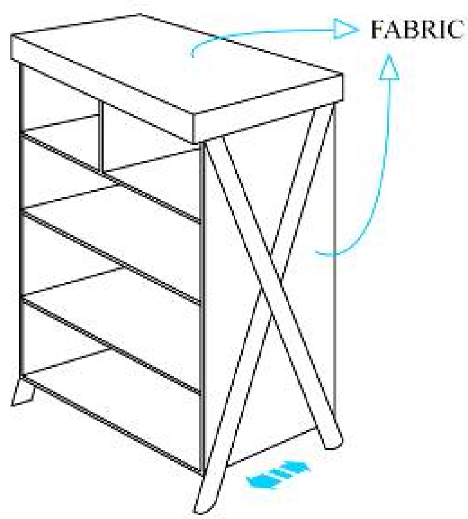


Figure 5.13: Initial concept sketch 13; the concept involves an X structure and foldable fabric pockets

Initial concept sketches 8 – 13 are six concepts that explore new ways of using a simple frame structure. All of the concepts shown are collapsible. Some are simply constructed by sticks, while others have pockets or shelves made of fabric or mesh (initial concepts 9, 10, 12 & 13).

5.2.3 Adding functions to normal looking storage

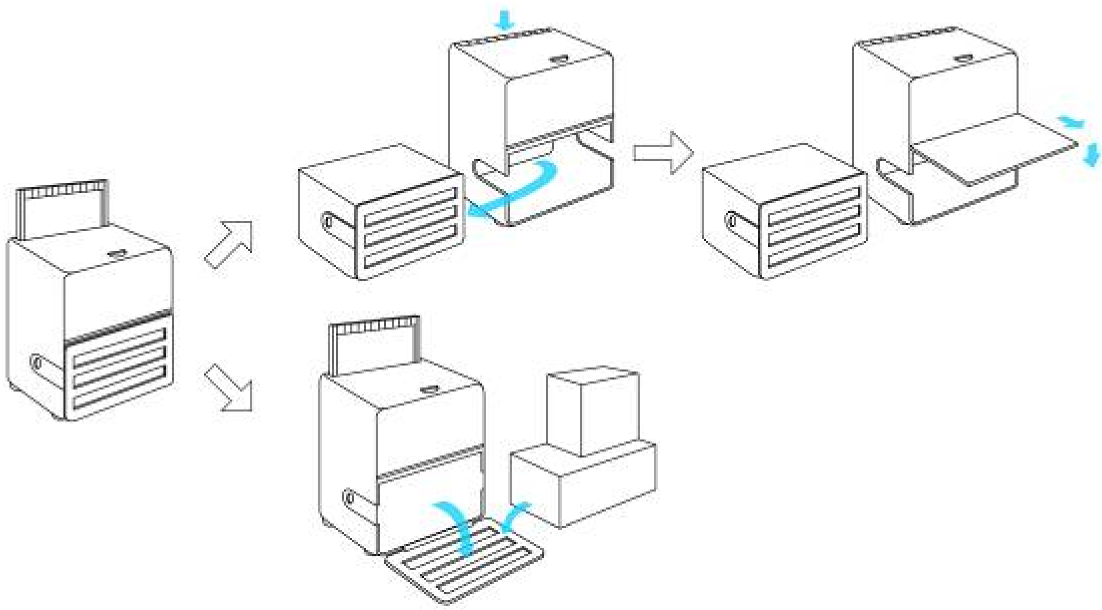


Figure 5.14: Initial concept sketch 14; the lower part can be pulled out for sitting, while the main park works as a desk, and the frame can be pulled down to become a shelf

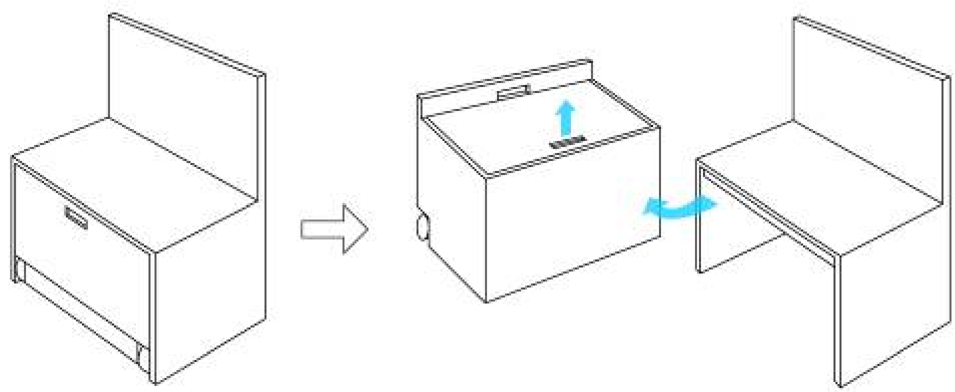


Figure 5.15: Initial concept sketch 15; the lower part of a normal chair can be pulled out to become a storage stool

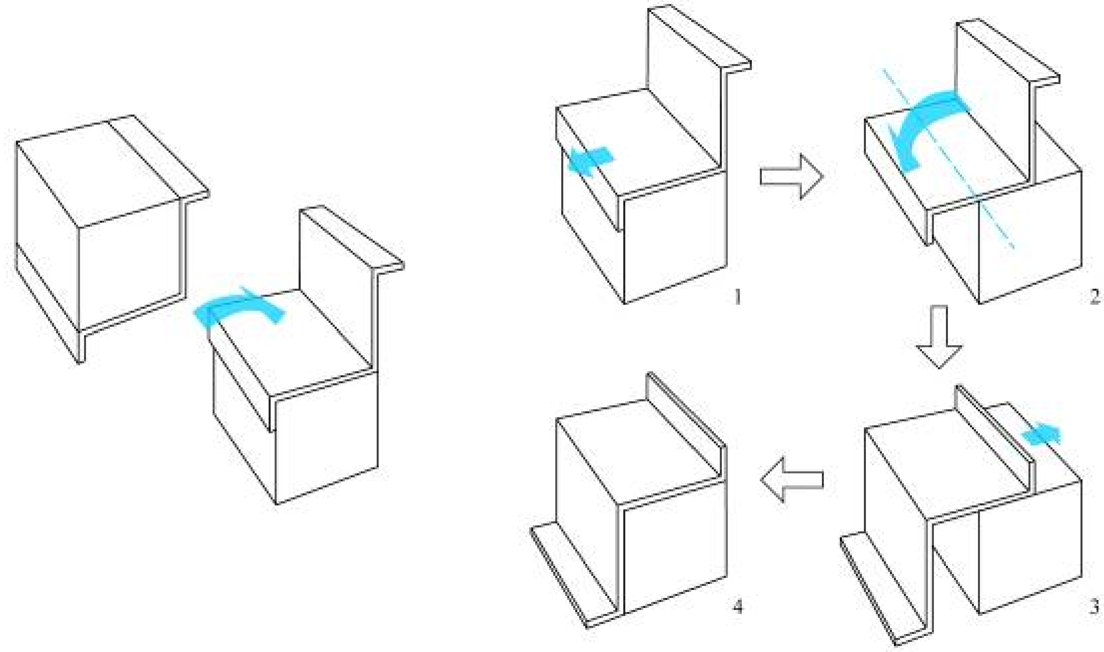


Figure 5.16: Initial concept sketch 16; the upper part can be flipped up and down to make the concept into two forms of chairs, and chairs in two forms can be stacked

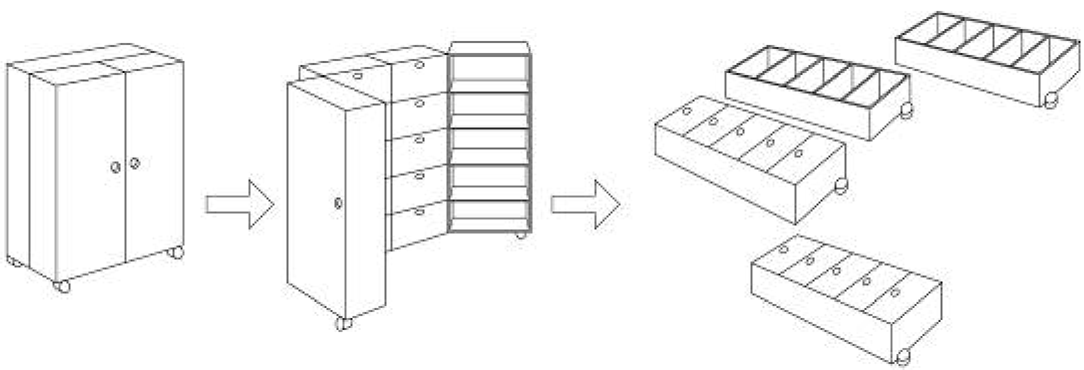


Figure 5.17: Initial concept sketch 17; the cabinet can be collapsed into four pieces for transporting

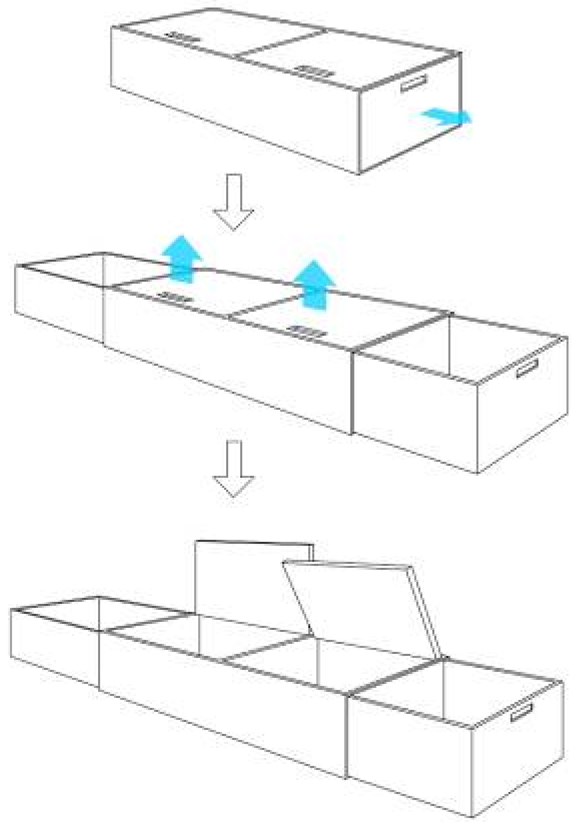


Figure 5.18: Initial concept sketch 18; drawers can be pulled out on both sides to double the amount of storage

Initial concept sketches 14 – 18 are five initial designs exploring adding new functions to regular existing furniture, such as combining seating and storing functions (initial concepts 14, 15 & 16) or collapsible (initial concept 17) and adjustable storage space (initial concept 18).

5.2.4 Twisting and rotating structure

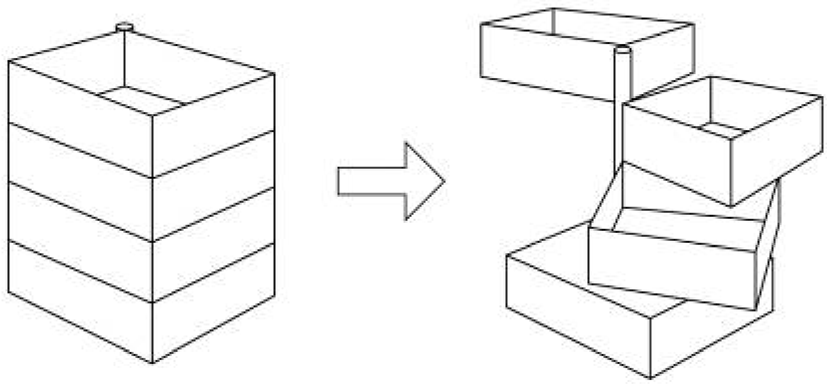


Figure 5.19: Initial concept sketch 19; drawers in lower level can be reached by twisting the product

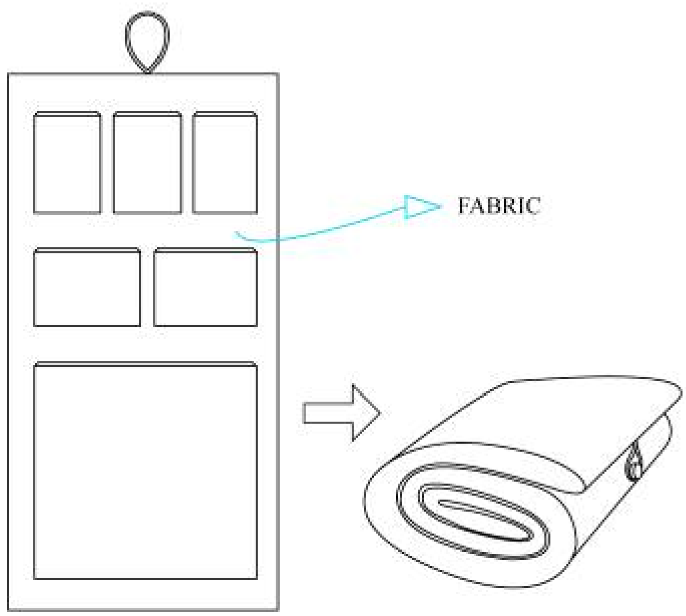


Figure 5.20: Initial concept sketch 20; the fabric pocket is able to be folded for less storing room and easier transporting

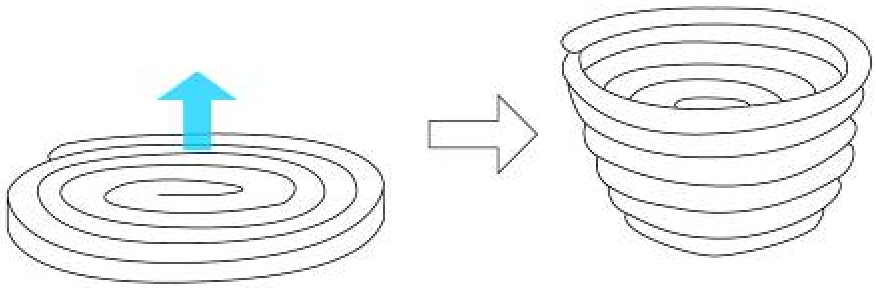


Figure 5.21: Initial concept sketch 21; by pulling up the rotating structure, a flat piece can turn into a basket

Initial concept sketches 19-21 are three initial designs involving certain types of rotating or twisting structures. The goal is to create a new use experience (initial concepts 19 & 21) and to add moving possibilities (initial concepts 20 & 21).

5.2.5 Exploring joint structures

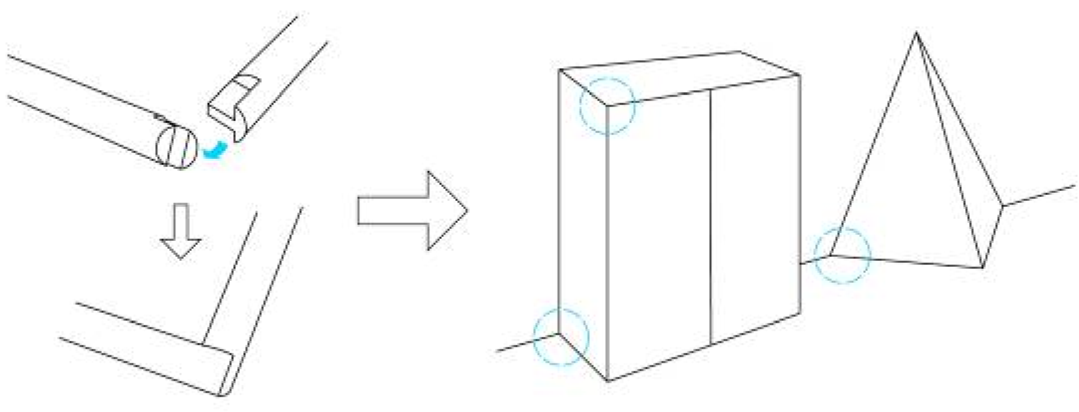


Figure 5.22: Initial concept sketch 22; a concept of using a simple structure to connect two sticks are used to create a corner

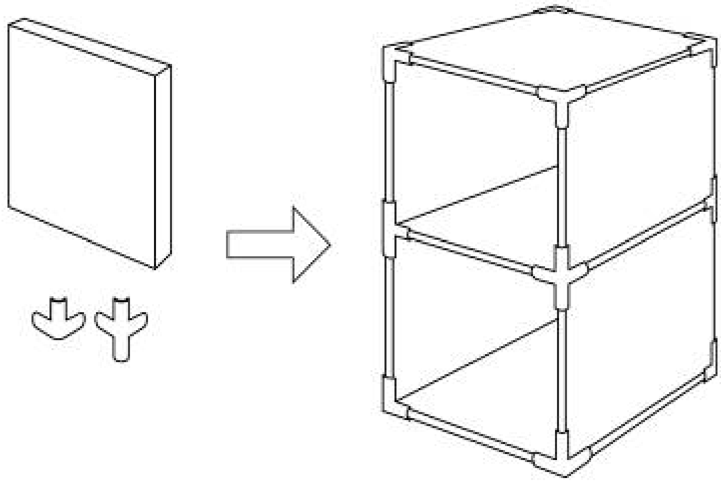


Figure 5.23: Initial concept sketch 23; the concept is using flat piece and special clamps to create storage cubes

Initial concept sketches 22 – 23 are two initial designs exploring different joint structures that may be used in storage designs. The goal is to make the storage designs collapsible.

5.3 Further development

Through the rough ideas above, the designer chose some ideas to develop further:

1. Frame structure: advantages of being lightweight, saving materials, collapsible features.
2. Fabric or mesh pocket: advantages of being lightweight, eco-friendly and easy to transport and store.
3. Flexible storage space: provide users' with the ability to adjust storage according to their personal needs.

The following are several sketches I did to further develop these ideas:

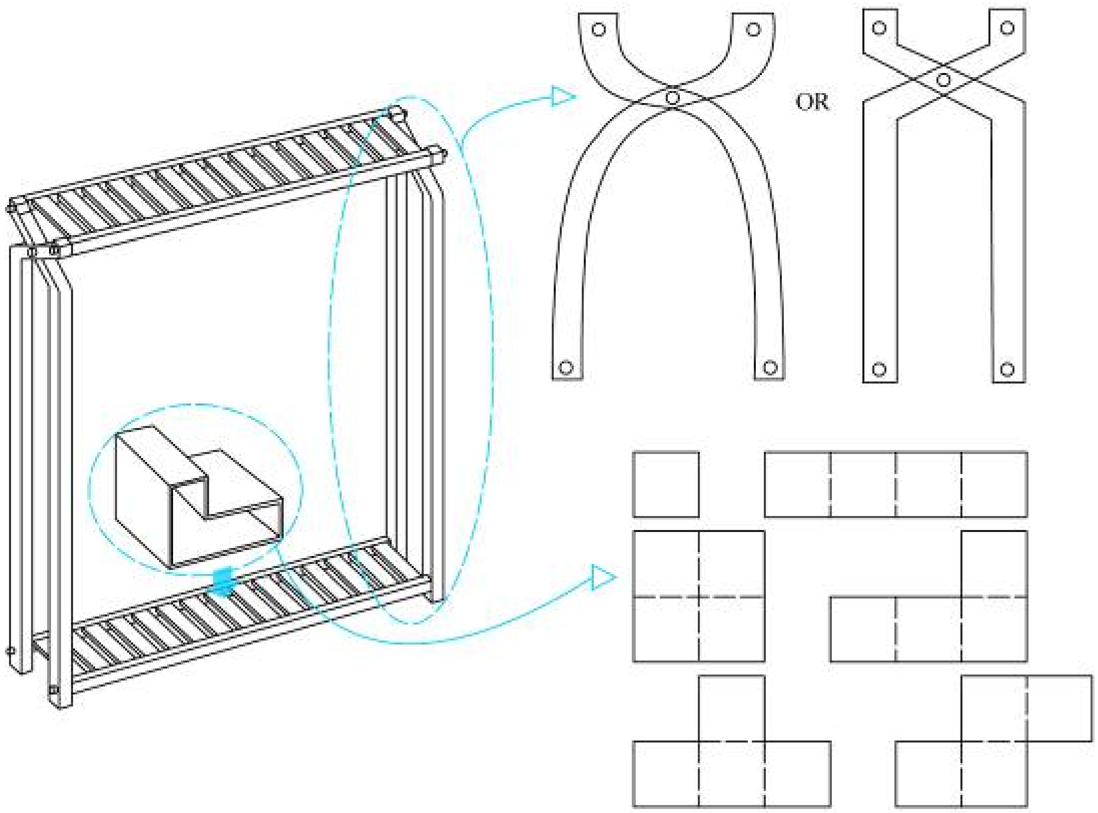


Figure 5.24: Further developed design sketches

In these sketches, the designer was trying to add curved X structures to the frame in order to make it look good. The frame also needs to provide room for both hanging clothes and folded clothes in separated, collapsible fabric units. The designer was thinking of making the fabric units in the shapes from game Arix Tetris in order to add playful value to the storage. In this stage, there were still several features with which I was not satisfied. One was that the total storage design still looked big. Another was that the shapes from the game Arix Tetris looked a little bit too complicated, while the fabric might be not hard enough to handle the required weight when stacked on each other.

Therefore, based on this direction, the designer kept modifying her designs. The next chapter introduces the designer's final nomadic furniture clothes storages design outcome.

CHAPTER 6: FINAL DESIGN: FENCE STORAGE

Based on the idea in further development section, the designer put effort on seeking a more simplified form in design. After getting inspired by racks used on backstage for hanging and transporting clothes using in fashion industry, the designer got the final design concept, which having both a simple look and an essential storage and moving function.

6.1 Final concept

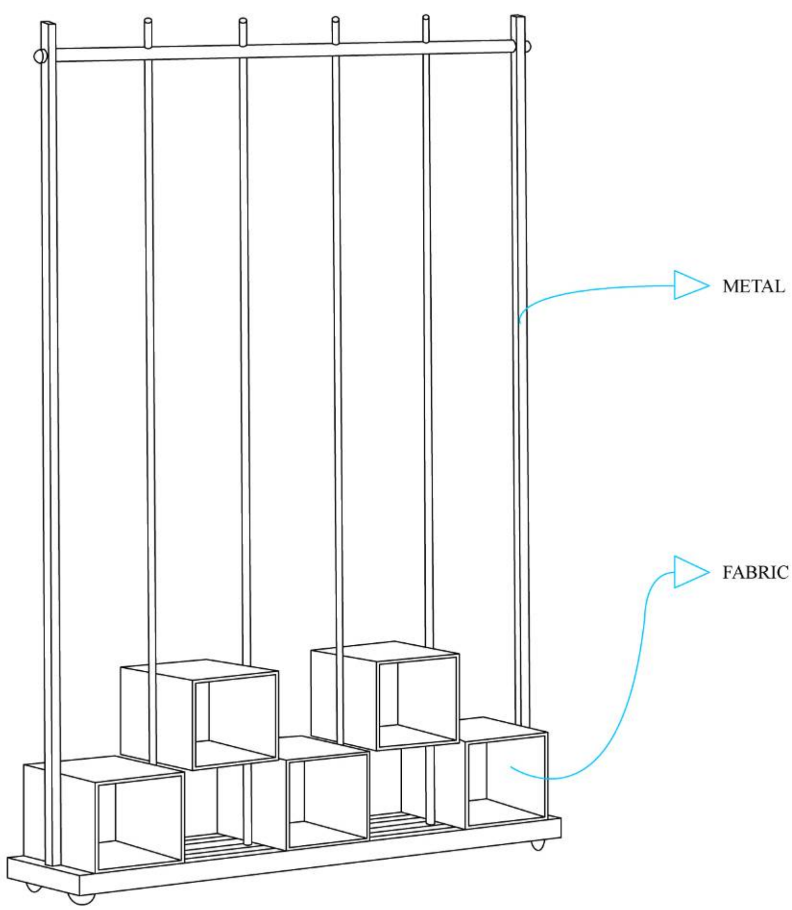


Figure 6.1: Final design sketches

The final design is called “Fence Storage”. This is because the main section resembles a fence when placed next to a wall. The Design contains two parts: the rack and storage boxes. The horizontal section can be used to hang clothes on and the shelf beneath is used to store clothes. The design can be easily moved using is four wheels underneath. The designer was also seeking to have a simple construction in order to make it collapsible. The majority of the action in assembling this design is setting one part into another, and the most “complicated part” is turning the cap onto the screw. Metal and fabric are used for the main elements. In order to fit into the trunk of vehicles, each part of the product will not exceed 58.1 inches (according to Table 1 in chapter 2).

6.2 Full-size mock-up test

To fully guarantee that the design can not only maximize storage volume for users, but also be easily fit in vehicle and transported, the designer built up a full-size mock-up to test the optimal size of the design.

The mock-up was built from wood boards (base), wood sticks (tubes), form board (hanging rod), metal (four wheels underneath the base), and cardboard (boxes). The vehicle used for testing the size is Nissan Altima (2009), with rear track width of 60 in. and cargo volume of 15cu.ft. Figure 6.2 are photos of full size mock-up. Figure 6.3 shows that the designer were testing two ways to move the product.

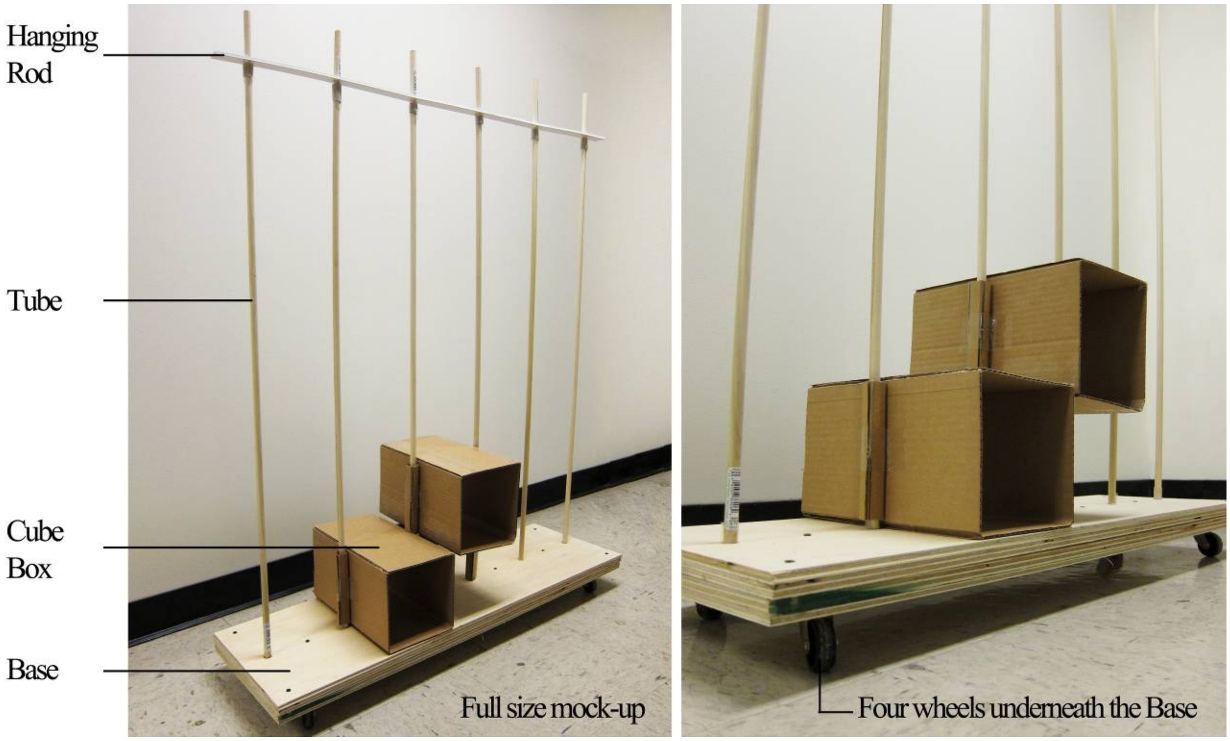


Figure 6.2: Full size mock-up of Fence Storage

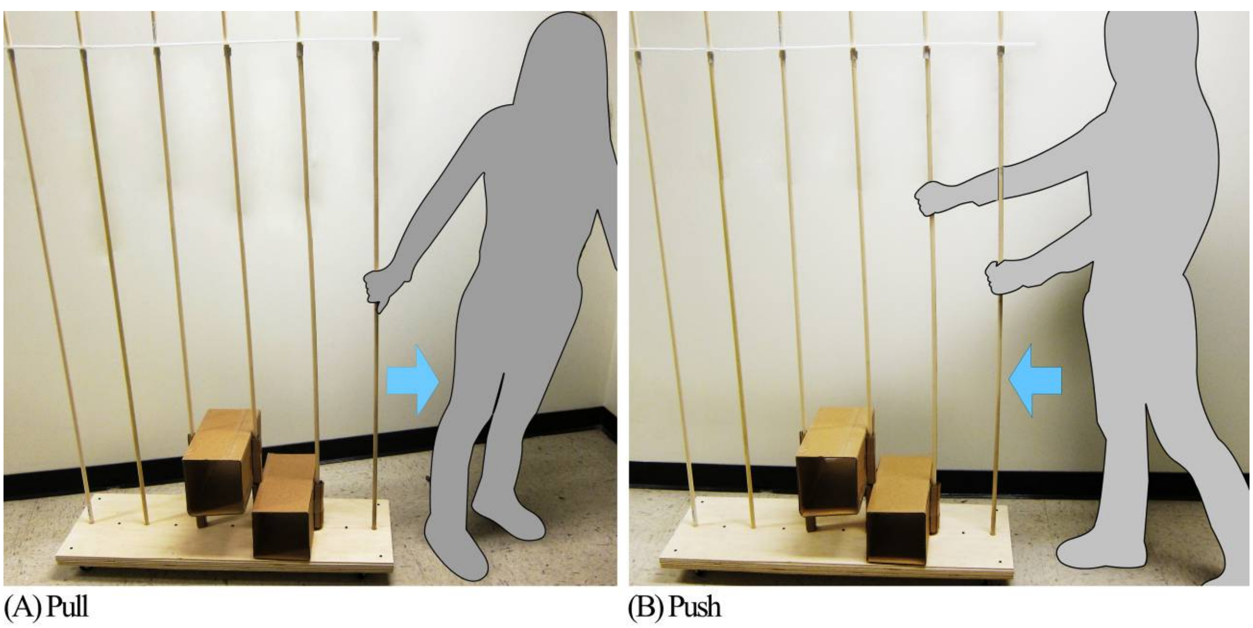


Figure 6.3: Two ways to move product (in test)

To fit the size limit (fit vehicle with 58.1 inches in rear track width and 12 cubic feet in cargo volume), the designer set the height of the mock-up originally from 68 in., and started to shorten the sticks in order to fix them in the chunk size. During the vehicle test, the designer figured out to fit the trunk, the optimal height of the mock-up is approximate to 50 in. However, the designer decided to make the stick dividable into two parts. In that case, the height of product in use can keep 68 in., and while in transportation the sticks divided to two separate ones with each less than 50 in., which can be fit for trunk. As seen in Figure 6.4, the Fence Storage Rack is broken down for transport to a new location. The base with structural components (tubes divided into two parts, channels, hanging rod) can easily fit into the trunk of a car. This test confirmed that the unit is easy to transport.

Figure 6.4: Photo of fitting full-size mock-up into trunk (in test)

6.3 Design details

Figure 6.5: Final design with clothes, shoes, etc.

Figure 6.5 shows the final design with clothes, shoes, etc. on. The final design generally includes two parts: Fence Storage Rack and Cube Box.

6.3.1Fence Storage Rack

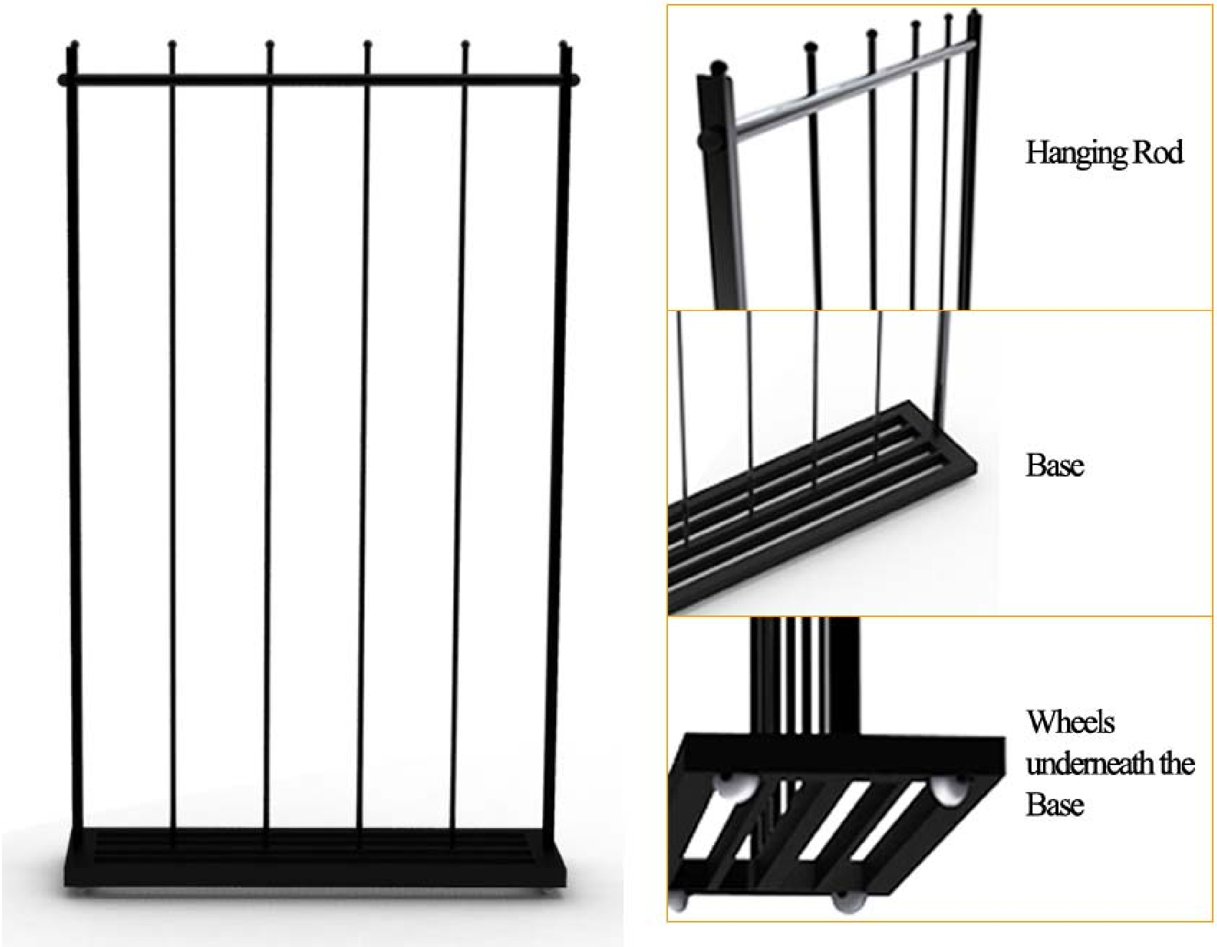


Figure 6.6: Fence Storage Rack

Figure 6.6 is the Fence Storage Rack. It is made using steel that can be easily assembled and disassembled. This part is inspired by a railing structure. The flat design allows it to fit in a college students’ dorm/room. The rack enables users to hang their clothes, while the vertical tubes are used to categorize them. The base beneath is used for stacked cubes for some folded clothes or accessories. Four wheels are installed underneath the entire rack so that users can easily move the storage inside the room, or use it as trolley. It can be disassembled into several pieces for transporting or for storing: one shelf with four wheels (you can choose to leave the four wheels on because they don’t take too much room, or take them down as well), two Channels, six Tubes with detachable top, one Hanging Rod, two Caps (which is used to help lock the rack in place). Figure 6.6 shows the family portrait of every components of the Fence Storage Rack.

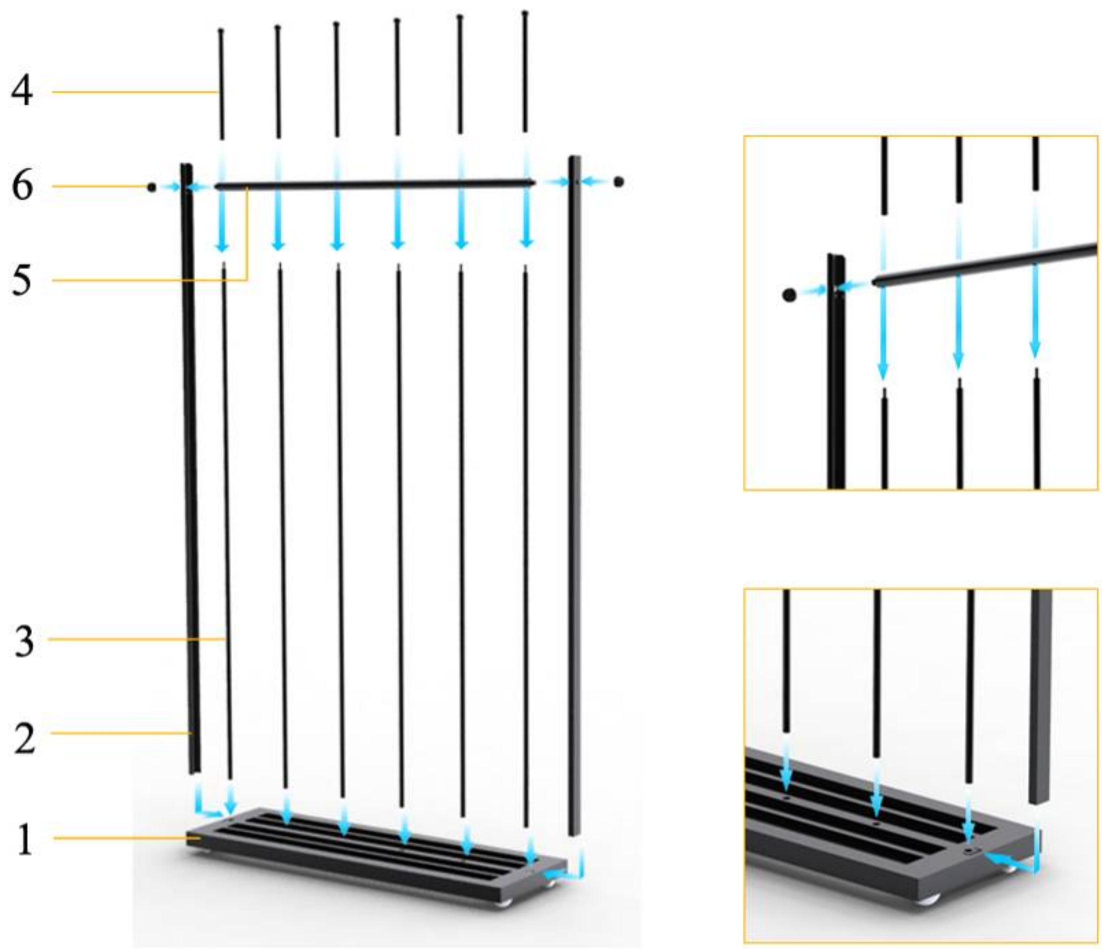


Figure 6.7: Family portrait of the Fence Storage Rack

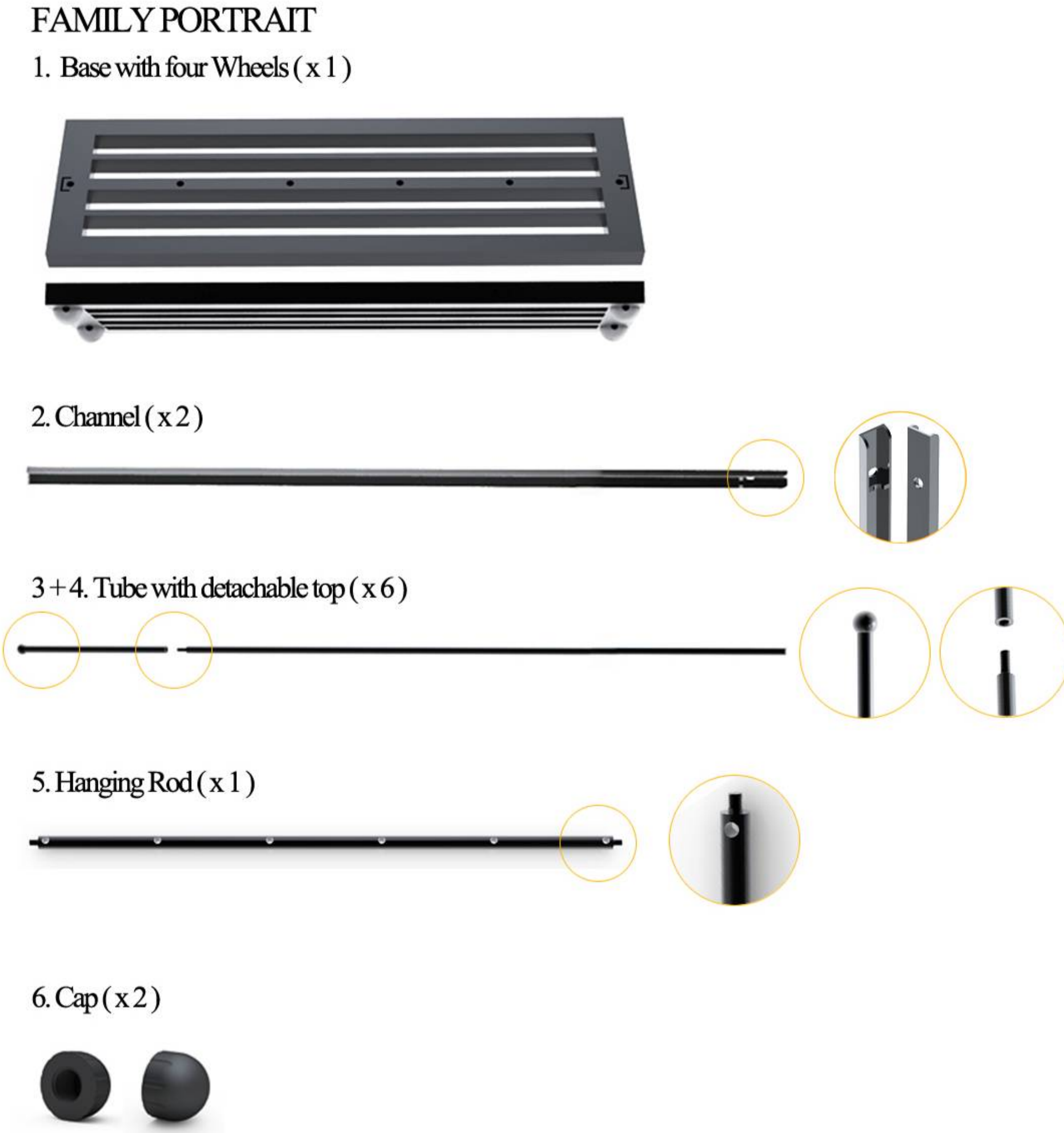


Figure 6.7 (cont): Family portrait of the Fence Storage Rack

6.3.2 Cube Box

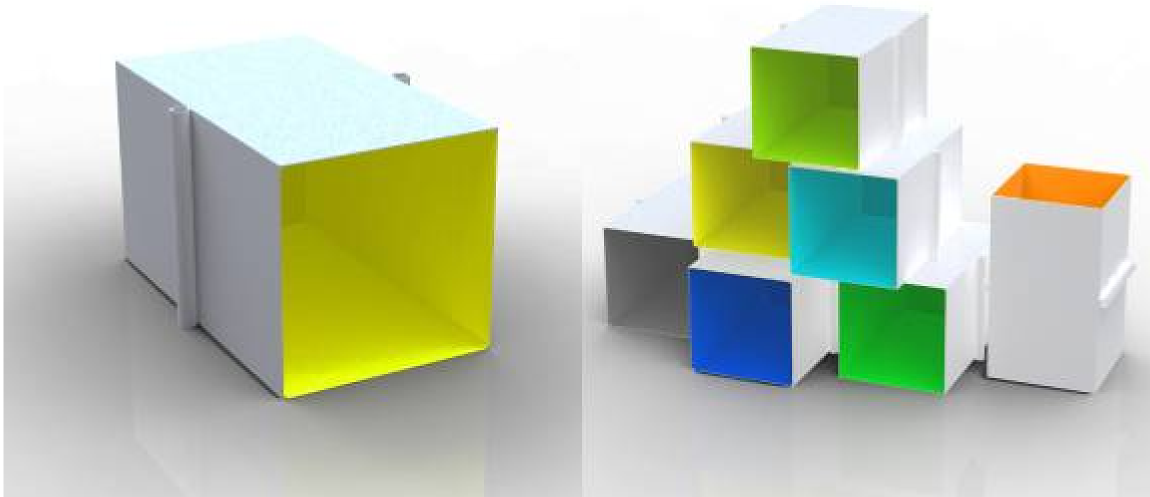


Figure 6.8: Cube Boxes

Several Cube Boxes can be set into the Fence Storage Rack to arrange space for folded clothes and accessories. Cube Boxes are made of durable fabric with steel support structures inside to support the shape during use (Figure 6.9). As Figure 6.10 shows, the steel structure enables Cube Box to be flattened for transportation or while not in use.

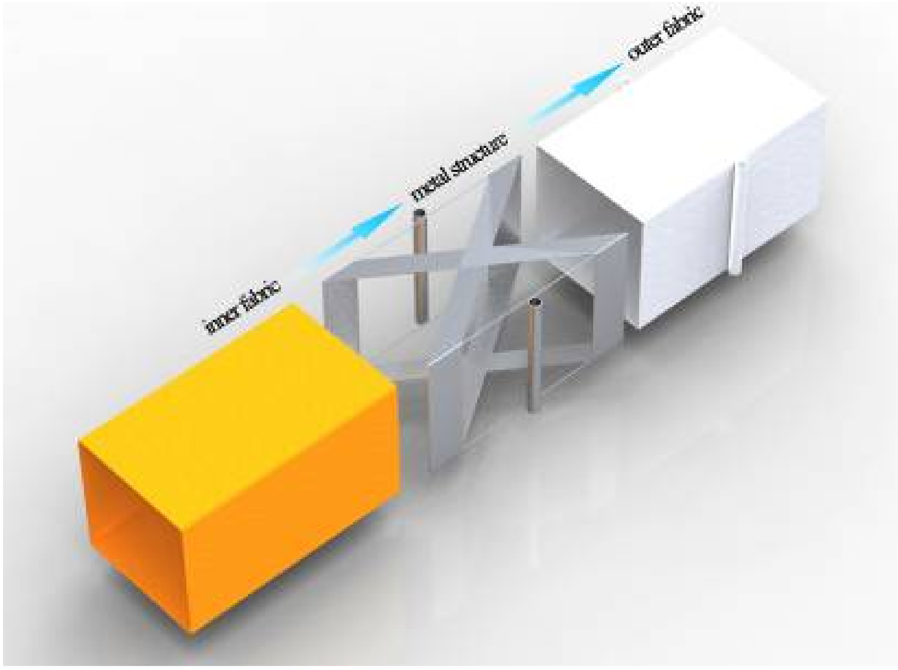


Figure 6.9: Cube boxes made by fabric with steel structures inside for support

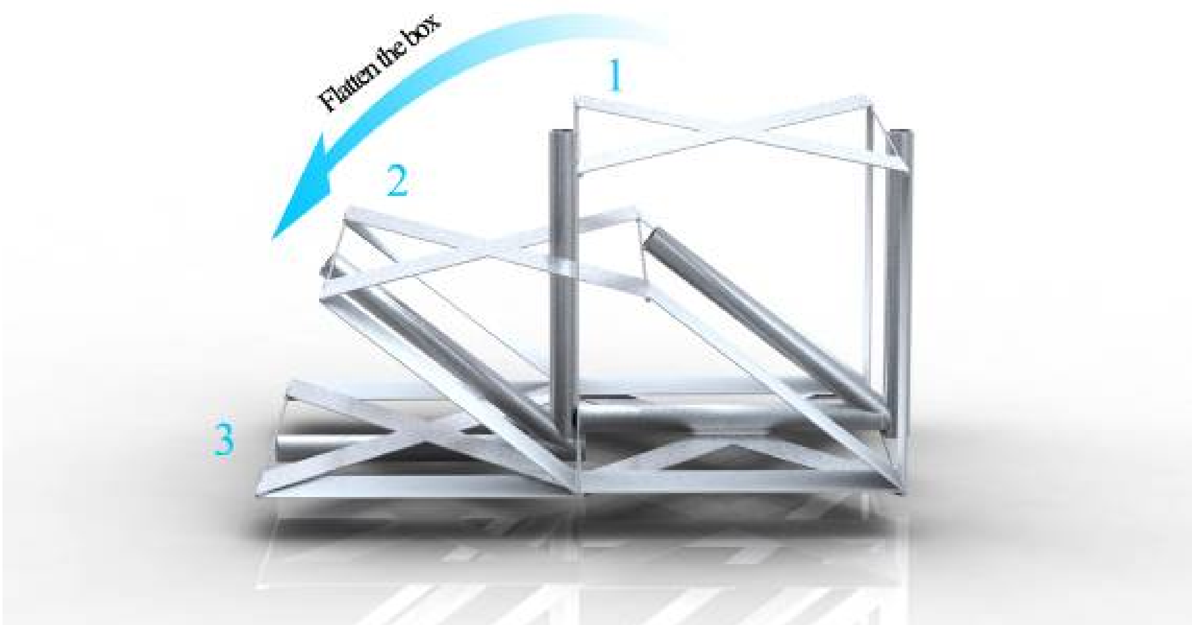


Figure 6.10: Steel structure in Cube Box

Two tubes attached on each side of the box are used to set in the circular sticks of fence rack. The process to set them in involves detaching the top parts of two Tubes, setting in tubes of box onto the Tubes (Figure 6.11), pushing box down and attaching the tops back.

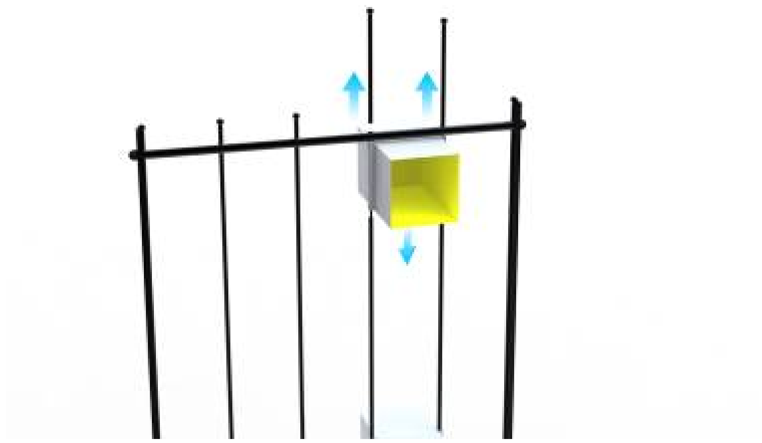


Figure 6.11: Set in Cubic Box to the Fence Storage Rack

The arrangement of boxes can be personalized according to people's various needs (Figure 6.12). The boxes can be also used as containers to carry items when moving.

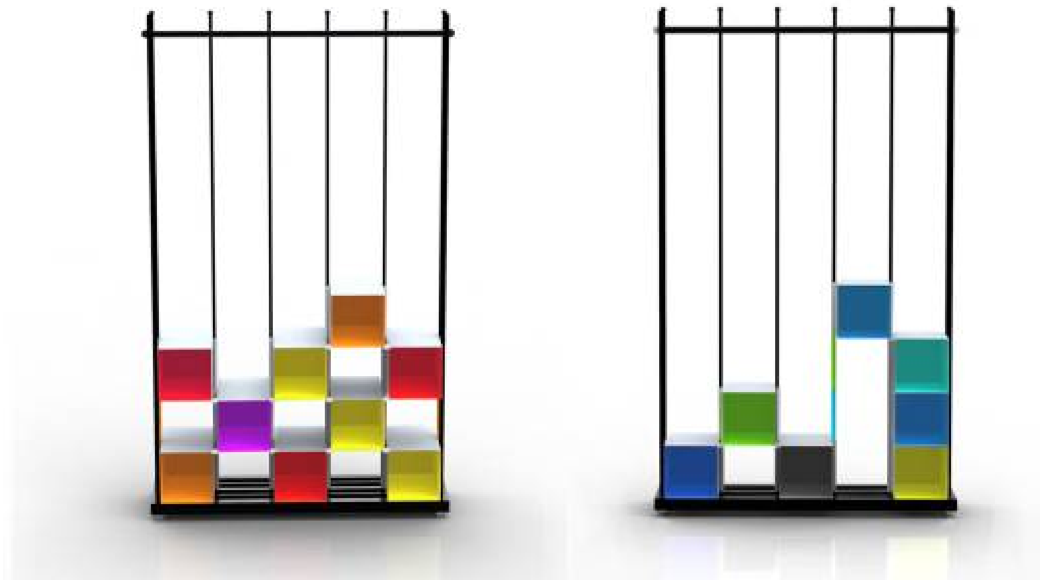


Figure 6.12: Various arrangement options of boxes for users

Two accessories are provided to help arrange the boxes: Individual Tube (Figure 6.13) and Clamp (Figure 6.14).

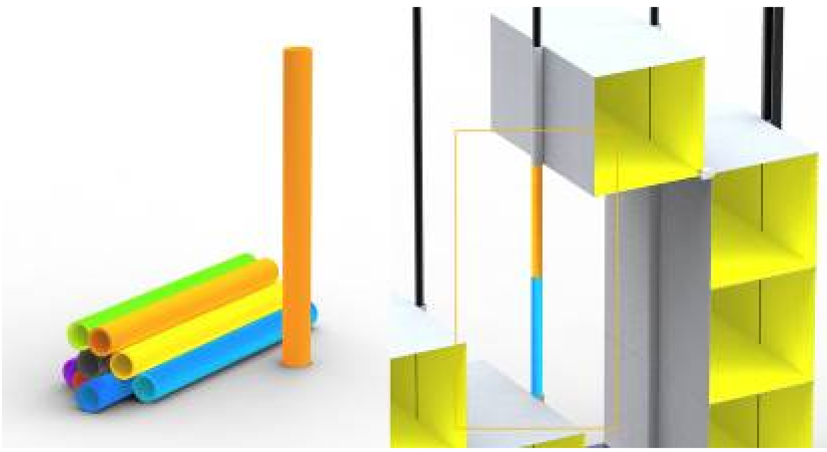


Figure 6.13: Individual Tube

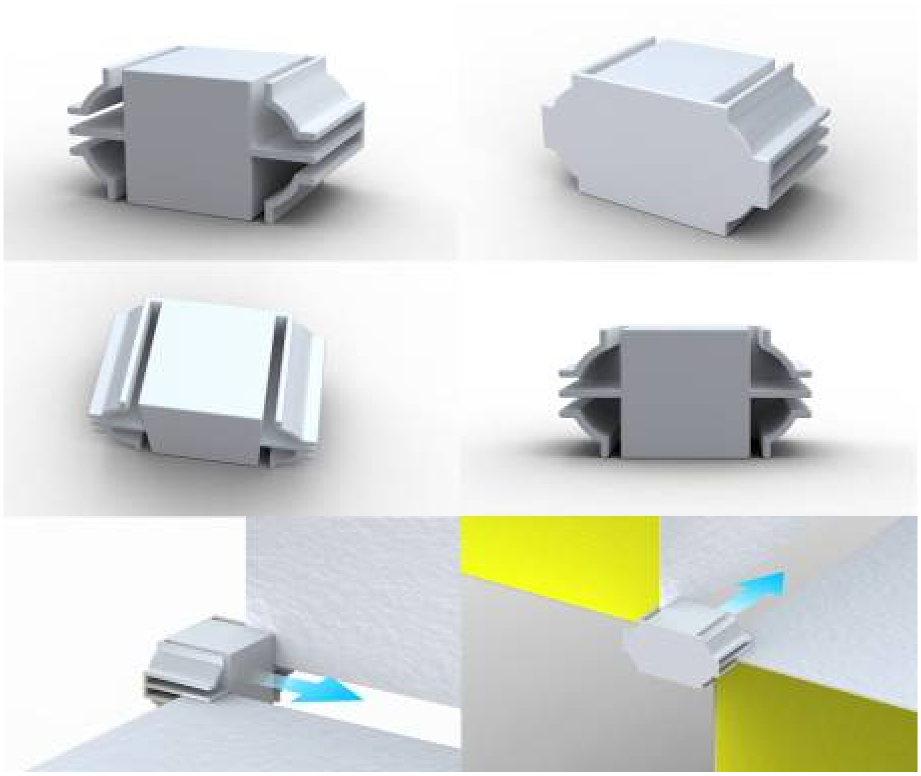


Figure 6.14: Clamp

Individual Tubes are used to support higher boxes. The position of the boxes is provided by stacking the attached tubes on boxes along the stick. When there are not enough attached tubes underneath to support the position of one box on top (such as one condition showed in Figure 6.13), Individual Tubes can be used as extra support. It is also made by steel with a fabric cover.

Clamps are used to fix the position between two adjacent boxes. The relationship between two boxes is locked by tucking both adjacent corners into the slots (Figure 6.14). Four slots enable the clamp to fit in every position. It is manufactured using a thermoplastic elastomer (TPE). TPE has good elasticity and at the same time it is eco-friendly to the environment during the manufacturing process and serves as a replacement to the traditional PVC (Polyvinyl Chloride).

6.3.3 Dimensions

Figure 6.15, 6.16 and 6.17 illustrate the dimensions of every part in Fence Storage design.

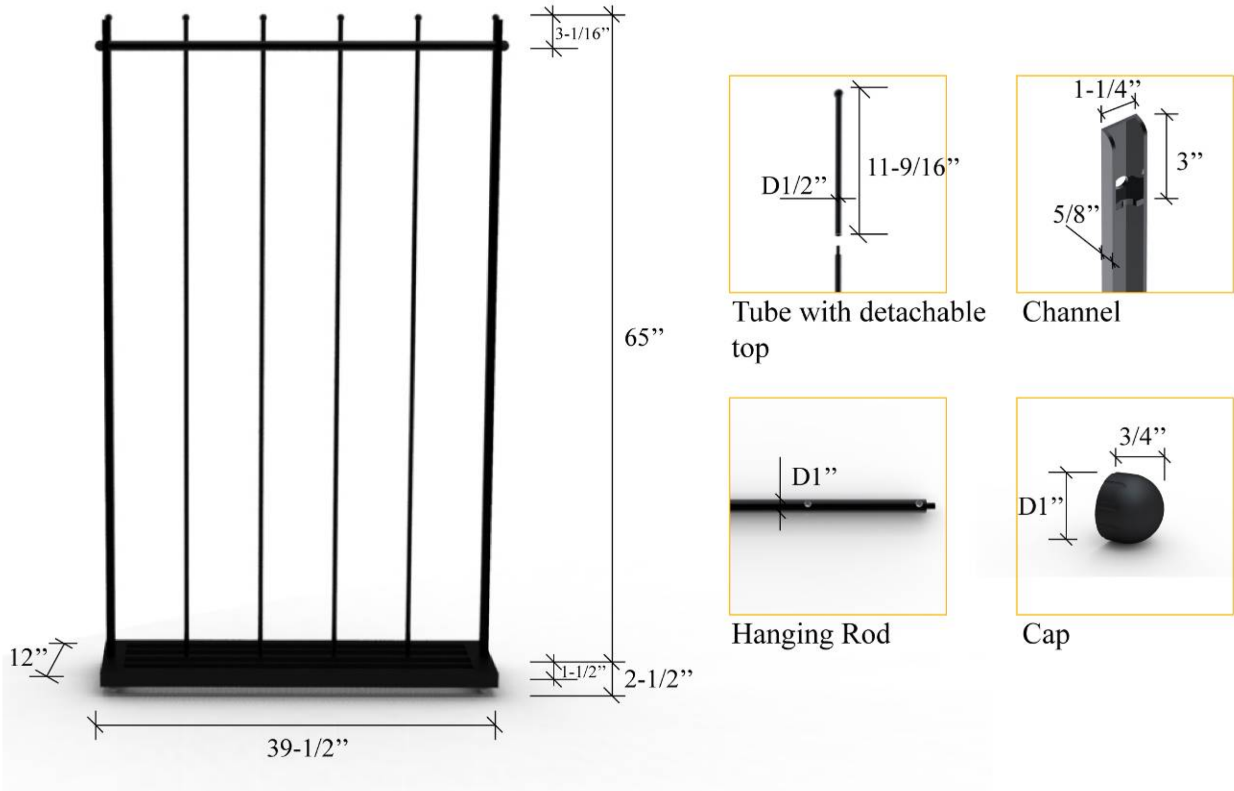


Figure 6.15: Dimensions of Fence Storage Rack

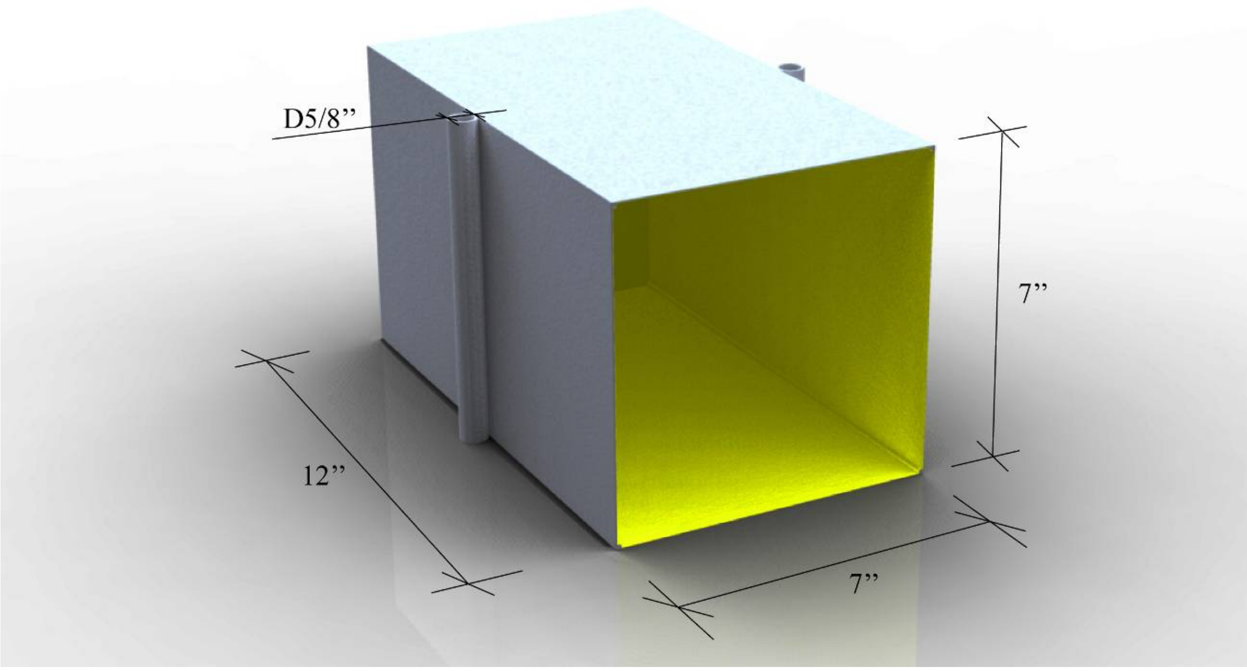


Figure 6.16: Dimensions of Cube Box

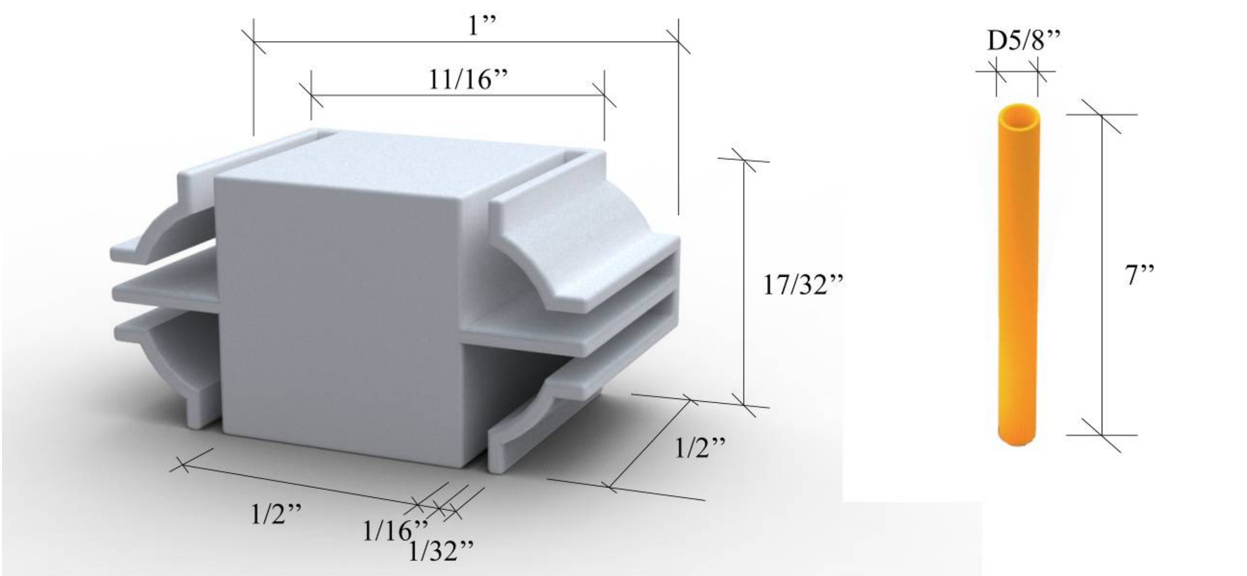


Figure 6.17: Dimensions of Clamp and Individual Tube

The longest part in the Fence Storage design is the Tube without its detachable top, which is 50 inches in length. It meets the size limit parameter that was pointed out in chapter 5 (Size Limit:

Should fit vehicle with 58.1 inches in rear track width and 12 cubic feet in cargo volume). The largest part is the Base, which is 39-1/2”W x 12”D x 1.5”H. It also transported easily. When collapsed, the design is broken down into a flat shelf, a bunch of metal sticks (including sticks from the rack and short individual tubes), several flattened boxes and a handful of clamps. The steel parts of the Fence Storage Rack are all hollow inside with a 1/16” wall thickness. This decreases the weight of the products. The dimensions of the products utilize the parameters in order to create maximum simplicity and function.

6.4 Design revisions

During a final design critique, suggestions were made in order to refine several components. Following are six design revisions incorporated into the final design following in order to improve the function and user experience.

6.4.1 Cube Boxes Enlarged (Figure 6.18)

The storage boxes were enlarged to 12”W x 7”H x 12”D in order to better accommodate the volume of clothes storage needed.

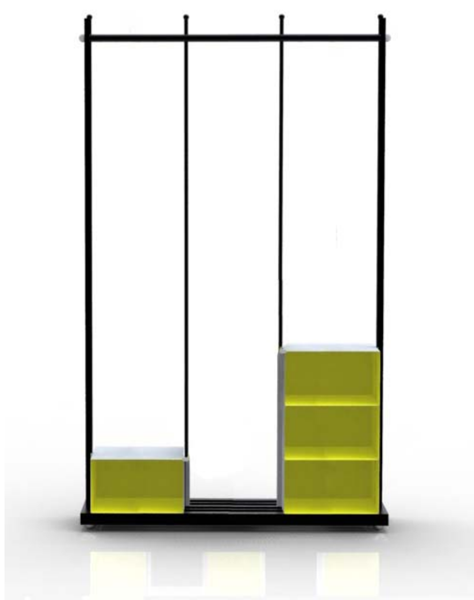


Figure 6.18: Design revision 1

6.4.2 Hanging Rod is supported by knob vertical tubs (Figure 6.19)

The hanging rods were changed as shown to facilitate easier assembly, disassembly and to increase the stability of the design.

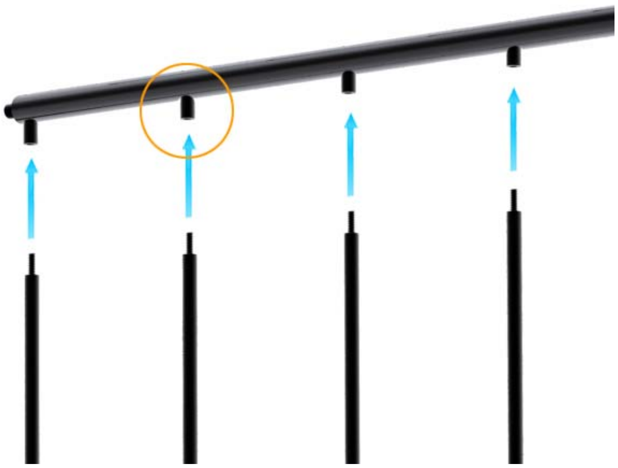


Figure 6.19: Design revision 2

6.4.3 Clip Cubic Box to the Tubes (Figure 6.20)

This change is envisioned to make it easier to assemble, disassemble and adjunct the Cube Storage Boxes.

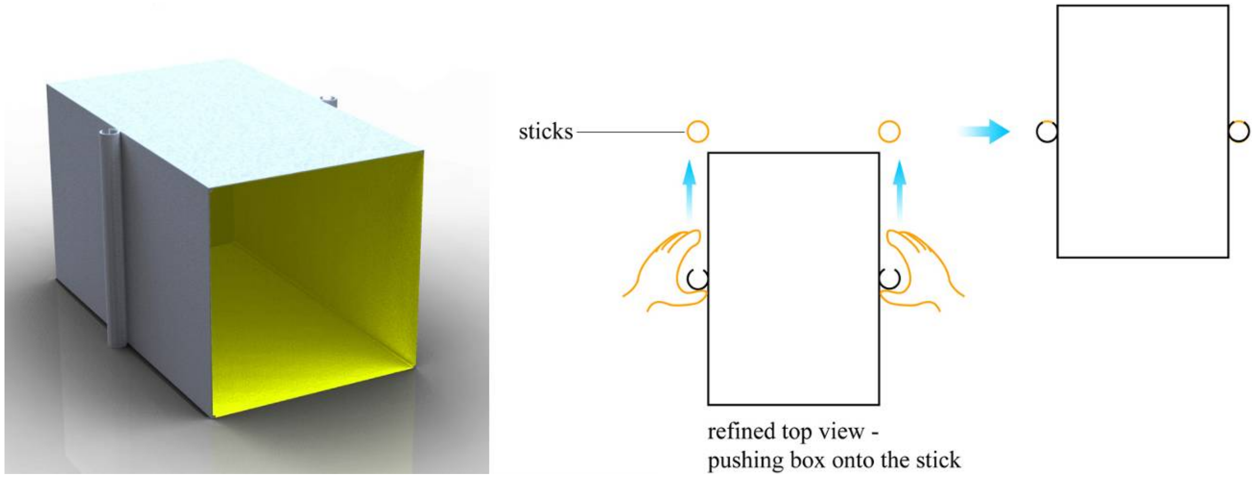


Figure 6.20: Design revision 3

6.4.4 Height Adjustment Button (Figure 6.21)

Depress button to adjust box height; release to fix box in new location at any height. A Height Adjustment Button will make it easier to position the storage cubes.

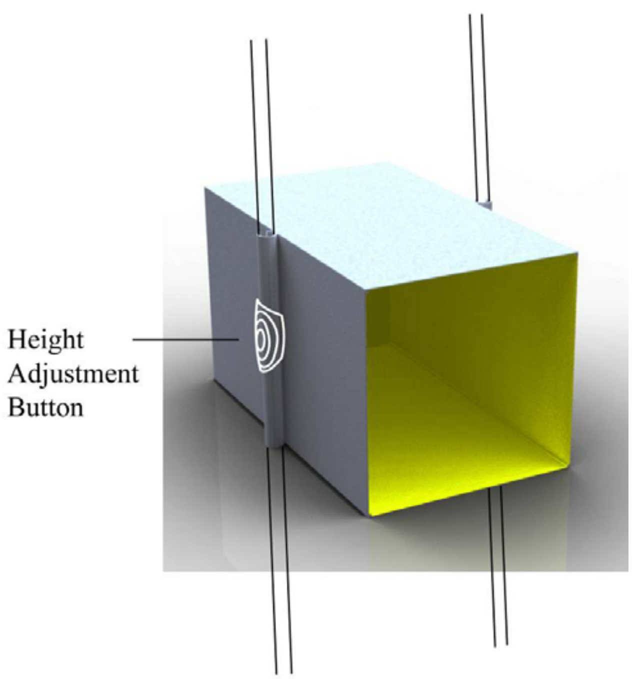


Figure 6.21: Design revision 4

6.4.5 Breakdown and use Base as storage of rack components for transporting (Figure 6.22)

This feature will allow all pieces of the design to be stored in the base when the unit is being moved.

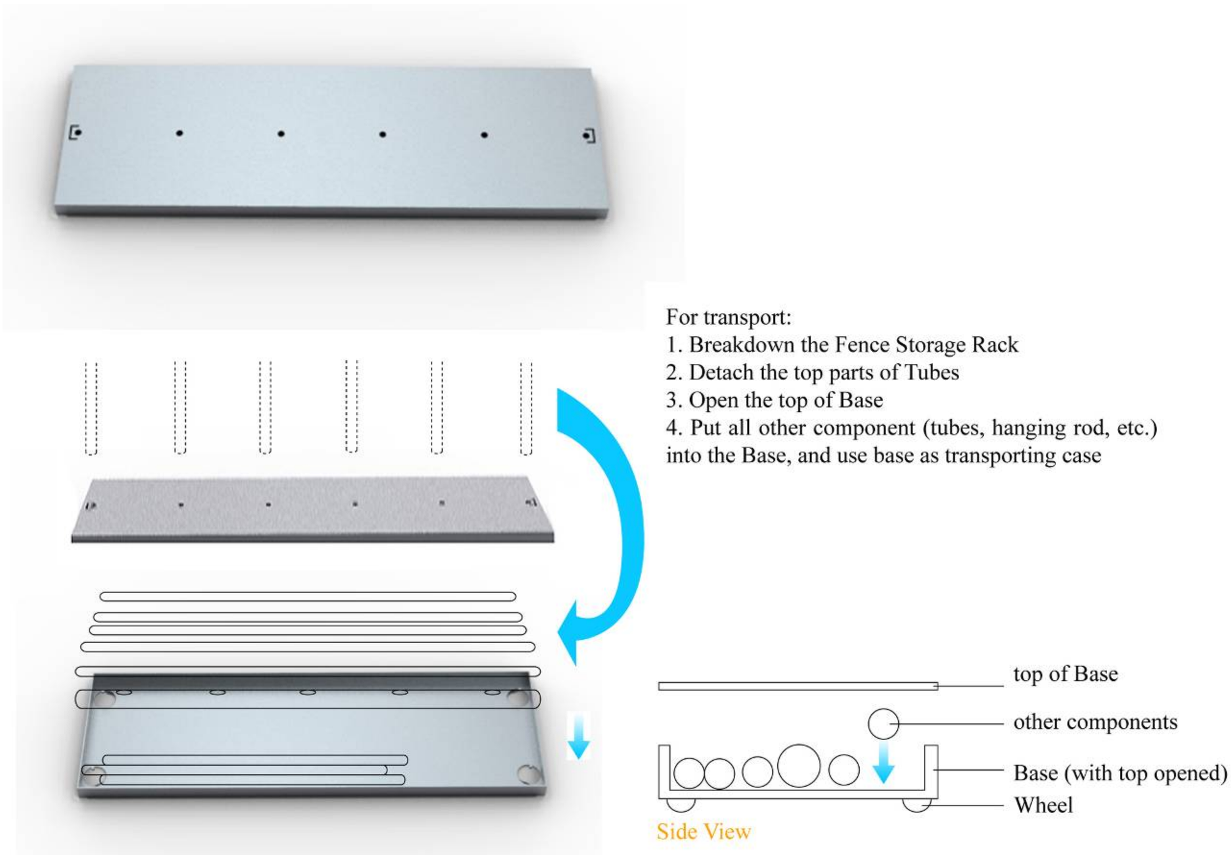


Figure 6.22: Design revision 5

6.4.6 Add-ons for Fence Storage system: multiple choices for users to DIY (Do It Yourself) (Figure 6.23)

This feature will allow the user to customize their Fence Storage Design to fit individual needs and preferences. Users can select a number of add on design items such as a laundry bag and various hangers.

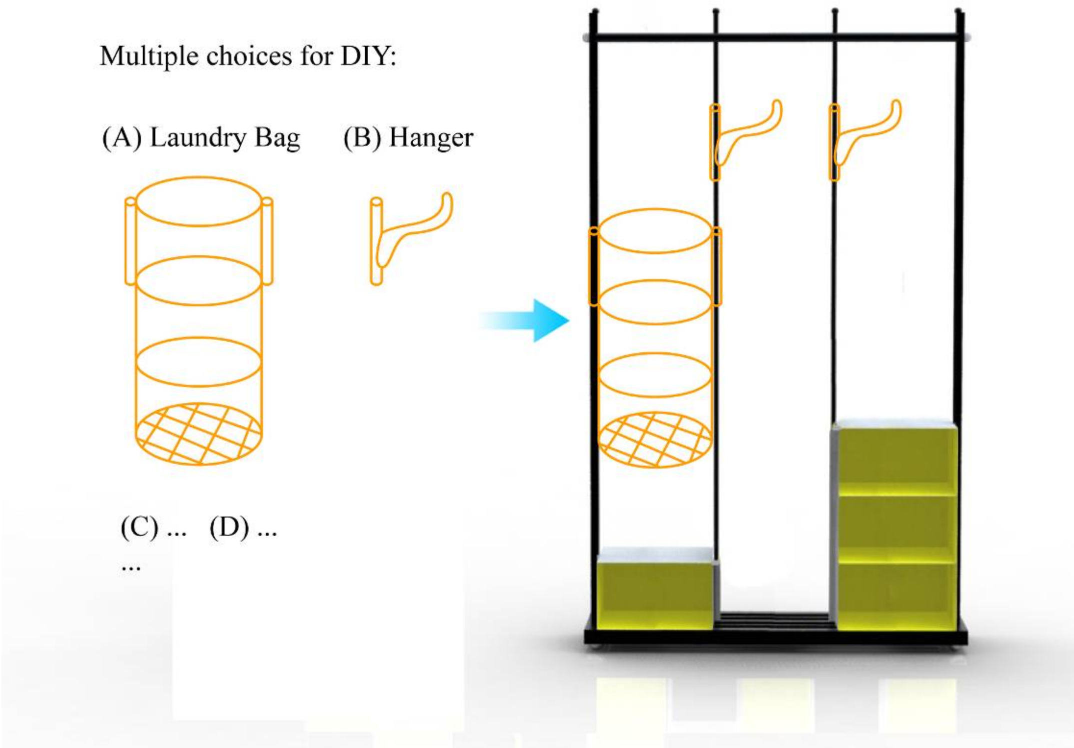


Figure 6.23: Design revision 6

6.5 Design evaluation

After completion, the design was evaluated based on project parameters that were concluded in Chapter 5 as follows:

- Target User: college students

- Material Requirement: eco-friendly
- Size Limit: Should fit vehicle with 58.1 inches in rear track width and 12 cubic feet in cargo volume
- Moving Capability: meet students' high moving frequency
- Direction of Feature: Functionality, Enhanced form quality, Flexibility, Simplicity, Durability to promote long-term use

Compared with the further developed idea at the end of Chapter 5, this final design decreases the product size by flattening the main shelf, while adding more functional capability. The Cube Box part uses a cube shape, which is elegant and able to be personalized. The metal structure frame inside the fabric box can be helpful to hold the shape of the box, as well as to support the weight of items both inside and above the box.

In accordance with eco material requirements, the main material used in the design is steel. According to Chapter 3, steel is an eco-friendly material that is not only easy to manufacture, but also easy to recycle and reuse. The other materials used in the Cube Box are fabric, which is made of natural material that is not harmful to the environment, and TPE as Cap, which is an environment-friendly substitute for the commonly used but toxic PVC. All these materials are commonly used and are not expensive. Therefore the price of the product in the market will be in an appropriate range for purchasing by college students.

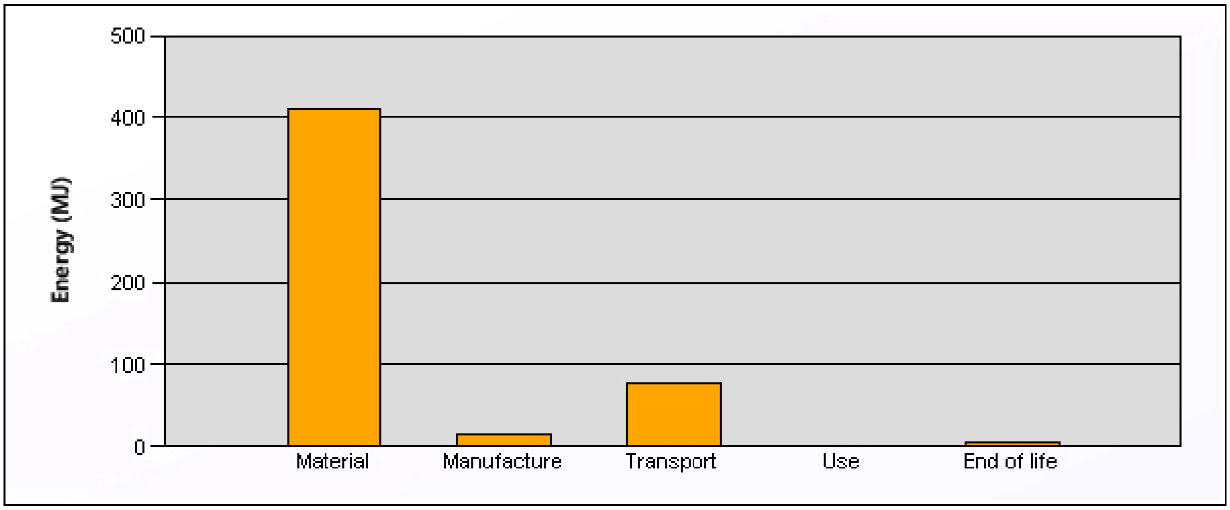
For this thesis, the designer used CES Selector software to calculate energy usage and CO_2 output of both current chest-of-drawer in dormitory and Fence Storage design. Figure 6.24 shows the result for Fence Storage design, and Figure 6.25 shows the result for current chest-of-drawer.

Energy and CO2 Footprint Summary:

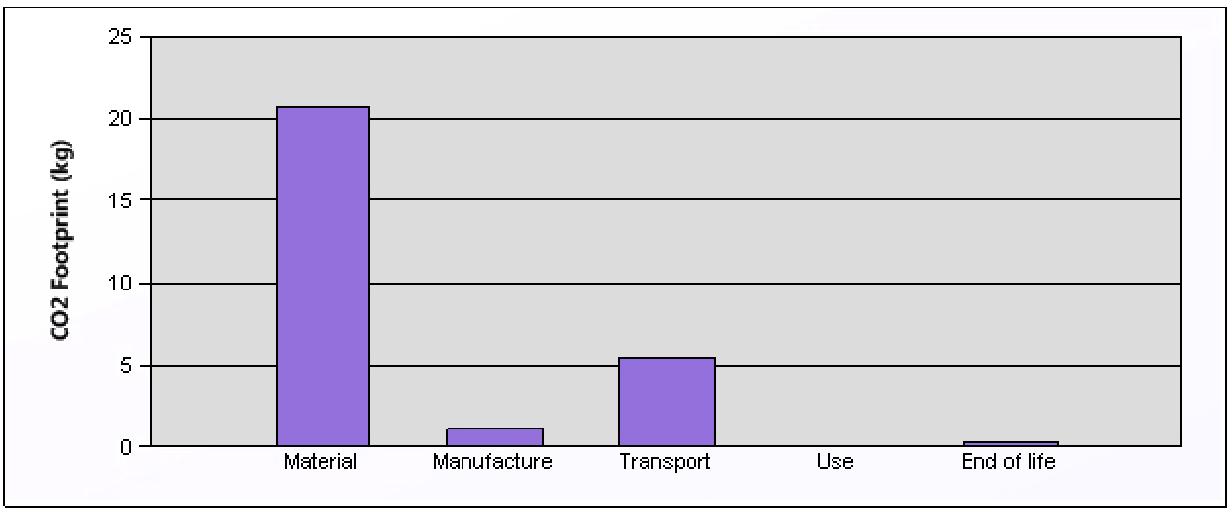
Phase	Energy (MJ)	Energy (%)	CO2 (kg)	CO2 (%)
Material	694	201.6	53.4	199.9
Manufacture	48.6	14.1	3.89	14.6
Transport	58.9	17.1	4.18	15.6
Use	0	0.0	0	0.0
End of life	-457	-132.8	-34.8	-130.1
Total	**344**	**100**	**26.7**	**100**

Figure 6.24: Energy usage and CO_2 output of Fence Storage design

Energy and CO2 Footprint Summary:



Energy Details...



CO2 Details...

Phase	Energy (MJ)	Energy (%)	CO2 (kg)	CO2 (%)
Material	411	80.9	20.7	74.9
Manufacture	13.8	2.7	1.11	4.0
Transport	77.5	15.2	5.5	19.9
Use	0	0.0	0	0.0
End of life	5.53	1.1	0.332	1.2
Total	**508**	**100**	**27.7**	**100**

Figure 6.25: Energy usage and CO_2 output of Particle Board Chest-of-drawer in dormitory

Comparing the existing Particle Board Chest-of-Drawers and the new Fence Storage design, the energy usage of new design is more than current chest-of-drawer. However due to the recycle of materials at the end of product life, the total energy usage is reduced to be less than Chest-of Drawers. Therefore, to make the design more eco-friendly, the new product should be manufactured in a way to achieve recyclable of the materials.

To the group of intended users, college students, this design addresses two important needs: storage space and portability. At first, the design uses a fame structure which takes less room, but provides two functions of storing clothes – hanging and folding. The Cube Boxes enable users to fully utilize the storage room under the clothes. This accomplishes the goal of using less room to create more storage space. Secondly, the four wheels make it easy to transport the unit. The design is collapsible as parts can be flattened and stored in the base for moving. This is expected to ease the students' awful experience during move-in day. Thirdly, the dimensions are such that the design can be placed in the cargo space students' cars.

Additionally, the top five features identified as desirable by students during research are accommodated in the new design. These are function, form, flexibility, simplicity and durability for long-term use. In "function", this design solves students' problem of both having little storage space and difficulty in moving. It also is flexible in that it provides two ways of hanging and folding clothes as well as meeting general storage needs. So this design first is functional. In "form", the frame structure is thin and is not visually obtrusive even in a small room. The simple structure gives an elegant, light and airy feeling to the design. The metallic luster combined with the use of colorful fabrics for the boxes creates a modern look and feel. The ability to personalize the box arrangement allows students to create their favorite color and shape and use arrangements.

In meeting the “flexible” design parameter, the collapsible rack and boxes enables the design to be flexible to meet students’ different storage needs. Students can decide the number of boxes they use and can create personalized arrangements. The product can be used against the wall, or in the center of the room. In “simple”, the design just uses a very basic shape that is not only easy to manufacture, but also easy to use. Assembly time is estimated at 10 minutes. Users simply attach one part to another. Screws fasteners are used so that extra tools are not needed to assemble the product. In meeting “durable or long-term” objectives, the majority of the design is fabricated using steel and aluminum. These durable and stable materials should make the product more sustainable as it is expected to last many years.

In conclusion, this design successfully addresses the important design needs established through interviews with college students. The design is envisioned to meet their needs while utilizing eco-friendly materials and manufacturing methods. It was not possible as part of this thesis to fabricate and test an exact prototype of the design. The designer hopes that this thesis will inform others about the needs of college students (and others) for new and improved ways to store and move clothing. In summary, this design meets the goal of this thesis, i.e., to create a new and improved eco-nomadic furniture design for college students. While the target audience of this thesis was college age students, the design may also have applications for other users with similar nomadic lifestyles. The designer hopes that this thesis will both inform and inspire others to create improved eco-friendly nomadic furniture designs for the marketplace.

CHAPTER 7: CONCLUSION

This thesis began by pointing out three keywords that were reiterated throughout the thesis: college students, eco materials and nomadic. The designer's investigation began with a detailed research of each keyword in order to gain a deeper understanding of topic and related issues. The research of target user group – college students focused on a deep understanding of their experience and needs with storage furniture. In addition, their perspective of ideal storage furniture guided the design process and final design direction. The research of "eco" materials was based on an understanding of eco. Materials commonly used in fabricating existing storage designs were studied. The research of nomadic was also based on the definition of nomadic furniture. Commonly used structures to achieve nomadic concept were investigated and documented. Based on this research, a new design was created to address the clothing storage needs of college students. Through a design process involving phases of research (search), design development and finalization, a final concept for an inexpensive, portable, easy to use and "eco-friendly" nomadic clothing furniture design was created. The Nomadic clothing storage design addresses the problems college students have with limited storage space and difficult to move furniture.

A summary of the major values created by this thesis design are as follow:

a. College students living in dormitories complain that they do not have sufficient storage for clothing. Moving twice each year on average during four years of college is a labor and time intensive experience. Moving and storing clothes is particularly problematic. The traditional storage furniture, the chest of drawers and closets, do not adequately address these problems. This thesis provides a solution to these problems, in addition to the traditional functions performed by existing dormitory furniture.

b. Additional improvements of this thesis design include the use of “eco-friendly materials” and an improved aesthetic value over existing furniture. Therefore, the design is expected to be more meaningful to the user group, based on an understanding of their needs. Satisfying user and environmental needs were central to this thesis.

c. In the first chapter, seven top trends in design were noted: Global, Green, Personal, Interactive, Simplex, Feminine and Health. The final design addressed most of these seven trends. It uses a simple design structure and shape that should appeal to consumers globally. By using eco-friendly materials, the design was “Green”. Also eco-friendly materials are not only good to environment, but also benefit our health as well. The design is personalizable to users according to their personal needs, so it can be seen as “Personal” and “Interactive”. It is a unisex design, with an elegant, slim, modern but also simple look.

d. In this thesis, there is an analysis of commonly used storage materials, and one of nomadic structure. These two can later be used to create other designs. So this thesis not only creates one solution to solve the problem, but also can be used as a resource to help inspire the creation of future eco friendly storage designs for college students.

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APPENDIX A: TOP SEVEN DESIGN TRENDS

ASME (http://www.asme.org), the American Society of Mechanical Engineers, is a non-profit professional organization that helps the global engineering community develop solutions to real world challenges. Its goal is to enable collaboration, knowledge sharing and skill development across society.

In recent years, design and engineering have merged with each other in many cross-cutting areas. In February, 2008, ASME published an article named “Top 7 Design Trends.” This article discussed seven global design trends that will last as long-term trends in the market worldwide. These seven design trends included: Global, Green, Personal, Interactive, Simplex, Feminine and Health.

Trend 1: Global

As the article mentioned, like so many other industries, industrial design is swept up in an increasingly global economy (Butcher, 2008). Today’s world is an international design world.

Recently, in the era of globalization, because customers in the market have more choices compared with past decades, they are able to make decisions based on their various personal needs. The market has created a demand for all brands to become diverse; this is the reason we see all kinds and shapes of products in today’s market. Industrial design has taken up a significant role in answering the demands of economic globalization by achieving diversity in the development of products and services for target groups. Diversity in product markets intensifies the competition between each brand; only brands that are capable of grabbing target groups’ attention and hearts can be the last ones standing.

Thanks to a globalized economic system, brands are not only seeking success in the markets within their own countries, but are also looking forward to the global market. In addition, markets within each country and the entire global market are influencing each other more than ever before. Businesses based on the internet have boomed as a result, and business communications among different areas has become more efficient and effective due to advanced network technology.

High internet technology also provides an opportunity for design to become globalized. We can easily collect information and knowledge from all over the world, as well as share this information and discuss it with people anywhere on earth. This provides comprehensive data to help designers study target groups.

Some companies go after the entire global market, while some cater more to regional and niche markets. For the latter, an increasing amount of companies are starting to design products for consumers in other countries. In this case, a mixing of cultures inevitably happens. People who come from different backgrounds may work together, and the product development process itself becomes international and global.

People around the world are now closely connected. Supported by the power of advanced technology, we are together creating a globalized and well-designed product market.

Trend 2: Green

As far back as 1990, “an emerging concern for social and environmental issues” was considered one of the “five facets” of contemporary industrial design (Butcher, 2008).

Since global competition poses new challenges for all market players, it has become increasingly important for designers to combine product designs with social and environmental responsibilities. Also, because the whole world is advocating green products, brands that put an effort into going green in their products’ manufacturing process are able to improve their reputations and promoted brand values.

A 2007 Goldman Sachs study also found that companies with a strong emphasis on sustainability and that introduced “green” products outperformed the Dow Jones Industrial Average stock market index, often by a large margin. PricewaterhouseCoopers also issued a report detailing how companies that report their sustainability efforts receive better returns on their assets than companies who do not (Skees, 2009).

Evidence suggests that consumer demand is growing for more environmentally and socially innovative products and service solutions. Although consumers believe that green products and services are more expensive than non-green products, the 2009 Green Brands Global Survey revealed that global consumers are ready to spend more of their income to ensure that the products and companies they support operate with a sustainable focus (Skees, 2009).

The entire market is calling for environmentally friendly products, thus this has become one of the most dominant trends on our planet. Designers therefore have to face this challenge and focus on cleaning up the production process and considering the environmental impact of production, shipping and disposal. One of ways to do this is to use sustainable materials, which will be discussed further in this thesis.

In the design discipline, designers have already been trying hard to utilize green design solutions. According to the AutoDesk/AIA Green Index, the number of architects incorporating sustainable design practices into their projects is quickly rising, with 90 percent of architects expecting to incorporate some sustainable elements by 2012. Additionally, some software is built to evaluate the sustainable value of projects before they are even started. AutoDesk is joining other companies like GreenBuild and Lucid Design Group to develop software that allows designers and engineers to measure environmental impact and to help make green design an easier process (Butcher, 2008).

Trend 3: Personal

Consumers have more options for consumption than ever before, which leads to the result that today's consumers are starting to look for products that are unique to them; in other words, people want products that express themselves. They have emotional needs that they try to satisfy by using certain styles of personal items to show their tastes, status, values and even incomes. Today's consumers are calling for original, functional and individualistic items for their dream products. "One-size-fits-all" is out of date; it is now a "Mass Customization" world, and customizable products are spreading throughout the market.

Figure A.1: NIKEiD personalized shoe

The easiest way to pursue customizable features is by giving consumers the ability to choose customized colors, textures, patterns or engravings, as with Nike iD shoes (Figure A.1). Some brands can offer even more possibilities. For example, in many cases, when purchasing furniture, customers go to a furniture company to choose their favorite style, and then the company measures the space of their house and makes a product for them based on the house's arrangement. Other furniture can be assembled by customers themselves. Through the assembly process, customers can customize their unique products by choosing different assembly parts, adjusting the position of each part or by choosing different orders when composing parts. The brand IKEA is a good example of this point. Another example is Apple's success. Its Apps contribute to a large portion of this success. Apple offers a platform allowing everyone to contribute to the diversity of its Apps library (Figure A.2). Simultaneously, Apple users are given multiple ways to customize their electronics.

Figure A.2: iPhone Apps

Sometimes the prices of customizable products are much higher than regular ones, especially in the vehicle and luxury industries. However, people are still willing pay the price to have personalized merchandise, because we all have a need to identify ourselves in the world, and customized features can physically and mentally help us to realize this identification. People with higher incomes prefer more about personalizable products.

Companies have to deliver what the customer wants in order to win in a competitive market, and designers have to figure out the way to help companies achieve this goal.

Trend 4: Interactive

In Trendwatching.com's November 2004 newsletter, as IMT noted, more than two years ago, the innovation website declared that letting customers have a say in product design and development was on the verge of hitting it big (Butcher, 2008).

Figure A.3: iPhone's touch screen

This is still right in nowadays. Another reason for Apple's success is its amazing user interaction. Apple products are easy to use and easy to understand, driving more and more people to become

Apple users; people do not need to take a class to learn how to use Apple products. Sometimes, people are afraid of getting hurt by new things. Failure in starting frustrates new users and leads to the fury of users towards products, as these failures make them feel stupid, which no one likes. Therefore, these people will decide to close the door on these unfriendly products, so that they cannot make them feel bad about themselves anymore. This is bad for these products, and they need a better interactive connection with users in order to act exactly as users want them to. When there is no more feeling of panic regarding a product's failure, people are happy to welcome a fresh product, and that product can be more easily accepted by the market.

There are several basic steps to approaching a good interactive system: watch customers and interact with them; talk to them; listen to them; act on their qualified input. By inviting people from target groups to give comments throughout the design process, designers can become both reactive and proactive with target users to create better designs.

Trend 5: Simplex

Less is more; this is an everlasting design philosophy. Industrial designers seek unprecedented function, brilliance in the everyday and, quite simply, better ways for us to use things (Butcher, 2008).

Simplex means multi-functional but approachable, ergonomically correct without compromising ease of use. Simplicity and directness can reduce unnecessary misleading in the user interaction process, such as Naotu Fukasawa's CD player (Figure A.4), which requires only pulling a rope to turn it on and pulling it again to turn it off - simple and easy. In the meanwhile, simplex feature can create the beauty of simplicity. Although individuals' tastes are very different from each other, beauty of concise design is easily accepted by most people, and is thus a profitable design feature for a company.

Figure A.4: Wall mounted CD player by Naotu Fukasawa

Trend 6: Feminine

TrendWatching calls women "the mega niche...the underserved market of all markets" (Butcher, 200).

More companies are realizing this potential market and are therefore trying hard to target girls and women in their product lines. Stepping into the 21st century, pink, as a special color for girls and women, has swept through the market. This is a symbol of femininity's rise. All types of products, from those smaller than a credit card, such as cell phones, earphones, mp3s, laptops and so forth, to those bigger than vehicle, have pink as a special version. In addition, pink and sometimes red is given the meaning of promoting breast cancer awareness, so people are also buying these products to show their support.

Besides special colors, some companies have also launched certain products particular to female users, such as Wicked Women Choppers (Figure A.5). Motorcycles are always huge, big, heavy and not designed for women users, while wicked women choppers pay more attention to the needs of potential women drivers. They adjust the sizes of each part, making these motorcycles fit female drivers' body proportions. This allows women, who were used to being rejected by the motorcycle world just because there was nothing suitable for them to drive, to have a chance at becoming a driver.

Figure A.5: Wicked Women Choppers in pink

Study of gender issues has become one of the minor majors at some universities and institutions. People understand that males and females are born to be different from one another. By thoroughly understanding these sexual differences, our society can truly achieve equality of men and women.

Trend 7: Health

Many companies are designing and providing products that "take the insult out of middle age," as the May 2007 issue of International Design Magazine put it (Butcher, 200).

Right now, people are starting to pay more attention to their healthcare. High technology also provides more options related to human health. Families, especially baby boomers, are doing everything to prevent illness from messing up their lives.

Consumers tend to have a healthy lifestyle, eating healthy food, using safe daily living goods, ensuring they get enough exercise and preparing quick fixes for some emergencies such as keeping first-aid boxes readily available and providing emergency calls. Furthermore, when purchasing products for kids, parents care about the materials used in the products and their safety considerations. They want to create a healthy environment in which to raise their kids.

When shopping at Wal-Mart, people can see tabs such as “organic,” “diet,” “healthy” and other similar words. People have started to read the nutrition labels on products and study materials’ compositions in building products. They care about doing good things to both themselves and the environment.

Figure A.6: Consumer purchasing organic vegetables