

# Designing and Fabricating a Chair as a Conceptual Model for Architectural Design

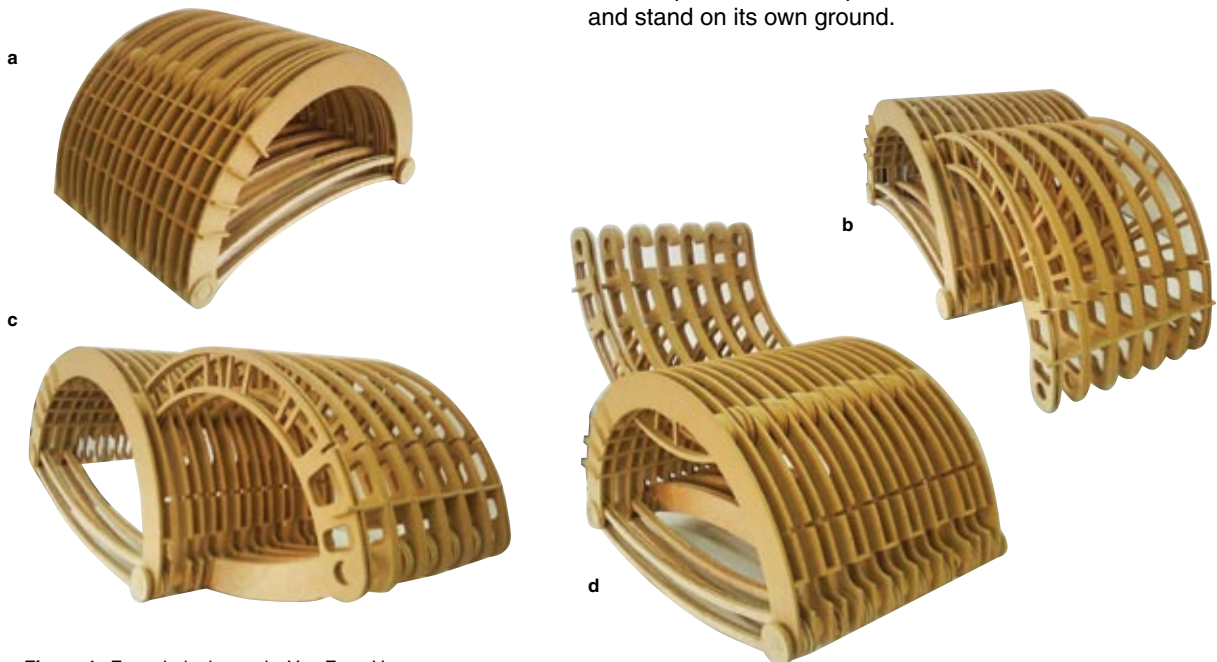
by **Chen-Cheng Chen**

Design Studio EA408 is one out of nine studios in the Department of Architecture at Tamkang University. These nine studios work individually and each studio, with approximately seven or eight senior students, has its own assignment to complete. The objective of the EA408 studio is to enable each student to create his/her own designs using 3D computer tools. In addition, our aim is that EA408 students learn to use CAD/CAM software to effectively transform their thoughts into actual designs. The studio mainly uses **form•Z** as its software. Most of the students already know how to use AutoCAD and fundamental 3D computer graphic functions before they enter the program. This article is a presentation of design work completed in the EA408 studio in the spring of 2008.

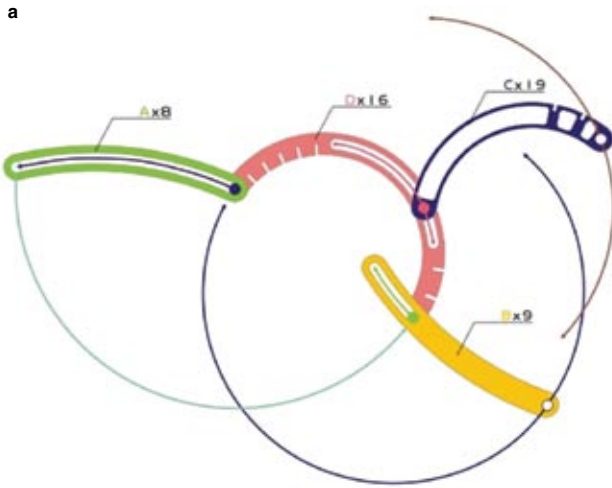
## First Stage Design Description

The studio's program began in the spring. Drawing inspiration from Taiwan's Arbor Day, we suggested that students choose one kind of plant to raise, and we were hoping that the plant would grow with them and their design projects. Perhaps they could even find similarities between their plants and their projects.

The first assignment was to design a "transformable" chair in eight weeks. We were looking for a design that might reflect the plant that each student was raising and we also required that the "transformable" chair could actually be manufactured. They had to use plywood as material. The "transformable" chair was originally virtual, designed on the computer, but we expected the chair to be made real and stand on its own ground.

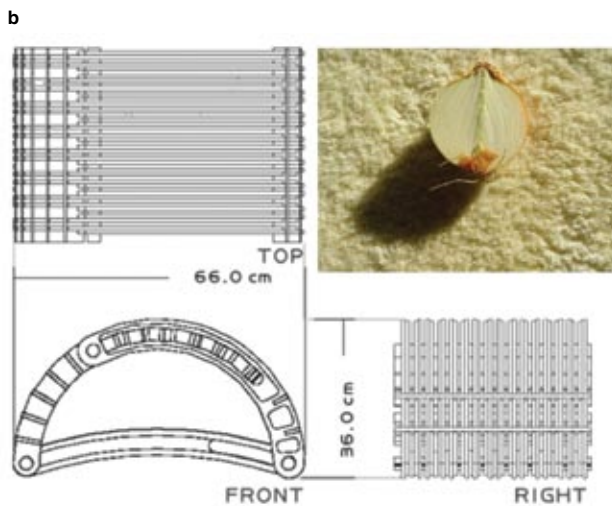


**Figure 1:** Four chairs in one by Yun-Fang Huang: (a) chair for one, (b) chair for two, (c) rocking chair for two, (d) rocking chair for one with a back rest.

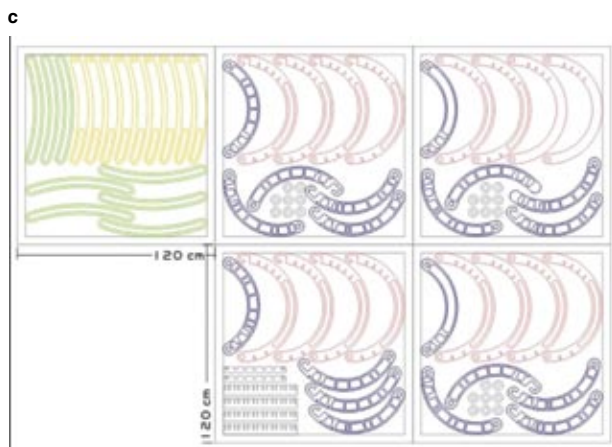


## Four Chairs in One

From the beginning, Ms. Yun-Fang Huang, the designer of “Four Chairs in One”, planned to make a long folding chair, but the plant she had chosen to grow, an onion (Figure 2b), influenced the design in a different direction. She changed the shape of the chair, using characteristics of the onion, specifically its round shape and the shape of its slices. The design began as a chair for one (Figure 1a), but gradually additional folding possibilities were developed, which led to additional types of chairs, namely, a chair for two (Figure 1b), a rocking chair for two (Figure 1c), and a rocking chair for one with a back rest (Figure 1d). So, altogether, there were four distinct possibilities. Because of this, each section of the chair became crucial to the overall design. The designer spent many hours graphically exploring the chair, as seen in Figure 2a. She then changed the size of the chair many times until the final design was completed, as shown in elevation in Figure 2b.



In order to produce the layout seen in Figure 2c, we used the Unfold function of **form•Z**. We laid out the chair onto the XY plane of the modeling environment and we then transferred it into the 2D drafting environment of **form•Z**, where we completed the connections and joints. The design had more than 82 parts, which required five 120 cm<sup>2</sup> plywood boards (6mm thick) to manufacture them. To save material, we layed them out close together, which was done manually. These five layouts also allowed the milling machine to work more efficiently (Figure 2d). As we reached the final stages of our production, we realized that the chair was heavier than what we had originally anticipated. While we concluded that some parts could be eliminated, we did not do it because we were out of time.



**Figure 2:** Four chairs in one drawings and construction by Yun-Fang Huang: (a) sections study, (b) section of onion and elevations of chair, (c) layout for fabrication, (d) the parts under milling.



Figure 3: Ciliate desert-grass.

## One or Three Chairs

Mr. Cheng-Yuan Huang, the designer of this project, borrowed his title and inspiration from American artist Joseph Kosuth. In addition, the long legs of his chair reflect an influence by the plants he had chosen (ciliate desert-grass, Figure 3). First, he modeled a long-legged chair in **form•Z** and then he used the “lightning” function to project a shadow onto the ground. He traced the edges of the shadow and derived a basic line, which he then used to produce the lower chair in **form•Z**. The third chair was made by the shadows of the first and second chairs. Therefore, the design is titled, “One or Three Chairs” (Figure 5).



Figure 4: Sketches of chair design by Cheng-Yuan Huang.

Next we had to figure out how to actually make the first and the second chairs. The preliminary design did not include all the details of the chair, so we had to think through carefully about the connections, joints, and bearings, before we could move to the production phase (Figure 6). We were able to set up three axes appropriate for manufacturing the 3-dimensional shapes. However, because of time limitations, students had only learned how to use flat cutting, which is what the chair was designed for.

The project had more than 300 pieces (Figure 7). We used six 120 cm<sup>2</sup> plywood boards of 3mm and 6mm thickness, which complicated the project further. At this time we had to redesign the details, using computer software, pretty much as we did during the preliminary stages. We had to redesign some of the parts and re-cut them to fit our initial design. The finished chairs (Figure 8) appear to be hand made, thanks to all the details that we worked out. However, presently, the chair is not strong enough for somebody to sit on. Thus we think that steel will be the perfect material to manufacture it with in the future. We shall be able to do it using the same designs we already have.

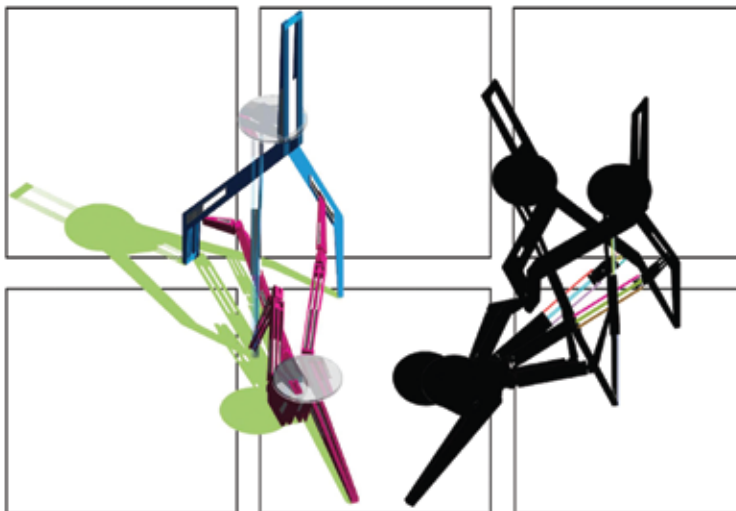


Figure 5: Chair shadow study by Cheng-Yuan Huang.

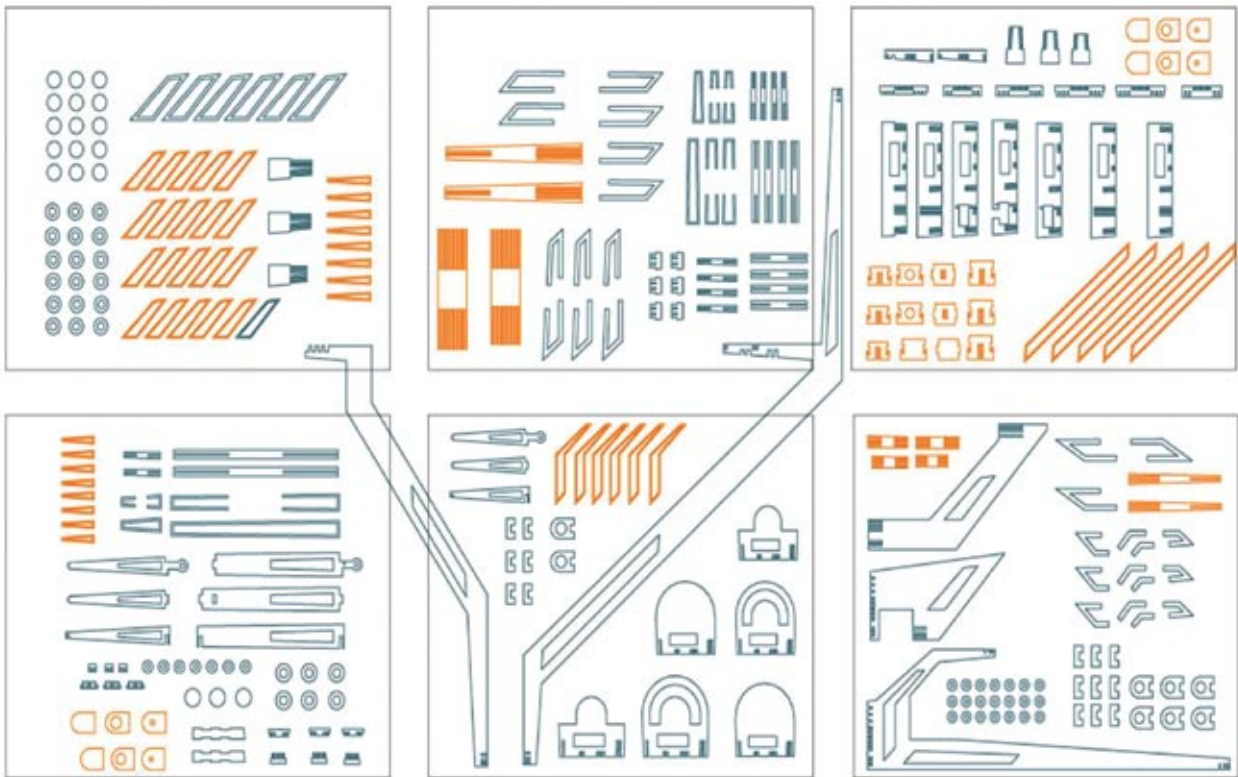


Figure 6: Layout for fabrication by Cheng-Yuan Huang.



Figure 7: Parts.

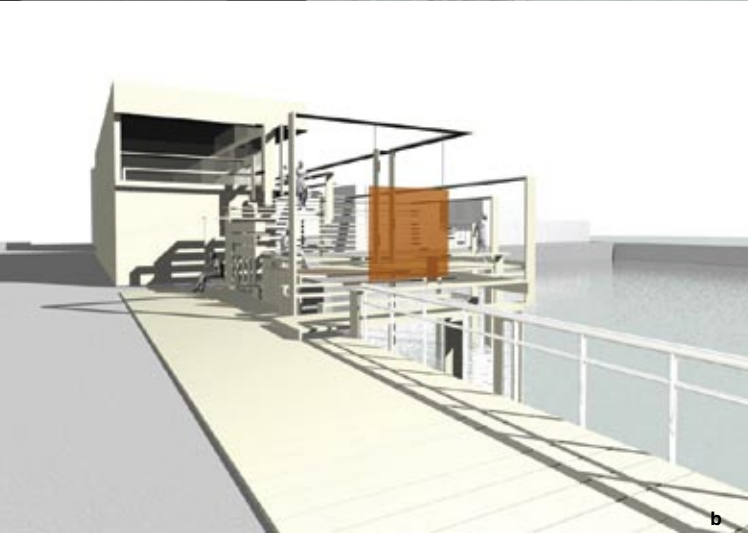


Figure 8: Finished product by Cheng-Yuan Huang.



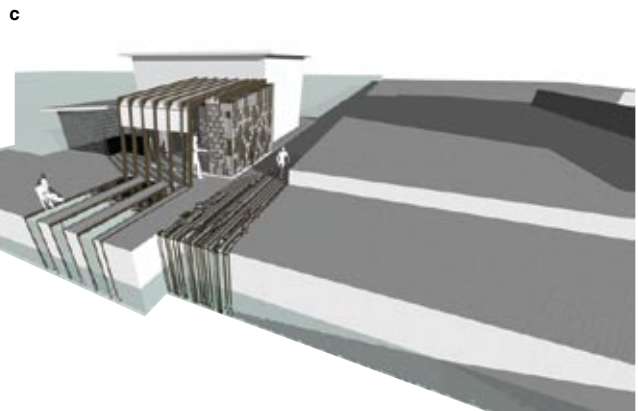
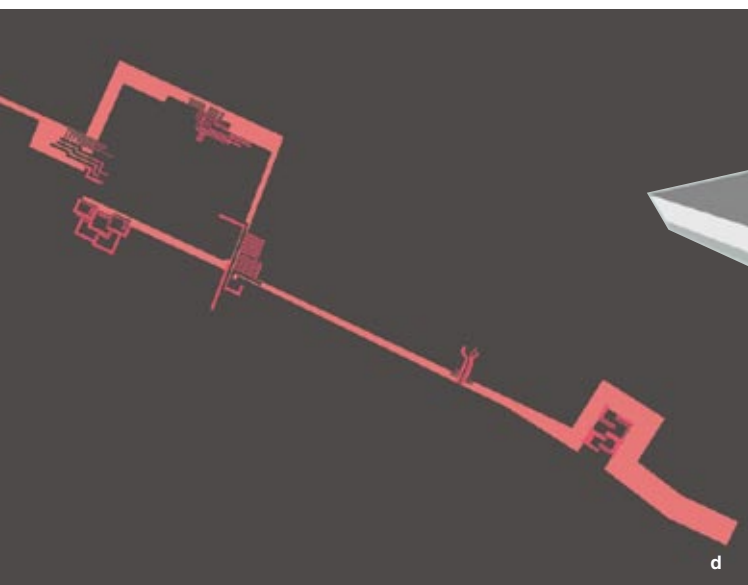
## Second Stage Design Description

After completing the chairs, the students had a week break from design, during mid-term exams. For the second stage of their studio, they had to choose a site and design six separate buildings (one large, two medium, and three small), trying to recognize the differences and the relationships between these six buildings and the site. We mainly used **form•Z** in order to quickly draft designs and this way we trained the students to think literally within the software. We also recommended that students use lessons learned from their chair designs in this second stage, which took about seven weeks to complete.



## Innovation of Tamsui Waterfront

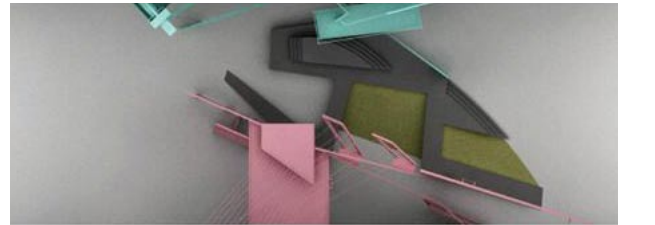
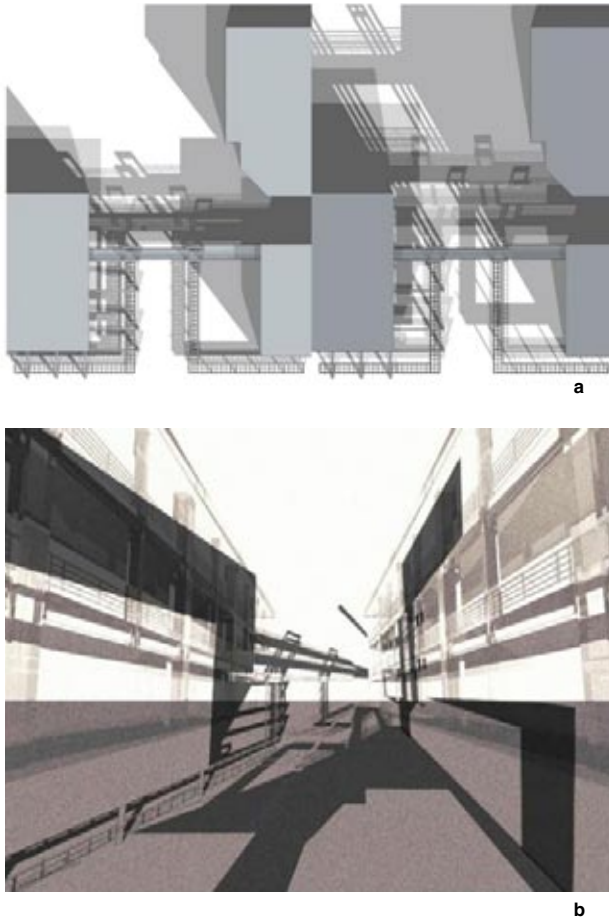
Student Yun-Fang Huang, who designed “Four Chairs in One”, chose a site in Tamsui, Taipei County, located in northern Taiwan. She observed that, once the MRT connected Taipei to Tamsui, people flooded to this town, but visitors did not stay for the views. She wanted to design something that could keep the visitors coming to this town and hopefully show them what makes it special. In this case, she picked six interesting sites and redesigned a little park, an observatory (Figure 9a), a fishing wharf office (Figure 9b), a wharf, a coffee shop, and a post card shop (Figure 9c). She started with the diagrams of these six different sites, using the same inspiration she had for her chair design, a slice of an onion (Figure 9d). Looking at this diagram, we can’t help but think of Christopher Alexander’s “condensed graphic form” in “Notes on the Synthesis of Form” [Alexander 1964]. She continued with her sliced design as she completed her project.



**Figure 9:** Innovation of Tamsui Waterfront by Yun-Fang Huang:  
**(a)** Observatory  
**(b)** Wharf office  
**(c)** Postcard shop  
**(d)** Diagram.

## Hsin-Yi Square Design

Student Cheng-Yuan Huang, who designed “One or Three Chairs,” picked the newly developed Hsin-Yi business square as his site, which still has many large empty spots. He created the building mass of the department stores around this area in **form•Z**. He used the same method as in his chairs project. He projected the shadows of these buildings at 3 pm on the spring equinox, the summer solstice, the autumnal equinox, and the winter solstice (Figure 10a). The edge of the shadows became the basic outline of his design. He worked hard on the plan, elevation, and section of his design (Figure 10c). He designed a passenger bridge, resting booth, outdoor theater, sitting area, display area, and garden (Figures 10b and 11). He used **form•Z** and designed his spaces applying a constructivist’s approach. With his project, he hoped to show the relationship between light and shadow in what was previously a homogeneous place.



**Figure 10:** Hsin-Yi Square Design by Cheng-Yuan Huang: (a) (b) (c) shadow studies, (d) site plan, (e) section, (f) elevations.

## Conclusion

This semester, we found the students' thought processes during the development of their designs quite interesting. They used different methods to solve critical design problems and they also resorted to different techniques for absorbing the concepts we taught them. At the end of the semester, the members of the jury were appreciative of the final results. However, we still have some issues that remain unresolved. For example, "Four Chairs in One" was too heavy when it was finally manufactured, because weight was not taken into account when it was designed on the computer. Also, "Three Chairs in One" was too fragile to be usable. These unanticipated problems remind us of a quote from Mr. Buckminster Fuller: "How much does your building weigh?" We need to keep in mind that students are always trying to come up with cutting-edge designs and when these designs turn out to be repeating designs that are already familiar to more experienced designers, they are very disappointed.

In our program, the content of the first stage design is directly affected by the second stage design. Consequently, it is especially important for a teacher to be thinking about the first stage design in terms of where it might lead with respect to the second stage design. In addition, the second stage design had a shorter production period than the first stage, and the design projects of the second stage were a bit more complicated for the students. Overall, these senior architecture students had an opportunity to learn different aspects of CAD/CAM and to use the friendly interface of **form•Z**. Thus they managed to operate the software effectively and to complete their designs in sixteen weeks (meeting twice a week, three hours a day).

## References

1. Alexander, Christopher, "Notes on the Synthesis of Form", Harvard University Press, Cambridge, MA, 1964.
2. Chen, Chen-Cheng, "Experiencing **form•Z** in TKU-EA408 Studio" in **form•Z** 2003-04 Joint Study Report, P74-77, AutoDesSys Inc., Columbus, OH, 2004.



**Figure 11:** Hsin-Yi Square Design by Cheng-Yuan Huang: perspectives of the square.



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