The Design of a Storage Product to Help People Live Happier and more Comfortably in Small Spaces based on Design Research and Environmental Psychology

THESIS

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ABSTRACT

As the consistent growth of urbanization continuing, the population living in urban areas can increase from 50% to 70% in 2050, reaching from 3.3 to 6.4 billion (World Population: 1950-2050, 2009; World Population, 2009; Population Density, 2009; Urbanization, 2009.) Although the growth of cities can benefit the worldwide economics, the movement of population can seriously change the living quality in urban areas. The living spaces in most metro areas can cause the occupants feel stressed and depressed easily because those housings are relatively small (Sommer, 1974; Freedman, 1975.) Moreover, for lower and middle-income person, the crowding results in even worse negative effects because they have more difficult to organize their lives (Harvard University's Joint Center for Housing Studies, 2006.) Eventually, they have permanent clutter as soon as they move into their houses (Guinness, 2006;) therefore, organizing and storage turn into a significant issue for people living in small spaces.

This thesis conducted a way to optimizing the small space to create a friendlier atmosphere for the occupants. The possible solutions may range from creating innovative furniture to developing a more inviting environment. The implementing methods will be as followings: building a open-space with proper lighting installed on furniture or creating extra storage spaces by using the upper space in the house: ceilings and walls.
Direct survey, questionnaires and interviews, were used to uncover the main problems of living in a tiny space. Along with the interview, the participants were encouraged to present their ideas with mock-up model, which is part of the co-design process. In addition, secondary survey, market potential and storage issues were implemented to support the findings of primary survey. After the survey, ideations, building open-space atmosphere and creating upper storage spaces, were executed for solving the storage issue. Consequently, the evaluation research was implemented by testing the above concepts in a virtual 3D model to acquire feedback from the end users. The main goal of this thesis is to explore the understanding of design and environmental psychology to implement a way to help people live happier and more comfortable in a tiny space.
DEDICATION

This document is dedicated to my family.
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I would like to express my gratitude to my supervisor, Dr. Noel Mayo, whose expertise, understanding, and patience, added considerably to my graduate experience. I appreciate his vast knowledge and skill in many areas (e.g., design, health, diet, ethics, poverty, society, and etc.), and his assistance in writing resumes and proposals (i.e., grant proposals and this thesis). I would like to thank the other members of my committee, Prof. James Arnold for the assistance he provided at all levels of the research project. Finally, I would like to thank Dr. John Sollers from the psychology for taking time out from his busy schedule to serve as my external committee.

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CHAPTER 1

LITERATURE REVIEW

1.1 Population Growing & Urbanization

The world population, the total amount of people living on the earth, doubled during the last fifty years, from 3.33 billion in 1965 to 6.77 billion in 2009 (World Population: 1950 – 2050, 2009.) The worldwide population density is 34 per sq mi, 6.7 billion persons \( \div 197 \) million square mile. People don’t live evenly on the earth, however, the global proportion of people living in urban areas, with population over 50,000 or population density over 1,000 sq. mi (Urban Area, 2009,) is significantly higher than that of rural areas. During the last 55 years, the population density of urban areas has grown dramatically from 29% in 1950 to 49% in 2005 (Urbanization, 2009.) Nevertheless, a high population city doesn’t always exist with high population density. Take the largest cities in America by population for example, Jacksonville Florida, rank 12, has nearly same population amount of Columbus Ohio, rank 15 (List of United States cities by population, 2009.) The population density of Columbus is about 3.45 times of that of Jacksonville.
On the other hand, the population density varies somewhat amongst different nations (Urban Area, 2009.) For instance, the population density of Dhaka, Bangladesh, the most crowded urban area in the world, is 11 times of the density of LA, America and 15.6 times of the density of New York city, America (76,879 ppl/sqm in Dhaka, Bangladesh; 6,670 ppl/sqm in LA, America, and 4,905 ppl/sqm in New York city, America.)

In addition, the United Nations Population Division projected that the worldwide population in urban areas will likely exceed 70% (6.23 billions) in 2050, which is approximately the amount of current total world population, 6.7 billions. The issue of extreme high population densities then diverts to numerous issues of living in urban areas.

1.2 Crowding & Emotional Reactions

There are several environmental psychological studies stating how the living in crowding places affects human’s behavior emotionally and physically. In “Tight spaces”, Sommer, R. describe the problems of existing buildings and how these living spaces cause negative reactions to residents (Sommer, 1974.) He demonstrates that the living situations can and should be improved from the perspectives of psychology environment, even though most of them were built for security purposes. For example, he stated that people living in prison are like animals living in Zoo. However, the awareness of design of shared spaces, where people can process their social activities, can prevent building a depressing environment. The ideas for building a healthy house he has shown in the books are still very influential for present residential buildings.
Moreover, Mr. Shelson (1999) also defined certain psychology environment terms (Cohen & Sherrod, 1978.) For example, there are two different definitions for density of living situation: internal density, a measure of dwelling space per person (e.g. rooms per person or square feet per person;) and external density, the number of people occupying a large residential area (e.g. people per acre, kilometer, or mile.) For a living spaces study, the internal density can tell us more information about people’s living condition than external density does. Essentially, these two terms don’t have a direct relationship to each other, e.g. a tiny country-style house occupied by a family in a rural area (higher external density) may be less spacious (higher internal density); conversely, a one-bedroom apartment occupied by a single guy in a big city (higher external density) may be more spacious (lower internal density.)

In addition, according to Kopec (2006), crowding space is strongly related to the human’s negative reactions, such as stress and depression (Kopec, 2006.) He presented that careful design can reduce the negative effects and helping people adapt to their home. For example, some design strategies were pointed out based of the perception of environment psychology. By the way, he also demonstrated several issues: human behavior, age, minority, education, and occupation types, which can influence the degree of negative effects which a crowding space cause to its residents. In the other words, for instance, higher-income and high-education people are less negatively influenced by the size of living spaces. Conversely, lower-incomes and lower-education people are more likely to be negatively influenced by their residential environment.
On the other hand, Freedman (1975) claimed that tiny space didn’t necessarily have negative effects on people (Freedman., 1975.) Based on his book, Crowding and Behavior, Mr. Freedman described the crowding situation in cities and how it affected human behaviors. Several modern issues, such as crime, social activities, and personal spaces, related to crowding spaces, were discussed. He concluded that people living in tiny spaces didn’t necessarily have negative effects. He noted that encouraging people to connect with others by providing more public space for social activities can improve the feeling of living in a city.

Therefore, crowding can cause negative effects and creates uncomfortable living experiences, especially for people with lower income or lack of education (Sommer, 1974; Kopec, 2006.) For instance, most people feel stressed, aggressive, and depressed staying in a crowding environment, such as high-rise buildings. Furthermore, in a high-density working space, people have difficulties to remember or perform tasks as well as people do in an open space. On the other hand, according to Freedman (1975), crowding is an essential but not necessary factor to negative effects. He pointed out that living standard: income, social status, and education, are also part of the influencing factors. In other words, crowding living space can negatively affect human emotion and physical conditions; furthermore, the condition gets even worse as residents with lower standard of living.
1.3 Personal Preference, Individual Differences

Alternatively, the criteria for indicating crowding are subjective, not like density which is objective (Kopec, 2006.) Sheldon showed people perceive the crowded level of a living space differently (Cohen & Sherrod, 1978.) Based of his statements, there are two factors influencing human’s feeling: “Perceived controllability” (e.g. other people restrict individual’s goals) and predictability (e.g. strangers) of environments.”

The environmental controllability and predictability, the abilities of managing space to a desired status, significantly influence human’s consciousness more than the square feet people occupied (Cohen & Sherrod, 1978.) For instance, standing in an organized elevator with friends may be less stressful than in a messy bus with strangers. Moreover, a high-density space may not be crowding if it is clean and consistent; a middle-density space may be crowded if it is messy and inconsistent.

Furthermore, according to Freedman (1975), the amount of time spent in a crowded environment also plays an important role to people’s emotional reactions (Freedman., 1975.) He went on to say that the amount of time spent in small spaces should be at least equal to being out of the space to get relieved from high-pressure environment. Therefore, as long as people can be able to well optimize the living quality and properly break out from the stressed space, living in tiny rooms can still be pleasure and comfortable.

Freedman (1975), Sommer (1976), and Kopec (2006) all reported that the shared spaces where people can engage social activities are significant for enriching residents’ emotions. Sommer (1976) also noted that people can be able to live joyfully in small rooms if their needs of social interaction are satisfied. In fact, they can be happier than people living in
bigger private rooms without social lives. However, unfortunately, most of the existing buildings were not built with the awareness of the importance of social interaction. For example, most of the high-rise buildings or apartments is lack of public social spaces or only have a few small private rooms. By the way, Sommer (1976) and Kopec (2006) both suggested that careful design can shift a depressing environment to a positive one. Based of their statements, unintentional conversation places: a friendly front lobby, laundry rooms for each floors, or children entertaining rooms, can absolutely encourage more nature conversations.

In conclusion, crowding can result in numerous negative effects, psychologically and physically; nevertheless, these effects get worse for people with lower controllability and predictability of their lives. Most of time, they are lower and middle-income classes. Along the way, for these lower-class people, simplifying space composition, organizing their living spaces, and getting a temperate break out of the stressed room are some useful strategies to reduce the negative feelings. Furthermore, lack of social interaction is also an important issue for people living in tiny rooms. Consequently, creating more shared rooms in public for unintended conversation or more interacting space in their private rooms can encourage residents to interact with others which can obviously help people live happier.
1.4 Small Space Living

Size of house is the third factor people considered when purchasing a house (price is the first and design/layout is the second (Adler, 2006.)) Based of the consumers’ demands in market, the average square footage of new single-family houses in America has doubled since 1950 (983 sq. ft. in 1950 and 2045 sq.ft. in 2004 (America's Homes Get Bigger and Better: As the American Family Shrinks, Houses Grow, 2005.)) For most of urban residents, however, affordability is still the main concern based of their lower standard of living. Taking the first-time house buyers for example, their houses are usually smaller and older. The medium size of house they purchasing is 1,500 sq.ft. while it is 2,000 sq.ft. for move-up buyers. Meanwhile, the medium age of their house is 33 years while it is 15 years for repeated buyers (Adler, 2006.)

Small space living has became a trend for modern life in urban areas. It is efficient, aesthetic, and provides the sense of belonging (Susanka, 1998.) The most obvious advantage is saving money: the mortgage, the heating and cooling, and the maintenance. The other advantage is saving time: cleaning or finding things. On the other hand, a small home is also more sustainable for our environment. A small home encourage simplified living which means less waste, less clutter, less use of power, and less water consumption. Most of all, a small home brings everyone in the home closer. Residents are forced to cooperate, and spend lots of time playing together (Susanka, 1998.)

There are a few challenges have to be planned before moving into a small home: 1. individual privacy, which is essential for every one living in a small home; 2. the design and layout, which means to extend the specious feeling of a space; and 3. storage issue,
which means to utilize every bit of space available. A considerable design plan can
definitely improve the living condition in small homes (Susanka, 1998.)

Open space, one of the interior design strategies for providing a special and welcoming
environmental, is addressed in the book, one space living by Inions, C and A. Wood. In
this book, the issues and strategies for living in a small space were proposed based of the
aspect of interior design. The author, Inions, C and A. Wood, argued that the
configuration for a small space should be able to bring people the feeling of openness,
flexibility, positivism, and also privacy. For example, a typical layout of open space is
having the living room, the kitchen, and the dinner area connected without being divided
by physical walls. This layout optimizes the feeling of openness of living in a small home.
On the other hand, the sleeping and resting areas were divided by walls or doors to
provide essential privacy for people living in a small room. The idea of open space
explores the conventional thinking of dividing space for numerous purposes, such as
cooking, bathing, or working, which gives innovative thoughts and identifications of
small space (Inions, 1999.)
1.5 Messy and Clutter

Alternatively, living in a small home requires a simplification of lifestyle. Ideally, before moving into a small home, residents have better get rid of the unused items. There is actually no room for unused items or clutters in a small home. Based on two of Guinness’s articles, he claims that people don’t need to create extra space, but need to get rid of their unused things (Guinness, Put it away, 2006; Guinness, Space, the Final Frontier, 2007.) Guinness states that storage makes people feel in control and how people get relieved after their homes get organized. He believes that “throwing clutter away is a better way than making extra storage space.” He also suggests that “ten percent of a home’s size should be used as storage,” which is a tip for addressing storage space (Guinness, Space, the Final Frontier, 2007.)

Along with Guinness, Terence Conran, a comprehensive designer (architecture, interior, product, and graphics,) who has published at least 33 books, believes that getting rid of things is one of most effective way to conquer clutter. He pointed out that purchasing encourages messy: people can’t help going shopping, but they don’t have enough space to store what they buy. People will live happier without mess, he stated. (Guinness, Put it away, 2006.)

In fact, getting rid of personal possession is not always easy for everyone. The personal histories attached on the old property are the main reasons stopping people remove the old things. In the article, That’s Not Old Stuff. That’s My Past, Mr. Buchan discussed the meaning of storing and possible solutions through his personal experiences. Most people keep old things which they rarely used as the property reminds them their past: their
histories (Buchan, 2008.) In the article, Hooked on Storage, a psychologist stated that some people, called hoarders, have a mental problem to avoid cut those unnecessary possession away. They feel guilt at throwing things away, but feel comfortable of keep them in extra storage space. Mr. Gannon (2007) stated that some people said they couldn’t live without the unnecessary but meaningful possession (Gannon, 2008)

Mr. Buchan pointed out that the possible solutions to conquer clutter are: 1. living minimally and 2. getting a storage locker. Gannon presented the storage market in US and discovered the renters’ desire for extra storage space. According to Gannon’s research, there are 11 million renters in US are using the storage service for longer period. Furthermore, the renting market has expanded 95 percents since 1995; although, it conflicts with the fact that people own more space than they did in the past: the size of living space is increasing and the scale of family is reducing. In fact, Most of the renters would rather pay thousands dollars (at least 3,000) per year keeping those unused things than throwing them away (Gannon, 2007.)

Overall, small space residents have the desire for extra storage space. In addition, storing is based on the desire of storing, not the value of the property. According to Burchan, “a storage solution should be pretty, practical, space-saving and, best of all, portable.” These four requirements are significant for designing a better storage system since most of the current products don’t fulfill all of the four requirements. For instance, a full wall of build-in bookshelves with a rolling ladder can provides a better accessibility for reaching the overhead things (Buchan, 2008.)
1.6 Audience

The research audience targets on the people who live in small spaces in urban areas. The populations of this target group are approximate 12 millions in US, 319 millions in China, and 196 millions in India and are continuously increasing (Urbanization, 2009.) Their ages are range from 25 to 44 yrs and most of them are house renters or first-time homebuyer. Their living spaces have the average smaller size, 200 to 500 sq. ft. per person. In other words, if there are three people who live together in one house, the house size can be 600 to 1500 sq.ft. Most of the small space residents are singles, DINK (double incomes without kids), or single family. Moreover, their income levels range from ($20,000 to $60,000 /yr,) which are lower-middle, middle, or higher-middle classes. They spend approximately 30 to 85% of their incomes for the house rents or mortgage. (US Census Bureau, income quintilea and Top 5 Percent, 2006; Vol. II of The Housing Indicators Program (New York: United Nations, 1993); Housing Characteristics 1993. June 1995, pp. 46-49, Table 3.4, 1995)

1.7 Lifestyle

Based on the categories of PRIZM NE Segmentation System for US, the lifestyles for the target audiences are the groups of Urban Uptown and Midtown Mix. Their lifestyles are as following: (RIZM NE Segmentation System, 2008)
1.7.1 Lifestyle 1: Urban Uptown

**Description**

Affluent to middle class, college educated and ethnically diverse, often these households are Asian or Hispanic. Although diverse in terms of housing and family sizes, these people tend to frequent the arts, shop at exclusive stores, drive luxury imported brands, travel abroad and spend heavily on the latest technology.

**Populations**

U.S. Households: 9,433,723

U.S. Population: 24,637,282

Median Income: $63,653
Segments

Young Digerati

Upscale, Younger Family Mix Young Digerati are tech-savvy and live in fashionable neighborhoods on the urban fringe. Affluent, highly educated, and ethnically mixed, Young Digerati communities are typically filled with trendy apartments and condos, fitness clubs and clothing boutiques, casual restaurants and all types of bars--from juice to coffee to microbrew.

Money and Brain

Upscale, Older Family Mix The residents of Money & Brains seem to have it all: high incomes, advanced degrees, and sophisticated tastes to match their credentials. Many of these city dwellers are married couples with few children who live in fashionable homes on small, manicured lots.

Bohemian Mix

The Cosmopolitans

Upper-Mid, Older Mostly w/o Kids Educated, upper-midscale, and ethnically diverse, The Cosmopolitans are urbane couples in America's fast-growing cities. Concentrated in a handful of metros--such as Las Vegas, Miami, and Albuquerque--these households feature older, empty-nesting homeowners. A vibrant social scene surrounds their older homes and apartments, and residents love the nightlife and enjoy leisure-intensive lifestyles.
American Dreams

Upper-Mid, Middle Age Family Mix American Dreams is a living example of how ethnically diverse the nation has become: just under half the residents are Hispanic, Asian, or African-American. In these multilingual neighborhoods--one in ten speaks a language other than English--middle-aged immigrants and their children live in upper-middle-class comfort.

1.7.2 Lifestyle: Midtown Mix

Description

Singles and couples, homeowners and renters, college alumnae and high school graduates who are often childless and have active social lives. They frequent bars, health clubs and restaurants and listen to progressive music, drive small import brands and buy latest electronics.

Populations

U.S. Households: 5,230,362

U.S. Population: 13,831,734

Median Income: $39,753

Segments

Urban Achievers

Lower-Mid, Younger Family Mix Concentrated in the nation's port cities, Urban Achievers is often the first stop for up-and-coming immigrants from Asia, South America, and Europe. These young singles, couples, and families are typically college-educated
and ethnically diverse: about a third are foreign-born, and even more speak a language other than English.

Close-in Couples
Lower-Mid, Older Mostly w/o Kids Close-In Couples is a group of predominantly older, African-American couples living in older homes in the urban neighborhoods of mid-sized metros. High school educated and empty nesting, these mostly older residents typically live in older city neighborhoods, enjoying their retirements.

Multi-Culti Mosaic
Lower-Mid, Middle Age Family Mix An immigrant gateway community, Multi-Culti Mosaic is the urban home for a mixed populace of younger Hispanic, Asian, and African-American singles and families. With nearly a quarter of the residents foreign born, this segment is a mecca for first-generation Americans who are striving to improve their lower-middle-class status.
CHAPTER 2

METHODOLOGY

This thesis research was structured around the three aspects: products, human, and the environment (Figure 1.) These three aspects were achieved based on the knowledge of the product design, the interior design, and the environmental psychology. A superior product would never stand out if its users and its surroundings were disregarded. The

Figure 1 Three Research Aspects: Product, Environment, and Human
coordination of the three fields provides comprehensive solutions for solving living issues of small spaces.

Each of these three aspects dealt with different issues unveiled in the design process. The research strategies from the product design were used to enhance the usability of the final results. In addition, from the aspect of the interior design, users’ living environments were carefully considered. Moreover, the research methods from the environmental psychology were used to emphasize the residents’ feelings about the product. Most of all, the goal of this study is to develop a product which people will use, live with, and love.

Figure 2 Research Methods

In terms of product, the research methods from the product design were used to develop a complete storage product. The methods include: structured online survey, concept development, patent analysis, and benchmarking/prototype testing (Figure 2.) To ensure
the final results were compatible to the residents’ environments, a co-design method and a virtual environment model were constructed. Alternatively, based on the environmental psychology theory, the feelings of small space residents who actually utilize the product and live with it were carefully considered. Two evaluation methods, buying intentions and emotional reactions survey, were implemented in the end of the design process. They both provide trustworthy statistical data to collect users’ feedback and to evaluate the final results.

2.1 Research Variables

This study is attempting to determine urban residents’ perceptions of living in small spaces. They are 25 to 44 years of age and most of them are renters or first-time home buyers. Their lifestyles fell in the marketing segments: the Urban Uptown and the Midtown Mix. These two segments out of 66 segments were defined by the Prizm marketing segment system mentioned in last chapter. The system analyzed general population data and demographics based on income levels and geographical locations. Looking into the segments under urban lifestyle, there are three segments clearly demonstrated the lifestyle of urban residents, so did the small space residents (Table 2 Prize Marketing Segment.)
Specifically, those urban residents are the lower-middle, middle, or higher-middle classes with income ranging from $26,931 to $65,698 /yr (Table 3.) They spend approximately 30 to 85% of their income on rent or the mortgage. The explanation of the Urban Uptown said, “Affluent to middle class, college educated and ethnically diverse, often these households are Asian or Hispanic.” And the description of the Midtown Mix showed, “Singles and couples, homeowners and renters, college alumnae and high school graduates who are often childless and have active social lives.” These two descriptions make a clear picture of the demographics of the urban residents.
<table>
<thead>
<tr>
<th>Household Classes</th>
<th>Income</th>
<th>Median Number of Income Earners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 5%</td>
<td>$157,176+</td>
<td>2</td>
</tr>
<tr>
<td>Top Fifth</td>
<td>$ 88,030+</td>
<td>2</td>
</tr>
<tr>
<td>Upper Middle</td>
<td>$55,331+</td>
<td>2</td>
</tr>
<tr>
<td>Middle</td>
<td>$34,738+</td>
<td>1</td>
</tr>
<tr>
<td>Lower Middle</td>
<td>$18,500+</td>
<td>1</td>
</tr>
<tr>
<td>Bottom Fifth</td>
<td>$0 to 18,500</td>
<td>0 or 1</td>
</tr>
</tbody>
</table>

Table 3 Household Classes
(US Census Bureau, income quintiles and top 5 Percent, 2006)

In terms of living spaces, there are two definitions for the living space density: total square feet divided by the number of residents, and as well as by a household. The former is more commonly used to describe a personal space. By the way, the former space density unit, square feet per person, was also used to identify the living spaces in this study.

For the size of living spaces, Americans have an average of 721 square feet of living space per person (Table 4.) The other industrialized nations have relative fewer square feet. In the other words, the general American household has 11 times more living space than the general urban population of very low-income countries such as China and India.
In addition, the average American poor people has more square feet of living space than does the average person living in London, Paris, and Tokyo.

This study focuses on living space of 200 to 500 sq. ft. per person. This range of living spaces symbolized the living space of general urban population in high-income and high middle-income countries. Actually, the income classes of small space residents, however, depend on the income level of their countries. For instance, a person lives in a 400 sq.ft. room can be the poor people (middle- and low-income) in US, but the high-income people in the low-income countries such as India and China.

<table>
<thead>
<tr>
<th>House Space per Capita</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>NA</td>
<td>721.2 sq.ft/person</td>
</tr>
<tr>
<td>U.S. Poor</td>
<td>NA</td>
<td>438.6</td>
</tr>
<tr>
<td>U.S. Poor Apartment Dwellings</td>
<td>NA</td>
<td>320</td>
</tr>
<tr>
<td>High-Income Countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$14,960-$23,810</td>
<td>United Kingdom</td>
<td>376.8</td>
</tr>
<tr>
<td></td>
<td>France, Germany, Japan</td>
<td></td>
</tr>
<tr>
<td>High Middle-Income Countries</td>
<td>$2,470-$10,450</td>
<td>Hungary, Greece, Korea, Spain</td>
</tr>
<tr>
<td>Middle-Income Countries</td>
<td>$1,620-$2,450</td>
<td>Turkey, Chile, Poland, Mexico</td>
</tr>
<tr>
<td>Low-Income Countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$500-$1,200</td>
<td>Egypt, Phillipins, Morocco, Columbia</td>
<td></td>
</tr>
<tr>
<td>Very Low-Income Countries</td>
<td>$1,620-$2,450</td>
<td>India, China, Nigeria, Pakistan</td>
</tr>
</tbody>
</table>

Table 4 House Space per Capita
2.2 Design Process

The research process employed an industrial design research strategy. John Chris Jones discussed the use of design processes as a research strategy (Jones, 1992.) He mentioned five overlapping activities to help deal with issues of design significance. The five stages of the design process are: planning, concept development, detail design, testing and refinement (Figure 3.)

![Figure 3 Theory Design Process](image)

The final design process followed his process, but was modified to meet the additional requirements of this project. The following Error! Reference source not found. showed the final design process:
2.2.1 Planning/Needs Identification

In this planning section, urban residents’ living issues and needs were the priority. People age from 18 to 45 years who lives in urban areas were reached by e-mail. Those people who received the e-mail were residents of the urban areas in US, China, Korea, India, and Taiwan: for instance, Columbus Ohio in US, Taipei in Taiwan, Shanghai in China. Most of them are college students or new graduates age of less than thirty-five. Some subjects age range from thirty-five to forty-five were reached as well, as some e-mail was spread out to their friends or family who live in urban households.
A structured online survey was executed to identify the needs of potential customers. There were a total of 14 questions developed for the questionnaire which included: 1. demographic information, 2. satisfaction of current living spaces, 3. desired price range for a new storage product (Figure 5 and Figure 6.) There were a total of 100 responses (88 effectives) which contributed to the comprehension of living in small spaces. The extensive needs identification research was conducted based on three reasons. First, general background information of the subjects was revealed. Useful demographics information of the subjects included: living country and city, age, house type, house size, rent rate, roommates (the number of people with whom they live). This data summed up the general demographic information before investigating the satisfaction of small space living.

The subjects’ satisfaction of their current living conditions was revealed as well. Those subjects were asked what they like and dislike about their living spaces. The listed reasons included: privacy, nature lights, decoration, interior lighting, clearness, and storage space. Additionally, subjects could fill their own reasons using the option of others (please specify) as well. This questionnaire unveiled subjects’ significant needs for extra storage spaces. Moreover, the desire for a storage product was reflected by a series of marketing questions. These questions included: the satisfaction with current products and the desired price ranges for a new storage product. Overall, the online interview provided much of the date needed for this thesis. Co-design interviews with actual small spaces residents also contributed.
small living space study

Age ______ Native Country/City __________________ Living Country/City ____________

Gender  ○ Male  ○ Female

House Types
○ Efficiency  ○ 1 Bedroom  ○ 2 Bedroom  ○ 3 Bedroom  ○ More Than 3 Bedroom

Sizes (sq. ft.)
○ 200—499  ○ 500—799  ○ 800—999  ○ More than 1000

Rent
○ 0—299  ○ 300—499  ○ 500—799  ○ 800—999  ○ More than 1000  ○ I own it

Number of Roommates

How much do you like your living space?

not at all  1  2  3  4  5  6  7  8  9  a lot

What makes you happy about your space?
○ Personal Decoration  ○ Color Composition  ○ Natural Light
○ Energy Consumption  ○ Interior Lighting  ○ Organized Space
○ Proper Storage  ○ Others ____________

What do you dislike about your living pace?
○ Poor Decoration  ○ Bad Color Composition  ○ Poor Natural Light
○ Energy Consumption  ○ Poor Interior Lighting  ○ Messy Space
○ Less Storage  ○ Others ____________

Overall, what are the main problems you have had about “living spaces”?
○ Low Privacy  ○ Less Storage  ○ Low Flexibility
○ Poor Aesthetics  ○ Poor Ambient Lighting  ○ Others ____________

Figure 5 Online Survey Questionnaire Page 1/2
small living space study

How important is organizing and storage for your living spaces?
1 2 3 4 5 6 7 8 9 10
not at all very important

Did you ever buy any storage product? If so, how much did you spend on them?
O 0—99  O 100—199  O 200—299  O 300—399  O 400—499  O Others ______

How do you like those storage products?
O 0  O 1  O 2  O 3  O 4  O 5  O 6  O 7  O 8  O 9

Where did you buy those storage products?
O Stores  O Internet  O Others ______

How much would you be willing to pay if a product can provide your room with twice storage you have now?
O 0—99  O 100—199  O 200—299  O 300—399  O 400—499  O Others ______
2.2.2 Co-design Interview

The co-design interview, part of the qualitative research, was conducted to develop better understanding of small space environment. The data was collected from the interviews with selected small space residents. Those subjects, opposite to those of the online survey who were reached via e-mail, were selected specifically based on their living conditions and interests in design. Five small space residents, three females and two males, studying at the Ohio State University were reached as their living spaces were generally smaller. Two of the female subjects rent rooms, nearly two hundreds sq. ft, in a graduate dormitory. The other female subject lives in a nine-hundred sq. ft. one-bedroom apartment with her husband. One of the male resides in a five hundreds sq. ft. apartment by himself. The other one shared a two-bedroom apartment with one of his colleagues. Moreover, four of them were international students who came from the urban areas of Taiwan and India, and the other one was a Columbus native. The cultural variety would make it possible to develop and explore aspects of small-space living that may never have emerged before.

Observation is a design method to identify the problems that can arise when people interact with products, services and environments. During the interview, user observation technique was implemented and the insights were significant for further design development.

In addition, the subjects’ interest in improving their living spaces was one of the other reasons for which they were chosen. For example, two of them have majored in design-related fields, architecture and graphic design, over two years. One of them was a
housekeeper interested in reading interior design magazines and applied the techniques to her own apartment.

There are three activities designed to inform the participants of the issues of small living spaces. They talked through their living issues and showed their ideas by interacting with the prepared interview tools. Those activities were a written questionnaire (Figure 5 and Figure 6), a photo sorting process (Figure 7), and a small-scale arrangement with blue-foam furniture models (Figure 8). The objective of each tool was to explore different aspects of the living issues from the subjects. For instance, the questionnaire was used to provide the subjects a general idea of their current living spaces; the photo sorting process helped express the subjects’ preferences of living spaces, which were quiet inconsistent with their current spaces; eventually, subjects showed their ideas by using the mock small-scale furniture models, which were very convenient for dissembling and assembling. Except with these three tools, as the interviews were processed, note taking, idea sketches, and photo taking were used to condense and organize key information in the research process.

The Co-design interview data served to give a more complete picture about the needs of storage spaces in small spaces. This data expanded, confirmed, and disconfirmed other data found regarding the various aspects of storage spaces in small living spaces.
Figure 7 Co-design Interview Tools / Photo Sorting

Figure 8 Co-design Interview Tools / Blue-foam Furniture Models
2.2.3 Concept Development

Concept development is a commonly used design strategy in the industrial design field. There are three activities to complement the process: concept generation, detail design, and concept refinement. As this phase was overlapping with the prior two phases, structured online interview and co-design interview, users’ demands were communicated as concerns as the researcher generated and refined concepts. Additionally, the detail design was developed based on the fundamental functions of concepts: lifting, lighting, and storage. For the reason, each function was systematically considered and developed.

2.2.4 Benchmarking and Prototype Testing

Benchmarking is a research strategy for conducting investigation of competitive products on the market. The method provided broad and in-depth data from the marketing viewpoint. Based on the sale perspective, distribution and material selection were considered significantly during the concept development process. For instance, easy-assembly and flat-package designs were explored.

2.2.5 Patent Analysis

Patent analysis is a commonly used research strategy in the engineering design field. The process included two activities: patent searching, and patent analysis. In terms of patent searching, the goal was to find all similar products currently in existence. In case some related patents were hid in other applications beside storage products, it was more effective to search patents by functions instead of application terms, e.g. lifting, overhead, and storage. On the other hand, patent analysis was conducted to ensure the patentability of the concepts. This requires the skills of reading and clarifying patent claims.
systematically. For this reason, the comparison of concept components and claimed items of highly related patents were executed as well.

### 2.2.6 Concept Evaluation

In terms of the product evaluation, Two questionnaires were used in order to collect customers’ emotional reactions and buying intentions for concepts (Figure 10 and Figure 11.) These two questionnaires were executed before and after subjects experienced the concepts in a virtual environment. The evaluation interview tool can be operated on a local computer or through the Internet. In the virtual environment, there were two concepts displayed in any two of the three living rooms built with walls and furniture. The only room left, without displaying any concept, was set as the baseline room. The time they stayed in each room was recorded for further calculations. The evaluation interview process was shown below:

![Evaluation Interview process](image)

Figure 9 Evaluation Interview process
small living space study

Age ______ Native Country/City ___________ Living Country/City ___________
Gender  □ Male  □ Female

Indicate by circling on the answer sheet, how you feel following the baseline condition. If you do not feel any particular emotion, circle 1. If you feel a lot, circle 5, or an intermediate amount, circle 3, etc.

<table>
<thead>
<tr>
<th></th>
<th>None</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serenity</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Interest</td>
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<td>1</td>
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<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Relaxation</td>
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<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Excitement</td>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Happiness</td>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Agitation</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Anger</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
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<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Tired</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Like</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Pleasantness</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Activation</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Stress</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Pain</td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 10 Emotional Reactions Questionnaire
small living space study

Below are a list of features that are part of the product. How important is each feature to you?

Appearance
1 2 3 4 5 6 7 8 9 10
Not At All Important Extremely Important

Adjustable Height
1 2 3 4 5 6 7 8 9 10

Lighting
1 2 3 4 5 6 7 8 9 10

How favorable is your overall reaction to this product?
1 2 3 4 5 6 7 8 9 10
POOR EXCELLENT

Based on the product description, how interested would you be in buying this new [Product] if it were within your budget? Please check one.
1 2 3 4 5 6 7 8 9 10
Not at all interested Extremely interested

What is it that you like most about the product? Please enter as many items as you wish.

What do you like least about the product?

About what would you expect to pay for a new [Product]?
$ __________ USD

How often do you use storage products?
- Once a week or more often
- Every 2-3 months
- Do not use
- 2-3 times a month
- 2-3 times a year
- Once a month
- Once a year or less

Thank you for your feedback.

Figure 11 Buying Intentions Questionnaire
The emotional reactions questionnaire (Figure 10) designed is a standard psychology questionnaire for acquiring individuals’ emotional changes. Using the questionnaire, subjects have to follow a specific process to have their initial status and consequent status deliberated. The initial status, also called the baseline status, has to be measured before the subjects experience the virtual environment. After viewing concepts, their emotional status changes were measured by the same questionnaire to see the emotion effects caused by the concepts.

The buying intentions questionnaire (Figure 11) was designed based on a product use/satisfaction questionnaire from an online survey program, the QuestionPro.com (Product Use/Satisfaction, 2009.) The survey materials on the site are widely used by private, governmental, and educational organizations. For instance, the Microsoft, the Air Force Sergeants Association, and the University of California all had chosen the survey tools on the site.

The goal of using the buying intentions questionnaire is to collect feedback about the concepts from the subjects. It was applied after the subjects explored the two concepts in the virtual environment. The results were expected to guide a clear direction for concept refinements.
CHAPTER 3

RESULTS

3.1 Structured Online Survey Results

In this section, a structured online survey with a questionnaire was conducted to explore the potential customers’ needs. The objective was to uncover the living issues of small spaces, and to seek for possible solutions through the subjects’ responses.

SurveyMonkey, an online survey software, was chosen to be the interacting interface. It was in part because of its conveniently customized interfaces, and in part because of the multi-language support. The Internet-based survey significantly increased the possibility to reach people from different continentals. Two languages versions, English and Chinese, by the way, also enlarged the range of participants from Eastern (China, Korea, Taiwan, and India) to Western (US, Germany, and Netherland.)

The survey was completed effectively after a total of 100 replies was collected in one month. Each questionnaire, with a total of 14 questions, took participants nearly 3 to 8 minutes to complete. They could skip or leave the survey if they felt uncomfortable with
the content. Those questions were divided into four sections: 1. demographic information, 2. living situation, 3. satisfaction of small spaces living, and 4. desired price range for a new storage product. All of these 14 questions were multi choice questions instead of open questions, which were designed intentionally to simplify the following analyzing process. The results of the online survey were revealed in the following charts:
3.1.1 Demographic Information (n=88)

Table 5 Age Proportion

Table 6 Gender Proportion
Table 7 Home Countries

- US: 12 persons
- Taiwan: 31 persons
- India: 2
- S Korea: 1
- Singapore: 1
- Colombia: 1
- Puerto Rico: 1
- Germany: 1
- Netherlands: 1
Table 8 Home Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>US/Lima, OH</td>
<td>1</td>
</tr>
<tr>
<td>US/Gahanna, OH</td>
<td>1</td>
</tr>
<tr>
<td>US/Cleveland, OH</td>
<td>1</td>
</tr>
<tr>
<td>US/Columbus, OH</td>
<td>3</td>
</tr>
<tr>
<td>US/Brentwood, TN</td>
<td>1</td>
</tr>
<tr>
<td>US/Baltimore, MA</td>
<td>1</td>
</tr>
<tr>
<td>US/Washington DC</td>
<td>1</td>
</tr>
<tr>
<td>US/Rockland, ME</td>
<td>1</td>
</tr>
<tr>
<td>US/Honolulu, HI</td>
<td>1</td>
</tr>
<tr>
<td>US</td>
<td>1</td>
</tr>
<tr>
<td>Taiwan/Taipei</td>
<td>3</td>
</tr>
<tr>
<td>Taiwan/Kaohsiung</td>
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</tr>
<tr>
<td>Taiwan/Taoyuan</td>
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<tr>
<td>Taiwan/Taichung</td>
<td>1</td>
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<td>Taiwan/Pingtung</td>
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<td>Taiwan/Chiayi</td>
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<td>Taiwan/Tainan</td>
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<tr>
<td>Taiwan/HSinchu</td>
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<tr>
<td>Taiwan</td>
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</tr>
<tr>
<td>India/Cochin</td>
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<td>India</td>
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<td>S Korea/Seoul</td>
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<td>Singapore</td>
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<td>Colombia/Bogota</td>
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<td>Puerto Rico/Humacao</td>
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<td>Germany/Berlin</td>
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<tr>
<td>Netherlands/Rotterdam</td>
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### Table 9 Residential Countries

<table>
<thead>
<tr>
<th>Country</th>
</tr>
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<tbody>
<tr>
<td>US</td>
</tr>
<tr>
<td>Taiwan</td>
</tr>
<tr>
<td>Netherlands</td>
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### Table 10 Residential Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>US/Columbus, OH</td>
<td>1</td>
</tr>
<tr>
<td>US/Pickerington, OH</td>
<td>1</td>
</tr>
<tr>
<td>US/Westerville, OH</td>
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<td>US/Ohio</td>
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<td>US/Hilliard, OH</td>
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<tr>
<td>US/Washington, DC</td>
<td>1</td>
</tr>
<tr>
<td>US/Dallas, TX</td>
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<tr>
<td>US/Orlando, FL</td>
<td>1</td>
</tr>
<tr>
<td>US/Pittsburgh, PA</td>
<td>2</td>
</tr>
<tr>
<td>Taiwan/Taipei</td>
<td>4</td>
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<tr>
<td>Taiwan/Kaohsiung</td>
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<td>Taiwan/Tainan</td>
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<td>Taiwan/Keelung</td>
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<td>Taiwan/Pingtung</td>
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<td>Netherlands/Amsterdam</td>
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<td>Netherlands/Rotterdam</td>
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### 3.1.2 Living Situation (n=82)

<table>
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<tr>
<th>Bedroom Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>more than 5</td>
<td>1.2%</td>
</tr>
<tr>
<td>5 Bedroom</td>
<td>3.7%</td>
</tr>
<tr>
<td>4 Bedroom</td>
<td>8.5%</td>
</tr>
<tr>
<td>3 Bedroom</td>
<td>17.1%</td>
</tr>
<tr>
<td>2 Bedroom</td>
<td>22.0%</td>
</tr>
<tr>
<td>1 Bedroom</td>
<td>31.7%</td>
</tr>
<tr>
<td>Efficiency</td>
<td>15.9%</td>
</tr>
</tbody>
</table>

#### Table 11 Numbers of Bedroom

<table>
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<th>Room Size</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>more than 2000</td>
<td>7.5%</td>
</tr>
<tr>
<td>1750-2000</td>
<td>1.3%</td>
</tr>
<tr>
<td>1400-1750</td>
<td>10.0%</td>
</tr>
<tr>
<td>1050-1400</td>
<td>6.3%</td>
</tr>
<tr>
<td>700-1050</td>
<td>30.0%</td>
</tr>
<tr>
<td>350-700</td>
<td>28.8%</td>
</tr>
<tr>
<td>1-350</td>
<td>16.3%</td>
</tr>
</tbody>
</table>

#### Table 12 House / Room Size
Table 13 Rent / Mortgage (USD) per month

<table>
<thead>
<tr>
<th>Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>more than 1921</td>
<td>2.5%</td>
</tr>
<tr>
<td>1601-1920</td>
<td>2.5%</td>
</tr>
<tr>
<td>1281-1600</td>
<td>1.2%</td>
</tr>
<tr>
<td>961-1280</td>
<td>2.5%</td>
</tr>
<tr>
<td>641-960</td>
<td>14.8%</td>
</tr>
<tr>
<td>321-640</td>
<td>50.6%</td>
</tr>
<tr>
<td>1-320</td>
<td>25.9%</td>
</tr>
</tbody>
</table>

Table 14 Numbers of Roommates

<table>
<thead>
<tr>
<th>Roommates</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>2.5%</td>
</tr>
<tr>
<td>4</td>
<td>9.9%</td>
</tr>
<tr>
<td>3</td>
<td>9.9%</td>
</tr>
<tr>
<td>2</td>
<td>13.6%</td>
</tr>
<tr>
<td>1</td>
<td>32.1%</td>
</tr>
<tr>
<td>0</td>
<td>32.1%</td>
</tr>
</tbody>
</table>
3.1.3 Satisfaction of Living in Small Spaces (n=81)

<table>
<thead>
<tr>
<th>Score</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>11.1%</td>
</tr>
<tr>
<td>9</td>
<td>8.6%</td>
</tr>
<tr>
<td>8</td>
<td>30.9%</td>
</tr>
<tr>
<td>7</td>
<td>22.2%</td>
</tr>
<tr>
<td>6</td>
<td>4.5%</td>
</tr>
<tr>
<td>5</td>
<td>8.6%</td>
</tr>
<tr>
<td>4</td>
<td>6.2%</td>
</tr>
<tr>
<td>3</td>
<td>6.2%</td>
</tr>
<tr>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>1</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

Table 15: Satisfaction with Current Living Space
Table 16 What do you like about your space?

Others (Please specify)

Park like backyard. Owning our own yard and vegetable garden.
Fairly roomy, considering it's an efficiency shared by 2 people; roommate is virtually never around
Large space

Great view of sight (8f.)
Location (close to campus)
Convenience
Landlord keeps it clean and modern
Independence
Close to Campus

High Privacy 55.1%
Personal Decoration 30.4%
Color Composition 15.9%
Nature Light 76.8%
Interior Lighting 18.8%
Energy Consumption 14.5%
Organized Space 36.2%
Proper Storage 29.0%
High Flexibility 21.7%
Others (please specify) 24.6%
Table 17 What do you dislike about your space?

<table>
<thead>
<tr>
<th>Reason</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Privacy</td>
<td>27.5%</td>
</tr>
<tr>
<td>Poor Decoration</td>
<td>17.4%</td>
</tr>
<tr>
<td>Bad Color Composition</td>
<td>14.5%</td>
</tr>
<tr>
<td>Poor Nature Light</td>
<td>20.3%</td>
</tr>
<tr>
<td>Poor Interior Lighting</td>
<td>23.2%</td>
</tr>
<tr>
<td>Energy Consumption</td>
<td>29.0%</td>
</tr>
<tr>
<td>Space Organization</td>
<td>24.6%</td>
</tr>
<tr>
<td>Less Storage</td>
<td>56.5%</td>
</tr>
<tr>
<td>Low Flexibility</td>
<td>26.1%</td>
</tr>
<tr>
<td>Others (please specify)</td>
<td>17.4%</td>
</tr>
</tbody>
</table>
Table 18 Overall, what are the main problems you have had about living spaces?

<table>
<thead>
<tr>
<th>Problem</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Privacy</td>
<td>24.6%</td>
</tr>
<tr>
<td>Poor Aesthetics</td>
<td>26.1%</td>
</tr>
<tr>
<td>Poor Lighting</td>
<td>21.7%</td>
</tr>
<tr>
<td>Energy Consumption</td>
<td>23.2%</td>
</tr>
<tr>
<td>Less Storage</td>
<td>53.6%</td>
</tr>
<tr>
<td>Low Flexibility</td>
<td>27.5%</td>
</tr>
<tr>
<td>Others (please specify)</td>
<td>7.2%</td>
</tr>
</tbody>
</table>

**Others (Please specify)**
1. Irresponsible roommates (messy)
2. Noise from other rooms
3. Space. I guess I would like to live in a larger place
4. They are rather oddly shaped
5. View
Table 19 How important to you is organizing and storage for your living spaces?

3.1.4 Price range for a new storage product (n=73)

Table 20 Do you ever buy storage products? If so, how much did you spend? (USD)
(ex: file baskets or plastic boxes)
Chart 1 Please rate your satisfaction with the product you purchased.

Chart 2 How much would you be willing to pay if a product can provide your room with twice storage you have now? (USD)
3.2 Co-design Interview Results

The primary goal of this section was to explore more insightful data by walking into users’ homes and observe how people interact with their living spaces. Observation is a design method to identify the problems that can arise when people interact with products, services and environments. During the interview, user observation technique was implemented and the insights were significant for further design development. Those subjects were selected as their interests in improving their living space. In addition, the other reason they were chosen was because of the subjects’ generally smaller living spaces. During the interview, picture taking, audio recording, and note taking were all implemented to record the key information. There were a total of three sections during the interviews: 1. the questionnaire, 2. the photo sorting process, and 3. mock small-scale furniture models. Subjects followed the order of these three sections to use to professional design vocabulary and to understand their own preferences, and finally used the insights for conceptual design.

3.2.1 Interviewee 1

Subject’s Name: Ting-Fen Lin (Female, Taiwanese, Graduate Student, OSU)
Subject’s residential place: Jones Graduate Tower (Graduate Student Dormitory, OSU)
Room Size: 200 sq. ft.
Rent: $350 / month
Lin was an international student who lived in Jones Graduate Dormitory (Figure 12.) She received income support monthly from a Graduate Assistant position and tried to save her spending from buying cars and renting bigger house. The dormitory provided her with convenient transportation and a secure neighborhood which were significant for a single female. She was not satisfied with the interior design of the dorm; however, the poor lighting and colors, dark green with middle gray, resulted in a dull and lifeless room. Nevertheless, the design of the storage furniture was terrible. She was not happy with the height of the storage and its top closet. It was way too high for her to reach the stuff over there even if she stood on a chair. Eventually, she stored little non-frequently-used stuff there or left it being empty, which was a great waste for a small room.

She pointed out that the storage needs of an apartment renter were actually reflected by their unique lifestyles. The storage space she had was enough for her temporary living in US. She said, “I don’t want to spend any money on evolving other people’s houses.” Conversely, if budget allowed, it will change to a totally different story. When we shifted our topic to redesigning a room with unlimited budget, she got excited and said
immediately, “I want a whole-wall closet with concealed doors to store my stuff (Figure 13.)” “The open shelves and closets really driven me crazy,” she added. In addition, her needs for a better lighting was clarified, “if the products can provide me better lighting that will be terrific.” In other words, her needs for a better storage system and lighting were positively indicated through the interview.

Figure 13 Lin’s ideas for redesigning her room
She wants a middle-height TV shelf near her bed in order to provide more privacy—block the direction sight from the exit door.

She wants a whole-wall closet for storage. The closet should have drawers or doors to hide clutters. She also thinks a build-in kitchen would provide great convenience.
She showed her ideas by using mock-up furniture. She likes to have more furniture that can be moved easily and flexibly.

Inspirations

1. For a small room, concealed cabinets avoid residents from seeing unwanted clutters, even though sometimes it could be a trade-off between accessibility and appearance.

2. Accessibility of storage is particularly critical for short residents.

3. Lighting and storage can be a good combination. A product providing nature lighting is particularly valuable for residents who live in dark and small spaces.

3.2.2 Interviewee 2

Subject’s Name: Chiu-Wen Lin (Female, Taiwanese, married for 3 yrs, no kids)

Subject’s residential place: One Bedroom Apartment

Apartment Size: 900 sq. ft.

Rent: $550 / month
Chiu-Wen is a housewife who is interesting in reading decoration and design magazines in her leisure time. She lived in a 900 sq. ft. apartment (Figure 14) with her husband, Wei-Feng. They both enjoyed cooking a lot and that also explains for why they choose this apartment —its large open-space configuration between the living room and the kitchen. Chiu-Wen spent time on keeping the apartment clear and organized; however, the inconsistent spicy jars and cooking equipments made the room looks messy. Moreover, as Wei-Feng's study table was located in the corner of the living room, the way he piling his books on the floor made the clutter even waste. When we reviewed their things in the open-space (the living room and the kitchen), surprisingly, everything were clear and organized. In other words, it was just visually massy.

Chiu-Wen and her husband thought they had enough storage space for that time, and the storing issue they had was more about the accessibility, e.g. she was terrified of standing on a ladder since she got pregnant. She could barely reach the overhead cabinet above the counter top or the open shelf on the top of the bar. "I only stored things I didn't use
frequently over there," she said. Along the way, "why I could not store things under my sofa or coffee table? or could I?" she asked (Figure 15.)

Figure 15 Chiu-Wen’s ideas about redesigning her apartment

When we talked about the consideration before purchasing a new storage product, She listed five thoughts that influencing her most: 1. no drilling installation, 2. functions and prices, 3.size, 4. color and materials, 5. flexibility. These five factors turned to be the primary considerations when she purchased products for the rented apartment.

Inspirations
1. A conventional ladder cannot fulfill the needs of reaching things stored on a higher space. It could cause serious dangers to people with special needs, such as pregnant women and the elderly.
2. A storage cabinet that providing better accessibility is as important as hiding visual clutter.

3. A lifting storage product can offer better space flexibility for a constrained-size apartment. E.g. If Wei-feng’s study desk could be lifted up to the ceiling, the living room would present more space when friends come. Or if the TV can be lifted to the ceiling, then the nature light wouldn’t be blocked by it.

4. Installation should be simple and easy. It is critical for apartment renders.
3.2.3 Interviewee 3

Subject’s Name: Matthew Stanford (Male, American, Design Graduate Student)

Subject’s residential place: One Bedroom Studio

Apartment Size: 500 sq. ft.

Rent: $550 / month

Figure 16 Interior shots of Matthew Stanford’s room

Matthew is a Visual Communication Designer. He has been living in the apartment nearly 4 yrs (Figure 16.) By knowing him for around two years, he complained a lot about his small living space, but couldn't really make his decision to move out. The reason why he stays in the apartment is because of the convenient transportation and the quiet neighborhood.
As we went through the photo sorting, Matthew particularly liked those spaces with well design and interior. For him, a better design means comfortableness, proper lighting (not over bright or dark), contemporary, modern style, and large windows. He emphasized that nature light was essential for his daily living, same to gloomy lighting for his living at night. Except the visual preference, he also pointed out the importance of furniture configuration for his small but functional apartment. "How can people reach the desk right behind the coach? That doesn't make any sense!" He asked when looking into one photo that he sorted into the dislike pile. Although he critiques those photos he disliked, he said he felt guilt when he talked about the downside of those places. "Shame to say...my apartment is just like one of them... but it is because the space is way too small. I don't even have one third of storage space I need."

“As storage is part of the decoration, I couldn’t find products fit into my lifestyle, modern and contemporary.” He stated that there were few storage products match his own lifestyle. He refused to spend money on the furniture that didn’t fit my lifestyle or couldn’t solve problems. He explained, “Eventually, that was the reason why my room looked so messy. This used furniture took too much space from my small room.” Gradually, he spent less hours staying at home and rarely brings friends home.

We also noticed that he stored most of the things he frequently uses on the high areas (above of the refrigerator, top of the dresser, or top of the closet), and the things he rarely uses on the lower areas (near the sofa, the chairs, the bed, or the floor.) It was opposite to the behaviors of other subjects. Definitely, his height, 6”, explained the unique storing
behaviors. He was more comfortable with reaching the things on the high areas. “That will be nice if I can reach everything without bending down.”

Regarding purchasing behavior, Matthew only spent money on the furniture that he thought it was worth. In his living room, the entertainment center and the collections of DVDs and CDs took nearly one third of the living space. Watching movies and listening to music were his life. He spent much money on the entertainment equipments. “I would pay a lot more money if a storage product does match my lifestyle. I mean if it is elegant and can help preserving my favorite collections (DVDs and CDs)(Figure 17.)”

Figure 17 Matthew’s ideas of redesigning his room
Inspirations

1. Some people choose to live in small spaces because of other residential reasons, such like safety, transportation, or neighborhood resources. They may not like the interior of their house and may complain it all the time, but it doesn’t mean they will move. That is the reason why and how we can help these people live happier.

2. In terms of height accessibility, tall people have the same problems as short people. An adjustable-height storage which provides great convenience for short people can also benefits tall people.

3. People pay for merchandise based on their preferences and personal needs. For the reason, matching people’s lifestyle is critical for designing commercial products.
3.3 Conclusions

Based on the results of the online survey and co-design interviews, here are the important findings: 1. Most subjects considered storage and organizing was important to their small living spaces. 2. Privacy, lighting, and storage were the top-three reasons that influenced subjects’ satisfaction with their living spaces. Therefore, small space residents can definitely live happier as if a product could provide highly privacy, proper lighting, and more storage space. 3. Overall, the subjects were not satisfied with the current storage products they purchased. The average rates of satisfaction for current storage products is generally low (5.7), and 74.9 percent of subjects rated their satisfaction under 7 out of 10 points scale. 4. In addition, based on the insights of user observation, a storage product that can utilize the upper space of a room can be extremely beneficial for small-space residents. A conventional ladder cannot fulfill the needs of reaching things stored on a higher space. It could cause serious dangers to people with special needs, such as pregnant women and the elderly. 5. A concealed storage is an effective solution for severe small rooms, such as school dormitories. For the reason, a better storage system that helps hiding clutters and organizing living spaces is demanded. 6. In addition, consumers purchase a storage product not only based on their needs, but also their lifestyles. The appearance and functions of a new product have better matching the resident’s living environment and their lifestyles. The conclusions in this chapter collected in the online survey and the co-design interview provided us with an insight into a conservative approach to concept development.
4.1 Concept Sketches

The primary aim of this section is to explore ideas of attached storage products, rather than to explore new ideas of built-in furniture. The main functions of the product include storing, lifting, and lighting which were clarified as the main users’ needs in the last chapter, results of the needs identification. I literally developed my ideas through hand sketches which is one of the commonly used skills in the industrial design process. The concept sketches allow these functions to be combined, modified, and factorized, to provide me, as the designer, with any design idea desired.

4.1.1 Storage

At the beginning of concept development, creating extra storage spaces in a size-constrained room was the primary goal. To utilize the every inch of a room, existing furniture was selected to be redesigned in order to add more storage spaces into it, e.g. Ideas of multi-function furniture (a sofa, a TV shelf, and a bed) and foldable furniture (a sofa and a bed) were generated as shown below.
Figure 18 Side View of a Multi-function Furniture
(a wall shelf which can be converted to a bed and a sofa.)
Furniture can be expanded to be full size or be shrunk and convert to be bookshelf-size. Each bookshelf-type module contained a specific kind of function, such as cooking, bathing, and sleeping. All those modules are movable, just like the movable bookshelves in library, and are pulled out to be used only when needed.

Figure 19 A Room with Bookshelf-type Modular Furniture
Both Figure 20 and Figure 21 show the initial ideas of storing things to the upper space of a room. Hooks on walls, vertical sliding tracks, and rotating shelves were all carefully considered.
Figure 21 An alternative way to lift and rotate a shelf to a ceiling
A electronic motor and cable wires were thought to implement raising and rotating movement at the meantime. The motorization also provides great convenience for lifting heavy loads.
Figure 22 The combination of a rolling cart and a ceiling shelf
The cart with drawers can be lifted to a ceiling by using four cable wires. The cart can also be used as a general storage drawer or a temperate table after being lifted down and removed the attached cable wires. Along the way, the creative components, wheels, provide great flexibility of a ceiling storage shelf.
The main thought of this concept is to let users attach storage boxes to wherever they want, which was inspired by one of a successful current products, Alfa of The Container Store. The alfa is a storage system that simply hangs shelves on a sliding track mounted to a wall. The system is extremely successful because it’s easily installed in any function of rooms. For the reason, this concept was evolved from shelves to storage boxes which can still sliding alone the wall track.
4.1.2 Lighting

People always need more lights. Base on the survey of last chapter, proper lighting is one of the important functions that users would like to see on a residential product. The participants clearly stated their needs of having more lights for their rooms. For instance, “I would like to see the top of a wall closet was illuminated. I think the room would look more spacious in that way.” one of the co-design subjects, Ting-fen, said during the interviews. In addition, a proper lighting can make a space feel more spacious, comfortable, and welcoming (Storey, 2008; Gordon, 2003) Architecture lighting and interior lighting were commonly used as a design technique to improve a residential environment (Russell, 2008.) For example, a room would look more spacious as if at least one of the walls is washed with a down light from the ceiling. For the reason, in this section of concept development, lighting also was added to products in order to enhance the users’ feeling of living with them.
Figure 24 Lighting was added to the lifting shelf
The lights can lid the shelf itself and the upper space of a room. For a considerably designed lighting fixture, people will just see the effects, not the light source itself. It is significant to keep direct lights away from sight. For the reason, to better reflect the lights, a flat cover with clear reflecting surface was utilized as well.
Figure 25 A Lifting Shelf System with Wall Sliding Tracks
A shelf can be lifted vertically along two sliding tracks which were separately mounted to two opposite walls of a room. The tracks were either powered manually with a cracker, or electronically with motors and gears. In addition, lighting here was added to the tracks to provide more general lights to a room.
Figure 26 The Inner Mechanical Components Design of the Lifting Shelf System

These two concepts were modified based on the concepts of Figure 25. For the upper concept, the sliding tracks were refined to attach to same wall. Besides, the lights were lit from the side of the tracks to avoid generating directing light which can provide better lighting effects. For the bottom concept, the tracks were now attached to another sliding track which was mounted horizontally to a wall. It simplifies the installation and allows horizontal repositioning.
4.1.3 Lifting

Lifting Ways

The sketches below focused on developing possible ways for the lifting mechanism of the storage system. A variety of existing components were modified or combined to explore ideas. Those components included cables, gears, sliding track, and air actuators. Different operating devices were carefully considered as well: such as electronic motors, manual crack handles, and compatible head for drillers. The primary aim was to explore an easy and economic way to lift a storage shelf.

Figure 27 A ceiling frame with two inner sliding boxes
The frame with two boxes was hung to a ceiling with four cable wires. The two storage boxes can slide vertically along the track of the frame to provide better accessibility.
Figure 28 Hanging Storage Boxes on a Ceiling
Both Figure 28 and Figure 29 show the concept of hanging a storage box on a ceiling by using a hock and a set of roll-up wires (like the wires for a roll-up blind.) Users to reach/store the box by using the roll-up wire to lift up/down the box.
Figure 29 Hanging Storage Boxes on a Ceiling – Detail Design
Shapes and functions of the hock, the ceiling sliding track, the box hanger, and the storage boxes were all carefully refined.
Figure 30 Shelf Lifting Methods – 1/4

Figure 30 to Figure 33 show the concepts of lifting shelf by using alternative mechanical components. In Figure 30, air or oil actuators were proposed to support the shelf.
Lifting by using worm gears
Worm gears were considered in this concept to lift the storage shelf. Two or four sets of worm gears can be attached to opposite side of walls in a room to stably support the shelf.
Figure 33 Shelf Lifting Methods – 4/4
This shows the detail design of worm gears concept. A self-lock key was considered to ensure the safety of the product as well.
This concept integrated cable wires with the concept shown on Figure 32 and Figure 33. One end of the wires is strung through the hocks on walls, and the other is attached to a motor on the shelf. When the motor rolls/releases the wires, the shelf can be lifted up/down at the meantime. For an economic version of the concept, a handhold drill can be an option to replace the built-in motor.
Cable Wires and Covers

Overall, cable wires are the easiest mean to lift a shelf as it can be stretched and shrunk without attaching to an additional track such as gears do. The size of a wrapped wire is generally small and provides better design flexibility. The downside for wires, however, is the poor stability and the swinging during lifting. For the reason, various ways to hang wires and to construct shelves were explored to decrease the swinging of the lifting shelf. Some light materials, cloth and flat plates, were used to strengthen the frames without adding more weight. In addition, to balance the heights of the shelf, a length-adjustable part attached to the wires was considered. The adjustable-screw idea used on bikes was studied and applied to the concept as well.
Figure 35 A Lifting Shelf System with Cloth Covers on Two Sides
Figure 36 A Lifting Shelf System with Cloth Covers as Structure Frames
Figure 37 Storage Box Frame
Lifting wires were strung out in a wider angle to stabilize the system (above.) Folding plates were utilized to support the flexible cloth frame (below.)
Figure 38 Storage Box Frame – Stripes
Plastic flat pieces were inserted to enhance the strength the cloth frame. The holes on the flat piece and the cloth frame were used to hang the horizon shelves.

Figure 39 Storage Box Frame – Wires and Stinging Methods
Lifting wires were strung across the bottom of the shelf to stabilize the system.
Figure 40 Various Ways of Attaching Wires to a Shelf
Figure 41 Quick Releasing Bolts for Lifting Wires
Quick release binder bolts for bikes were used in this concept to simplify the height adjustment of the cable wires.
Hangers

The hangers that support the whole storage system were important regarding safety concern. The hanger frame has to be strong enough to evenly support the shelf and the loads on it. Therefore, a serial shape design was conducted to find a reliable frame shape.
Shelf

Figure 42 Adjustable-width Shelf
The width of the lifting shelf has to be expanded and to be shrunk to fit the width of different rooms’ layouts.
In this concept, a module shelf unit can be assembled to different length and width. The T-shape and L-shaper were considered to be the basic figure of the unit as it can better support the lifting loads.
This concept was inspired by the alfa storage system from the Container Store. The system is mounted to two opposite side walls and is allowed to reposition vertically and horizontally. There are a total of five kind of parts used for this expandable shelf system. Those components are vertical frames, horizontal frames, sliders, triangle frames, and expandable shelves.
4.3 Patent Reviews

Patent review is a design strategy commonly used in the Mechanism Design. It helps designers understand the opportunities of techniques by logically analyzing current patents which can be current products or just concepts. Designers can utilize the findings to develop an innovative concepts which around those current patents. In addition, by reviewing patents, designers could also be encouraged by similar applications in related fields. For instance, the mechanism used in a lifting bed of a RV vehicle may be relevant to a lifting storage system. For these reasons, a study of patent reviews was conducted in this section for concept exploration. A total of 105 patents were searched, pre-viewed, filtered, reviewed, and analyzed in three months, Sep. to Dec. 2008.
4.4 Current products and prototype testing

In order to get more practical understanding about the lifting storage products, I ordered two current products from Amazon.com and Target.com for testing. One of them was Racor PHL-1R Pro HeavyLift manufactured by Racor Inc., and the other one was the Garage Gorilla Motorized Hoist Storage System sold by V-bro Product IIc. In addition, I also made a functional prototype by using the parts from the two current products. These three products were installed, tested, measured, and uninstalled to evaluate their performances. The installation, costs, function, and appearance of these three products were all well documented for further specification comparisons (Figure 45.) The purpose of this section is to understand their market competitiveness via practical testing.

The Racor was delivered in one week after ordered Amazon.com, which was faster than the this opponent, the Gorilla, which arrived in two weeks. These two products were chosen because of the similarity to my final concepts. Moreover, they are two of the outstanding lifting storage products on the market. Both of them were designed to be used in garage areas; for the reason, their appearance was not so exciting, more industrial-oriented looking.

In terms of product costs, these two products were sold for nearly the same prices which includes shipping fees (the Racor,$153.99; the Gorilla, $ 181.46.) The Racor, however, was powered manually by a hand cranker, and the Gorilla product was powered electronically by a motor. The motorization of the Gorilla, initially designed for electronically lifting four bikes, does provide greater convenience than its opponent.
## Product Testing Comparisons

<table>
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<th>The Garage Gorilla</th>
<th>Prototype</th>
</tr>
</thead>
<tbody>
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<td>$161.46</td>
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</tr>
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<td>(pay $89.00 for add on rack)</td>
<td></td>
<td></td>
<td></td>
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<td>Load Capacity</td>
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<td>125 / 220 lbs.</td>
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<td>9’x 1’x 1’</td>
<td>2’x 4’x 1’</td>
</tr>
<tr>
<td>Lifting Height</td>
<td>8’</td>
<td>9’ 9”</td>
<td>8’</td>
</tr>
<tr>
<td>Lifting Speed</td>
<td>Full lift in approx 60 sec. with a hand cranker</td>
<td>33” per min Full lift in approx 20 seconds.</td>
<td>Full lift in approx 60 sec. with a hand cranker</td>
</tr>
<tr>
<td>Cable Length</td>
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<td>13’ 9”</td>
<td>8’</td>
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<tr>
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<td>Approx 50lbs</td>
</tr>
<tr>
<td>Delivery</td>
<td>In one week</td>
<td>In two weeks</td>
<td></td>
</tr>
<tr>
<td>Includes</td>
<td>Heavy-duty steel beams</td>
<td>Motor mounting plate</td>
<td>Heavy-duty steel beams</td>
</tr>
<tr>
<td>4’ x 4’ platform</td>
<td></td>
<td>Motorized hoist with push-button control</td>
<td>2’ x 4’ platform</td>
</tr>
<tr>
<td>Winding axle</td>
<td></td>
<td>Ceiling-mount upper channel bar</td>
<td>Winding axle</td>
</tr>
<tr>
<td>Vinyl coated steel cable</td>
<td></td>
<td>Hook bar with eight sliding hooks</td>
<td>Vinyl coated steel cable</td>
</tr>
<tr>
<td>Hand crank</td>
<td></td>
<td>Storage net</td>
<td>Hand crank</td>
</tr>
<tr>
<td>Optional drill driver</td>
<td></td>
<td>Four bike cables</td>
<td>Mounting hardware</td>
</tr>
<tr>
<td>Mounting hardware</td>
<td></td>
<td>Installation hardware</td>
<td></td>
</tr>
<tr>
<td>Instructions</td>
<td></td>
<td>Instructions</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 45** Product Testing Comparisons
4.4.1 Racor PHL-1R Pro HeavyLift

“Load and lift heavy items to the ceiling without using a ladder. Easy storage for file boxes, outdoor furniture, lawn mowers, big tools, snow throwers, large toys, canoes, kayaks, holiday ornaments, tires, ladders lumber, third row car seats and just about anything else you can imagine. Includes heavy-duty steel support beams, 4’ x 4’ platform, winding axle, vinyl coated steel cable, hand crank and all mounting hardware. Lift will lower eight feet from ceiling. Assembly required.” – the Racor instruction.
4.4.2 Garage Gorilla Motorized Electric Storage System

“Hook all your bikes, golf clubs, tires, ladders, tools, sports equipment and other garage clutter on the 9' wide hook bar, then with the push of a switch the powerful electric motor (mounted on the ceiling 8'6" to 15' high) will pull it all up into the air. You can even lift your Kayaks and Canoes. Everything remains out of your way until you turn the key and switch the motor on to retrieve any item. It’s safe, easy, and affordable! The Garage Gator can raise or lower eight 25 lbs bikes, or 220 lbs of your most frustrating clutter, off your garage floor up to the ceiling” – the Garage Gorilla instruction.
4.4.3 Prototype I

This concept was accomplished based on the idea of attaching shelf to a wall instead of a ceiling in order to simplify installation. The prototype was assembled by using the parts of the above two products and the alfa storage system of the Container Store. Eventually, the net shelf was successfully hung by using four cable wires, two pulleys, one winding axle, and a few frames. The wires were strung through the front pulleys, rear pulleys, and then rolled on the rear winding axle. By cracking the rotating axis, the shelf was lifted up and down smoothly.

This prototype was a successful functional model built on a limited budget. It proved the research questions for further design, such as “is it possible to hang a shelf on a wall instead of on a ceiling?” and “How far does the shelf have to be distant from its hanging wall?” Furthermore, it also disclosed the poor stability issue of the wire-hanging concept. The shelf swung when lifting, loading and unloading. For the reason, the stability of the lifting system would definitely be carefully considered in the following chapter.
CHAPTER 5

PRODUCT EVALUATION

5.1 Evaluation Method

Both buying intentions and emotional reactions interviews are conducted in order to evaluate the final concepts of the design development. As shown in Figure 46, the buying intentions interview reveals the connections between humans and products. For example, we would know how the users like/dislike the concepts and what their reasons are.
However, a product never exits alone. It is significant to discover the relationships between users, a product, and its surroundings. For instance, drinking a cup of coffee in a Starbucks is definitely different from in a bus station. Accordingly, the emotional reaction questionnaire applied in this survey can provide useful information to unveil the relationships.

To better visualize the final concepts, the 3D models of three small rooms and two final concepts were built. The models were used to construct a virtual environment for users to evaluate the designs. These three room models, duplicated from the same room model, have exactly the same in size and configuration. The two concept models were placed separately into two of the rooms. The room without concept model was set to be a baseline room, which was a required for the emotional reactions questionnaire (Figure 47 and Figure 48.)

![Figure 47 The Manu of the Interview Tool](image-url)
To better represent a small room, the configuration of the virtual room was designed thoughtfully. The size of the room was designed to be 200 sq. ft. (nearly 14’x14’), which is 100 to 40 percent space of our target small spaces, a 200 to 500 sq.ft. room. It gives the subjects a general spatial feeling of a small space. In addition, a set of furniture was imported from the interior 3D model in the book, *Introducing to Maya 2008*. The model shows a typical set of furniture for a living room, including a sofa set (three pieces), three magazines on a coffee table, an end table, a standing lamp, two bookshelves, an indoor plant, and two paintings on the walls. All the separate pieces of furniture were placed naturally, not ideally. The books in the book shelf were tilted; the pillows on the couch were flat. The purpose of doing this is to immediately connect subjects’ personal experiences to the virtual environment. Using this technique can increase the sensitivity of the interview and help us understand how the designs influence a small-space resident.
n addition, the interactive interface of the interview tool was implemented based on the core of user experience. To enrich the experience of exploring the virtual room, subjects are taught to navigate the room freely. To accomplish this goal, this interview tool was designed to allow the subjects to move, look around, adjust view height depending on their height, switch between sit or stand height, control the height of the concepts, and exit the interview (Figure 49.) The total time they stay in each room was recorded as well.
5.2 Evaluation Interview Process

Figure 50 Evaluation Interview Process

Figure 50 shows the evaluation interview process. The subjects were asked to sequentially explore the three rooms (Room 1 without concepts, Room 2 with Concept 1, and Room 3 with Concept 2) in less than 10 minutes per room. Their emotional reactions were monitored before and after the room exploration by using the emotional reaction questionnaire. In addition, after the exploration of Room 2 and Room 3, subjects were requested to fill out another questionnaire about buying intentions. Overall, the goal is to collect customers’ physical and emotional responses through a natural and economic interface. The feedbacks is expected to help the designer be aware of the effectiveness of the products on improving the living of small spaces.

Ten subjects interviewed were contacted through my personal network. All of them are graduated students studying at the Ohio State University, with ages 24 to 35. They were selected based on their current living situations. Some of them live alone in a studio, a college dorm, or an apartment. Some of them live with their family or friends in an
apartment or a house. Generally, they are all living in small spaces that range 200 to 500 sq.ft. per person. In addition, a few of the subjects have experienced living both in crowded cities in Asia and in uncrowded cities in the US. They were encouraged to describe more issues based on their experience of living in multi residential situations.
5.3 Evaluation Results

5.3.1 Buying Intentions – Close Question Section

Table 21 Buying Intentions of Design 1

<table>
<thead>
<tr>
<th>Factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of Appearance</td>
<td>8.6</td>
</tr>
<tr>
<td>Importance of Lifting Function</td>
<td>7.8</td>
</tr>
<tr>
<td>Importance of Storage Capability</td>
<td>7.9</td>
</tr>
<tr>
<td>Overall Reaction</td>
<td>7.9</td>
</tr>
<tr>
<td>Buying Intention</td>
<td>7.4</td>
</tr>
</tbody>
</table>

Table 22 Buying Intentions of Design 2

<table>
<thead>
<tr>
<th>Factor</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of Appearance</td>
<td>8.4</td>
</tr>
<tr>
<td>Importance of Lifting Function</td>
<td>7.8</td>
</tr>
<tr>
<td>Importance of Storage Capability</td>
<td>9.1</td>
</tr>
<tr>
<td>Overall Reaction</td>
<td>7.1</td>
</tr>
<tr>
<td>Buying Intention</td>
<td>7.3</td>
</tr>
</tbody>
</table>
Table 23 Ethnicity and the Buying Intentions of the Designs

<table>
<thead>
<tr>
<th>Design</th>
<th>All</th>
<th>Asian</th>
<th>Non-Asian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design 1</td>
<td>7.4</td>
<td>6.4</td>
<td>8.4</td>
</tr>
<tr>
<td>Design 2</td>
<td>7.3</td>
<td>8</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Table 24 Ethnicity and the Money They are willing to Spend on the Designs

<table>
<thead>
<tr>
<th>Design</th>
<th>All</th>
<th>Asian</th>
<th>Non-Asian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design 1</td>
<td>$255</td>
<td>$192</td>
<td>$317</td>
</tr>
<tr>
<td>Design 2</td>
<td>$450</td>
<td>$498</td>
<td>$401</td>
</tr>
</tbody>
</table>
### 5.3.2 Buying Intentions – Opening Question Section

Table 25 Design 1 Responses – Pros

<table>
<thead>
<tr>
<th>Design 1 Pros</th>
<th>Safety</th>
<th>Things above head</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Storage Capability</td>
<td>The product can save the room space.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provides more space in the room.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Store a lot of stuff in the closet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I think it is nice to save space to storage something you don't use that much.</td>
</tr>
<tr>
<td>Design &amp; Style</td>
<td></td>
<td>The design of the product is interesting. I just showing off, because this product.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Makes the room look more clean and comfortable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Style, design idea, function.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The design is great and color looks fantastic!!!!</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I see it compatible and fit to the environment and room when it is small and when it gets lower and more accessible to me.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Portability, moveability, the ability to be “hidden in plain sight”, the use of vertical space for storage (vs valuable floor space).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I like how this product is smaller than the last one and would be more practical for the amount of visual free space in the room.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smaller size because it seems more portable and easier to fit everywhere, and not hit other things from the living room.</td>
</tr>
<tr>
<td>Convenience</td>
<td></td>
<td>Drawers can separate my stuffs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Big space and easy to control.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I like how it has drawers.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>It is even more flexible and it seems easier to install.</td>
</tr>
</tbody>
</table>
**Table 26 Design 1 Responses – Cons**

<table>
<thead>
<tr>
<th>Design 1 Cons</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety</strong></td>
<td>Things above Heads: I may always feel something on my top.</td>
</tr>
<tr>
<td></td>
<td>Cause the feeling of pressure.</td>
</tr>
<tr>
<td></td>
<td>Will my head hit the shelf when I stand?</td>
</tr>
<tr>
<td></td>
<td>I did find it a little bit unsafe and far from being something ergonomic.</td>
</tr>
<tr>
<td></td>
<td>Otherwise, it might feel a little heavy hanging overhead.</td>
</tr>
<tr>
<td><strong>Product Reliability</strong></td>
<td>I concern the product may broken very easily.</td>
</tr>
<tr>
<td></td>
<td>Children may use it as a toy. As a result, the closet may break more easily.</td>
</tr>
<tr>
<td><strong>Storage Capability</strong></td>
<td>Below the Shelf: I still couldn’t use the space below the product.</td>
</tr>
<tr>
<td></td>
<td>The space below the storage cannot be used for and decoration of other furniture.</td>
</tr>
<tr>
<td></td>
<td>The produce provides more floor space, but doesn’t actually increase the total storage capacity.</td>
</tr>
<tr>
<td></td>
<td>and the room appearance is little bit strange because of the empty space under the storage.</td>
</tr>
<tr>
<td></td>
<td>Limit below storing space.</td>
</tr>
<tr>
<td></td>
<td>Waste the lower space.</td>
</tr>
<tr>
<td><strong>Design &amp; Style</strong></td>
<td>The style of the storage need more change.</td>
</tr>
<tr>
<td></td>
<td>Too small.</td>
</tr>
<tr>
<td></td>
<td>Actually if the way books are stacked was a little bit more organized, that would be more interesting to me.</td>
</tr>
<tr>
<td></td>
<td>I’d like it better if it served a dual purpose - for example, if the shelf, when lifted up, could also be a lighting fixture.</td>
</tr>
<tr>
<td></td>
<td>How it looks. I think that as much it can be well designed, I don’t think it would look nice in a social space of the house/apartment, as living room or bedroom. But it can be very nice in a garage.</td>
</tr>
<tr>
<td><strong>Convenience</strong></td>
<td>I don’t see it necessary to have such a coming-up-and-down-shelf to store my books.</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>It may use more power than the traditional closet.</td>
</tr>
</tbody>
</table>

**Table 27 Design 2 Responses – Pros**
<table>
<thead>
<tr>
<th>Safety</th>
<th>Things above Heads</th>
<th>The whole room feel bigger than before.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Storage Capability</td>
<td>The product can storage more items than previous product.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increases home storage capacity, provides more living space on the ground.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Length, space.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Storage volume is satisfied.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Super big space. Save the space.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saving the stuff in the upper space can get the messy away from sign view.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The storage capability, the use of vertical space for storage, the technology of the system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I like that the product moves and keeps items out of living space / line of sight for objects that are not being used everyday.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I think it is nice the storage capacity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flexibility, storage capacity.</td>
</tr>
<tr>
<td>Design &amp; Style</td>
<td>The product could involve the whole room design, if I draw some picture on it.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>People may not feel it existence.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Style.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Color and materials is fine.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The width of shelf matches the couch.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I like it the way it keeps my books and reading stuff but if I had it in some more hidden place not the one that I looked around.</td>
<td></td>
</tr>
<tr>
<td>Conveniences</td>
<td>Good solution for old man.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drawers fit my needs, I like to separate my stuff into different drawers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>It seems easy to use and is more practical than having boxes that clutter a living space.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easy to use.</td>
<td></td>
</tr>
</tbody>
</table>

Table 28 Design 2 Responses – Cons
<table>
<thead>
<tr>
<th>Design 2 Cons</th>
<th>Things above Heads</th>
<th>Sofa height is limited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Don’t like drawer (safety and space limitation), a bookshelf with upper lifting shelf would be nice</td>
<td>Why we need the lifting function? why waste space for lifting the shelf?</td>
</tr>
<tr>
<td></td>
<td>Safety is my biggest concern.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Afraid of the height affect the resident’s position. (person might be hit by the shelf when lifting.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The size makes me a little nervous -- it would be hard to sit directly under (did not feel this with the smaller one)</td>
<td></td>
</tr>
<tr>
<td>Product Durability</td>
<td>Books are heavy, can the shelf support it safely?</td>
<td></td>
</tr>
<tr>
<td>Design &amp; Style</td>
<td>The color i don’t like</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The style of the product need change</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Too big, makes the room looks smaller</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A wider product with separate narrowed sections might be a solution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>More customer adjustable spaces, not drawers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need more lights from the product</td>
<td></td>
</tr>
<tr>
<td></td>
<td>It is too long and occupies much more space than enough and it is more exposed to me that it could function for me.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I dont like how it looks in the living room.</td>
<td></td>
</tr>
<tr>
<td>Convenience</td>
<td>Conveniences (lifting function)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>it seems a little bit more complicated for the storing shelf to keep the books.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When I go to someone’s home, I like to be able to browse their bookshelf in their living room. But I would be distracted by boxes and clutter, and this product does a good job of getting unnecessary things out of the way.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>This product would allow for only necessary things to be in a viewer’s immediate line of sight.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I couldnt look what was inside. I dont like how it stops over the couch.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation of the product may be hard.</td>
<td></td>
</tr>
</tbody>
</table>
5.3 Emotional Reactions

Ethnicity Split; LS Means
Wilks lambda=0.6561, F(2,5)=35.605, p=0.0010
Effective hypothesis decomposition
Virtual Bars denote 0.95 confidence intervals

Figure 51 Buying Intentions of Design 1 versus Ethnicity Group
(Group 1: Asian, N=5; Group 2: Non-Asian, N=5)
The figure shows the non-Asian subjects reported higher buying intentions to Design 1.

Figure 52 Buying Intentions of Design 2 versus Ethnicity
(Group 1: Asian, Group 2: Non-Asian)
The figure shows the Asian subjects reported higher buying intentions to Design 2.
Figure 53: Pleasant Emotion versus Viewing Orders

Order and Pleasantness Emotion

Viewing the Design 1 before the Design 2
There is no statistically significant difference between point A and B.
There is no statistically significant difference between point B and C.
There is no statistically significant difference between point B and D.
In statistic, this line can be seen as a flat curve.

Viewing the Design 2 before the Design 1
There is no statistically significant difference between point a and b.
There is a statistically significant difference between point b and c.
There is no statistically significant difference between point b and d.
In statistic, this line can be seen as a cubic curve.

Conclusion
There is a statistically significant difference between point c and C.
It also means the subjects who saw the Design 2 before the Design 1
reported more pleasantness comparing to the subjects who saw the
designs in opposite orders.

Figure 54: Pleasant Emotion versus Viewing Orders – Conclusion
5.4 Discussions

This research collected the participants’ overall responses to the designs in order to evaluate the effectiveness of the designs and the methodology for future reference. Based on the emotional reactions and the buying intentions interviews, the feedback showed the participants having highly positive reactions to the designs. Overall, the participants, who are all small-space residents, like the designs and rated them with a high average-score—7.9 out of 10 point for Design 1, and 7.1 for Design 2.

What they like most about both of the designs is the large storage-capability. There were seven out of ten subjects who commented on their preferences for the huge storing space of Design 2. In addition, the appearance of the designs also showed attractive to the subjects as well. The underneath drawers were seems as a useful function to sort things which was pointed out three times by the female subjects. For Design 1, the patrons see it as an interesting design which has a clean appearance, and high portability. Its ability to "hide things in plain sight" is also likable. For Design 2, the convenience of use was reported to be one of the significant benefits, which will provide high accessibility to the elderly.

Security was a significant concern of the participants. For instance, the subjects felt unsecure about having things hanging above their heads. Some subjects reported feeling relieved when the design was not placed above the couch where people sat. In addition, the reliability of the product was also questioned. For instance, one subject reported, “the books on the shelf should be very heavy; could the shelf support them safely for a long
time?” In fact, these two concerns reflect one of the issues of presenting concepts in a virtual environment. It is still true that viewers can’t sense as much information from a virtual room with a concept design as they can from a reality room with real products. Once the essential information is missed, the quality of a product will be doubted (Hansen, 2005.) For this reason, it is essential for the sellers to better communicate the missing information to their customers through other methods, like knowledgeable salesmen, or trial samples. This is especially important when the product is new and complex since its qualities and attributes are unfamiliar to their customers.

The overall buying intentions of both designs are relatively high. For Design 1, the average buying intention is rated 7.4 out of 10 points. Five of the ten subjects rated over 7 points for Design 1. On the other hand, the average buying intention of Design 2 is rated 7.3, and eight of the ten subjects rated over 7 points. Moreover, Error! Reference source not found. Figure 51 and 52 present that the subjects who saw Design 2 before Design 1 reported more pleasant emotion than the subjects viewed the designs in the opposite orders.

Interestingly, the design preferences are different based on the subjects’ ethnicity. As shown in Figure 52, the Asian subjects like Design 2 more than Design 1( p value =.00110.) Their average buying intention for Design 2 is 8 points, and 6.4 points for Design 1); On the other hand, Figure 51 shows that the non-Asian subjects like Design 1 more than Design
Their average buying intention for Design 1 is 8.4, and only 6.6 for Design 2.

Similarly, the money that the subjects are willing to spend on the designs also varied based on the ethnicity and their preferences (see Table 24.) The average spending money for Design 1 is $255, whereas for Design 2 it is $450. However, the subjects are willing to spend more money on the designs when they rated higher buying intentions on them. The Asian subjects are willing to spend $192 on Design 1 and $497 on Design 2; whereas the non-Asian subjects are willing to spend $317 on Design 1 and $401 on Design 2.
CHAPTER 6

CONCLUSIONS

Hypothesis
1. This thesis was conducted to find a way to optimizing small spaces and create a friendlier atmosphere for the occupants.
2. The main goal of this thesis is to implement a way to help people live happier and more comfortable in small spaces based on the perspectives of design research and environmental psychology.

Previous Research
The results of this study identify design guidelines for improving small-space living. These design principles are lighting, privacy, and storage.
For small-space residents, first, adding better lighting can effectively improve their living spaces. A better lighting design can increase the feeling of spaciousness, openness, and comfort. In addition, personal privacy should not be sacrificed in order to optimize interior openness. A living space with various level of privacy can better satisfy residents’ multiple needs in their daily lives. The last but not the least, storage space are the most important feature for increasing a living quality. The use of vertical space for storage (vs
valuable floor space) is encouraged. For an extreme small-space resident, keeping the clutter veiled reduces the negative reactions caused by the uncontrolled feeling to the mess. This study also focuses on the storage issue as the direction of design development.

**Design Development**

Based on the third principle of the guidelines—storage, two design concepts were developed in this study to optimize small spaces. Depending on the idea of utilizing vertical space, the concept was developed – a lifting storage shelf. Two versions based on the concept were conceptualized, a narrow and a wide designs. Then, these two designs were evaluated by the participants’ buying intentions and emotional status after experiencing the two designs in a virtual environment.

**Overall Responses – Opening Question**

Overall, the participants, who are all small-space residents, like the designs and rated relatively high scores to them, 7.9 for Design 1 and 7.1 for Design 2. This positive reaction to the designs is highly related to their buying intentions and the money they would like to spend on the designs. Interestingly, the result also showed the preference difference based on the subjects’ ethnicity. The Asian subjects reported more interests in Design 2, whereas the non-Asian subjects showed more interests in Design 1.
Safety

The features which the participants like most are the storage capability and the appearance of the designs. However, safety was the most critical concern that caused the designs to lose their credibility to the participants. For instance, the participants concern about the loading capability of shelf and think the stored things might fall from the shelf. It is encouraged to address the perceived safety issue when taking the research a stage further.

Emotions

The results of the emotional status questionnaire were supposed to reveal the participants’ feeling about using the designs in small spaces. Moreover, their emotions were assumed to have positive relations to their buying intentions (Kolter, 1974; Babin, B. J. & Darden, W. R., 1996.) However, they didn’t show any change in their emotional status participating in our research. There was no statistical significant finding showing that the participants reported more positive or negative emotions after interacting with the designs in the virtual living room, since the number of subjects was limited. In other words, there was no direct evidence showing that the users feel happier and comfortable when using the designs in their small spaces. Meanwhile, the designs didn’t depress the users or cause any negative effects either.

However, the trend of feeling more of certain positive emotions (interested, relaxation, and happiness) was displayed after exploring the designs in the virtual rooms. Likely, the trend of reporting less of certain negative emotions (sad, stress, and agitation) to the
designs was also presented. If more subjects were acquired, this would be a good direction of the small-space research for other researchers to explore.

**Emotions and Buying Intentions**

For Design 2, the participants’ buying intentions was related to certain positive and negative emotions. The positive emotions include interest and like, whereas the negative emotions were agitation, anger, and sadness. For example, the participants reported higher buying intentions to Design 2 when reflecting higher interests and like emotions to it. Oppositely, for Design 1, there was no similar finding showing the relation between the emotions and the buying intentions.

**Attitude, Behavioral Changes, and Culture**

Interestingly, emotional status, buying intentions, and the actual amount that people reported they would spend were inconsistent based on their ethnicity. In this study, the Asian subjects’ buying intentions were only related to their positive emotions, whereas the non-Asian subjects’ negative emotions showed highly relations to the amount of money they reported to pay for the designs. These negative emotions include agitation, anger, sadness, stress, and pain. Take the anger emotion for example, the result presented that the angrier the subjects reported, the higher they priced the two designs.

The inconsistency of the non-Asian subjects’ attitude (emotional status) and their behaviors (buying intention, likely spending money) can be explained as cognitive dissonance. Leon Festinger, a psychologist, proposed this idea, cognitive dissonance, that
people feel uncomfortable when their attitudes and behaviors are inconsistent (Elliot, A. J. & Devine, P. G, 1994; Festinger, L., & Carlsmith, J. M., 1959.) People may change attitudes to match behaviors in order to relieve the cognitive dissonance (Cialdini et al, 1995.) Some researchers have also proposed that the cognitive dissonance can influence people differently based on their cultures (Gonzaka & Khokhlov, 1977; Hiniker, 1969; Khokhlov & Gonzalez, 1973.) In addition, for Western culture, individuals are expected to having a stable personal faith in different situations. They are more likely to have their attitudes and behaviors matched. For Eastern culture, individuals tend to behave themselves to fulfill the social expectations. Therefore, their behaviors tend to be more consistent to the group demands then personal attitudes. There is more flexibility between their attitudes and behaviors. Furthermore, another psychology expert proposed that individuals growing in Asian cultures tent to hide their negative emotions and only show their positive emotions to friends (Gudykunst, 1993; Kacen, 2002.) This literatures explains why non-Asian subjects showed both negative and positice emotions where as Asian subjects only reported their positive ones when participanting in the interviews. In other words, the non-Asian subjects tended to preserve in their true feelings; the Asian subjects tended to report a compromise between their feelings and the researcher’s expectations.
Based on the previous study, I propose a chart of design presentation for design evaluation method. The chart reveals the relations between the physical conditions (products and the environment) and the receivers’ reactions (the participants’ emotional reactions and buying intentions) during a design evaluation process. The physical condition includes the reality levels of the objective product and its surrounding environment. As shown in Figure 55, the receivers’ involvement levels increase (showed as a bigger heart) when the reality levels of products and environment move to the upper right corner of Figure 55. Being placed in an environment with more stimuli, they are
more involved in the purchasing process, judge the product critically, and make decision thoughtfully. In contrast, the receivers’ involving levels decrease (showed as a smaller heart) when the reality levels of products and environment move to the lower left corner. Being placed in an environment with less stimulates, they are less involved in the purchasing process, judge the product uncritically, and make decision thoughtlessly.

However, purchasing is an action taken after a complex consideration of cost and benefits. The involvement is not the only factor that relates to consumer decision making. Based on Hansen’s 2005 article, “consumers do not make their purchasing decisions independently on either cognitive (perceived quality, price, developed attitude) or affective skills (emotional reactions.)” His article said both of these two skills affect each other when consumers making decisions (Hansen, 2005.) It is essential to evaluate a design by considering all of these perspectives, rather just a serial of preferences questions about a product itself.

Based on the previous research, the subjects’ would like to pay more money on the designs if they reported more positive emotions and stronger buying intentions. The influence is significant if the participant is more involved in the process. In other words, a consumer would more likely to take a purchasing action if he is highly involved in a purchasing process and feeling positively. As showed in the Error! Reference source not found., the color red and the blue demonstrate the participants’ emotional reactions and buying intentions (the red show positive reactions; the blue illustrates negative reactions.) When a participant is a highly involved in a physical condition (the bigger
heart,) and report more positive feelings (red color,) they are more like to take a purchasing action (a bigger red heart on the upper right.) In contrast, if a participant is less involved in a physical condition (the smaller heart,) and report more positive feelings (red color,) they might finally not take a purchasing action.

Interestingly, the conflict between the reality levels of a product and its environment can affect people’s emotions negatively. In the evaluation interview tool, the concept designs were built and presented in a reality virtual room. The reality level of the virtual room was optimized to create an atmosphere of a real small-room. On the other hand, the
reality level of the designs was reduced to simplify the further analysis. For instance, the colors and the materials variations of the concepts were limited to enforce the subject to focus on the concept of designs. During the evaluation interviews, the subjects sensed the noticeable presentation conflict between the designs and the environment; then, reported the uncomfortable feelings on the results of the emotional reactions (showed as the heart with half blue color on Figure 56.) Similar to the idea of cognitive dissonance mentioned last section, I propose this situation as presentation dissonance – the perceived reality-conflict between a product and its environment. This explains why the subjects in previous research showed strong buying intentions regarding to the designs, but didn’t report significantly positive emotions on the designs.

To avoid the negative effects of the presentation dissonance, the presentations of a design and its environment have to match each other in a similar reality level, as the diagonal line showed on Figure 56. For example, visualizing an idea in a correlated sketched environment is a good way to clarify the idea in the pre-design stage; conceptualizing a concept in a colorized environment is a proper way to evaluate the concept in the middle-design stage; and displaying a real product in a showroom is an effective way to motivated a buying action in the post-design stage.

Eventually, this design presentation chart gives a reference to examine the ways designers communicate their designs and the ways users react to the designs during a design process. Utilizing the advantage of the upper right corner on Figure 55, customers are more willing to display true reactions, like their emotional feelings and buying
intentions. A distance away from the diagonal line on the left can result in negative feelings to the subject. Designers should consider or avoid this kind of presentation dissonance when implementing a design interview.

**Future Research Suggestions**

1. Regarding the lifting storage system, perceived safety is the most critical issue. It can be improved by adding sensors to monitor the lifting height and loadings. The sensors should be able to detect danger (such as over loading) and inform signals to the users visually or audibly. When needed, the users should be able to stop the system immediately.

2. Use the other principles to improve the small-space living: lighting and privacy. Lighting and privacy are two of the features that the small-space residents like about their dwellings. The positive influences are predicted if these two features of a small space are improved. A further research is encouraged for developing a design providing better lighting, flexible privacy levels, and accessible storage spaces.

3. Based on the evaluation interview, there are a lot of variables that may affect the results: interview methods (selected interactive media), number of subjects, order of viewing designs, ethnicity (culture background), and individual differences (individualism and collectivism.) It is encouraged to test how these variables affect other design research.
4. The further research to understand the emotional reactions for the area on the right side of the diagonal line on the design presentation chart (Figure 55) need to be implemented. The presentation conflict might not cause the same negative feelings like the left side of the diagonal line does.
BIBLIOGRAPHY


Environmental Psychology

Sommer, R., Tight spaces; hard architecture and how to humanize it, 1974, Englewood Cliffs, N. J., Prentice-Hall, ix, 150p

In “Tight space”, Sommer claimed the problems and possible solutions for existing buildings. The living situations can be improved from numerous perspectives, even though most of them were built for security purposes. For example, he stated that people living in prison are like animals living in Zoo. However, there are several ways to prevent the depressing environment by awareness of design of shared spaces, where people can process their social activities. I am astonished by how early (70’s) this book represented the strategy for building a healthy houses which we still can’t be able to implement them nowadays.

Freedman, J.L., Crowding and Behavior, 1975

Mr. Freedman described the crowding situation in cities and how it affected human behaviors. Several modern issues, such as crime, social activities, and personal spaces, relating to crowding, were all discussed in his book. He concluded that people living in tiny spaces didn’t necessarily have negative effects. Moreover, encouraging people to connect with others by providing more public space for social activities can improve the feeling of living in a city. However, some of the statements presented in the book didn’t verified by any statistic number or real examination. I would keep them as his personal opinions rather than reliable truth.

This article discussed how crowding effects people’s behavior and identified the basic knowledge of environment psychology. For example, the author defined density of living situation in two ways: Internal Density, a measure of dwelling space per person (e.g. rooms per person or square feet per person;) and External Density, the number of people occupying a large residential area (e.g. people per acre, kilometer, or mile.) In addition, he also stated that environment influences people in two different ways: “Perceived controllability” (e.g. other people restrict individual’s goals) and predictability (e.g. strangers) of environments.”

According to his research, which supporting “open-space idea in certain way, how can we create a more controllable and predictable environment? How can the resident reach stuff more easily? The wall, doors, or the shelves should not block the goals (what kind of goal? Watching movie, extended views.) If a crowding situation doesn’t affect controllability and predictability, the environment doesn’t cause negative effects. Consequently, this statement supports the reason why we need a better design for a tiny room because the room need looks more like a controlled environment.


In one space living, the issues and strategies for living in a small space were discussed based on the interior design perspective. The author argued that the configuration for a small space should be able to bring people the feeling of openness, flexibility, and positivism. For example, instead of top to end solid walls, semi-height walls can be used to avoid blocking lights from windows. It explored the conventional thinking of dividing space for numerous purposes, such as cooking, bathing, or working. Definition of space and various techniques to improve the constrained space are all shown in the first chapters. Furthermore, for well understanding the new concepts, a few case studies categorized by function, sleeping, working, or cooking, were also presented in the last chapters of this book. In fact, this book is a photo portfolio rather than a professional context book. However, it gave me a new perspective of space and living activities. Although, the descriptions of the case studies are not clear enough for people to follow, even seem a little unrealistic, they still shown readers the useful idea, one space living.
Mr. Kopec discussed numerous design applications of environment psychology. It demonstrated several issues of the environmental psychology: human behavior, ages, minority, education, and occupation types. In the way, it clearly identified the design consideration for residential areas where were very relative to the small space design. On the other hand, the relationship between crowding space and negative effects were pointed out, providing an obviously support for redesigning small spaces. In my opinion, this book, described most issues between environment and human, is extremely helpful for designers and people interested.
Population Trend

Population in the world
http://www.census.gov/ipc/www/idb/

Population Trend in Urban Areas

Urban Density in the world
PDF file Page 79
www.demographia.com/db-worldua.pdf

These three sites demonstrated the increasing growth of worldwide population. Along the way, the average population in urban areas will grow 20% from 2007 to 2050. Urbanization, a constant trend since the industry revolution, will continue its development as least until 2050.

Population Growth and Urbanization in China


The population structure in China tells two facts: one is the increasing rate of the elderly; the other is the high percentage of fertility group.

Population Growth in China

{Mainland, HK, Taiwan (but actually, Taiwan is not part of China)}
http://www.iiasa.ac.at/Research/LUC/ChinaFood/data/pop/pop_2.htm

This page discussed the population structure changing in China. The report predicts that, except of the elderly (over 50), the population may start to decrease in the future from 2010 to 2050. For example, the growth of the elderly population may increase 422 millions, however, the middle-aged population may decrease 65 million from 1995 to 2050. Even though the middle-aged population has growed for over twenty years, it may be able to decrease in the following thirty years. In this decade, the reproductive ability of China increases because of the growing of the productive population, which ranges from the teenage (5 to 19,) to the middle-aged (20 to 49.) Moreover, it may also influence the selling potention of the middle-aged orientated market.
**Population Growth in US**

**Population Density in US Cities**
http://www.census.gov/population/censusdata/90den_stco.txt
http://austinzoning.typepad.com/austincontrarian/2008/03/weighted-densit.html
http://austinzoning.typepad.com/austincontrarian/2008/03/perceived-densi.html

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**Affordable Rate in US**
http://www.publicpurpose.com/

Most of the houses in big cities of US are way too expansive. For example, housing rent in San Francisco is about 10 times of the residents’ average salary. Middle-income classes have to pay 30% to 85% of their income for their two bedroom houses.
Storage Issues

Daphne Guinness, Put it away, Sydney Morning Herald, Australia, September 14, 2006.

This article is a report of interviewing Terence Conran, a comprehensive designer (architecture, interior, product, and graphics) who has published at least 33 books. Mr. Conran believes that people will live happier without mess. In this interview, he described the problem that causes clutter and provided possible solution to get rid of it. He pointed out that purchasing encourages messy: people can’t help to go shopping, but they don’t have space to store what they buy. The possible solutions he proposed are open-plan space and upper space (ceiling.) Open-plan space can provide a multi-purpose room without be divided by solid walls, where people can eat, cook, read, sleep. In addition, the upper space can also create extra rooms for storage; however, people may need a ladder to reach the upper shelves and some people fall off ladders. Therefore, according to Conran, the open-plan and upper space may be very useful solutions for conquering clutter.


In this short article, Alex mainly explained the idea: people don’t need extra space, but get rid of the unnecessary stuff. The writer stated that storage makes people feel in control and how people get relieved after their homes get organized. However, he believes that “throwing clutter away is a better way than making extra storage space.” On the other hand, one very interested “cut clutter tip” is listed in the end of the article: ten percent of a home’ size should be used as storage. It is very useful for me to rethink the “extra” storage solutions.

The author presented the storage market in US and discovered the renters’ desire for extra storage space. According to his research, there are 11 million renters in US are using the storage service for longer period. Furthermore, the renting market has expanded 95 percents since 1995; although, it conflicts with the fact that people own more space than they did in the past: the size of living space is increasing and the scale of family is reducing. In fact, Most of the renters would rather pay thousands dollars (at least 3,000) per year for keep those stuff they don’t need rather throwing them away. Along the way, a psychologist stated that some people, who called hoarders, may have a mental problem to avoid cut those unnecessary possession away. They feel guilt at throwing things away and keep stuff in these extra space help them feel comfortable. On the other hand, Mr. Gannon stated that some people said they couldn’t live without that unnecessary but meaningful poverty.

In this article, Mr. Buchan discussed the meaning of storing and possible solutions through his personal experiences. He pointed out that the possible solutions for conquering clutter are living minimally and getting storage locker. He stated that most people keep old stuff which they don’t need because that poverty reminds them their past: their histories. In the other words, storing is based on the desire of storing, not only the value of those stuff. In addition, according to Burchan, “a storage solution should be pretty, practical, space-saving and, best of all, portable.” These four requirements are significant for designing a better storage system since most of the existing products are lack part of them. Even though, in the end of the article, a wall of build-in bookshelves attached a rolling ladder is introduced as a better solution for small rooms, I didn’t agree with the use of ladder since it may cause danger. Therefore, in my opinion, portable ability is the most challenge part of designing a storage solution.
http://online.wsj.com/article/SB120606089260853653.html

According to Nancy Keates, the market of “smaller-scaled” furniture is increasing since the downsizing of the new buildings. Real estate’s downsized the floor plan for new houses, since market demand for smaller houses dramatically increases after the depressed economic. Even though the average sizes of new building is still bigger than those build ten years ago, people already changed their buying criteria. Those shredded furniture can well satisfies the demands of people who live in restrained situations, such as condos or small apartments which don’t just limited in metro areas. In the way, several intelligent companies in U.S. already benefited significantly by modifying furniture to fit the needs of the market. Furthermore, the author, Nancy Keates, also predicted that the needs don’t just exist in US. In economic-growing countries, i.g. China and DuBai, the high-income consumers are also seeking for elegant and smaller furniture. This article clearly stated the smaller-scaled furniture trend by demonstrating experiences of existing companies. In my opinion, this article gave me a more comprehensive evidence to believe that size will be a most important issue in the future.
Market

Leva. M. Augstums, Eco-friendly furniture a big trend at High Point show, Updated: 04/18/08 8:45 AM

This article discusses on the potential needs of green furniture and the companies which implement the green idea. The market is based on people’s desire to do good for our environment, could be one or two pieces of their whole furniture. Several companies already applied new green materials to their new products displayed on the High Point show, a twice-annual furniture and decoration trade show. Looking deeply into those companies’ websites, Ecollectionhome is promoting their products by marketing them with green and nature concepts. On the other hand, Precedent and Rowe Fine Furniture Inc. focuses more on the custom furniture and smaller-scaled furniture, which are also reported on the magazine AZURE (January/February 2008.) In my opinion, even though the green idea seems very obviously necessary people aren’t wildly accepted yet in recent market that are most tricked and confused for enterprisers.

Relative Sites
Original News
http://www.buffalonews.com/185/story/326075.html
Ecollectionhome
http://ecollectionhome.com/index.php
Precedent
http://www.precedent-furniture.com/
Rowe Furniture
http://www.rowefurniture.com/default.htm
Furniture Companies

Custom Furniture Design

There are two methods to customize furniture as followings: 1. Customers have their own ideas or sketches. And then, furniture companies help them realize their idea. 2. Customers send the foot-plan of their spaces to those companies and tell designers the purpose for the furniture. The companies design the furniture that can fit the size and their needs. Both of them can provide quote services. It is helpful to know the information since I might need the quote services as well; however, I should prevent them from stealing my ideas. Best of all, the existence of these online companies prove that the custom furniture is desirable.

Relative Sites
http://www.mcustom.com/design.html
Drawing, quote price
http://www.customfurnituredesign.com/index.html
http://www.louchheimdesign.com/concept.htm

Columbus Apartment Association, Presentation. May 17, 2007
http://www.danter.com

This report represented the demand and trend of living space in Columbus OH. Generally speaking, the housing vacancy rate has been decreasing since 2005; however, one and two bedroom still have the highest vacancy rates, especially in Southwest and southeast areas. On the other hand, most of householders’ ages range from 24 to 44; for the first-time buyers, condominium are the most popular choices. After that, when reaching the ages from 45 to 54, most of them may change their houses again. In this survey, the increasing growth of population has raised the high vacancy rate a little since less new buildings were permitted since 2005. However, the high vacancy rate of small space (one and two bedroom) still needs to be explained by a stronger reason because it is not reasonable for a college town.

IKEA, USA, English, April 11, 2008

Ikea, fund by Ingvar Kampa in Sweden, is the most popular furniture company in the world. They’re accepted for providing modern furniture in affordable prices for most
population, though they emphasized main clients on students, the youth, or small family. Moreover, they are famous for the “flat-component” idea, also called “flat-pack”, then wildly used by other Internet furniture company since it dramatically reduces the cost of shipping for their clients. Their international market also largely expanded by selling on Internet and providing cheaper shipping. Even though people complain about the quality of their product a lot, they are still the first choice in the young’s market.

**Blue Dot**
http://www.bludot.com/

This firm was fund by three college friends. When they first furnished their home, they note that “we didn’t like the stuff we could afford and we couldn’t afford the stuff we liked.” It states the potential demand of the middle-income people: they want something unique with acceptable quality and the price should be still affordable. In the way, they products are expensive than Ikea, but still very successful in the middle-income market. However, in my opinion, the reasons why they successes are the model appearance: clean and unique. However, there are more opportunities in the market if the product itself really solves some problems, such as storage and limited space.

**House of European Design**
http://design-eu.com/

A company, located in San Francisco, US, specializes in selling furniture manufactured from Germany and Italy. In my opinion, they understand use the culture crush, e.g. the American crush the European, and the Asia crush the west, to market their importing products. Moreover, House of European Design imports furniture from several companies in European, instead of just one company or one brand. It is a smart way to test which product may be sold best. This is a special technique to save cost by not design but still sell good design furniture.
Current Products and Concepts

Bonbon bed

The main idea of their products is to reduce the space bed takes when it is not in use, for example in the day time. This company combines a bed with a sofa, a desk, a book shelf, or another bed. The idea might not be new, but how they implement the idea is surprise good. The reason why they success may be the combination of the mechanism and the simple design.

The top-level people don’t really care about the price. They have money but don’t have space. (For example, people in HK pay 1 million per year for burial instead of burning their bones up after they die.) Creating the extra space in their existing rooms turns the key factor to improve the rich’s living.

Relative sites
Bonbon
http://www.bonbon.co.uk/clei/leader.htm
Resource furniture (Bonbon’s retailer in US)
http://resourcemodernfurniture.com/space_savers/index.html

Relative Information

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M-ch: micro compact home
http://microcompacthome.com/index.php

“M-ch, the micro compact home, is a lightweight compact dwelling for one or two people.” All living spaces of “sleeping, working / dining, cooking and hygiene” are included in a 2.6m cube. About two and half years ago, November 2005, the first product was build and tested in Munich for survey study.
Ceiling Storage Products on Sky Mall

Ceiling storage has been produced for several years; however, those existing product are still very industrial and conventional. For example, most of them are manually controlled, only one product (Rise Bike) use motors for easily accessing.

Product Codes
Reclaim your garage floor with ease
#14068D
#14069D
Space saving storage makes it easy to find the spice you want
#81722D
Heavy Lift
#270829D
Rise Bike
#164655D

Casulo: An Entire Apartment’s Furniture in One Small Box
http://www.treehugger.com/files/2008/02/casulo_an_entir.php

All furniture one person needed living in an apartment is designed in a 31”x47” box. An armoire, a height-adjustable chair, two more stools, a small table, a bookcase with six levels, and a bed with a mattress are all included in this box. The biggest innovation of this design is to explore people’s imagination for furniture. It shows that furniture can be light, movable, flexible, and easily-assembled.

Matroshka Compact Living Concept: You’re Life in 43 Square Feet

This concept is more complex than Casulo. It has more social activities (12 people) involved in this small room. Every space of the solid furniture was designed for certain purpose. None of them are wasteful. There are two questions rise in my mind as followings: why not using the top space behind the compact furniture? And where is the clothing space?
Mechanism & Manufacturing

Sustainable Materials

Questions to ask before you buy, The Buffalo News: Life, ASSOCIATED PRESS, Updated: 04/18/08 6:44 AM

This page described the guideline for choosing a sustainable products (or furniture.) The resources of materials, such as manufacturing countries, methods, and consuming energy, are the most important criteria to judge how sustainable the product is. For example, the VOC’s is a harmful pollutant which may be left in the furnished home and causes health damages. Since this article just gave a brief introduction about buying guidelines, it can be a general prerequisite reading for understanding eco-furniture products.

C Stanley, Spaces and places of the limit: four strategies in the relationship between law and desire, 1996

Spaces and places of the limit: four strategies in the relationship between law and desire. It reminds me the ceiling storage idea may conflict with some laws. It would be useful to look at some law of construction.

Apartment information in Tokyo, Japan
http://www.space-d.co.jp/en/list_bsite.html

Apartment information in New York, US
http://www.apartments.com/NewYork
Interview & Evaluation Tool
Find Your Furniture
http://www.findyourfurniture.com/index.html
There are several choosing tips for purchasing right furniture in specific rooms. Those suggestions are very useful for understanding the relationship between furniture and consumer’s behaviors. On the other hand, this site has a custom design page where users can arrange furniture in a 2D foot plan screen.