Cardboard Chair Challenge

by
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Introduction

"Create a chair that can hold the weight of an adult using only cardboard. No glue. No tape. Just cardboard."

"What? Are you kidding me Miss Kleekamp? That won't work!"

"Oh yes it will. Students at MIT did it and so can you."

"No way- I'm no MIT student! I'm a freshman in high school!"

"Don 'worry- I *know* you can do this. I wouldn't give it to you if I didn't see success. I'm gonna break the project into small steps and I promise you if you follow them- you *will* be able to do this. Oh, and by the way, your chairs need to hold the weight- because you'll have to sit in them at the final presentation if you want to pass."

At this point…the room grew quiet. I could tell a few student has wished they signed up for Choir instead of Art I.

This is how Art I students started the school year at the Liberal Arts and Science Academy in Austin, Texas. Working in teams of 3, they were challenged to design a full scale chair that could hold the weight of an adult using only cardboard. No adhesives of any kind were used- students relied on their knowledge of geometry and support structures to build their chairs. This project lasted 2 months and consisted of several steps. Students studied famous industrial designers and architects including Charles and Rae Eames, Frank Gehry and the Bauhuas School. We took field trips to Design Within Reach and an industrial design firm to learn about ergonomics and aesthetics. We built scale models, drew patterns and then began final construction. Professional architects and industrial designers attended our final presentations to give advice and encouragement. Although at first this project was difficult for many- by the final 2 weeks of construction the energy was phenomenal. I had students staying after school every day until 7pm to finish their chairs. For the final presentations, we displayed the chairs in the hallways. The entire school came to view the chairs and everyone was talking about them.

As well they should be. This project is traditionally a college-level assignment. Freshman at MIT's School of Engineering, Carnegie Mellon's School of Architecture, and RISD's School of Design (to name just a few) have pulled all nighters constructing their cardboard chairs. This project is so famous, that it has become a rite of passage at these institutions. However, high schools in disadvantaged parts of NYC have also assigned this project to their students with astounding results. I believe the secret to success is to set expectations very high. The clearer you can be in demonstrating proper construction and aesthetic standards to your students, the better the results will be.

Although some may see the cardboard chair project as an unorthodox "Art I" curriculum, I choose to start the year off with it because I wanted to encourage the students who were afraid of drawing. Don't we all

have the students who only take Art I because it is required to graduate? I had many students who felt they were "terrible" in art, and besides "art is not practical." But because this project is so interdisciplinary, it is a great way for students to learn how art is integrated into every aspect of our lives. Creating models in 3-D as opposed to drawing often helps those who are afraid of drawing to come out of their shell.

What is my favorite memory of this project? In September, five students (who later created some of the top chairs in the class) told me "I hate art because I am terrible at it." They now see otherwise. They are incredibly talented- and are all applying to college for either architecture or industrial design. I could not be prouder to have helped someone raise their self esteem and realize how gifted they truly are. Because this project is hard, there is more opportunity for praise compliments and a chance for students to build their self esteem. In the end, that is what this project is all about.

I wish you the very best with this project and wish I could supply you with all the accompanying Powerpoints, image files, and examples. Sadly, the day after Christmas my house was broken into and my computer, back up flash drives and school laptop were all stolen- I lost every lesson plan I ever created. Although I cannot pass on my digital files to you I am more than happy to answer any questions. Please contact me at
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Liz Kleekamp
Art Teacher

Cardboard Chair Lesson Plan

Objective:

- Design and build an aesthetically pleasing and original chair built entirely of cardboard using no glue or adhesives of any kind
- Chair must be at least 17" off the ground
- Chair must have a backrest (aka- no benches or stools)
- Chair must successfully hold the weight of an adult – approx 120lbs.

Goals:

- Design an aesthetically pleasing chair demonstrating mastery of the Design Principles/Elements and the concept of Form Follows Function
- Design a comfortable chair for a specific user demonstrating mastery of ergonomics
- Design a successful support structure demonstrating mastery of physics and engineering skills
- Understand the significance of industrial design in the 20th century

Time required for project:

Approximately 65 hours or 1 full semester

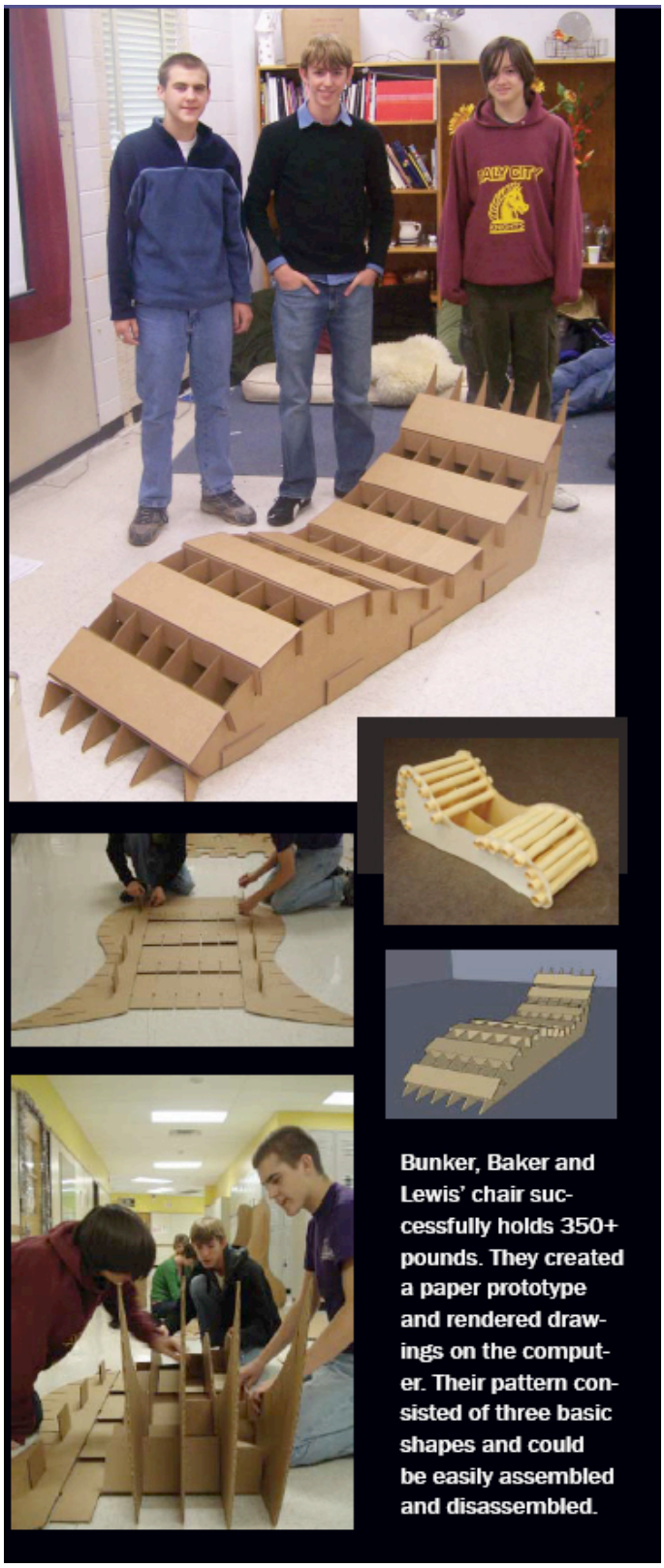
Materials:

For *Prototypes*:

- Several pieces of tag board
- Scissors

For *Construction Techniques* exercises:

- Scrap pieces of single ply cardboard- can use old boxes
- utility knifes
- extra blades



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Cardboard Chair Lesson Plan 2008

- screwdrivers to replace blades
- 12 & 18" Metal rulers with cork backing (to prevent skidding)

For *Scale Model*:

- Chip board
- utility knifes
- extra blades
- screwdrivers to replace blades
- 12" & 18" Metal rulers with cork backing
- transparencies & pen
- overhead projector

For *Final Chair*:

- 4 sheets of 48" x 96" **DOUBLE** corrugated cardboard (per chair). New cardboard is strongly recommended. If you use old boxes, the chairs will not be as strong or as aesthetically clean.
  Important Note: *Many teachers choose single ply cardboard. This will be cheaper and easier for your students to cut. However, I chose to buy double ply cardboard as it yields stronger chairs therefore allowing more elaborate designs.*
  Also, you will need significant storage for this project as the cardboard sheets alone will take up almost 8 x 18 feet of space. When the chairs are being constructed- you will need an empty room to store these in as well.
- 24" Metal rulers with cork backing
- 48" Metal rulers with cork backing

Resources:

1. Google Video/ Utube: "carboard chair" Show your students clips of chair critiques from high schools and universities to professionals. They are exciting and will help your students better understand what the level of your expectations are. For example:

- Chishen Chiu, a young designer based in Miao Li, Taiwan has "flexible love seat" that is amazing: http://video.google.com/videosearch?hl=en&rls=WZPA,WZPA:2006-09,WZPA:en&q=cardboard%20chair&um=1&ie=UTF-8&resnum=7&sa=N&tab=wv#q=cardboard%20chair%20folding&hl=en&emb=0
- 
- http://www.youtube.com/watch?v=7i4ZVk5EbLM

2. Google Web: "cardboard chair" and/or **"cardboard furuture"**
There are many professional designers that sell cardboard products, especially in this day and age of environmental concern.

- **http://www.cardboardesign.com/**
- **http://www.leokempf.com/cardboard.html**
- **http://www.designboom.com/cardboard3.html**

3. Google Image: "Cardboard Chair" Print out tons of examples and post them around the room for your students to get ideas. Talk about these chairs and their users.

- Frank Gehry Chair is a great one to include if you would like to have more of an architecture focus

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4. Ed Goldman
Ed Goldman from Brooklyn Technical High School is the king of the cardboard chair project. He has many online videos that show clips of his classes at every stage. I regret to say the website I had of his information has changed addresses, but if you can locate them- they will be invaluable to you and your students. This is all I was able to find.
http://www.tiesmagazine.org/archives/sep_2002/pdf/sep_2002_ChairDesign.pdf.

Assessment:

This project is broken down into at least 9 steps. It is necessary for the teacher to assess the student's progress at every step to ensure students success. If the student does not meet with at least 80% success, they must re-do that step of the project. Its almost like a math class- you have to understand addition before you can attempt algebra.

Please see the ***Deliverable Checklist*** for a more thorough description of what is expected from students at each step.

For the final critique, students were asked to present their chair to the class with a powerpoint presentation that proved their synthesis of information. Both the chair and this presentation were graded. See the ***Chair Rubric*** and ***Presentation Rubric*** for more details.

Community Involvement:

Students relax in chairs at Design Within Reach. We learned about the Bauhaus, Charles Eames, and many other modern architects and designers who created chairs in the 20th century.

Below that, Hayes Urban, Senior Industrial Designer at Design Edge gives LASA students a tour of his company and explains more about the profession of industrial design.

Local professionals, parents and the store Design within Reach were invaluable to the students for this project. They provided breaks throughout the project to give students a much needed breather. It also helped "send the message home" for students to hear about the design process or history from a source other than their teacher.

Here are some ideas:

Invite an architect to class: I invited 6 different architects (several who were parents) to attend our final critique and help question the students about their work. The architects also stopped by the classroom periodically to help the students with their chairs.

Take a field trip to an industrial design company. Austin has many, wonderful industrial design firms. Call an agency to see if they would be willing to give students a tour. Even better, have your students bring their scale models so they can be critiqued by the professionals and get some free advice!

Visit chair stores so students can study chair designs in person. Have you or your students ever sat in an Aeron Chair or Eames chair? There's no better way to learn about ergonomics than in person. This field trip is also a great reward for students after they have learned about industrial design of the 20th century.

Safety:

This project uses utility knives which can very dangerous. Take ALL precautions:

- Demonstrate to students how to correctly use (and not use) a utility knife. See ***Knife Safety Sheet*** for more details.
- Demonstrate how to change a blade and how to properly dispose of them (put them in a glass container)
- Demonstrate how to store knife when not in use (always close them)
- Have your students and their parents sign a letter saying they have read and understand all safety directions.
- Create a "safety test" and do not allow students to use utility knife until they pass with 100%
- Clear all safety procedures with your principal
- Use metal rulers with CORK backing. If you can't afford them – buy some 1/8" cork in sheets at a craft store and glue it to the back of metal rulers with E3000 glue. Without the cork, rulers will slide, and students will be more likely to cut themselves.

Step 1: Introduction

Objectives:

- **Understand the Design Process**
- **Understand project deliverables and grading for the entire project**

Materials:

- Utube videos of cardboard chairs (see Resources Section on Page 5)
- PPT Images of other cardboard chairs
- Chair ***Deliverable Checklist***

Procedures:

- Introduce project goals and objectives

- Show students (UTUBE) videos and photographs of cardboard chairs from various universities, high schools and professionals.

- Discuss the difference between "poor" results and "good" results. Students find examples of poor/good craftsmanship, aesthetics, support systems, etc. Have students pinpoint WHY certain chairs are "cool" and why others are not. Make a list on the board for all to see

- Give students an overview of all the "steps" for the project so they know what to expect. Explain grading for each step. ***See Deliverable Checklist.***

- Explain the Design Process to the students. ***See the Design Process Handout***.

    a. Define the problem

    b. Research

    c. Brainstorm

    d. Test and evaluate

    e. Build

    f. Re-evaluate

    In professional design companies, the "research" phase is the most important step and takes the most time. This project is the same way. Students will say, "Let's just get started. Just give me the cardboard already!" I found that skipping the research will more often than not, doom the final construction. If you tell the students up front about the Design Process and why all these steps are useful, they will be more patient for the "Build" phase- which is invariably everyone's favorite.

I enlarged and printed the "***the Design Process***" handout to 5 feet and posted it in the room for the entire project. At the very beginning of every class, I would walk over to the poster and point to which step in the process we were on. This helped alleviate anxiety and the question, "What are we doing today?"

Step 2: Aesthetics and Marketability

What makes a chair visually attractive? What makes a chair desirable and novel?

Objectives:

- Understand the word "aesthetic"
- Analyze the design elements (shape, form, texture, color) in famous chairs (to help later apply toward the cardboard chair design)
- Answer "what makes a shape original?"

Materials:

- Xacto knives
- extra blades
- Eraser
- Pencils
- Construction paper
- 18 x 24 newsprint
- Tape

Introduction:

At the beginning, of this class, I place a picture on the front board that looks like this:

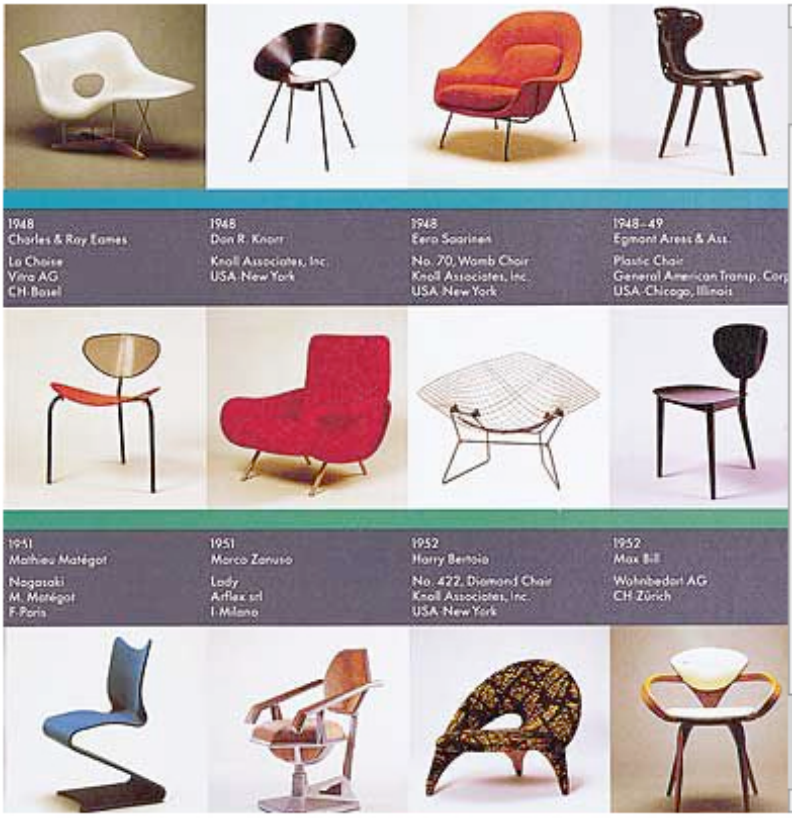
"This is what most people thing of when they think of a chair. Right? Four legs, and a back. But this is so boring. This is the lamest chair in the world. There is nothing attractive about it. Functional, yes. But attractive no. If you build a chair like this- you'll fail this project."

Groans and moans quickly erupt. "But that was my idea!" "No way- that's not fair."

"Okay, calm down" I say, "let me explain why this won't work….first of all, you can't use glue, and this chair uses glue. Second, one of the MAJOR goals of this project is aesthetics- what makes a chair visually attractive? How creative can you be? How original can you be? How can your chair stand out from the crowd. This chair does not stand out from the crowd."

I then led the class in a discussion about the design elements and conducted an activity for them to focus on **SHAPE.**

I had a box of about 60 famous chairs from design history. Each one very unique in shape. I tried to use photos of chairs that were of ¾ angles. I cut many chairs out of architecture magazines, furniture catalogs and printed others from the internet. For example:



Procedure:

Each team of three students needed to complete the following project:

- Choose three chairs
- Take a 18 x 24 piece of newsprint and fold into 16 squares.
- On the top row tape each chair
- On the left column write the following .
    - Chair
    - shape
    - user & purpose
    - why is it desirable? Why is shape unique?

See example below:

Chair			
Shape			
User & Purpose	anyone. to rock. leisure, talking, watching	adult. Office or computer work.	adult. leisure. Watching tv.
Why is it desireable? Why is shape unique?	bright color. Novel idea. big top, skinny legs.	extremely comfortable. adjustable.	lots of individual pads. Curves to spine.

Student should **draw** the shape of their chair on construction paper. (This ensures no one traces.) After they draw their chair, I have students CUT OUT their drawings with xacto knives. This helps them see the shape. I find that students rarely think in shape. If left on their own, they will hurry and just draw lines- not the shape. See below.

What I usually get when I ask students to draw the "shape" of a chair. Sloppy, rushed and only lines.

I am aiming for this. Clear, consise shapes. So I ask students to **cut out** their chair with an xacto knife after they drew it. All of a sudden, you get the result you were looking for!

Assessment:

When this project is finished, each team presents their findings to the class, taping their shapes to the wall. I compared the myriad of new, unique shapes to the original, boring chair. I tell the students we have created a "shape library" of chairs. That chairs can come in many shapes, so please do not restrict yourself to the conventional. See below.

I collected each poster as a grade. You may want to create a rubric for what you expect from your posters. Specific requirements for the poster will yield more finely crafted shapes and more thoughtful responses… they will not take the exercise seriously if they do not think they are receiving a grade for it.

A key to the success of the cardboard chair project is craftsmanship, so even though we are just cutting out construction paper- I insist on straight lines, careful cuts, etc from the very beginning.

Additional Resources:

Google the following:

- Charles and Rae Eames Chair
- Herman Miller
- Frank Gehry Cardboard Chair
- Museum of Modern Art Chairs
- Design Within Reach
- Bauhaus Chairs
- History of Chairs http://www.techitoutuk.com/knowledge/designhistory/historyods.html
- Vitra Chairs

There is a great poster from Design Within Reach. Its expensive….but it is a timeline of the most influential chairs in modern design history. I used it as a basis for my PPT presentations and had it displayed in the room at all times.http://www.dwr.com/product/vitra-chair-poster.do

Step 3: Ergonomics

Why is a chair comfortable?

Objectives:

- To understand the world "ergonomics"
- To evaluate chair design as it applies to the human body
- Students will take measurements of their own body to help them define the size their chair needs to be
- Students will brainstorm ergonomic shapes for chair arm rests and seat

Materials:

- Ergonomics handouts (see ***Ergonomics Worksheet***)
- 6.5' feet of butcher paper per team
- 3 different colored magic markers per team
- pencil/eraser
- Aeron Chair (I was fortunate to make ties with a software company that uses Aeron Chairs for all its employees. It was not difficult to convince them to let me borrow one for a few days to show my classes.)
- Herman Miller Aeron Chair Video- "Groovy Movie" http://www.hermanmiller.com/CDA/SSA/Product/0,,a10-c440-p8,00.html

Introduction:

"This is the Aeron Chair. It has claims of being the worlds most ergonomic computer chair. It was designed by a team of top designers and material engineers from the Herman Miller Company. It uses some new materials- like the breathable back meshing. It comes in 3 different sizes, and each size is completely adjustable."

I ask Johnny, a 6'3", 200 pound boy and Amy, a 5', 100 lb girl to take turns sitting in the chair.

Johnny, can you figure out how to adjust the arms and the seat height?" (It's pretty user friendly, so it doesn't take long.") How does it feel compared to your school chair?"

"Pretty sweet."

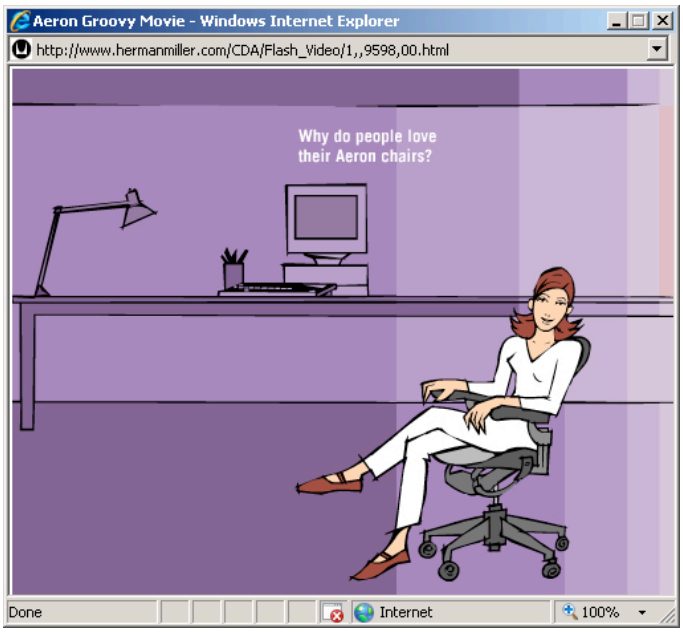
"Do you wanna know how much one of these things runs?"

“Yeah!”

“About $800”.

“No way! That’s so not worth it. How come?”

We get into a discussion about how people desire items that work well. (A plug that not all artists are poor and starving as well.) I show them the “Groovy Movie” from the Herman Miller Website: http://www.hermanmiller.com/CDA/SSA/Product/0,,a10-c440-p8,00.html



Using the Ergonomics handouts, I give a brief lecture about Neutral Body Positioning. When designing chairs, it is helpful to understand the concept of neutral body positioning. This is a comfortable working posture in which your joints are naturally aligned. Working with the body in a neutral position reduced stress and strain on the muscles, tendons and skeletal system and reduces your risk of developing musculoskeletal disorder, pinched nerves and carpal tunnel syndrome. Generally, body joints should be at 90 degree angles. Hand wrists and forearms are straight, inline and roughly parallel to the floor.

The class is asleep now. So I ask Amy, “Amy, can you take a turn in the Aeron chair now? Can you adjust the arms and chair height so your body is at neutral body positioning/” The class wakes up a bit while Amy adjust the chair.

I continue….elbows stay in close to the body and are bent between 90 and 100 degress. Armrests that are not adjustable, or those that have not been properly adjusted may expose you to awkward postures or fail to provide adequate support.

“Amy, can you move the armrests so they are in close to the body?”

The Chair Height is appropriate when the entire sole of the foot can rest on the floor. Knee should be the same height as hips. Thigh should be parallel to the floor.

“Amy- is your sole on the floor? No? Let’s lower the seat a bit” *Whoosh.* The chair’s pneumatic pumps lower her to the ground fast. This is often the student’s favorite part about the chair.

Finally, your back is fully supported with appropriate lumbar support with sitting vertical or leaning back slightly.

“Amy, how does the back mesh fell to you? Can you describe to the class what it feels like when you move?”

I conclude the lecture with a design history presentation. I then lead the students in a hands-on guide to determine their measurements.

Basically, they take turns lying down on a piece of butcher paper and trace their shapes. They take certain measurements (ie., forearm length, hips width, etc.) and then write the average of their measurements. Remind students to keep these measurements. Students will need to refer to this average measurement in order to design a chair that fits their team.

Process:

- Lie down on the floor on top of a piece of butcher paper.
- Trace the outline of each person of the team with a different color
- Take the measurements listed in the ***Ergonomics Worksheet***
- Figure out the average measurement of your team and write them on the Ergonomics Worksheet. This will be the guideline for the measurements of your cardboard chair to ensure the chair is ergonomically correct.
- Complete the 2nd page of the Ergonomics worksheet.

Assessment:

When completed, each team of students should have their outlines on the paper with measurements. I ask them to measure their drawing as opposed to their real body because it helps to have all three outlines superimposed on each other so you can visually see the differences.

I collect and grade their ergonomics worksheets. Carefully check their drawings/brainstorms for arm rests and seat shapes. Are they successful shapes? Will they work? If not, ask student to try again.

An explicit rubric will help students spend more time on their work and create more careful responses.

Resources:

Herman Miller Website, **Aeron Chair**:
http://www.hermanmiller.com/CDA/SSA/Product/0,,a10-c440-p8,00.html

Check out the "Groovy Movie" and the QuickTime film, "The Official Chair of Office Hockey"

Step 5: Construction Techniques

How to create joints and structural systems from cardboard (without glue)

Objectives:

- Learn how to use cardboard to maximize its strength
- Understand how to cut and score cardboard
- Learn safety procedures
- Design a planar enclosure, wedge, and cross brace
- Develop craftsmanship with cardboard

Materials:

- Construction Techniques Handout (see ***Construction Techniques***)
- Scrap pieces of single ply cardboard (old boxes work great)
- utility knifes
- extra blades
- screwdrivers to replace blades
- 12" & 18" Metal rulers with cork backing (to prevent skidding)

Process:

Go over Safety Rules. Demonstrate to students how to cut properly. I then have students take a "safety exam" where they prove they can cut properly. Finally, students sign a piece of paper saying they have read and understand the safety rules of using a utility knife. (The rules are also printed on the top of the paper they sign.)

Utility Knife Rules

- Always cut with a ruler as a guide. Do not cut without one or your lines will be sloppy
- Use metal rulers with cork on back. If you use a wood ruler, the utility knife will get jammed in the wood. The cork on the back of the ruler prevents the ruler from skidding so there's less of a chance of cutting yourself.
- Always watch the location of your left thumb. (If you are left handed, this would be your right thumb.) Keep your thumb on top of the ruler. (Not hanging over the edge.) **The #1 cutting accident is running over your thumb with the knife because you are not watching the location of your hand.**
- Change blades often. You have less of a chance of cutting yourself if the blade is very sharp (not dull.) A sharp knife will glide smoother and easier.
- Change the blade at least 1-2x a class. (Demonstrate to class how to change a blade)

- Dispose of blades properly (in a glass jar.) Do not throw in trash or you will injur custodians.
- Never leave your utility knife on the floor with an open blade. Immediately close the blade of the knife as soon as you are finished scoring.
- Cut slowly
- Always cut on top of a piece of extra cardboard. NEVER cut directly on a table or ground for two reasons: #1- you will ruin the table for when we draw. #2: The hard surface of the floor will dull or break the tip off the blade. Therefore, you'll get a sloppy cut, and you will have to change the blade immediately.
- Cut to the side of your body. If the knife slips- you don't want it to run into your chest or leg. If you cut to the side, you'll miss your body if the knife slips.

Identify the Grain
I pass several pieces of cardboard to the class and ask them to identify the grain of the board. I rip the top half of the cardboard off, so they can see what the "grain" looks like. The grain runs parallel to the corrugation inside.

We then conduct some experiments to help us understand which direction the grain should run when you want to place weight on top of cardboard. Rip apart a cardboard box to see what direction the grain is. Talk about it with the class. Or, I also cut out a 8" x 8" square of cardboard. I stand it up on the table and placed my hand on it. Depending on which direction the grain is running, the piece of board will collapse.

Scoring Techniques
I then go over scoring techniques. In order to have clean folds, it is necessary to score cardboard before you fold it. If you just fold cardboard without scoring you will run into two problems- #1. it will be hard to fold, #2. the fold will look bad and not be straight. I demonstrate how you always want to score **against** the grain in order to have clean folds. Scoring with the grain will is unnecessary as the cardboard is already pliable in this direction.

I show the class two pre-made cardboard cylinders. One is scored against the grain, one with the grain. Demonstrate how the one scored against the grain is very strong when it is stood up and weight is applied to the end, but the cyclinder scored with the grain is useless.

joints and support structures using cardboard
There are three main types of joints and support structures that do not require glue when you are creating cardboard furniture: a wedge, cross-brace, and planar enclosures (see ***Construction Techniques*** worksheet.) I have pre-made examples to the class. I take them apart for all to see. We discuss grain direction and scoring. I show them how to make cylinders for the circular planar enclosure (by scoring every ½'.) I show the class photos of other cardboard chairs- the class determines which support structure the chair uses. We discuss how successful they were.

The assignment is for each team to make an original example of a
- wedge,
- cross brace
- straight edge planar enclosure
- circular or organic planar enclosure

Give students a copy of the ***Construction Techniques*** handout. Read it together.

Have students design unique examples. Require them to think of new shapes to use- organic shapes, polygons, etc. I had one student create a heart-shaped planar enclosure! Regarding the crossbrace- I required students to use a minimum of 6 pieces (or else students take the easy way out and just do two pieces.)

Assessment

This is one of the hardest parts of the chair project believe it or not. Good, Clean craftsmanship does not come easy and that is a main goals of this lesson. Insist on sharp edges, rectangles with right angles and scores in the right direction. Have students identify their errors, and then redo. I told my student upfront that they needed to be perfect, or they would have to redo that piece. But also, not to feel bad if that was the case. Because it takes many, many tries to learn how to make a clean cut. It almost impossible to get it right on the first try. Students should expect to do this over a few times.

Although there will be complaints, this exercise is one of the best way to teach craftsmanship with cardboard. A specific rubric will help ensure quality work. I also did not allow them the option for failure. If the piece was not up to standards, they had to do it again.

Besides learning craftsmanship, these exercises will provide a strong foundation for the students in the next phase- where they will design small, paper models of the chair. Some students will have no idea where to begin. If this is the case, remind them about these structural systems. Show students how an entire chair can be built around a cross brace, or a wedge. As long as students remember these structural systems- they will have a greater chance at success in building their chair.

Note: For this exercise, I used **single ply** cardboard. It is easier to cut, and a better way to introduce students to scoring/cutting cardboard. However, Sometimes, I asked students to choose one example and use **double ply** cardboard. I made sure students understood the difference between them, and that they understood the final chair would be created with double ply cardboard. There are additional safety rules when using double ply cardboard. I have students cut on the ground so they can use their entire upper body strength. This makes it much easier to cut. (If a student sits at a desk and tries to cut double ply board- they will be miserable.) I also require the students kneel and cut to the right/left of their body.

Step 6: Rapid Prototypes

Quickly brainstorm ideas & visualize plans in 3-D

Objectives:

- Using tag board, students will create two chairs- one that is a "curvy" design and one that is a "straight" design. (Each team will end up with a total of 6 chairs.) In the next stage, the team will combine the best ideas from these chairs, or use the best one to create the final scale model. Chair should be about 6" high and should be able to sustain some weight when you press down on the seat with your finger.

Materials:

- Several pieces of tag board
- Scissors

Introduction

Professional industrial designers use a technique called "Rapid Prototyping" to come up with ideas for their products. This means to quickly brainstorm ideas in 3-d. Depending on the project, designers may use clay, or paper, or cardboard to name a few materials. I show the class some PPT examples of rapid prototypes from professional designers. (Many industrial design companies show examples of their process on their websites. Cars companies have some great ones too.) Working in 3-D is a lot easier than drawing for many people, which is another benefit of rapid prototypes.

The goal of this lesson is for students to begin thinking about their chair design in 3-D. Remember the types of construction techniques- the wedge, cross brace, and planar enclosure. If a student is not sure where to begin, have them start with one of those structures and try to build a chair around it.

Process:

Each person should design two chairs. One chair will use mainly straight edges and one chair should use mainly curvy edges. (This is to help push the students in their creativity.) When done, each team will have a total of 6 chairs. As a group, students will decide which chair has the most potential to succeed and they will turn that design into a scale model. Or, they can mix and match the best ideas from everyone to build a new chair.

Remind students that the chair needs to be at least 17" off the ground and have a backrest that supports weight so their model should likewise.

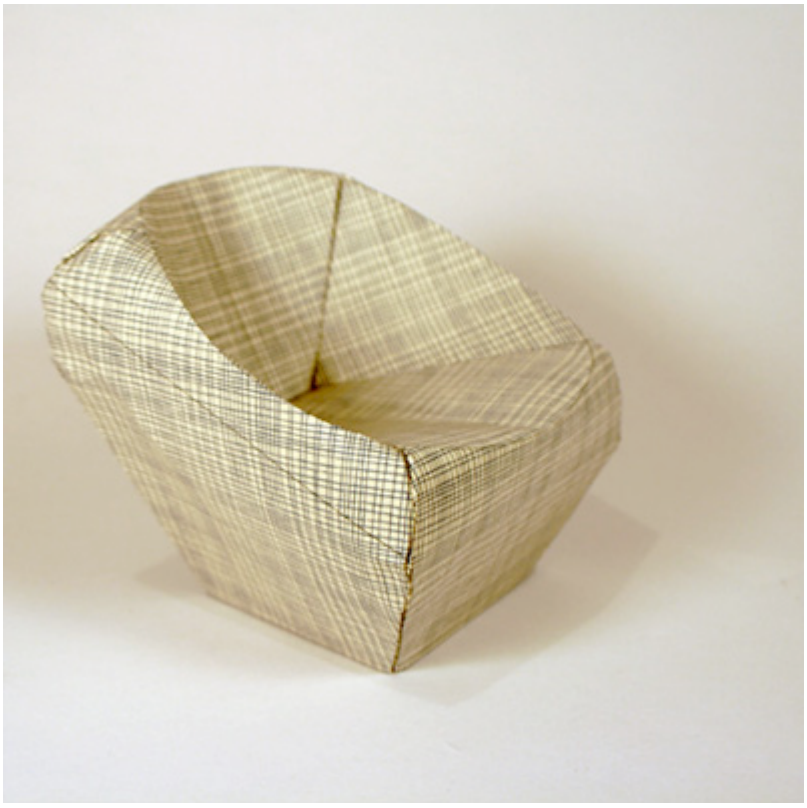
Since we are using tag board and it is very flimsy- use scissors. Also, each prototype should be about 6" high.

Assessment:

I grade each person's chairs based on strength and stability. I also take into consideration uniqueness of form and shape and craftsmanship. A specific rubric will yield higher quality results.
If the student's chair completely buckles with any kind of pressure put on it, have them address the problem before they turn it in.

As the teacher, you will be able to quickly see which students "get it" and which don't. You may need to rearrange groups at this time to ensure all groups a chance at success. Group/class critiques where students present their ideas and describe what they think works and doesn't to the entire class is very helpful as well. I found a few students who were confident enough to share their work and openly discuss problems in front of the class. This really helped the rest of the class to catch on.

Note: Have students SAVE ALL their prototypes. They will need to show them at their final presentation.



Step 7: Scale Models

Objectives:

Revise and finalize design. Construct a 3-D model from chipboard that is proportionally accurate.

Materials:

- Chip board
- utility knifes/xacto blades
- extra blades
- screwdrivers to replace blades
- 12" & 18" Metal rulers with cork backing

Introduction

One of the biggest mistakes a designer can make is to think they will get it right on the first try. The Toyota Prius was developed after years of research, changes and modifications. The design we know today, was completely different than what the designers started with.

Along the journey, Toyota designers learned many ways to improve their Prius. I showed the students a PPT presentation of early drawings and prototypes of the Prius. We talked about how and why changes were made.

Many students will encounter a creative block at this point in the cardboard chair project. I encourage them by explaining this is normal, and professionals experience this constantly. But there is always a solution. Professionals never get it right the first time. They take baby steps- which is what we are doing here. High school students are also so afraid of failure. I constantly remind them that starting over, or rebuilding a new idea is not failing. That's trying! That's showing effort and can only help improve their grade.

Assignment:

Analyze your 6 paper prototypes. What are their strengths and weaknesses? Which design is the most successful? Do you need to modify it in anyway? Are their parts of other chairs that you would like to incorporate?

Decide on the best option(s) and design a scale model of the chair using chip board. Chip Board is stronger than paper but easier to bend than cardboard. Students will need to use utility knives or xacto knives (not scissors) and score all pieces before folding. Models should be roughly 5" to 8" tall.

Assessment:

From this point on, the students will receive a "group" grade. There is only 1 scale model due, so students share a grade. During class, I monitor groups closely to see which individuals are not pulling their weight. When I notice this happening, I assign specific tasks to that person/group.

The chair design is graded on strength and aesthetic. The model is also graded on craftsmanship. At this point, the teacher will have a clear idea of whether or not the chair will be successful at actual size. If the chair will not succeed, do not allow the group to continue to the next step. Help the team realize where the chair will break structurally and brainstorm solutions.

Note: Have students SAVE ALL their prototypes. They will need to show them at their final presentation.

Step 8: Patterns

Objectives:

Translate a design from a 3-D model to 2-D. Create a pattern for the final chair

Materials:

- graph paper
- overhead projector
- transparencies
- markers
- rulers

Assignment

Using the scale model, students must now create a pattern for the your final chair.

- Take apart the chipboard model
- Draw a rectangle that is 4.8 x 9.6 inches (or $1/10^{th}$ the size of the cardboard) on the graph paper. All pieces must fit in four of these rectangles.
- Trace the shapes onto the graph paper
- Trace the graph paper pattern on a transparency
- Project the pattern it onto the 48" x 96" cardboard and trace with pencil. Make sure students **do not use marker-** or it will ruin their aesthetic.
- Have students SAVE their paper pattern. They will need it for their final presentation.

There are many things students should consider while doing this assignment:

- Students only have 4 pieces of 48" x 96" cardboard. Students have to make sure they can build the entire chair from only those 4 pieces.
- Students have to arrange the shapes on the cardboard so they are going in the correct direction of the grain. Will all the pieces fit? The grain of the cardboard is only 48" tall. Will this work with the design or do you need to redesign? I have examples (that I pre-made) of this to show the entire class. I hold up the graph paper with the pieces drawn the wrong direction. We discuss possible solutions. How can the pieces be revised in shape?
- Will you chair fit? Aka- if the seat is only 8" across when you project your pattern on the cardboard- your design is too small. You will need to enlarge your entire pattern.

A lot of confidence building is needed at this point. Students may get discouraged if their shapes do not fit on the first try. I avoid this by telling them (before I even pass out the graph paper) that this will "probably" happen. It is totally acceptable- in fact it is ENCOURAGED to get more chipboard and build some more models to help refine the pattern. Remind students that it is not a "bad" thing if you need to try some more chipboard shapes. It is a good thing. They are ensuring their chances of success by taking the time to do this.

Assessment:

When students have their pattern drawn on their graph paper, have them turn it in for a grade. Help them to identify any of their problems so they can fix it before they proceed. You as the teacher are responsible for finding errors and preventing failures. If the design will not work, have them re-do before they proceed. Make sure all pieces are facing the correct grain direction. This means, you as the teacher will have to understand each and every piece of the chair/pattern and how it will be used.

Step 9: Final Construction

Objectives:

Build the final chair from cardboard obeying all safety procedures. Develop craftsmanship, scoring, cutting and assembly techniques. Problem solve when "issues" occur

Materials:

- 4 sheets of 48" x 96" **DOUBLE** corrugated cardboard (per chair). New cardboard is strongly recommended. If you use old boxes, the chairs will not be as strong or as aesthetically clean.
  Important Note: *Many teachers choose single ply cardboard. This will be cheaper and easier for your students to cut. However, I chose to buy double ply cardboard as it yields stronger chairs therefore allowing more elaborate designs.*
  Also, you will need significant storage for this project as the cardboard sheets alone will take up almost 8 x 18 feet of space. When the chairs are being constructed- you will need an empty room to store these in as well.
- 24" Metal rulers with cork backing
- 48" Metal rulers with cork backing
- scrap cardboard to use underneath your good pieces while cutting to protect the floor

Assignment

At this point, all students should have their pattern traced on their cardboard. Review all safety procedures. Go over final rubrics with students (see ***Cardboard Chair design Rubric***). Students should begin cutting out their shapes and assembling their chair. This is the most fun part of the process. Students finally see how their project is coming together. We needed a LOT of space to do all the cutting, so we actually had to work in the hallways in order to have the room we needed.

You will also require a great amount of storage space for the chairs in progress.

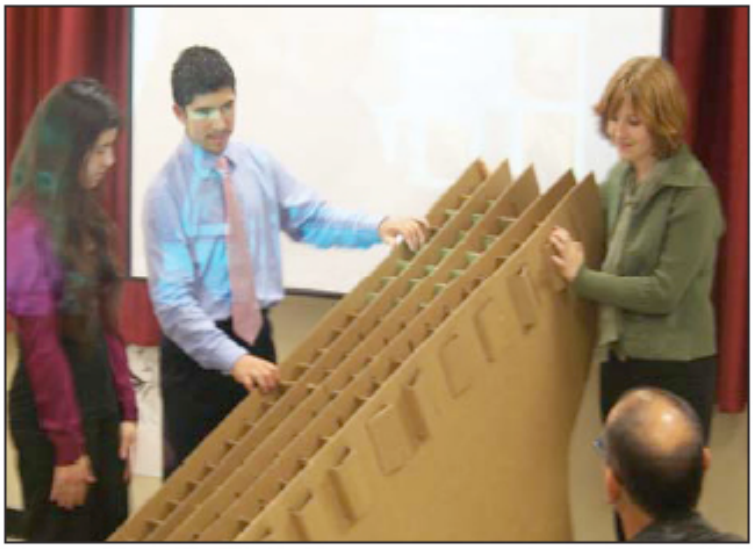
Assessment

See *Cardboard Chair Rubric.*

The end of this project is the perfect opportunity for a formal critique. Two professional architects or designers attended each critique to ask questions give varying ideas, advice, and encouragement to the students. We reserved the entire week for the presentations and invited parents, administrators, other teachers and friends to attend. Because it was so formal, students were more motivated to finish their project on time.

At the critique, the students were asked to give a presentation showing their design process, from the very early paper prototypes to the scale model, to the pattern and final design. Students needed to discuss how and why they made changes, what problems they encountered and how they solved those problems.

Again, having a rubric was invaluable for this presentation. Students could give their presentation with a piece of posterboard, or by PowerPoint. Please see the *Presentation Rubric*



Top: Guest architects Chris Allen and Smith Hayes ask Smadar, Arami and Anastasia about their chair.

Middle: Guest architects Robert Floyd and Jen Murril from Arc Inc. compliment Jacquelyn and her team about their chair.