Session 12

Planning for Models and Tests

Making, Modeling, and Materializing

In This Session:

A) Thinking Again About Design (45 minutes)
- Student Handout

B) Materials and Modeling Plans (45 Minutes)
- Student Handout
- Student Reading

C) Structural Considerations (60 Minutes)
- Student Handout

This session prepares students for building models and testing systems or components of their design project. This is Step 7 of the design process. In an opening activity, *12A: Thinking Again About Design*, students review their experience of the design process and think about their revisions up to now. They see that the design process is not linear; there are cycles or iterations of review, testing, revision, and change. In the second activity, *12B: Materials and Modeling Plans*, students survey available materials for constructing models and plan their first constructions. In the final activity *12C: Structural Considerations*, students learn about collapsible objects and the principles of collapsibility. They then review structural considerations related to storing, moving, and assembling their projects.

Supplies

A variety of materials to build models.
Supplies for Structure

- Foam (Styrofoam* in sheets and several shapes, including foam tubes for pipe insulation)
- Foam core board
- Balsa wood (sheets and pre-cut strips from craft supply stores)
- Modeling clay
- Aluminum foil
- Pipe cleaners and plastic straws
- Cardboard (tubes, boxes of all sizes, flat pieces)
- Paper (including poster board or card stock weights)
- Erector* set
- Lego* set
- Dowels, bamboo skewers
- Wheels

Other Optional Structural supplies

- Recyclable materials such as wine corks, aluminum soda cans, bubble wrap, packaging peanuts, and twist ties

Session 12, Planning for Models and Tests (continued)

- Sample items (for students to acquire and use in larger constructions): PVC pipe and connectors, lumber (plywood and 2x4s) of different sizes

Parts and Materials To Connect Things

- String
- Wire
- Rubber bands
- Rubber tubing
- Tape (duct, masking, packaging, and electrical)
- Glues (epoxy, superglue, glue sticks, glues for hot glue gun, and rubber cement)
- Hinges
- Nuts and bolts, washers, assorted screws
- Nails, thumbtacks

Tools

- Several sets of each: pliers, saw, hammer, screwdriver, hot glue gun, and tin snips

Collapsible Items Suggestions

- Umbrella, folding chair, window blinds, stackable cups, sleeping bag, fold away rain jacket, tent, fold up map, pop-up book, paper lantern, easel, ladder, pocket scissors, glasses, Swiss Army knife, measuring tape, stackable measuring cups and spoons, balloon, inflatable raft, rubber band, plastic bag, jump rope

Planning for Models and Tests

Key Concepts: Session 12

In Session 12, students begin to make their ideas tangible—going from what's in their mind to things in their hand. They build initial **models**. This could be a model of the overall design, a model of a single working component, or a test of materials for a single part. Later, students will build working **prototypes** to test form and function of their designs.

Key Concepts
Both models and prototypes are constructions that determine if a design or components of a design will work in both form (how does it look and feel) and function (does it work?). Both models and prototypes are used to:

- Test and trial a concept.
- Test and trial the way something looks or feels to the user.
- Try out dimensions and fit between components.
- Test a mechanism or subsystem of a design.

Models tend to be smaller in scope than prototypes; they are not as concerned with representing a final product in functionality, size, materials, and scope.

Model: Models can be visual representations of a total design that is nonfunctional. Or, they represent some aspect (form or function) of a specific component.

Prototype: Prototypes tend to demonstrate some aspect of the design as a whole, either its form, function, or both.

More on Models and Prototypes
The Intel QX3 progression of models and prototypes in *12A Handout: Thinking Again About Design*. In Session 12, students study the progression of models and prototypes in the development of the QX3 digital microscope.

Dial* soap dispenser models and working prototypes in *14A Reading: ZIBA Designs a Soap Dispenser*. In Session 14, students study the progression of models and prototypes in the development of the Dial soap dispenser.

Models Plus
www.modelsplusinc.com/html/body_prototypes.html*
The company, Models Plus, Inc., has a nice display of prototypes. View prototypes for a Motorola cell phone and learn what materials were used to make the prototype.

Session 12, Activity A

Thinking Again About Design

Goal
Understand that the design process involves many cycles of revision as each step presents new information and ideas for refinement of a design.

Outcome
Students know that change and possibly even complete redesign of their solutions are part of the process of good engineering and design.

Description
This activity begins with a review of the design process as students have experienced it up to now. A group reflection and discussion encourages them to think about the value of the revisions to their idea along the way. The design process has many cycles or iterations that lead to changes and improvements to their original solution. A review of Intel QX3 microscope prototypes reinforces the process of modeling, testing, and prototyping.

Supplies
None

Preparation

1. Students will need their notebook, design brief, design requirements, drawings, and any other notes about their design project.

2. Try to arrange for mentors to attend this session.

3. Optional: Arrange for actual prototypes and/or models from a design firm, if possible.

Procedures
Project Progress

1. Have students take a few minutes to review and think about the changes to their projects as they have moved through the design process. Discuss and share examples:

    - Do you have exactly the same solution in mind since the beginning?
    - Which steps take longer?
    - Which steps produced the most change to your original idea?
        - Developing a design brief (Step 4)?
        - Getting research and feedback from others (Step 5)?
        - Analyzing feasibility of solution (Step 5)?
        - Developing design requirements and drawings (Step 6)?

12A: Thinking Again About Design (continued)

2. It is likely that all students will have modified and revised their projects to some extent already. Discuss how this is an important part of the process:

   The design process is really not a set of linear steps but has many cycles (or iterations) of revision and change that lead to improvements to their original solution. In fact, with each step that makes the idea more real (moving from "think" to "thing"), revisions get more comprehensive—even to throw out a solution and back up to an earlier idea.

Models and Prototypes

1. Distinguish prototypes and models

   Model: Models can be visual representations of a total design that is nonfunctional. Or, they can represent some aspect (form or function) of a specific component.
   Prototype: Prototypes tend to demonstrate some aspect of the design as a whole, either its form, function, or both.

   Students will eventually build a working prototype of their idea, but at this step, they construct models. These allow students to test or trial their concept, try out dimensions and fit between components, or test a mechanism or some system in their project.

2. Review QX3 microscope development. Discuss the progression of prototypes shown in the images on the handout.

3. Review other examples of models and prototypes. Take a look at the Leatherman* Web site to see the history of this useful product, from idea to inception, www.leatherman.com* (Go to *About Leatherman* and select *History*.)

Follow with
Activity *12B: Materials and Modeling Plans* has students surveying the materials for building models and planning what they will build.

Checking in on the Design Process

Handout: Session 12, Activity A

The steps of the design process rarely happen one after another but often are repeated or revisited in many cycles (or iterations) of change that lead to improvements. For example, drawing your idea may have caused you to revise your requirements in some way. In fact, with each step in the process that makes your idea more real (moving from "think" to "thing"), revisions can get more comprehensive as you see new ways of looking at your idea—you might even throw out a solution and go back to an earlier idea.

It's time to make project ideas tangible—to go from what's in your mind to things in your hands. You are now at the stage of building models—a way to test, revise, and improve your design. Models allow you to see your idea as a "trial run." You might build a model to test dimensions and fit between components. Or you might build a model to test a mechanism or some system in your project. Eventually you will build a prototype—a model that works.

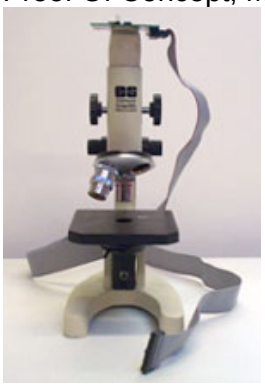
Model: A small but exact copy of something
Prototype: A working model of a machine or other object used to test it before producing the final version

Even your first working prototype will go through revisions. Follow the progression of prototypes that resulted in the Intel QX3 microscope:

QX3 Requirements

- Fun to use computer microscope
- Meet $99 retail cost target
- Must really work technically
- Must be mobile, capture images at the source
- Easy to use; plug-and-play simplicity
- Everything included ("just add specimen")
- No batteries, no AC adapter, no external lighting
- Fully exploit computer capabilities: capture, time lapse, collection, printing

Proof Of Concept, May 1998



This is the first model to test the concept of transferring a magnified image to a computer for viewing, saving, and manipulating. This is a demonstration or "works-like" prototype. It used a standard off-the-shelf microscope, external lighting, with circuitry and a ribbon cable for connection to the computer. It was tested with kids to see if they felt that a computer-connected microscope had "play value" (was fun). It also allowed the engineers to ask kids questions about what they would want to look at and what magnifications were interesting to them.

12A Handout: Thinking Again About Design (continued)

Microscope in a Box, May 1998

This version was an exciting breakthrough... in function. The box fit in your hand and included the necessary lighting and electronics for capturing the image. It proved that you could take the microscope to what you want to see instead of bringing the object to the microscope. Clearly, this version proved the function (with form to follow). The key was that this prototype had the light source on the top (as opposed to the bottom for conventional microscopes). It didn't have a base and could be pointed at just about anything in the environment. It allowed children to explore objects that were opaque or too large or heavy to fit under a traditional microscope. This was a major fun feature. Kids wanted to look inside their mouth, in their ears, and the weave on their sweaters, their pets, and so on. This later became the "handheld" mode of operation of the QX3 product, where the unit can be lifted out of the base and used exactly like that.

A First Look, June 1998

This version is all form and no functionality; it was the very first industrial design foam model to combine the traditional microscope mode (in the base) and handheld mode into a single design. The vertical piece is removable. This model represents desired form (without function). This version was developed prior to knowing the size and dimension specifications.

A Working Prototype, October 1998

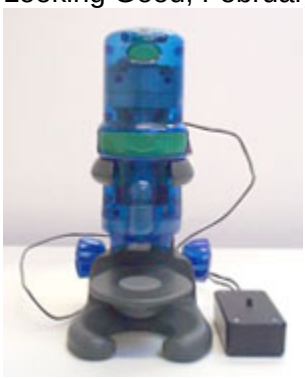
Here is the first working prototype with full functionality. It works, but the wires on the outside belong inside. The ideal shape or color weren't right yet, and the designers didn't know yet what they should be.

12A Handout: Thinking Again About Design (continued)

Getting Closer, January 1999

This second working prototype has functionality, but the power supply is still on the outside. This one was called the "albino" model. The shape is very close to final. The engineers knew that everything inside (electronics, optics) would fit inside this shape; it also fit the size of kids' hands well, and looked good.

Looking Good, February 1999



This version tested a new look for a debut at a national toy tradeshow. It looks good with transparent plastic, but it wasn't fully functional—the power supply was still external.

Presenting QX3, September 1999

The final product—the QX3 is born!

Session 12, Activity B

Materials and Modeling Plans

Goal
Learn about available materials and plan model(s) to build.

Outcome
Know about available materials, select those useful for their needs, and plan model building.

Description
After a brief introduction to the variety of materials available for modeling, students have time to study the materials and plan what models they want to build. The materials are organized into three groups: materials for structure, materials for connections, and tools.

Supplies
A variety of materials to build models.

Supplies for Structure

- Foam (Styrofoam* in sheets and several shapes, including foam tubes for pipe insulation)
- Foam core board
- Balsa wood (sheets and pre-cut strips from craft supply stores)
- Modeling clay
- Aluminum foil
- Pipe cleaners and plastic straws
- Cardboard (tubes, boxes of all sizes, flat pieces)
- Paper (including poster board or card stock weights)
- Erector* set
- Lego* set
- Dowels, bamboo skewers
- Wheels

Other Optional Structural Supplies

- Recyclable materials such as wine corks, aluminum soda cans, bubble wrap, packaging peanuts, and twist ties
- Sample items (for students to acquire and use in larger constructions): PVC pipe and connectors, lumber (plywood and 2x4s) of different sizes

Parts and Materials To Connect Things

- String
- Wire
- Rubber bands

12B: Materials and Modeling Plans (continued)

- Rubber tubing
- Tape (duct, masking, packaging, and electrical)
- Glues (epoxy, superglue, glue sticks, glues for hot glue gun, and rubber cement)
- Hinges
- Nuts and bolts, washers, assorted screws
- Nails, thumbtacks

Tools

- Several sets of each: pliers, saw, hammer, screwdriver, hot glue gun, and tin snips

Preparation

1. Gather the materials well in advance of this session. Send home information to parents and request donations of used building materials or any of the suggested recyclable items. Purchase what is not supplied or donated.

2. On the day of the session, lay out the modeling materials organized by: a) things to build with, b) things for connecting and attaching, and c) the tools.

Procedures
Planning

1. Introduce the modeling materials. Explain, demonstrate, and answer students' questions about any unusual or unfamiliar materials or tools. Build a common vocabulary as you introduce and students study the materials.

2. Plan what to model. Have students write down the following questions and answers in their design notebooks:

    - What do you want or need a model of? (List at least three possibilities.):
    - For each model possibility
        - Is this a system or a component of your design project?
        - What will this model help you understand about your idea?
        - Will it be a small or full-scale version?
        - What will you need to build it?
        - What materials on hand will work for your model?
        - What is not on hand for building your model?

3. During this planning time, students should select and manipulate different materials as they plan. Encourage them to make notes about the materials that they study: their flexibility, strength, and their suitability as a modeling material. Note: It may be helpful to have students review the *13A Handout: Making Models*.

12B: Materials and Modeling Plans (continued)

Sharing

1. While students are planning, have mentors meet with students and discuss their plans. Mentors should help students articulate the purpose of the model and answer the above questions as they plan. It is important that students are intentional during the model building. They should have a purpose, something they'd like to test or trial in each model.

2. Remind them that they can model different systems, subsystems, and components as well as the whole product. Encourage them to make large enough models so that they can see, test, and understand the systems, parts, and components.

Wrap Up
Ensure that each student has a plan and a clear purpose for constructing at least one model.

Have the students read *12B Reading: Meet a Modelshop Manager*.

Follow With
Activity *12C: Structural Considerations* provides the opportunity for students to consider the structure of their projects.

Materials and Modeling Plans

Handout: Session 12, Activity B

In this activity, you will start to plan your model. Like anything, the more planning you do in advance, the better your chances of achieving what you want. It's best to put answers to the questions below in your design notebooks.

1. What do you want or need a model of? (List at least three possibilities.)

2. For each model possibility, consider the following questions and answer them in your design notebooks:

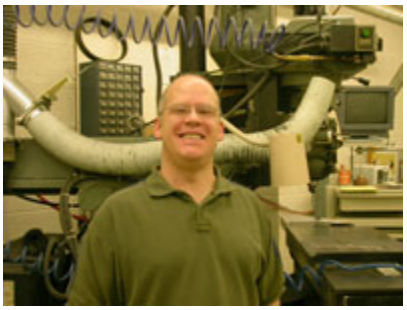
    - Is this a system or a component of your design project?
    - What will this model help you understand about your idea?
    - Will it be a small or full-scale version?
    - What will you need to build it?
    - What materials on hand will work for your model?
    - What is not on hand for building your model?

3. As you plan, you may select and manipulate different materials. Be sure to make notes about the materials that you study: their flexibility, strength, and suitability as a modeling material.

Tip: When planning your model, it is better to plan to build a bigger model so that the details can be seen, tested, and understood.

Meet a Modelshop Manager

Reading: Session 12, Activity B



Bruce Willey
Modelshop Manager
ZIBA Design

Background
I'm originally from St. Paul, Minnesota. I've worked at ZIBA Design for almost eight years. I decided to study modelmaking after I had graduated from college and taught English in Japan for two years. I enrolled at Bemidji State University in Minnesota and took Industrial Technology and modelmaking courses for two years. I performed a three-month internship at an architectural modelshop in Boston, Massachusetts. After that I got a job at the Industrial Design Center for NCR in Dayton, Ohio. I worked there for five years, then I visited Portland, got a job offer, and moved here. I became the manager of the modelshop about four years ago. In each case, my managers and co-workers have mentored me. Since a new person often brings new skills into a workplace, I sometimes have taught my manager and I've been taught by those who work for me.

A Typical Day
In a typical day I discuss the current and upcoming work schedule with the other modelshop staff and project managers and their team members who bring us the work to do. I will often order modelmaking supplies by phone or Internet from a variety of vendors, and I might have to arrange to have an outside modelshop do work for us if we don't have the time or resources. I have to fill out paper or electronic forms to order things or hire outside shops or schedule projects. There is a project meeting or a group meeting or a management meeting or a brainstorm meeting on almost any given day.

If there is still any time left or if there is a tight deadline, I will do model work too. Sometimes that is just spending a couple of hours painting things or using a table saw or band saw to cut material up and using hand tools like chisels and files and sandpaper to form it. Sometimes I work on very complicated models that take weeks to finish and involve planning, measuring, using computer aided design (CAD) and computer aided machining (CAM) software, sanding, polishing, painting, and careful assembly.

Favorite Thing About Job
I like having such a wide variety of different activities to do every day.

12B Reading: Meet a Modelshop Manager (continued)

Advice To Young People

You have to decide if you are interested in how things go together and work. You should be comfortable using tools and working with your hands. You will be using math and science and art skills. Any kind of commercial and industrial arts classes and art or craft classes or hobbies will help you a lot. All designers and engineers and almost all modelmakers use computers very frequently. Take computer classes and classes that expose you to advanced technology. Watch carpentry shows and similar programs to see if you are interested in solving problems by designing and making things.

About ZIBA Design

ZIBA Design is an international design firm that has designed products from many global companies, including FedEx, Microsoft, Intel, Fujitsu, Black & Decker, Sony, Pioneer North America, Dial, and Clorox. www.ziba.com*

Session 12, Activity C

Structural Considerations

Goal
Consider structural decisions about the project before making a model.

Outcome
Students consider and make structural decisions about their project.

Description
Will it fold? Expand? Roll? Inflate? Many products are collapsible; they fold out for action and fold up for storage. Students take a look at some of these objects and consider collapsibility issues for their project.

Supplies
Samples of collapsible items such as umbrella, folding chair, window blinds, stackable cups, sleeping bag, fold-away rain jacket, tent, fold up map, pop-up book, paper lantern, easel, ladder, pocket scissors, glasses, Swiss Army knife, measuring tape, stackable measuring cups and spoons, balloon, inflatable raft, fireplace bellows, rubber band, plastic bag, or jump rope.

Preparation
Bring in as many samples of collapsible items as possible. Alternatively, have students bring in collapsible items. Spread them all out on a table.

Prepare cards with the collapsible principles below for students to sort the objects.

Procedures
Collapsible Items

1. Have students gather around the collapsible objects on a table.

2. Ask what the items have in common. Define collapsible: Objects that can be folded and unfolded again and again.

3. Review the chart below. Ask them to sort the items into different mechanical categories by collapsible principles (written on cards). Many collapsible objects apply more than one of these principles

Collapsible Principles	Definition	Examples
Stress	1. Something that is stressed (compressed) for storage and relaxed for action 2. Something that is stressed (stretched) for action while relaxed for storage	Sleeping bag, rubber band

12C: Structural Considerations (continued)

Collapsible Principles	Definition	Examples
Folding	Soft materials that are flexible and directionless can be folded	Clothes, blankets, towels, tents, curtains, flags, plastic bags, jump ropes
Creasing	Something that can be folded along preset lines or creases giving an object (folded and unfolded) neater appearance, may also facilitate the act of folding and unfolding	Maps, pup-up books, newspapers, boxes
Bellows	Used where a flexible and sealed connection is needed	Airport bellows gates, hanging fabric shoe-shelving, paper lanterns
Assembling	The whole is separated into parts for storage	Jigsaw puzzles, Lego* blocks, motorized wheel chairs
Hinging	Objects with flexible joints	Laptop computers, pianos, mobile phones, handheld computers, umbrellas, ladders, glasses, folding scissors, scooters, folding bicycles, strollers, pocket knives
Rolling	Objects that are rolled and unrolled repeatedly	Extension cords, tape measures, roll-up dog leashes
Sliding	Collapsibles that expand and contract as their parts slide open or closed	Telescopes, car antenna, sliding ladders, autofocus camera lenses, lipstick
Nesting	Two or more objects that fit together to occupy less space than they do individually	Russian dolls, measuring spoons/cups, shopping carts
Inflation	Something that blows up to expand	Balloons, inflatable rafts, inflatable neck cushions
Fanning	An object that has a pivot that holds its leaves together to allow multiple leaves to be viewed at the same time	Fans, sample color swatches, fan-mounted Allen wrench keys
Concertina	Collapsibles that have a number of equal rods connected by pivots to form a string of Xs which can be expanded and retracted	Retractable mirrors/lights

12C: Structural Considerations (continued)

4. Explain that collapsibility is never the purpose function—it is always the support function. Discuss the benefits of each collapsible item (such as space saving, can perform different functions when open and when collapsed, safety.)

Structural Considerations

1. Ask students to consider what structural principles would improve their own projects. In doing so, they can consider the following questions:
    - How will their project be stored?
    - How will their product be moved?
    - Will their product need to be disassembled? If so, how?
    - Where will their product be placed? Are there any structural considerations to keep in mind based on its placement?
2. Students can sketch any structural improvements to their projects.

Chart adapted from Mollerup, Per. *Collapsible: The Genius of Space-Saving Design.* San Francisco: Chronicle Books, 2001.

Wrap Up
Review and share students' ideas.

Follow With
In Session 13, *Making It! Models, Trials, and Tests*, students build models and test the results.

Structural Considerations

Handout: Session 12, Activity C

Have you ever noticed how many products change shape depending on their usage or non-usage? For example, an umbrella is quite different when in use and when not in use. In this activity you will study collapsible items and make structural considerations for your project.

1. In your notebook, fill in the "Examples" for each Collapsible Principle like chart below. These may be items that are in your class or items that you discuss.

Collapsible Principles	**Definition**	**Examples**
Stress	Something that is stressed (compressed) for storage and relaxed for action Something that is stressed (stretched) for action while relaxed for storage	
Folding	Soft materials that are flexible and directionless can be folded to create new direction	
Creasing	Something that can be folded along preset lines or creases giving an object (folded and unfolded) a neater appearance; may also facilitate the act of folding and unfolding	
Bellows	Used where a flexible and sealed connection is needed	
Assembling	Something whole is separated into parts for storage	
Hinging	Objects with flexible joints	
Rolling	Objects that are rolled and unrolled repeatedly	

12C Handout: Structural Considerations (continued)

Collapsible Principles	Definition	Examples
Sliding	Collapsibles that expand and contract as their parts slide open or closed	
Nesting	Two or more objects that fit together to occupy less space than they do individually	
Inflation	Something that blows up to expand	
Fanning	An object that has a pivot that holds its leaves together to allow multiple leaves to be viewed at the same time	
Concertina	Collapsibles that have a number of equal rods connected by pivots to form a string of Xs which can be expanded and retracted	

2. What structural principles would improve your project? Consider the following questions:

   - How will your project be stored?
   - How will your product be moved?
   - Will your product need to be disassembled? If so, how?