Session 6

One Problem, Many Solutions

Engineering Fundamentals

In This Session:

A) Clocks of All Varieties (45 minutes)
- Student Handout
- Student Reading

B) Form Meets Function (45 Minutes)
- Student Handout

C) Tick Tock: How a Clock Works (60 Minutes)
- Student Handout

This session places students in the shoes of both engineers and product designers as they apply analytical skills to understand how the requirements of a product are met—in this case, a clock. To prepare for this session, you'll need a digital alarm clock and a mechanical clock for each participant, pair, or group. These can be donated by parents or guardians throughout the first sessions or purchased at a thrift store. It is important to know that they will be taken apart and may not be easily put together again.

In *6A: Clocks of All Varieties*, students look closely at the clocks and as a class come up with design requirements for clocks. In *6B: Form Meets Function*, they see how the requirements are met in different clock radios as they consider form and function. The activity *6C: Tick Tock: How a Clock Works* has the students disassembling the clock radios to see how the electronics and mechanics work to make a clock "tick."

Supplies

- A clock radio for each participant, pair, or group. Ideally, there is one clock radio for each pair.
- Screwdrivers
- Windup mechanical alarm clocks for each participant, pair, or group (at least one for demonstration)
- Flip chart and markers

One Problem, Many Solutions

Key Concepts: Session 6

In Session 6, students think as engineers and product designers and analyze the **design requirements** of a clock radio. As they compare different clock radio designs they begin to see the necessary tie between form and function. The comparison of mechanical and electric clocks allows students to see how the same design requirements can result in very different products. Writing design requirements is the key to getting what you want in a product.

Key Concepts
In this session, the focus is on developing accurate design requirements. Consider the basic requirements for a clock radio. A clock radio must play, have alarm settings, sit on a shelf with numbers visible, be reliable, have volume control, and have a mechanism for changing radio stations. The manner in which the product requirements are met can be extremely varied.

Requirements define *what* the project is ultimately supposed to do. Later on, students will develop requirements for their design project. They also develop specifications which define *how* requirements will be met. *Design requirements* are general product goals, while *product specifications* are much more detailed and should be clear enough to hand off to a production group to build. *User requirements* are another type of requirement designers and engineers rely on to describe the needs, goals, and characteristics of the proposed users.

Design Requirements
Requirements provide general statements of what you want your product to do or what qualities you want it to have. For example, a requirement you might have for a stereo is a way to control the volume. You might also require the stereo be able to hold multiple music CDs at one time.

Design Specifications
Specifications provide more detail and are often measurable. The specifications provide detailed statements that might deal with materials, proportions, and exact placement of specific components. Specifications guide the engineering of a product. A design specification for a stereo might state that the stereo will hold five music CDs which are loaded into a compartment at the top of the stereo.

Examples of design requirements and specifications are embedded throughout the *Design and Discovery* curriculum:

1C: Toothpaste Cap Innovations
8B Handout: Sample Design Brief
12A Handout: Thinking Again About Design

Session 6, Activity A

Clocks of All Varieties

Goal
To examine one object and see the different ways it can meet requirements.

Outcome
Students will begin to consider the relationship between form and function.

Description
Participants study a clock radio and consider how it meets requirements.

Supplies

- A clock radio for each student, pair, or group. (Ideally, there is one clock radio for each pair.)
- Flip chart and markers

Preparation
Gather digital clock radios beforehand. These should be clock radios that can be disassembled. Broken clocks are fine—they do not have to work. (Ideally, each student will have one clock radio.)

Set up a flip chart on which to write the requirements.

Procedures
Each participant, pair, or group should have a clock radio in front of them. Present the following questions to discuss as they look at their clock radios.

1. List the main functions of a clock radio.
2. Describe all the things yours can do in addition to the basics listed above.
3. Describe its size, shape, and materials—everything you can see—in detail.
4. Now think carefully about where it sits in a bedroom. How it is it used? What does a user have to do to use a clock radio? Be very specific. You are collecting data about a user.
5. When it is it used?
6. What are the conditions (time of day, user's attitude, etc.) under which someone usually uses it?

Wrap Up
Discuss and share responses. Generate a group list of the basics of what a clock radio is supposed to do. *(The radio must play, be easy to set alarm, sit on a shelf with numbers visible, be reliable, have volume control, and include the ability to change radio stations, etc.)* Explain

6A: Clocks of All Varieties (continued)

that these are called requirements.

Read *6A Reading: Meet a Project Manager*.

Follow With
In *6B: Form Meets Function*, students compare clocks and consider how problems are addressed.

Clocks of All Varieties

Handout: Session 6, Activity A

Have you ever been in an electronics store and seen how many different types of clock radios there are (or TVs and stereos, for that matter)? Clock radios are an excellent product for understanding form and function. To begin, look at one clock radio and consider what the basic requirements of a clock radio are. Record your observations in your design notebook.

1. List the main functions of clock radio.
2. Describe all the things the one in front of you can do in addition to the basics listed above.
3. Describe its size, shape, and materials—everything you can see—in detail.
4. Now think carefully about where it sits in a bedroom. How it is it used? What does a user have to do to use a clock radio? Be very specific. You are collecting data about a user.
5. When it is it used?
6. What are the conditions (time of day, user's attitude, etc.) under which it is used?

Meet a Project Manager

Reading: Session 6, Activity A

David Thorpe
Senior Project Manager
ZIBA Design

Introduction
Hello, my name is David Thorpe. When I was young, I was always making things, drawing and writing. I made puppets, wrote my own comic books, built things from a big bucket of Lego* blocks (not the prepackaged kits), and built tree houses, forts, and rafts for our pond. I went to college at Stanford University thinking that I was going to be a computer programmer, but after a few semesters of "flipping bits," I changed to the Product Design program in the Mechanical Engineering department. The Product Design program teaches problem solving, brainstorming, and sketching skills to engineers along with the technical aspects of engineering. After college, I worked at Hewlett-Packard designing and engineering inkjet printers for four years and then joined ZIBA Design in 1993.

A Typical Day
My day usually consists of a combination of meetings to make sure everybody knows what they are supposed to be doing, group brainstorms, and then some detailed design work on my own. I alternate between design on the computer and rough concept sketching. There is usually a lot of informal interaction with others in the office as we bounce ideas off one another, get updates on other projects, and banter back and forth.

Most Interesting Thing About My Job
I really enjoy the diversity of projects that I work on and interacting on a daily basis with talented, creative co-workers.

Advice
My advice to younger people entering the design or engineering field is to understand both the technical and creative side of both. There are plenty of great designers and engineers, but not as many that can bridge both disciplines.

Session 6, Activity B

Form Meets Function

Goal
To understand what is meant by "form follows function."

Outcome
Students will understand the difference between form and function and how form usually follows function. They will draw a design for a new and improved clock radio.

Description
Students examine various clocks in order to understand form and function.

Supplies
A clock radio for each participant, pair, or group

Preparation
Gather all the clock radios on one table for students to view at once. Show the requirements sheet that the students created in the last activity.

Procedures
Clock Radio Requirements

1. Have the students gather around the table with the clock radios and pose the following questions:

    - What do you notice about the radios around the table?
    - In what ways are the radios the same? Different?
    - Why are the radios all different?
    - Choose one requirement and examine five clock radios. Record how the five different clock radios met this requirement.
    - How do the requirements force products to be similar in function, yet allow for differences?
    - How do the requirements force products to be similar in function, yet allow for differences?
    - What does it mean when people say "form follows function"? How does this relate to the clock radios?

Form and Function

1. Explain that engineering is about function: Does the product work? Does it meet requirements? Can it be manufactured efficiently, etc.? The form of an object (how it is designed and constructed) should follow the task it is to perform. In other words, you must know exactly what you want something to do before you can design and build it. In the case of clock radios, once the electrical and mechanical aspects of the product are developed, many creative forms can follow.

6B: Form Meets Function (continued)

2. Encourage students to think like engineers, but with the benefit of the skills of good industrial designers who are attuned to the subtle but powerful influences of the "visual attraction" and "tactile appeal" of a product.

3. Pair students and have them each take a clock radio. In pairs, have them examine and compare two clock radios very closely. For each function, tell them to discuss the form it took on each clock and what they like or dislike about the form on each clock radio.

4. Ask the pairs to pick one requirement and improve upon it. They can draw a sketch of their ideal clock radio in their design notebooks.

Wrap Up
Have pairs share their sketches of their new and improved clock radio designs.

Follow With
Students will take a look inside the clock radio to see the inner workings in *6C: Tick Tock: How a Clock Works*.

Form Meets Function

Handout: Session 6, Activity B

In this activity, you will look at the clock radios closely and observe how the requirements are met.

1. Record the requirements that the class came up with for clock radios.
2. Choose one requirement and explain how five different clock radios met this requirement.
3. In pairs, consider one requirement and how you could improve upon it. Now, individually, draw a sketch of your ideal clock radio. This can be done in your design notebooks.

Session 6, Activity C

Tick Tock: How a Clock Works

Goal
To understand how clocks use electrical and mechanical components to make them tick.

Outcome
Students will disassemble the clock radios and mechanical clocks to see electrical and mechanical components at work.

Description
Students learn about the electronics and mechanics behind clocks.

Supplies

- A clock radio for each participant, pair, or group. Ideally there is one clock radio for each pair.
- Wind-up mechanical alarm clocks for each participant, pair, or group (at least one for demonstration)
- Screwdrivers

Dual Alarm Clock

View a short video of a student sharing her Dual Alarm Clock design solution.

To view the video, select a player and then click on your connection speed.

Select a Player

Dialup High Speed

Preparation
Each student (or pair) should have a clock radio and a wind-up alarm clock (if feasible). Provide enough screwdrivers (both flat head and Phillips, in different sizes) for them to take the radios apart.

Procedures
Inside a Clock

1. Ask students if they have ever looked at a clock and thought about how it works. Explain that they will have the opportunity to get inside clocks to see how they work and to compare mechanical and electric clocks. Explain what is needed to make a clock tick:

    - A source of power. In an electric clock radio, this is an electrical power supply, typically either a battery or 120-volt AC power from the wall. In a mechanical clock, the weights and springs provide the power.
    - An accurate time base that acts as the clock's heartbeat. In an electric clock, there is a time base that "ticks" at some known and accurate rate. In a mechanical clock, the pendulum handles this.
    - A way to gear down the time base to extract different components of time (hours, minutes, and seconds). In a digital clock, there is an electronic "gearing mechanism" of some sort. Generally, a digital clock handles gearing with a component called a "counter." In a mechanical clock, gears serve this role.

6C: Tick Tock: How a Clock Works (continued)

- A way to display the time. In a digital clock, there is a display, usually with either LEDs (light emitting diodes) or an LCD (liquid crystal display). In a mechanical clock, the hands and face do this.

2. Have the students explore the electrical and mechanical components of their clocks. They should be able to identify the following:

   - LEDs
   - Wires
   - Circuits
   - Buzzer
   - Speaker
   - Belts
   - Motors

3. As a demonstration, or individually, have students disassemble a mechanical clock to see how the gears work.

Wrap Up

Students can wander around the room and look at the insides of the different clock radios. Remind students to add to their list of design opportunities. They may want to consider electrical or mechanical ideas.

Follow With

In Session 7, *The 3 R's Of Problem Identification*, students begin to consider their own design opportunity.

Tick Tock: How a Clock Works

Handout: Session 6, Activity C

In this activity, you will have an opportunity to look inside clocks and see the inner workings of both mechanical and electrical clocks. As you examine the clocks, notice that they have the following:

- A source of power. In an electric clock radio, this is an electrical power supply, typically either a battery or 120-volt AC power from the wall. In a mechanical clock, the weights and springs provide the power.
- An accurate time base that acts as the clock's heartbeat. In an electric clock, there is a time base that "ticks" at some known and accurate rate. In a mechanical clock, the pendulum handles this.
- A way to gear down the time base to extract different components of time (hours, minutes, and seconds). In a digital clock, there is an electronic "gearing mechanism" of some sort. Generally, a digital clock handles gearing with a component called a "counter." In a mechanical clock, gears serve this role.
- A way to display the time. In a digital clock, there is a display, usually with either LEDs (light emitting diodes) or an LCD (liquid crystal display). In a mechanical clock, the hands and face do this.

Now identify the following components in the clocks:

- LEDs
- Wires
- Circuits
- Buzzer
- Speaker
- Belts
- Motors