Session 13

# Making It! Models, Trials, and Tests

## Making, Modeling, and Materializing

**In This Session:**

A) Making Models (150 minutes)
- Student Handout
- Student Reading

Students' design projects move to the tangible and testable. This session provides time to build and test models of components, systems, or the product itself. In the single activity for the session, *13A: Making Models*, students are encouraged to be methodical as they build and report on their models, tests, and results in their design notebooks. This is a session where mentors can support students' work and help them take time to reflect on results and be thoughtful about appropriate next steps.

**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

## Session 13, Making It! Models, Trials, and Tests (continued)

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

Session 13, Activity A

# Making Models

**Goal**
Learn how models contribute to design.

**Outcome**
Build models, evaluate results, and consider design modifications.

**Description**
Students work on their models of the project or trials of components, systems, or subsystems. They are encouraged to be methodical by keeping records of what they plan to construct and why, and what the results show for next steps or modifications to their design. Mentors assist with constructing and testing their models by helping students analyze design issues as they build their models.

**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

## 13A: Making Models (continued)

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

Safety Guidelines

1. Cut away from the body.
2. Never push into the palm.
3. Stabilize what is being cut.

**Preparation**
Invite mentors to this session

**Procedures**

1. Have students review the handout.

2. Discuss some model building tips:

    - Use found materials to construct models. Point out that the initial model for the Apple* computer mouse, for example, was a butter dish with parts glued to hold the rolling ball.
    - It is easy to get carried away by the fun of making an exciting model, but the materials must not outshine the design concept.
    - The range of materials used in model making is endless. Experiment with different materials or use them in inventive new ways.
    - Respect the physical properties of materials. Revisit the materials' test results from *3A: Properties of Materials*. Try running materials' property tests for materials you may be considering.

## 13A: Making Models (continued)

- Know the differences between adhesives. Read labels on glue to understand which glues work best for different applications. Use the least amount of glue possible.
- Always place cardboard or some sort of cutting board underneath the material being cut.
- For straight cuts, cut against a metal edge.

3. Emphasize the value of good records as students build and learn about their design. Point out that they need to take the time to be methodical and write down what they plan to do and why. As they build and think about what the modeling process shows them, they should keep records about what the design issues come up as they build models. When students complete a model, they "test" it, gather data about results, and write notes about modifications and next steps which may be another model, depending on time available.

4. Clean up and organize storage or transport of models home for further work.

**Wrap Up**
Have all model makers show what they built and state one or two things that they learned in the process.

Optional: Have students read *13A Reading: Meet Materials Engineers*.

**Follow With**
Session 14, *Prototype Practicalities*, allows students to develop the next stages of the project.

Note: If you are running a two-week summer camp, you may need to end project work with this session and move to *Session 17: Fairly There*.

# Making Models

## Handout: Session 13, Activity A

It is helpful to keep good records of your model-building efforts. Good records allow you to adjust your design based on what you learn from each model you build. For each model record your plans, purpose, tests and results, and next steps using the questions below. Use your design notebook for these records.

**Plans**
What do you want to build a model of? Is this a system or component of the product? Is this a full-scale model?

**Purpose**
What will this model help you understand about your design?

**Tests and Results**
What did your model show you about your design? What features did you test? Does it meet requirements? Did it function as intended? Did the form suit you? Are the materials suitable? What modifications do you need to make? What new ideas do you have for your design?

**Next Steps**
What do you want to do next? Adjust this model? Build another version of this model? Build a model of something else?

# Meet Materials Engineers

## Reading: Session 13, Activity A

Pratima Rao and Jill Barrett
Materials Engineers

When it comes to designing or improving a product, finding just the right material is a critical step. From artificial knees to firefighters' uniforms to fiber optic cables for the ocean floor, everything that gets manufactured benefits from the expertise of materials engineers. Two *Design and Discovery* mentors developed an early interest in materials engineering.

**Early Interests**

When Jill Barrett was growing up, she and her two sisters routinely turned their garage into a laboratory for conducting science and engineering investigations. Their enthusiasm wasn't dampened even when they ruined the family pots and pans by cooking up a pot of paper pulp. Looking back, Barrett can see how developing projects for school science fairs was a natural step toward her career in materials engineering. She earned a bachelor's degree in materials science from North Carolina State University and did master's studies in metallurgical and materials engineering at the Colorado School of Mines.

For Pratima Rao, being on a high school Science Olympiad team motivated her to pursue scientific studies in college. She originally planned to become a doctor. During her undergraduate studies at Rensselaer Polytechnic Institute in New York, she decided that materials engineering was a better fit for her interests. She also liked the idea of contributing to the development of new and improved materials that would benefit society. Rao eventually earned a Ph.D. in materials science and engineering.

**On the Job**

Materials engineers work on a range of projects, from large industrial plants to laboratories where research focuses on the molecular structure of substances. Plastics, metals, wood, textiles, medicine, ceramics, and semiconductors are only a few of the fields where breakthroughs have come about through the efforts and insights of materials engineers. "Materials engineers are on the cutting edge in almost every field," says Rao.

Barrett's career has involved her in everything from steelmaking to testing the properties of

## 13A Reading: Meet Materials Engineers (continued)

components that go into basketball shoes. She typically gets involved after initial product development is underway and brings her expertise to focus on process improvement during manufacturing.

Rao has worked in the field of photonics, improving photosensitive glass used in the telecommunications industry. She enjoys taking scientific research concepts and applying them in practical ways in manufacturing. She also likes the hands-on nature of her work, from melting powders to making glass samples to operating a transmission electron microscope. While she worked at Corning, Inc., in New York, she was part of a research team that received a patent for an invention called "Lens Array and Method for Fabricating the Lens Array."

Materials engineers often work as part of a team, contributing their technical knowledge to evaluate a product or improve the production process. As Barrett explains, "You talk with the design team about how a product is supposed to work. You ask a lot of questions about different materials: Is it too sharp? Too brittle? Will it break easily? Will it melt if exposed to heat? Can it be molded?" Engineers also pay attention to costs, evaluating whether using a certain material will be economical or drive production costs over budget.

Designing tests to evaluate whether different materials will meet design specifications is another part of the job. The engineer's role is not only to find what works but to rule out what doesn't. "You should never be afraid of failure," Barrett stresses. "Failure teaches you more than success ever will."

Being able to communicate and ask good questions are important job skills, too. "Communicating your ideas clearly is crucial to your success," Barrett says.

**Career Preparation**

Barrett and Rao credit their career success to family support and encouragement. "My parents always told me I could be anything I wanted. I heard that early and often," says Barrett. During college, they found themselves in the minority as women in engineering. Both women say they benefited from internships and hands-on experiences that gave them insights into the real world of engineering. Rao says persistence is a quality worth cultivating, and so is "learning how to ask for help. This is a valuable lesson. Support from others is important as we work to overcome obstacles." Barrett shares a final tip for anyone considering a career in engineering: "Make friends. Make lots of friends. They'll help you every step of the way."