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Rochester Institute of Technology

Rochester, New York

A Thesis Submitted to the Faculty of
The College of Imaging Arts and Sciences
in Candidacy for the Degree of
Master of Fine Arts in Industrial Design

Collapsible Furniture for the Contemporary Work Environment

Yoko Taniguchi

2004

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Yoko Taniguchi

Date 9-1-04

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Introduction

This thesis is about space-saving furniture for a contemporary urban work environment where there is limited space. Most major cities in the world, New York City, Tokyo, London, Hong Kong, etc, often have to face the problem of a shortage of space. Those cities are so densely populated and overloaded with buildings and transportation systems that space-saving has become a big issue. Our work environment has been changing dramatically in the past few decades along with our work styles, because of advanced technology, wireless communications, and the capacity of portable computers. Wireless communications allow us to work from anywhere we want. Our work style has changed in so many ways, and I realized that our office furniture hasn't changed to keep up.

Since advanced technology changed our way of work, it is time to make a change in our office furniture to help workers adapt to their new style. After researching this generation's work style, work atmosphere and lifestyle, I want to focus on designing user-friendly furniture for offices. New generation workers are more aware of good designs, and they want to be surrounded by them (Barber 2003). The aesthetic value, feel and functionality are very important to them. I focused on non-traditional office furniture for the new generation of people who work in a new economy in metropolitan areas. This gives workers the freedom of choice for their work style, and an opportunity to work wherever and whenever they want. If they want to work at home, they need a table and a chair for their workstation for a short period of time. Or if they have to do some

collaborative work at the office, they need a temporary work station. It is convenient if they have furniture that can be easily set up by anyone and won't take up much space for storage. The furniture I am designing for the contemporary office will be suitable for the new generation's lifestyles. I want to design office furniture that is flexible and collapsible to give workers the freedom of choice. My goal is to research and design space-saving furniture for a contemporary work environment in an urban area that is collapsible, portable, lightweight, and user-friendly.

Research: Contemporary Work Style

The new generation's work style

New generation workers have changed their values, attitudes, expectations and demands toward their work places (Barber 2003). The new generation is clear about what they want and how their work has to be done. They ask for freedom of choice, such as work hours--what time they get into work and when they leave the office rather going to work at 8:00 am and leaving the office at 5:00 pm as in traditional work environments. They also care about their work surroundings--where and how they work. High-speed wireless telecommunications and lap-top computers allow them to work wherever they want. Most lap-top computers are very small, thin, and lightweight, and most of all, they are as powerful and fast as desktop computers. Staying in an office and working at the desk eight hours a day is not a necessity for employees anymore. They have become more independent in the way they work. Today, more people have achieved higher levels of education than ever before, especially a growing number of women. "Women have made significant gains in higher education enrollment in most regions of the world; in some regions, women's enrollment now equals or surpasses that of men." (The United Nations 2000) Because of this increased number of educated workers, there is more diversity in skills, talents and personalities. Also, the new generation tends to work with teams to develop their ideas and projects. Many believe that collaborative work will make better projects and is more productive. To accommodate this, new generation workers

tend to ask for open spaces in the office with more room. They don't want to work in a cubical office set-up.

"The cubicle is the symbol of everything 'Old economy' in work place design, evoking images of 'prison', conformity, being a number or stamped with a barcode. In a way, open architecture, with well-spaced working areas solves the privacy and intimacy need." (DYG, Inc., 2001) New generation workers believe that open space will be more conducive to high productivity and collaboration than old traditional cubicles, and will give them more light and space. Their personal work spaces become more open and comfortable. Therefore, my idea of collapsible furniture applies to these types of work environments where the ability to create an instant office for meetings or other occasions is essential. Paola Antonelli, curator of architecture and design at the Museum of Modern Art in New York, says that "design can provide the power, grace, clarity, and balance necessary to accommodate these stressful circumstances...major changes are happening in the workplace, brought about by the rapid evolution of information technology...Good design can act as the mediator between technology and human beings and is always an advocate of the latter" (Antonelli 2001, 8). A designer's job is to introduce a design that will improve the quality of our lives. I believe that designers can improve our quality of life by designing furniture that is based on understanding human behaviors and our rapidly changing lifestyles.

Advanced technology, and the increased numbers of female workers change not only the work environment, but also the priorities placed on private and professional life. Some workers prefer to work from home so that they can spend more time with their families. The companies don't necessarily offer a permanent office to each individual if

they can work from home; it is as efficient for many as working at the office because of portable computers and wireless networks. Therefore, collapsible furniture is suitable for people who don't have individual offices at the work place. If the workers who normally work at home have to go to offices because of meetings or to see clients, they can simply use the collapsible furniture to create an instant office for those occasions.

I was working at PEN-International office during graduate school as a graphic designer, and the office had a family atmosphere. The way we worked and the way we acted toward co-workers were far from the old-style office environment which only cares about productivity and growth of their companies. I was taught to be a member of the team in my office, and we took care of each other, and helped each other at the office. We did not work for just our own individual profits, but for the team's profits. I learned a great deal about being a team member for collaborative work. Everyone has their own talents and skills that will contribute to the collaboration. We have small gatherings for co-worker's birthdays and other special occasions once in a while. These types of gatherings would help reduce the tension at work and relieve the stress. My workplace was one of the new type workplaces. Some of my co-workers worked from their homes and came to the office occasionally for meetings. When I couldn't go to the office because of my schoolwork and classes, I was able to work from my apartment, instead of worrying about the office closing time. There was no necessity for a cubical, although we each had our own desk and computer to work on. I always thought that we should have some open space to work together, or some collapsible furniture so that we could instantly make a workstation for meetings and collaborative projects.

The built-in cubical at offices is becoming history. I believe new generation workers need a work environment where they can have control over an easy arrangement of desks and the ability to choose where they want to work.

Green in the office

There is a study about greenery in the office, and how people are affected by simply viewing natural vegetation from their office windows, and natural outside light. It does make a difference in their behaviors. Many people prefer to have a window in their office and love to look at nature. The study by Dr. Roger S. Ulrich, director of the Center for Health System and Design at Texas A&M University, found that natural views can help alleviate pain and anxiety in patients who have had heart surgery. Even when they are in intensive care, it helps in reducing stress and anxiety. Therefore, gazing at greenery from their workplace can have a positive impact on workers' mental and physical functioning along with their productivity. Designing office furniture while considering workers' physical and mental health issues is one of the important factors for designing office furniture in our future. Portable office furniture is suitable for workers who want to work close by a window, or simply want to work outside under the trees. My design needs to consider portable office furniture that will give workers an opportunity to work anywhere they want. Paola Antonelli says "When the workplace can be everywhere, so can inspiration" (Antonelli 2001, 13). She believes that people do their best thinking when they are somewhere other than the office. Changing their surroundings has a positive effect on people's productivity. The office furniture that I am

designing should be suitable for people who want to have freedom of choice in their work environment.

Research: Collapsible Furniture

Collapsible objects are one of the smartest ways to solve space-saving problems. They are expandable and collapsible. We are surrounded by collapsible objects, such as umbrellas, tents, picnic chairs, tripods and ladders, and we find them to be convenient products. Per Mollerup, designer and director of Mollerup Designlab, says that "Collapsibles are by definition also expandable, but to qualify as a true collapsible, an object must also be repeatedly collapsible and expandable. One-night stands do not qualify; encores are mandatory" (Mollerup 2001, 11). Collapsible objects have to be reusable; therefore, they have to be well-constructed to last a long time. It can not be a disposal object. Mollerup also says that "Since the whole idea of folding objects is size reduction, the concept of collapsibility inevitably implies a measure of minimalism" (Mollerup 2001, 182). Expandable and collapsible furniture is suitable for solving the issue of space-saving in crowded office space. Much collapsible furniture is designed for mobility and flexibility. I decided to apply collapsible functions to my space saving office furniture.

The advantage of collapsible furniture is that it can be stored in small spaces. It is convenient not just for the office, but also at home if workers need a workstation for temporary projects or for a short time period for other occasions. The collapsible furniture that I am going to design will be portable and lightweight. It will be light and compact enough to create instant work stations. It can be put easily into cars or carried on a train or bus.

Research: Materials

Translucent Polypropylene Sheets

Translucent polypropylene sheets have been widely used in public for many different purposes and people are familiar with this material (see figure 1). Translucent polypropylene sheeting has excellent living-hinge potential and is tear-resistant, yet those sheets can be folded as easily as paper, allowing the designer to create many different shapes (Lefteri 2001, 04). I want to apply translucent polypropylene sheets for the collapsible office furniture because its contemporary looks will be compatible with the contemporary work environment. It is a very light material that is also strong and durable. It can be easily folded, and living-hinges make the sheet foldable for repeated uses. The aesthetic value of translucent polypropylene sheeting is that it has a dense yet paper-like quality that makes it more translucent than plastics such as acrylic or polycarbonate (Prisham 2003, 104). The overlapping translucent polypropylene sheets create three dimensional figures (see figure 2). Translucent polypropylene sheeting is applied to many products, because it is lightweight, recyclable, resistant to water, and low cost. Polypropylene, PP, is also friendly to our environment because "PP is exceptionally inert and easy to recycle, and can be incinerated to recover the energy it contains...PP is made by processes that are relatively energy-efficient, making them the least energy-intensive of commodity polymers" (Ashby 2002, 189).

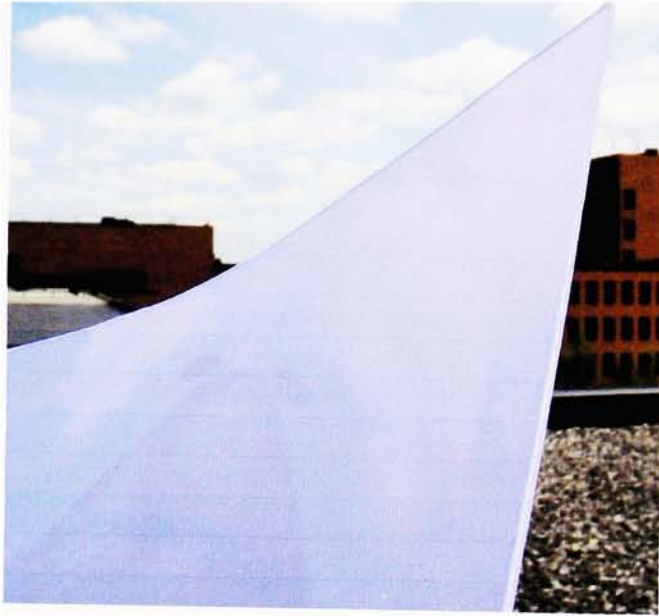


Figure 1. Translucent polypropylene sheet

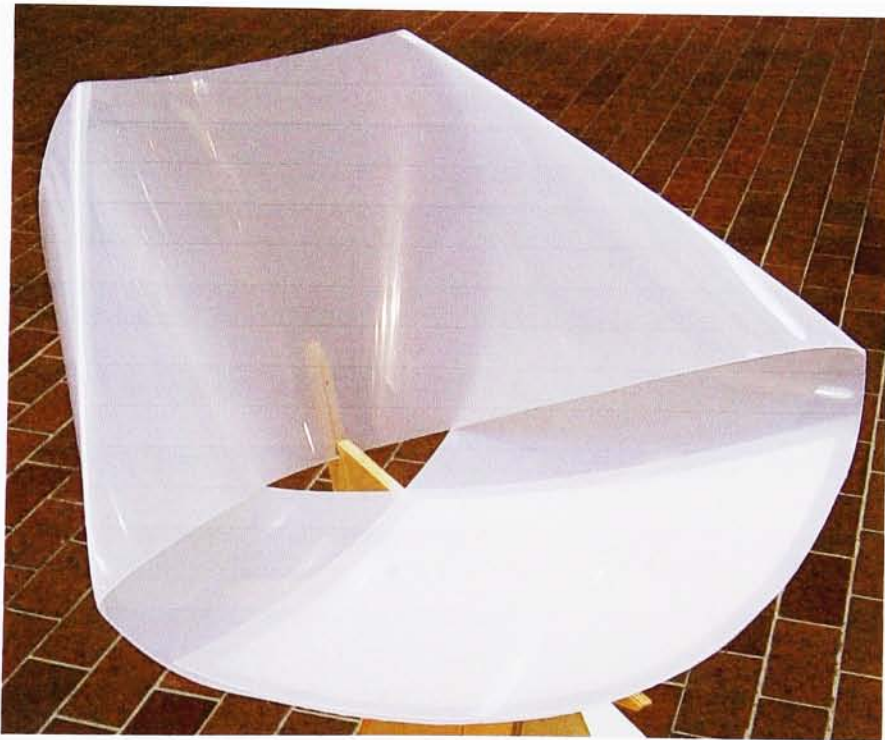
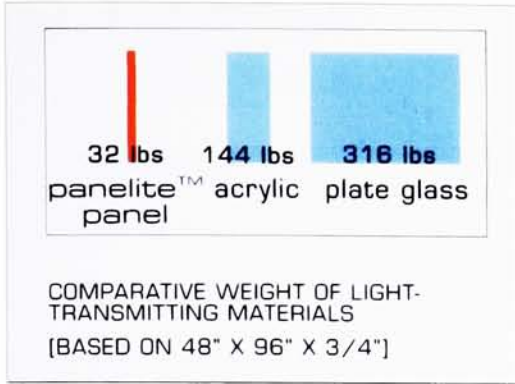


Figure 2. The overlapping translucent polypropylene sheet creates a three dimensional figure.

Translucent Honeycomb Panels

The advantage of a honeycomb panel is that it is strong and rigid, yet lightweight. Honeycomb panels can make a strong structure without making it vulnerable. Most honeycomb panels used to be applied only for aerospace, and designs in the US. Navy, but recently, they have been used for architecture and furniture designs (Van Onna 2003, 62). Honeycomb panels are becoming familiar to the public, but these materials are still new to many design solutions. Some companies have started to introduce uniquely styled honeycomb panels to the public, such as translucent, transparent, or opaque honeycomb panels. Panelite manufactures many different types of translucent honeycomb panels. The Panelite translucent honeycomb panel has a sandwich construction. It has a lightweight aluminum core and translucent fiberglass acrylic on both sides facing out (Panelite 2004). The aesthetic value for a translucent honeycomb panel is that light can go through the translucent fiberglass acrylic panel and reveal the aluminum core, making the inside of structures visible (see figure 4,5). The honeycomb panel that Panelite produces is much lighter weight than acrylic or plate glass, yet it is strong and stiff (see figure 3). The honeycomb panel is suitable for my design solution because it is lightweight for portability, stiff enough to provide adequate support for items placed on the table top, and translucent for aesthetic reasons.



(Source: Panelite)

Figure 3. Comparison of weights

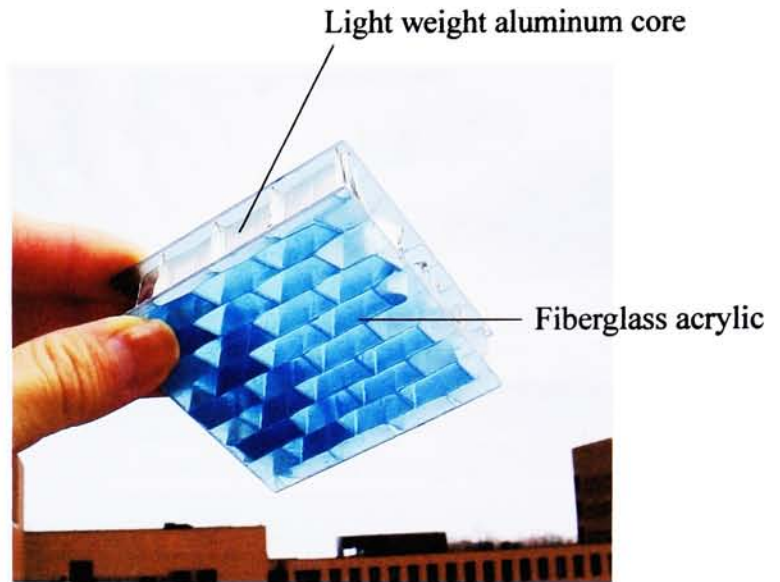


Figure 4. Panelite translucent honeycomb panel



Figure 5. 2' x 4' Panelite translucent honeycomb panel

Baltic Birch Plywood

Baltic birch plywood is popular for use in furniture designs and has been widely used in many types of applications. The advantage of Baltic birch plywood is that it is reasonably priced, yet strong and lightweight. Because many layers of thin veneer are glued together in all different grain directions, it is stronger and more rigid than solid natural wood. It also has a high degree of stability---less occurrence of shrinking, warping and twisting problems. Therefore, Baltic birch plywood is suitable for the collapsible furniture that I am designing.

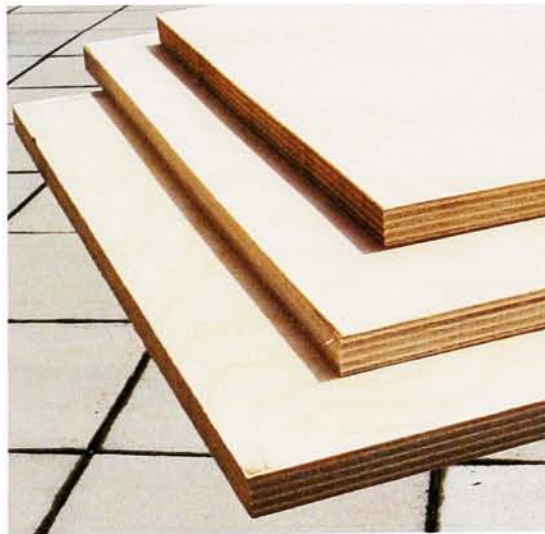


Figure 6. Baltic birch plywood

Concept

The purpose of this thesis is to develop ideas and study furniture for the contemporary office environment in order to improve the workers' quality of life and simplify often complex working arrangements. My concept is to design a collapsible chair and a collapsible table for the contemporary work environment where there is limited space. It also becomes an instant office whenever it is set up. The collapsible furniture will be easily folded down flat to minimize needed storage space. Workers are able to relocate their work station depending on their needs or simply their mood to work somewhere else besides the office. The collapsible chair and the collapsible table must be well-structured for repeated collapsing and expanding, must be lightweight, and easy for anyone to use. I will develop the idea of minimizing and will simplify the joints and hinges for the collapsible chair and the table so they are user-friendly. I also want my collapsible furniture to be aesthetically pleasing and a reflection of the modern lifestyle in which it must function. My goal is to make collapsible furniture with as little material, and as few joints and hinges as possible. Simplicity is one of the elements that I am emphasizing in my furniture design.

Design: The Collapsible Chair

I decided to create a seat by using one large sheet of thin translucent polypropylene and creating living-hinges. By folding the translucent polypropylene sheet, it became a three dimensional object and was able to create organic shapes. Since I wanted to develop the idea for the new generation by breaking old traditional office furniture concepts, introducing translucent polypropylene to the office was evolutionary.

I challenged myself to make a collapsible chair by using a minimum number of joints hinges and materials to make the chair lightweight for portability. To develop the ideas for forms and elements of the chair, I studied by sketching and creating 1/4 size 3D sketches (see figure 7).

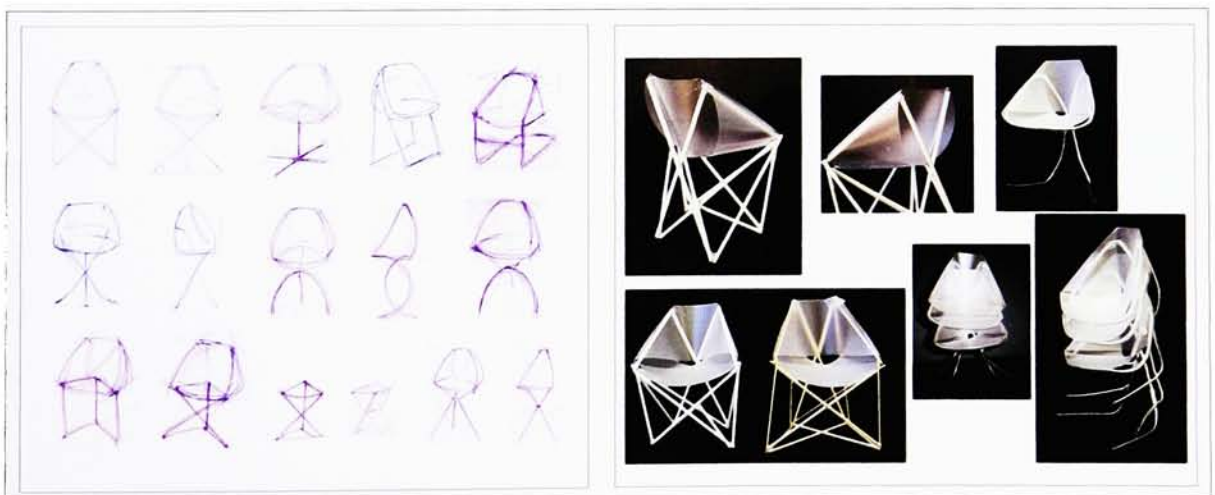


Figure 7. Sketches

Using a 14" wide x 72" long, 1/16" thickness sheet of translucent polypropylene, I was able to create a three dimensional seat by folding and bending (see figure 8, 9). By making a full-scale model, I was able to see whether this seat was comfortable enough for a person to sit on. This translucent polypropylene sheet was strong enough to hold a person. Since the 1/16" thickness polypropylene had some flexibility, the seat comfortably molded itself to the shape of the user's body. I used a 1/32" thickness polypropylene sheet for the first attempt, but it was too weak, and wasn't strong enough to lean back on comfortably.

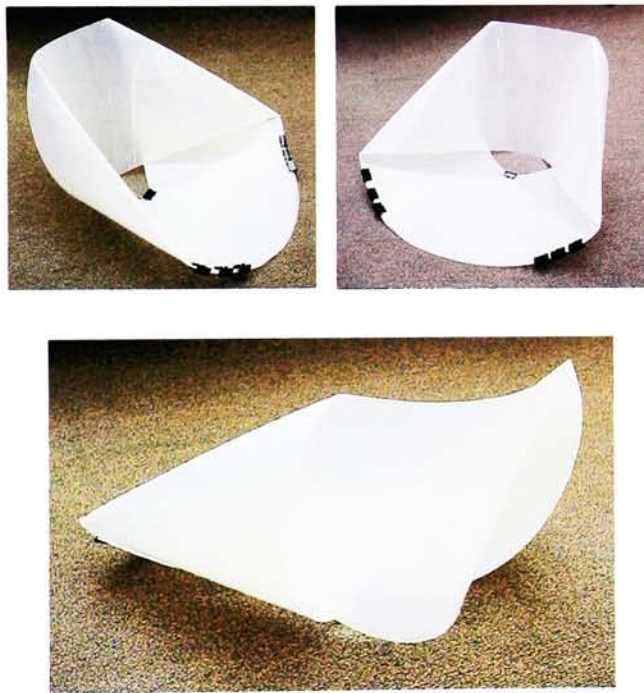


Figure 8. Full scale mock-up of the seat

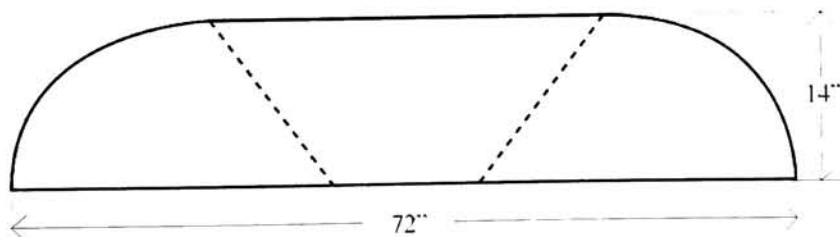


Figure 9. Technical drawing of the translucent polypropylene sheet



Figure 10. Full-scale mock-up of the chair I

The full scale model (see figure 10) was unsuccessful. I encountered the problem of stability. The legs were not strong enough to hold up the seat portion. This complicated design did not match up with the elegant shape of the seat. If I wanted to use wooden rods for the legs, they would have had to be much thicker rods. I also considered using steel rods or tubing for stability and strength. However, their weight would defeat the purpose of the concept of being portable and lightweight. I decided not to use the thick wooden rods for the legs for the same reason.

The picture (see figure 11) contains 1/4 size 3D sketches. Using slot joints, I was able to eliminate nails and screws for the construction of the chair legs, and minimize the number of joints. The problem with these models is the lack of harmony between the seat and the legs. The organic element of the polypropylene seat did not match with the oversized legs. I had to make large slits in the polypropylene sheets for the legs, and that made the polypropylene sheet vulnerable. I had to redesign the legs so that they would not require large slits in the polypropylene sheet.

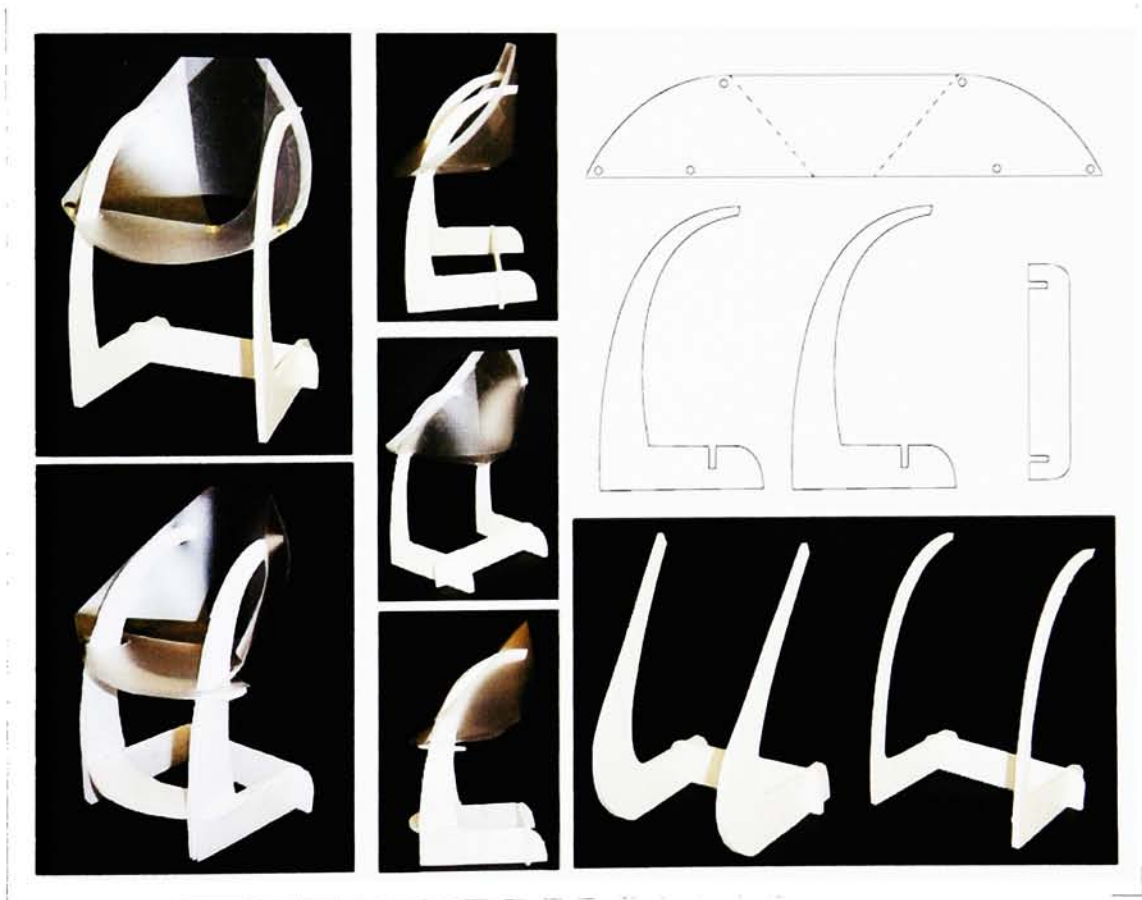


Figure 11. 1/4 size 3D sketches

Making a slot in each of two Baltic birch plywood sheets and fitting them together (see figure 12, 13), creates a rigid construction for the leg of the chair. The picture (see figure 14) shows the development of my concept for the leg. I used cardboard to see the forms and elements of the structure for the initial full-scale 3D sketches, and then used plywood to see its actual thickness and weight.

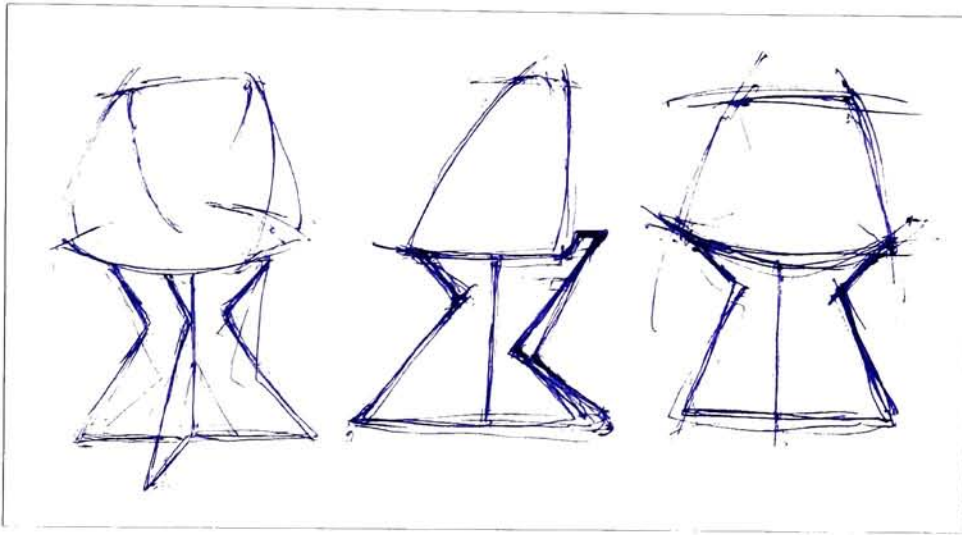


Figure 12. Sketches for the slot joint chair

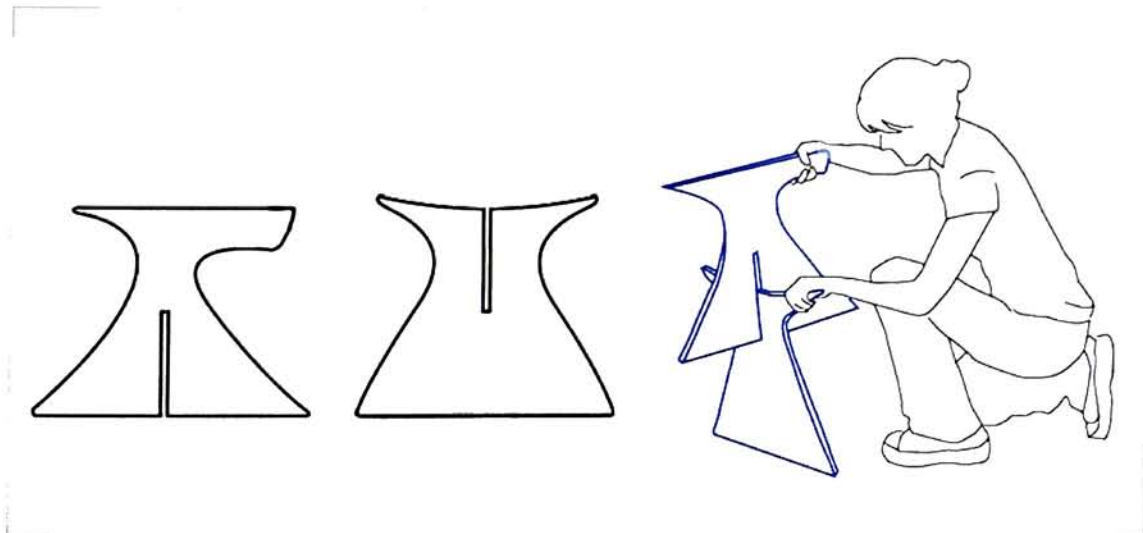


Figure 13. Illustrations of the slot joint

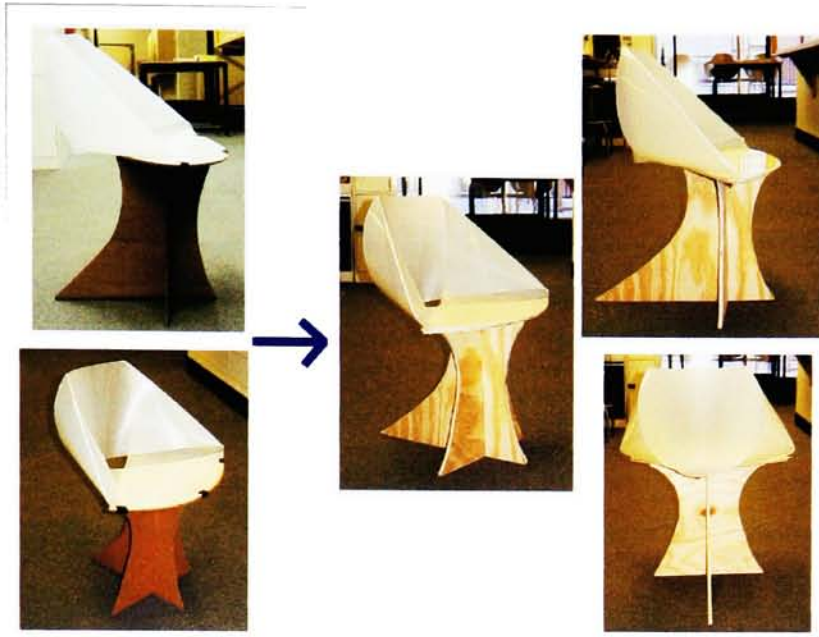


Figure 14. Full scale mock-up of the chair II

After building a full-scale prototype with the actual material that I was planning to use for my final model, I was able to test the durability and stability of the chair with a single slot joint. I redesigned the backside of the panel, and made a groove to secure the seat for more back support. (see figure 15, 16, 17).



Figure 15. Full scale mock-ups of the chair III



Figure 16. Close-up look of the back support

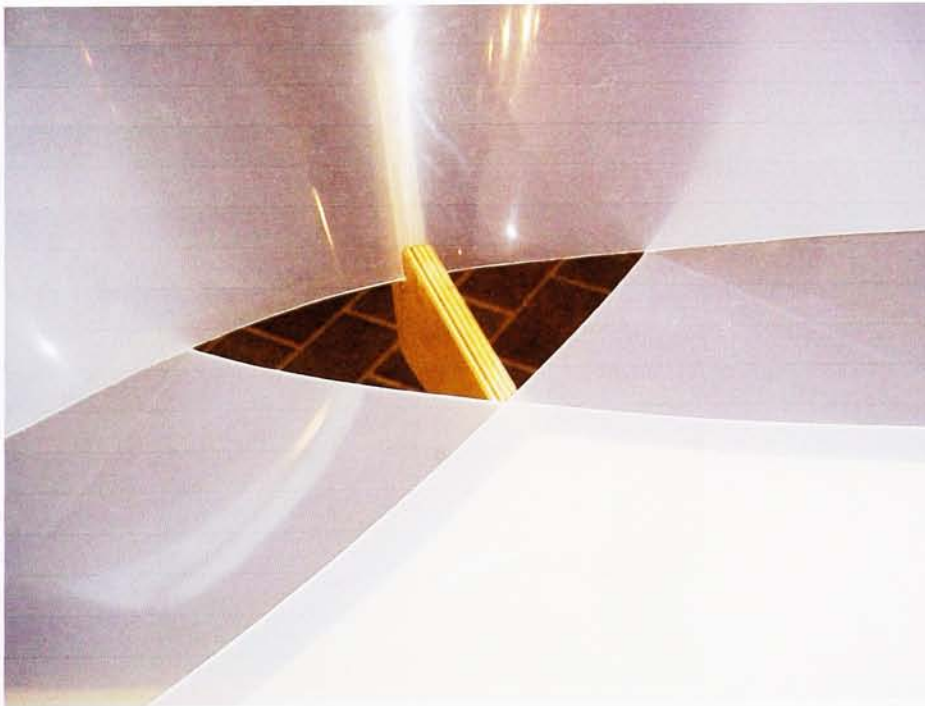


Figure 17. Close-up look of the groove

I encountered a problem with shape of the seat. My original idea was to have a flat seat, but after testing the seat for many hours, I found it wasn't comfortable for a long period of time. Since I was using polypropylene that can create any type of curve and shape, I decided to take advantage of the characteristics of the material. I decided to use laminated curved plywood as a seat support underneath the translucent polypropylene for stability (see figure 18, 19). This curve-shaped seat provides comfortable support for seating for a long period of time.



Figure 18. Testing a flat seat



Figure 19. Testing a curved seat

Minimizing the hinges was another problem that I had to solve. The attachment between the leg and the seat has to be secure for safety and stability. My first design was to make a groove underneath the seat (see figure 20), but it wasn't successful. Next, I decided to make a curved veneer laminated seat for the underneath seat support with screws. I used screws that can be easily unscrewed and screwed back without using any tools (see figure 21).

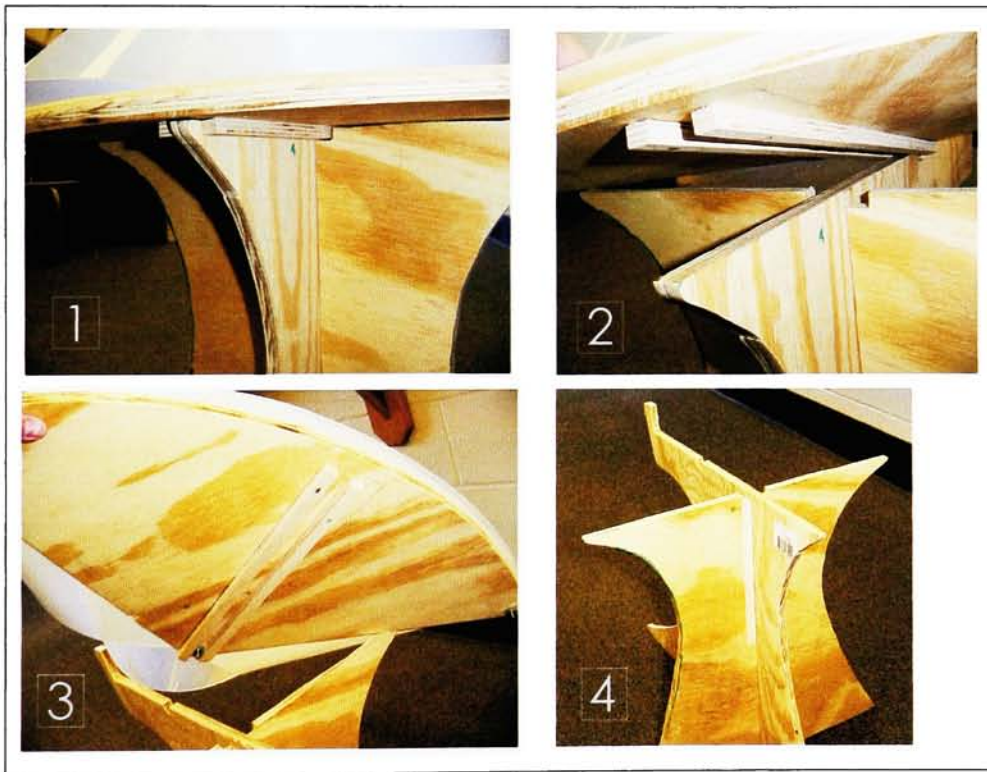


Figure 20. Full scale 3D sketch of grooves



Figure 21. The final model I



Figure 22. The final model II

Design: The Collapsible Table

For the collapsible table, I used a translucent polypropylene sheet, a translucent honeycomb panel for the table top, and Baltic birch for the legs.

The first idea for the collapsible table was to use slot joints for the legs just as I did on the chair, and use simple construction with minimizing joints and screws so it would be user-friendly (see figure 23).

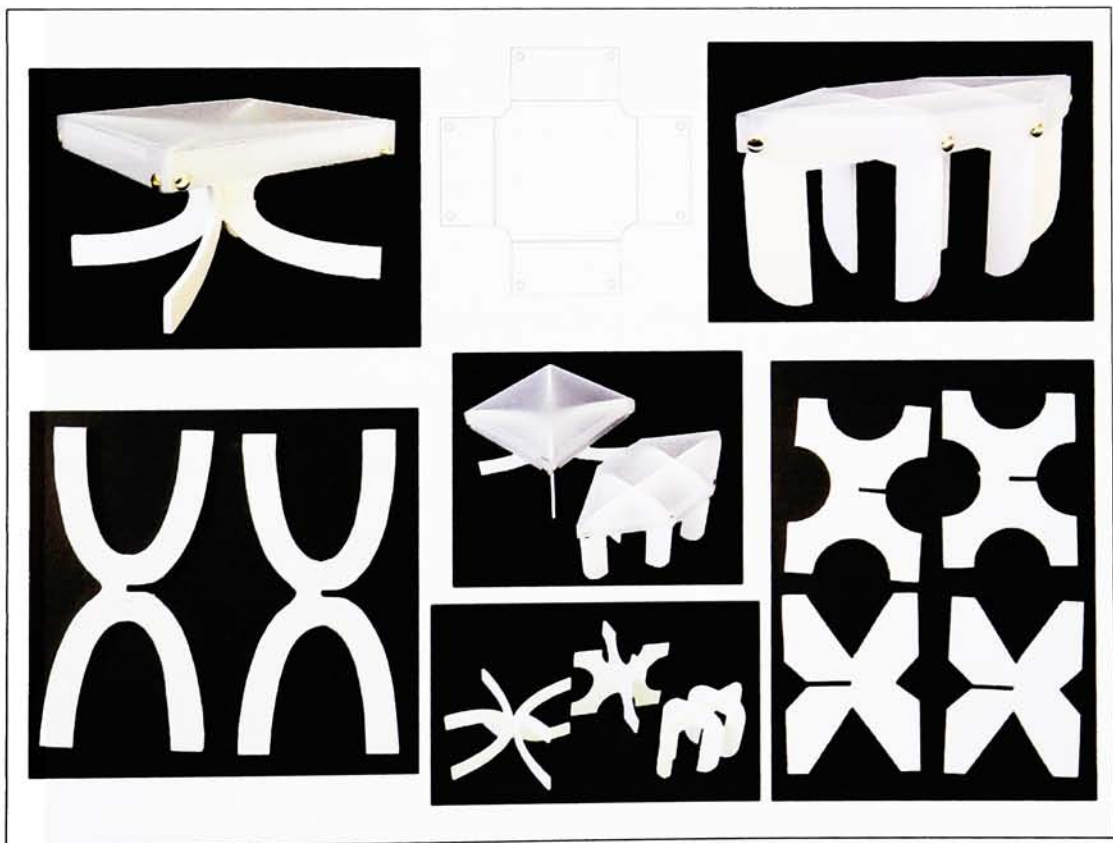


Figure 23. 1/4 size 3D sketches I

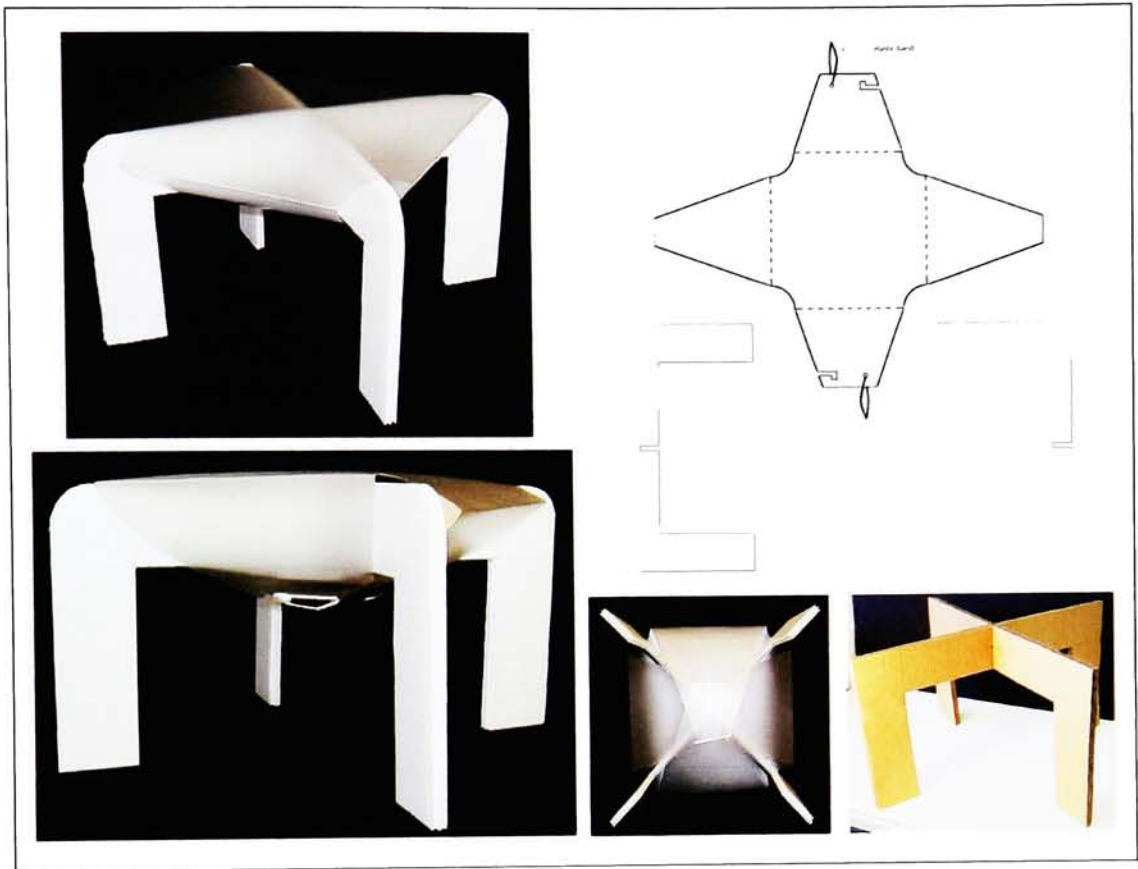


Figure 24. 1/4 size 3D sketches II

While I was developing ideas by making 1/4 size 3D sketching, I discovered that weight became an issue. In order to reduce the weight, I had to use as little Baltic birch as possible, yet still have it be strong enough for the table legs. I used the 1/16 thickness translucent polypropylene sheet to wrap around the table to create the figurative sense of a tablecloth (see figure 24).

I sketched and made 1/2 size 3D sketches to develop the concept of using the translucent polypropylene sheet for the table top (see figure 26). I had to figure out how to fasten the polypropylene sheet to the table legs in order to wrap the translucent polypropylene sheet over the table leg. One of the ideas was to use elastic bands fastened underneath the table. Another idea was to make slits and hook the sheets together. I also studied how slot joints can make a strong construction for the table legs. The pictures below show five sets of slot joints for the table legs (see figure 25).

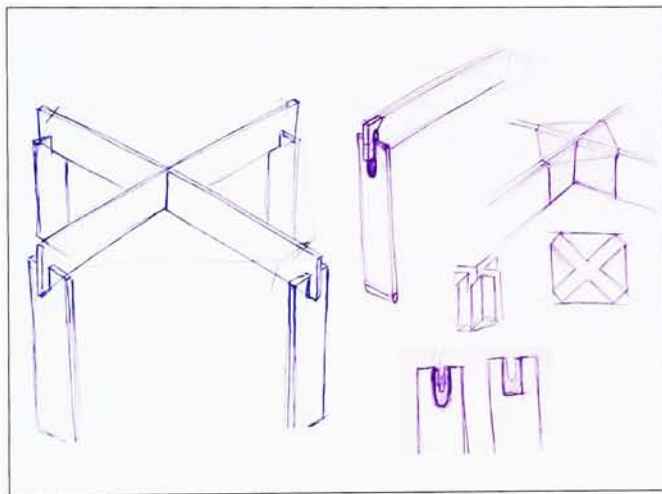


Figure 25. Sketches of slot joints



Figure 26. 1/2 size 3D sketches

I made a full-scale prototype to study the stability and durability of the table legs. The strength of the legs became an issue. Since I was using the minimum size of plywood, the legs were thin and long, so the five slot joints were not strong and were not able to make the secure joints (see figure 27). I had to redesign the joints of the legs for better stability, eliminating the idea of using the slot joint (see figure 28).



Figure 27. Full scale mock-up with wood and cardboard

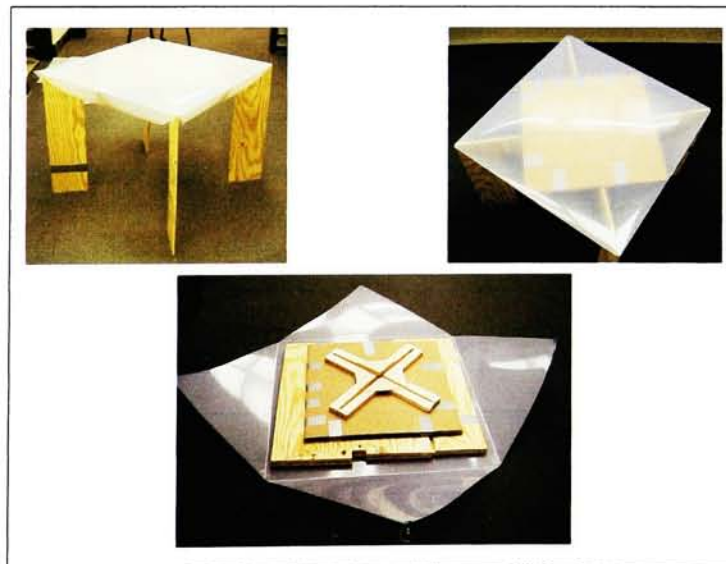


Figure 28. Full scale mock-up with plywood and polypropylene

Quarter inch thick legs were wobbly and not sturdy enough to support the whole table (more details of the scale, see figure 30). I had to solve the problem of this weakness of the table legs, yet not increase the thickness of the plywood or the weight. By using the same thickness of plywood, 1/4 inch, I was able to redesign the legs by laminating five panels of minimum thickness plywood, making the legs stronger and thicker (see figure 31). There are two variations of the design and I decided to use the second one (see figure 32).

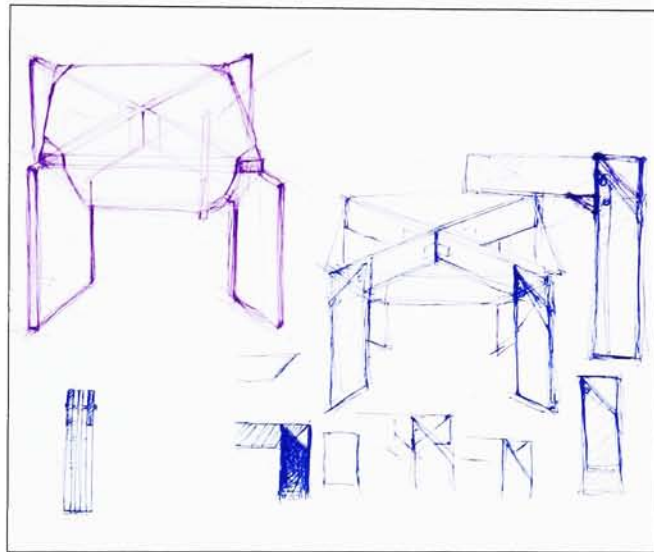


Figure 29. Sketches of the table legs

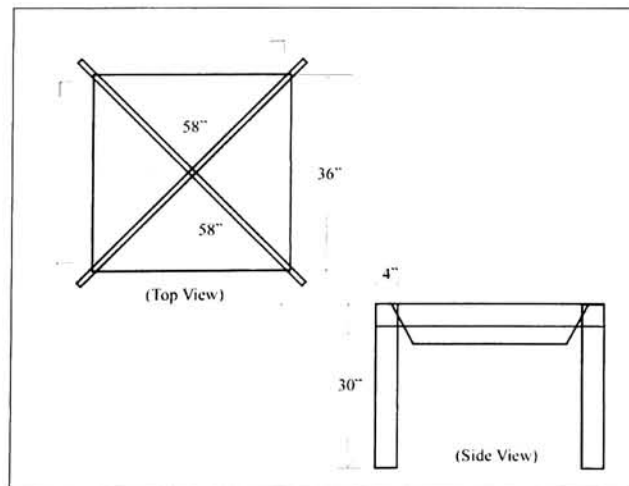


Figure 30. Technical drawing of the table

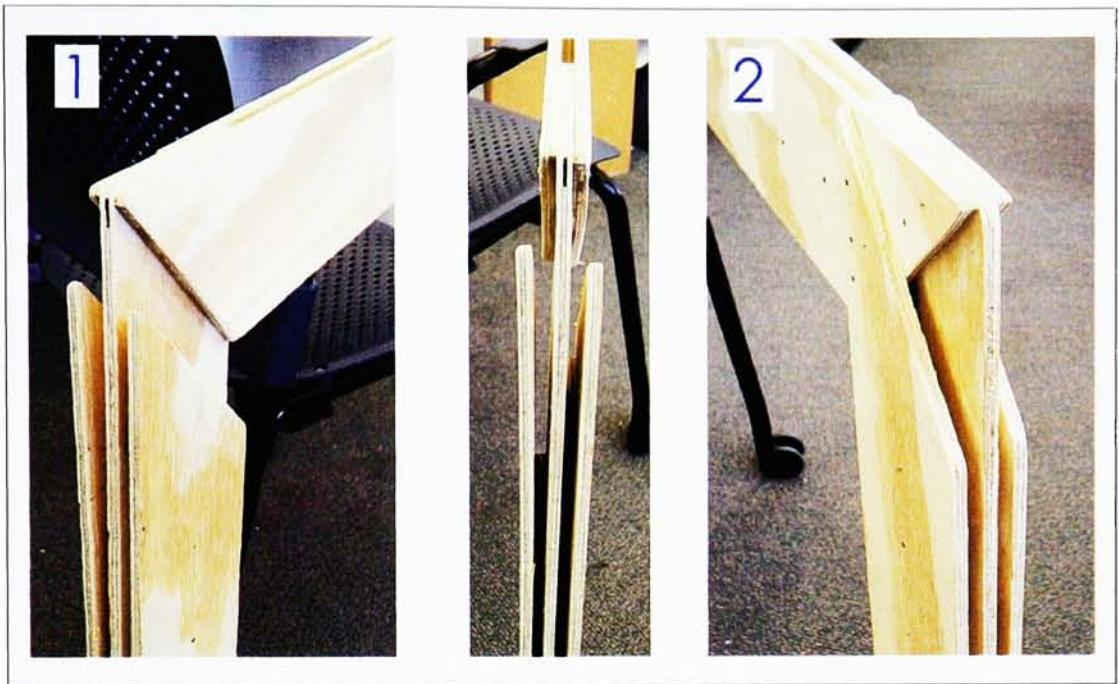


Figure 31. Full scale prototypes: laminations of five layers of plywood



Figure 32. Close-up look of the final model

These are the instructions for the collapsible table (see figure 33). There are five steps to building the table with minimum screws and no tools. A single person can assemble it easily.

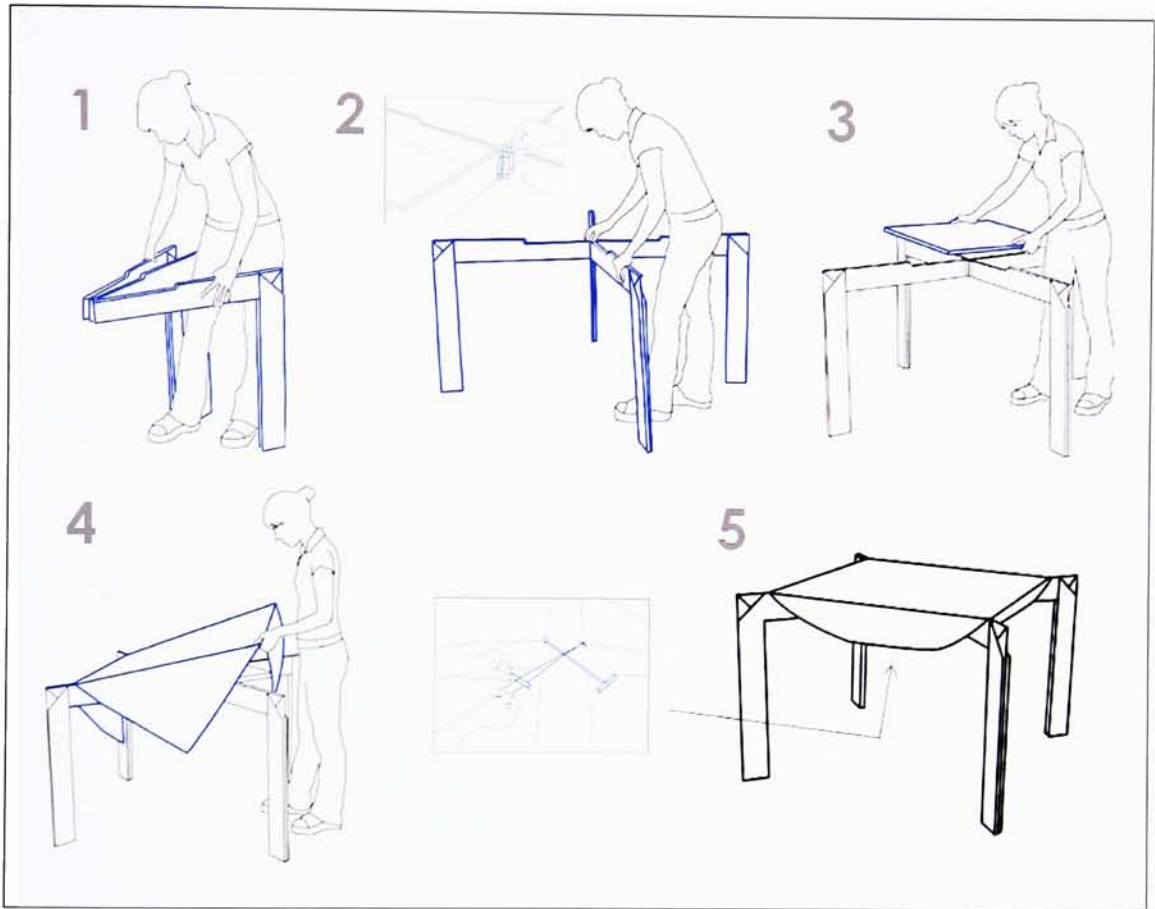


Figure 33. Instructions

- 1) Three table legs are already one unit. Open the legs to attach the fourth leg.
- 2) Attach the fourth leg to table unit with two screws inserted manually.
- 3) Place the translucent honeycomb panel in the center of the table.
- 4) Cover the top of the honeycomb panel with the translucent polypropylene sheet.
- 5) Fasten the translucent polypropylene sheet with the elastic bands.

For storage, it can be collapsed flat and the polypropylene sheet used for the table top can be wrapped around the rest of the parts like an envelope (see figure 34).

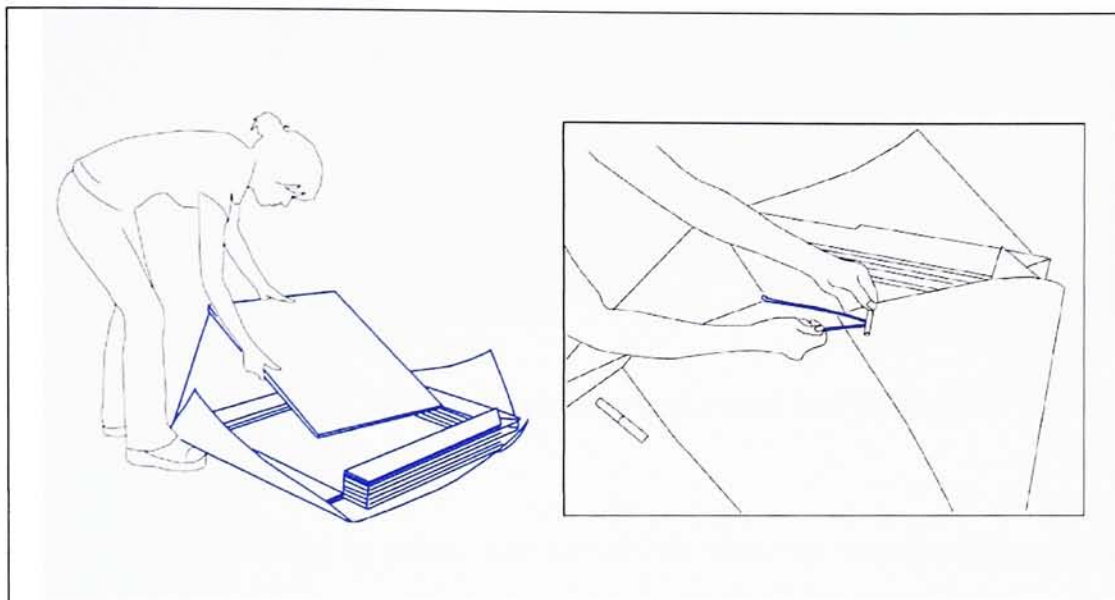


Figure 34. Instructions for storing the table



Figure 35. Full-scale mock-up of the table and the chair

I tested the design by putting the chair and the table next to each other as a set to see if the scale of the table and of the chair would be compatible (see figure 35). The geometric shapes of the plywood legs of the table and organic shapes of the plywood legs of the chair create an elegant contrast (see figure 36).



Figure 36. The final models as a set



Figure 37. The final model of the table

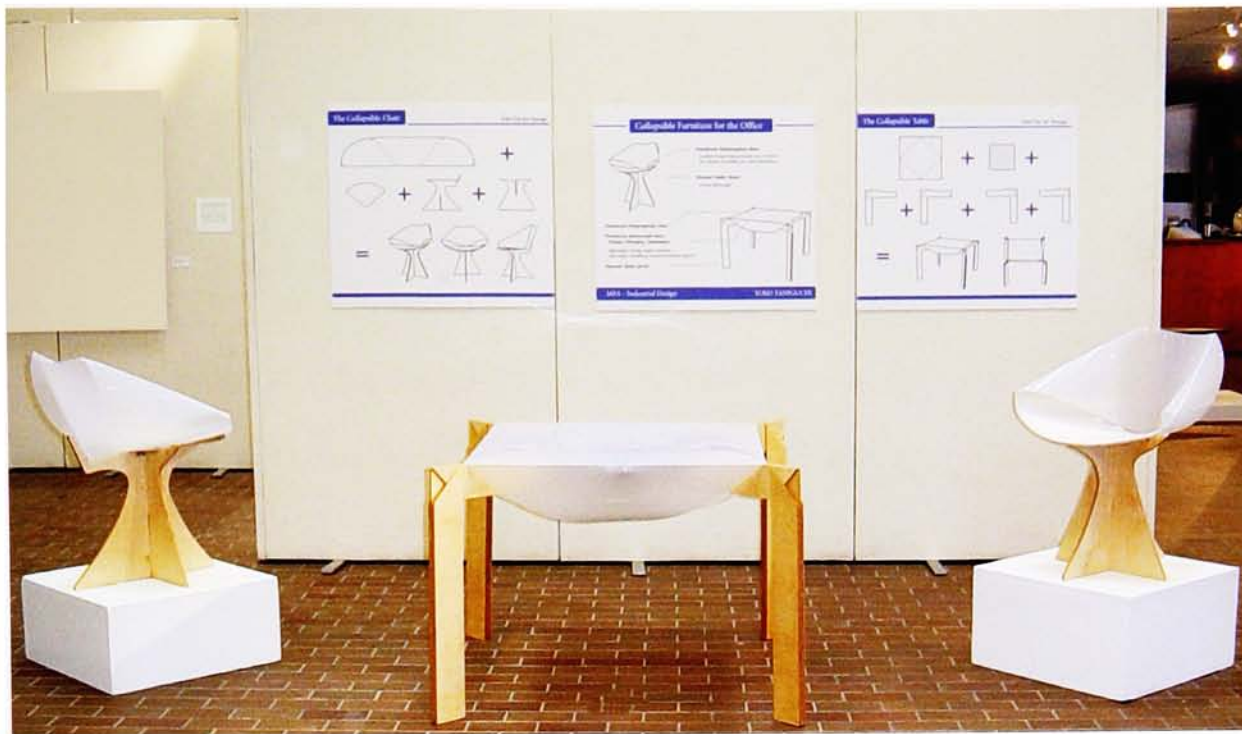


Figure 38. The graduate thesis show at Bevier gallery

Conclusion

One difficult task that I had to research and solve was that of the joints and hinges for both the chair and the table to simplify the furniture, making it user friendly. To minimize the use of joints and hinges, using a slot joint for the chair was successful. However, I wasn't able to apply a slot joint for the table legs, because of the scale of the table. Its size required multiple slots, but those same slots compromised the stability of the table. I had to use screws and hinges for the table.

The storing of the table was successful, the way the polypropylene sheet becomes the envelope case for the table legs and frame and becomes one unit to store. On the other hand, I still need to develop an idea for how can I make the chair collapse and store as one unit. I need to work on different ways to make living-hinges for the polypropylene sheet, so that the polypropylene sheet can become the storage case for the legs of the chair when it is disassembled and therefore be stored compactly.

I received many responses and comments about my collapsible furniture from students while I was building the models in the studio, and also from the public after I exhibited my work at the graduate thesis show at Bevier Gallery (see figure 38). The most common question was whether this furniture is strong enough for the office. My answer was "Yes." Most people still have the mindset of office furniture that has to be set-up in the room permanently. I want people to know that we don't have to work at the office all day. The collapsible furniture that I made is strong and comfortable enough to

use for temporary settings. I wanted to provide an alternative environment in the office, where workers are able to rearrange the office easily or relocate themselves efficiently.

One of the common responses that I had from people after I let them sit on the chair was how comfortable the chair was. The collapsible chair and table might intimidate people when they first see it, but afterwards, they will realize how comfortable the furniture is. I designed this furniture for the office, but there are many applications for this furniture unit. It can be used at home or outdoors.

The contemporary work style keeps changing rapidly every day. More than ever, we are aware of good design that will improve our quality of life. I will keep researching our changing lifestyle so I can design furniture that will improve our lives.

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