Out-of-the Box: A Furniture Design + Engineering Challenge

Days 1 and 2:

Introduction

The history of the chair goes back two thousand years. Although its style and design have changed, its core function has remained the same. In its many different shapes and forms, a chair is an object that “seats” us. Some of the earliest examples of chairs, across cultures, are ceremonial thrones designed for royalty. In these cases, they are often one-of-a-kind objects, custom made for one specific person. Technological innovation starting in the late nineteenth century allowed chair designers to break from tradition and incorporate new materials and production methods. Now, most of the chairs we use on a regular basis are designed and mass produced for consumers of all kinds to purchase. In the course of our daily lives, we use a variety of chairs—on buses and trains, and at school, work, and home. Development in technology and materials continues to shape the ways chairs are designed and produced. And, as with all design, inspiration plays a vital role in the process. This lesson explores a selection of chairs through the lenses of inspiration, innovation, and materials.

In your Engineering Notebook

1. Define “innovation.”
2. Whom do you consider to be innovators?
3. What are their characteristics?
4. Make a list of these ideas on and explain which of the things they use every day are innovative, and why?
5. Students will research for architect profiles in the 40 Most Famous Architects of the 21st Century article [https://www.archute.com/2015/08/03/40-famous-architects-of-the-21st-century/](https://www.archute.com/2015/08/03/40-famous-architects-of-the-21st-century/). Then will select one of them to be the inspiration for your design.

Maker Challenge Recap

Student teams are challenged to design and build architecturally inspired cardboard furniture, guided by the steps of the engineering design process. They cultivate their industrial engineering and design skills to design furnishings that meet functional, aesthetic and financial requirements. Given constraints that include limited building materials and tools, groups research architectural styles and period furnishings. The teams brainstorm ideas, make small-scale quick prototypes, then make detailed plans and create full-scale prototypes of their best solutions. The full-size prototypes are evaluated by peer critique for aesthetic alignment to the targeted architectural style and tested for functionality.

Maker Materials & Supplies (Due first class next week)

- initial, small-scale quick prototyping materials, such as heavy-weight paper, cardstock, chipboard, lightweight foam core board, toothpicks, (optional) orthographic paper for orthographic production drawings
- cardboard of all kinds, such as corrugated, smooth, rigid, flexible, paper towel tubes, mailing tubes, carpet roll tubes; appliance boxes work well and can be obtained at big box stores; make enough available so each team could build any of the identified furnishings
- cutting tools: box cutters, craft knives, cutting mats, self-healing mat boards, (optional) hand saws
- measuring tools: metal rulers, yardsticks (those with non-skid backings are best), tape measures
- adhesives: white school glue (available in bulk from school supply retailers), tape, spray-on adhesives for temporary and quick prototyping, kraft paper tape (traditional brown packaging tape that requires moistening, but provides strong, long-lasting seal on boxes and cartons; available at [http://www.dickblick.com/products/kraft-paper-tape/](http://www.dickblick.com/products/kraft-paper-tape/), Office Depot or packaging stores)
- small buckets/bins, for moistening kraft tape
- inexpensive paint brushes; available in paint sections at hardware stores
- safety equipment, such as safety glasses and eye protection, depending on tools used
- computers with internet access, for research
Maker Time

Groups of 4 or 5 students will follow the steps of the engineering design process as outlined in the Out-of-The-Box Engineering Log. Students have to document their work by taking photographs, making/attaching sketches and completing the log throughout the entire design process. Some teams naturally identify roles for each of their team members to fulfill certain tasks such as taking pictures, blogging, organizing materials, etc

Identify the Need:

Research the Problem: During this phase, students will research for measurements of similar furnishings they live with every day at home and at school to make observations of structural and design features. In addition, much information is available online about ergonomics and standard heights and measurements of furnishings.

Days 3, 4 and 5:

Imagine Possible Solutions: Industrial designers and engineers use prototyping as a way to model and test ideas before investing in the manufacture of final products. The process of ongoing brainstorming and playing with paper and experimenting with form and shaping/joining techniques often leads to new and improved ideas. Encourage students to work quickly and make as many small-scale 3D sketch models and prototypes as they can—focusing on basic forms at this stage, not details. Remember to review safety as well as cutting tips and techniques before students use craft/utility knives. One of many helpful online resources is a four-minute YouTube video, How to Cut (X-Acto) Like an Architect.

Plan: Select a Promising Solution: Consider to informally present the top two or three prototypes you are considering to either the entire class or another team—in order to obtain feedback. Prompt the students who give feedback to consider the design challenge goals and constraints when analyzing the prototype candidates. Once you have selected your top choices, make formal front, side and plan (top) view drawings with measurements. If desired, provide students with more instruction/practice on orthogonal drawing skills. Also use TINKERCAD to 3D Modeling your final design.

Days 6, 7 and 8:

Create: Build the Scale Prototype: Consider reviewing the excellent Making Society three-part instructional series with photographs and tips on prototyping with cardboard. The series presents a variety of cutting, folding and joining methods. Consider how you will join pieces and experiment on practice pieces. Emphasize the importance of well-crafted products. Establish the expectations that glue should not be seen and that cuts be clean and straight. Remind to continue to document your progress with notes on challenges and solutions, as well as detail sketches and photographs.

Days 9 and 10:

Test + Evaluate the Prototype: You will have 2 days for prototype peer critique and testing so teams have adequate time to present and receive constructive feedback. Facilitate the critique by setting some ground rules: Make all comments kind, helpful and specific. Focus on the work, not the person. Evaluate how well the work meets the goals and consider where it falls short. Instead of “You should...” you should say, “Have you considered...” or “What would happen if you...” Make sure a group member captures in notes the critique feedback for the team. For more information, refer to Ron Berger’s In-Depth Critique Protocol.

Day 11:

Improve and Re-Design as Needed:
Out-of-the-Box Design Challenge

Your team challenge is to design a piece of furniture that is inspired by the style of a famous architect. After researching the architect, decide what type of furnishing you will build—table, chair, bookshelf, etc.—to occupy a particular room or space in your school building—classroom, conference room, student lounge or commons area, library, etc.

Criteria

Your prototype must...
- Serve its purpose; that is, be functional
- Be to scale
- Reflect essential design elements of the selected architect’s style
- Be well crafted

Constraints

Your prototype must...
- Be made entirely of cardboard
- Maintain the original color of the boxes (no painting or coloring)
- Use no fasteners other than glue and paper Kraft tape

Follow the Engineering Design Process

- Identify the need
- Research the problem
- Imagine possible solutions: quick prototyping
- Plan: select a promising solution
- Create: build a scale prototype
- Test + evaluate prototype: peer / professional critique
- Improve + redesign as needed
Out-of-the-Box Engineering Log

Document your work by taking photographs, making and attaching detailed sketches, and completing this log throughout the entire design process.

Team name:

Team members:

➔ Identify the Need

What is the problem to solve?
What are the project requirements? What are the limitations?
Which architect do we want to choose?
What furnishing do we want to design?
Where will it reside?
Who would use it?
Other factors to consider:

Notes:

➔ Research the Problem

What is the function of the furnishing?
What are essential design elements/stylistic features of the architecture that we want to include?
What are essential structural features that need to be included?
What should the furnishing dimensions be?
Other questions to research:

Notes:
Imagine Possible Solutions: Quick Prototyping

This is the time to brainstorm since all ideas are viable at this point! Grab some heavy-weight paper, cardstock, chipboard, lightweight foam board, toothpicks, tape, glue, x-acto knives, self-healing mat boards and play! Make as many possible small scale (think 1:1, that is 1 inch =1 foot) models of as many ideas as you can in one class session.


Notes:
Plan: Select a Promising Solution

Spend some time looking at and considering which of the small-scale quick prototypes meet the requirements and seem feasible within the given constraints. As a team, decide which model to develop as your ultimate prototype. Considerations:

- Consider **design features** such as interlocking shapes for support, positive and negative spaces, angles and proportions.
- Consider **structural features** that provide strength and durability, functionality, weight distribution, withstand expected forces and load requirements, brace and support types, and comfort/ergonomics, as applicable.

Identify which prototype you have selected to pursue and explain why:

![Example chair design sketches showing top and side views.
Source: Karina Larsen + Christina Wadstrom Design, http://karinalarsendesign.dk/work/chair.html. Used with permission.](image)

Create front, side and plan (top) view hand drawings of your final prototype design.
- Include dimensions.
- Attach the hand drawings to this log.
- Attach any additional sketches, photographs, inspirational images or other source material.
- Use TINKERCAD for 3D Modeling your final prototype design.
Create: Build a Scale Prototype
Build your full-size, to-scale cardboard prototype! Take photographs along the way.
Record any challenges you encounter, and changes you decide to make and why, and attach them to this log.

Test + Evaluate Prototype: Peer / Professional Critique
Designate one team member to record feedback during the critique.
Share your prototype with the class. Describe your goals for the furnishing, any challenges and solutions, and explain how you met the criteria for aesthetic design as well as functionality. Consider creating design boards that include inspiration, notes, sketches and photographs teams collected throughout the design process, which could be displayed on easels or wall displays near the furnishings.
Test the prototype—does it work/serve its purpose? (For example, does a chair support the weight of a person? Is it comfortable? Does a bookshelf hold the weight of books, etc.?)

- What is working well? Why?
- What needs improvement? Why?

What (if any) re-designs do we plan?

Improve + Redesign as Needed
Record and explain any changes and or improvements here.
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